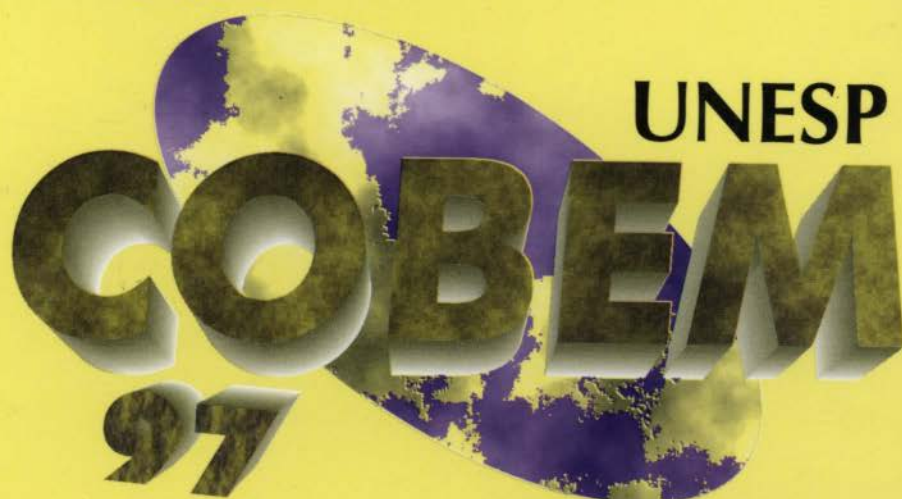


XIV CONGRESSO BRASILEIRO DE ENGENHARIA MECÂNICA



14 th BRAZILIAN CONGRESS OF MECHANICAL ENGINEERING

08 a 12 de Dezembro de 1997

December 8-12th 1997

Centro de Convenções Obeid Plaza Hotel
Bauru - SP / Brasil

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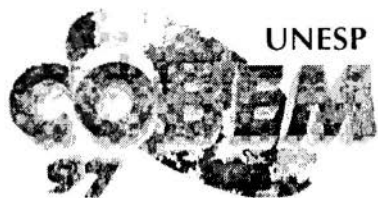
Associação Brasileira
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XIV CONGRESSO BRASILEIRO
DE ENGENHARIA MECÂNICA

COBEM 97

Proceedings - Abstracts

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XIV CONGRESSO BRASILEIRO DE ENGENHARIA MECÂNICA

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COB1503 MACRO-TO MICROSCALE HEAT TRANSFER: THE LAGGING BEHAVIOR

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Thermal lagging is a physical phenomenon in heat transport becomes pronounced as the physical scale and/or transient time shorten. The resulting phase-lag concept extends the macroscopic approach that is familiar, and probably more palatable, to practicing engineers to accommodate the thermalization and relaxation behavior in small-scale heat transport. Several sets of experimental results, including femtosecond ultrafast laser heating on metal films, fast-transient heat transport in amorphous materials, heat propagation in superfluid liquid helium, and energy dissipation in sand are revisited to reveal the insufficiencies in the existing models and the need for a more refined approach. The dual-phase-lag model then follows, aiming at accurate descriptions of the salient features that reflect the interweaving behavior of thermalization and relaxation in these experiments. Physical meanings of phase lags are summarized, with emphasis on the interrelations with the existing macroscopic and microscopic models. Lagging behavior in rapid thermal oxidation in silicon dielectrics is demonstrated, which appears as the counterpart of thermal lagging, but occurs in mass transport with time delays due to species diffusion and chemical reactions.

Keywords: *Thermal lagging, relaxation, thermalization, phase lags, microscale*

COB1504 CONSTRUCTAL THEORY: FROM ENGINEERING TO SHAPE AND STRUCTURE IN NATURE

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This is a review of two new and important developments in thermal science. First, there exist fundamental optima in the constitution and operation of flow (non-equilibrium) systems, man-made and natural. These optima can be identified based on the simplest models that still retain the essential features of the real system. Examples are the spatial allocation of heat transfer area in a power plant, and the temporal optimization of on & off processes. The second development is that the engineering method of modeling and optimization has been extended to natural systems, animate and inanimate (e.g. tree networks). This step has been named constructal theory for reasons given in Section 3. The objective of such work is to predict the macroscopic spatial and temporal structure (organization) that is everywhere. It is to inject a dose of determinism (theory) in a field that until recently considered natural structures to be non-deterministic: results of chance and necessity. These developments bring to mind the advice left to us by J. W. Gibbs more than one hundred years ago:

“One of the principal objects of theoretical research in any department of knowledge is to find the point of view from which the subject appears in its greatest simplicity”.

Keywords: *Constructal, Fractal, Self-organizing, Non-equilibrium thermodynamics*

COB1507 MATHEMATICAL MODEL FOR PIEZOELECTRIC MOTORS: AN EXAMPLE OF MECHATRONIC MODELLING**Peter Hagedorn***Department of Applied Mechanics, Darmstadt University of Technology, Germany*

Traveling wave ultrasonic motors have recently been attracting considerable attention: they are beginning to replace at least in certain areas small electromagnetic motors. This development has been made possible by recent advances in power electronics, material research and digital control, which allow utilization of the piezoelectric effect for low power motors. In these motors the mechanical energy is generated with frequencies of the order 40 kHz via piezo-elements producing elastic waves in a stator, which usually has approximately the form of a circular plate, a ring or a thin walled cylindrical tube. The rotor is then driven by a stator via contact forces. With an extremely simple mechanism, frequency reductions of 1 : 40 000 and more are obtained between the stator vibration and the rotor motion. As a consequence, one can work in the 40 kHz range on the electrical side, while a low frequency of rotation is obtained on the mechanical side, as is desirable for many applications. Traveling wave ultrasonic motors combine features such as high holding and driving torque, low speed, etc., which make them extremely attractive and promising for many applications. In many cases they can be used directly without an intermediate speed reducer. This paper addresses the problem of mathematical modeling of ultrasonic traveling wave motors and the recent advances obtained in this field.

Keywords: *Ultrasonic Motors, Piezoelectric Motors, Traveling Wave Motors***COB1508 VIRTUAL MEASUREMENTS IN EXPERIMENTAL STRUCTURAL ANALYSIS****Randall J. Allemang***Structural Dynamics Research Laboratory (UC-SDRL), University of Cincinnati
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One of the most interesting advances in experimental structural analysis over the past twenty years is the extensive use of linear transformations to formulate virtual measurements. Simply stated, virtual measurements are linear transformations of physical measurements where certain characteristics of the data are preserved or enhanced. In experimental structural analysis, virtual measurements result from linear transformations that are based upon theoretical estimates of the modal vectors, experimental estimates of the modal vectors and/or vectors derived from singular value decomposition (SVD) or eigenvalue decomposition (ED) of analytical or experimental information. Principal force analysis, the enhanced frequency response function (eFRF) and Kalman filtered order tracking are discussed as examples of the use of virtual measurements in experimental structural analysis.

Keywords: *Virtual, Measurements, Experimental, Structural, Analysis***COB1509 MECHATRONICS, A POWERFUL CONCURRENT ENGINEERING FRAMEWORK****Hendrik Van Brussel***Katholieke Universiteit Leuven, Division PMA, Celestijnenlaan 300B, B-3001 Heverlee,
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Mechatronics is emerging as a concurrent-engineering thinking framework in the process of designing complex machines. It is argued that mechatronics can be defined as the science of motion control. The different steps in the evolution from smart machines to intelligent autonomous systems are discussed and illustrated with many examples, mainly taken from the author's research experience.

COB1510 ASSESSMENT OF ADVANCED ALLOYS AND COMPOSITES UNDER FATIGUE LOADING

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The assessment of many advanced alloys and composites when subjected to cyclic loading is one critical area in their development. Moreover, such issues will often determine the widespread application, or otherwise, of these materials in load bearing components and structures. In some cases life prediction can be based on relatively simple extensions to existing concepts applied to conventional metallic alloys, but for many cases alternative approaches may be required. This presentation will address current areas of interest within ceramics, intermetallics, CMCs and MMCs. It will illustrate a number of crack-tip shielding phenomena with detailed and specific examples taken from: (i) fibre reinforced titanium MMCs; (ii) α based and α_2 based monolithic titanium aluminides; (iii) monolithic titanium alloys; (iv) partially stabilised zirconia; (v) particulate reinforced silicon carbide; and (vi) fibre reinforced GCMCs. In many of these examples fracture mechanics concepts such as the effective stress intensity factor range, and the maximum stress intensity factor applied over the fatigue cycle, are extremely useful if micromechanisms of local crack extension are to be rationalised, elucidated and quantified. The evaluation of such micromechanisms of local crack extension can be aided markedly by in-situ crack growth observations and examples will be considered within the presentation. Where possible, if detailed micromechanisms of crack extension can be combined with numerical analysis of effective local stresses and/or effective local stress intensity factor ranges, then a complete description of the process is possible and life prediction models may be developed. Although the approach outlined above is of clear scientific interest, and will be explored in detail, in many instances it will be far too involved to gain wide acceptance in engineering design against fatigue. In addition, K or DeltaK based philosophies will often be inappropriate. Problems with their application to advanced alloys and composites include: steep crack growth resistance curves (monolithic and particulate reinforced materials); the absence of single, dominant cracks (fibre reinforced ceramic composites); and non-unique crack length - load - stress intensity factor relationships for bridged cracks even when dominant matrix cracks are produced (fibre reinforced titanium composites). Such situations may necessitate the use of simpler total life (S-N based) concepts where the accurate determination of local stresses in service will be critical to the engineering use of these materials. These issues will also be considered.

COB1511 ENSINO DE ENGENHARIA FACE A SOCIEDADE

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A organização dos Cursos de Engenharia tem padecido de uma incrível seqüência de mal entendidos. A nível de Mestrado e Doutorado, sofre do erro histórico de se ter instituído uma forma de pós-graduação copiada "in totum" do sistema norte-americano, em cima de uma forma de graduação de estilo e origem tipicamente europeus, o que, aliás, é a base de nossa cultura. A Reforma Universitária deu um passo em direção à "americanização" da graduação, semestralizando as disciplinas e organizando a universidade em Departamentos, sem entretanto aliviar a carga horária nem flexibilizar os currículos, para lhe dar o toque final da citada "americanização". Esquecem, os planejadores dessas formas e reformas sucessivas, que nossa base cultural não pode ser alterada nem por Decretos e nem por Portarias, resultando assim numa grande incongruência do sistema de ensino da Engenharia. A atualidade mostra uma situação empresarial que, novamente exige uma reforma, previsível já faz tempo, mas que caminha a passos tão lentos que, no momento de sua "decretação", será certamente obsoleta, a menos que leve em conta a dinâmica das tecnologia e, portanto, cuide da flexibilização e, de certa forma, da universalização dos Cursos. Nesse sentido, desejamos apresentar algumas idéias que surgiram de nossa atuação no ensino, na administração e na prática da Engenharia nos últimos anos, tanto no país como no exterior.

COB1515 PARTICLE WEIGHTED SCHEMES FOR CONSERVATION LAWS, RECENT DEVELOPMENTS AND APPLICATIONS

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In the last ten years new Particle Weighted methods for Partial Differential Equations have been introduced. There is a lot of applications in the field of Fluid dynamic, and we must quote Vortex and Vortex like methods for inviscid Euler equations and Navier Stokes equations. PIC (Particle in Cell) methods are also well known in the field of compressible gas dynamic. Together with Vortex methods they use a specific numerical or semi-analytical methods to compute differential terms such as pressure terms:

- Green kernels for Vortex methods
- particle grid coupling for PIC methods.

Keywords: *Particle weighted, partial differential equations, vortex methods, PIC methods*

VIBRATION MEASUREMENT BY LASER DOPPLER TECHNIQUES

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TEMA 11 - Energia Eólica

COB63 CONSTRUÇÃO DE UM ROTOR EÓLICO COM TRÊS PÁS DE MADEIRA / CONSTRUCTION OF A WIND ROTOR WITH THREE WOOD-EN BLADES

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The construction of a 5 m diameter, three bladed horizontal axis wind rotor is presented. The blades are made of laminated wood and they have their pitches controlled by a synchronised centrifugal device. Simple solutions are employed to allow rotor fabrication in small workshops with common machines.

Keywords: *Energia eólica, rotor eólico, métodos de fabricação / Wind energy, wind rotor, fabrication methods.*

COB1144 INFLUENCE OF STEADY VERTICAL WIND PROFILES ON WIND TURBINES CYCLIC LOADING AND STABILITY

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This paper analyses the influence of steady wind shear (vertical wind profile) on the wind turbines structural stability. The wind speed, in general, increases with altitude (up to about 500 to 1500 m) above the earth's surface. However, for wind turbines, the altitude is limited to about 120 m at the most because beyond this level the cost of tower becomes prohibitive. It should be emphasized that we are talking about the wind turbine's rotor diameter of the order of 15 m or more. Hence, the wind speed at the extreme points of the rotor disc, considering perpendicular to the upwind would certainly be different magnitude, results into wind shear. The latter would cause cyclic load 1/revolution. This paper describes very briefly the equations of blade motion that determine the dynamic stability. This equation then is used to estimate the load due to wind shear. We have assumed a linear shear profile. The effect of it is estimated to calculate the bending moments. A step by step procedure is shown so as to have a real feel of the complexity involved in it.

Keywords: *Wind Energy, Wind Turbines, Dynamic Stability, Wind Shear, Cyclic loading.*

COB1145 MODELAGEM DE TURBINAS EÓLICAS CONTROLADAS PELO PASSO E POR "YAW" / WIND TURBINE PITCH AND YAW CONTROL MODELLING

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This work presents the modelling of wind turbines operating above rated power. The new controller is designed to make the system operate close to the rated power by actuating on the blade pitch and on the yaw devices, simultaneously. Regarding the design of the controller, it is necessary to linearize the rotor torque function with respect to the rotor velocity, w , the pitch, q , and the yaw angle, d , around the steady state. The direction and velocity of the wind are considered random variables. Then, the closed loop representation of the wind turbine can be approximated, in the frequency domain, by a second order function. The optimal controller gain is also obtained by three different methods that lead to close results.

Keywords: *Turbina eólica, Wind Turbine Pitch Control, Controle pelo passo da pá, Regulação por "yaw", Yaw Power Control.*

COB1280 TURBINA EÓLICA OHM-30KW - CARACTERIZAÇÃO DA CURVA DE POTÊNCIA / WIND TURBINE OHM-30KW - POWER CURVE CHARACTERIZATION

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An experimental 30 kW wind turbine OHM-30 has been installed in the Brazilian Wind Turbine Testing Center. The main aim of the project is development of special wind turbines for moderate wind. This paper presents the first part of the project involving the measurement of the power curve of the turbine OHM-30 according to I.E.A. (International Energy Agency). Several modifications in the turbine rotor and control strategies are emphasized.

Keywords: *1. turbina eólica / wind turbine*

2. curva de potência / power curve

TEMA 12 - Energia Solar

COB47 ANÁLISE NUMÉRICO-EXPERIMENTAL DA DISTRIBUIÇÃO DE TEMPERATURA EM UM RESERVATÓRIO DE ÁGUA QUENTE / NUMERICAL-EXPERIMENTAL ANALYSIS OF TEMPERATURE DISTRIBUTION IN A HOT WATER STORAGE TANK

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This work presents a numeric-experimental analysis of temperature and velocity fields inside a hot water reservoir in transient conditions. Initially the tank is at an uniform temperature and thereafter subject to a slow cooling at ambient temperature. A finite volumes method is applied in order to perform this analysis, with a bidimensional model in cylindrical coordinates. The program is continuously fed by 14 polynomials, which prescribe the tank wall temperature. These polynomials vary with the tank height and have time as argument. They were originated from experimental tests on a tank with an aspect ratio (height/diameter) close to unity. The temperatures of the walls and the center were measured by means of iron-constantan thermocouples. Errors caused by contact resistance and by the thermocouples themselves were also analyzed, with satisfactory results. Numerical tests show an excellent agreement between theoretical and experimental results.

Keywords: *Análise numérico-experimental, armazenamento de calor, energia solar, convecção transiente / Numerical-experimental analysis, heat storage, solar energy, transient convection*

COB506 MODELO PARA SINTETIZAÇÃO DE DADOS DE RADIAÇÃO SOLAR EM SEQUÊNCIAS COM INTERVALOS DE 5 MINUTOS / METHOD FOR SOLAR RADIATION DATA SYNTHESIZING IN SEQUENCES WITH INTERVALS OF 5 MINUTES.

Arno Krenzinger

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This work presents a method to generate sequences of solar radiation data in intervals of 5 minutes with the use of a computer program. The data are generated starting from information of hourly horizontal global solar radiation values, date and local latitude. The method was developed with exclusive interest in simulations of solar systems being more important for photovoltaic applications than for water-heating simulating. It is very important that the frequency and the intensity of variation of the radiation have some similarity with measured data. The effort was concentrated in finding a simple method, that didn't demand many input data but that could correspond to a behavior waited as typical in most of the places. The results were compared with measured data and there was obtained very good agreement.

Keywords: *Energia Solar, Radiação Solar, Sequências de Dados, Simulação de Sistemas Solares Solar Energy, Solar Radiation, Meteorologic Data Sequences, Solar Systems Simulation*

COB735 VENTILAÇÃO NATURAL INDUZIDA POR ENERGIA SOLAR: ANÁLISE TEÓRICA E EXPERIMENTAL / SOLAR ENERGY INDUCED NATURAL VENTILATION: THEORETICAL AND EXPERIMENTAL ANALYSIS**Lurdes Zunino & Alcir de Faro Orlando***Departamento de Engenharia Mecânica, PUC-Rio, R. Marquês de S. Vicente 225, Rio de Janeiro CEP 22453-900, Brasil, e-mail ajo@mec.puc-rio.br*

The influence of different architectural elements on the performance of a solar energy induced natural ventilation system has been experimentally studied. It is basically composed of a chimney, a solar energy air collector and architectural elements on the top of the chimney to protect it from outside. A vertical screen, placed between the chimney top and its horizontal cover was found to be the most effective element, as far as the air flow is concerned. A venetian blind was found to have the best performance when its slats are set inclined 60° to the chimney wall, upwards. The cover was necessary to induce a higher natural ventilation. The design of the collector entrance was found to be important for better performance. Finally, a simulation procedure was used to predict the natural ventilation device under different insolation levels.

Keywords: *Natural Ventilation, Solar Energy, Chimney effect, Air Collector / Ventilação Natural, Energia Solar, Efeito Chaminé, Coletor para Ar*

COB780 ESTUDO DO ESCOAMENTO LAMINAR EM SISTEMAS AERO-SOLARES / LAMINAR FLOW ANALYSIS OF SOLAR-AIR SYSTEMS**Marco A. dos S. Bernardes, Márcio Fonte-Boa Cortez, Ramón M. Valle.***Departamento de Engenharia Mecânica, Universidade Federal de Minas Gerais Av. Antônio Carlos, 6627, CEP: 31270-901, Belo Horizonte-MG, BRASIL - E-mail: marco@oraculo.lcc.ufmg.br*

Solar Chimneys are devices used to convert solar energy into thermal and electrical energy. These devices are built with a transparent radial canopy covering the ground and a chimney positioned at its center. In the present work, the thermal hydrodynamic behavior of air in free convection in a Solar Chimney was theoretically analyzed to verify the geometrical and operational effects. The mathematical model formulation was performed considering laminar flow and prescribed boundary conditions. The visualization of the flow and the temperature profiles were allowed by the use of Finite Volume with Generalized Coordinates. Geometrical variations were introduced in a basic configuration to verify the system performance under variations of geometrical parameters. Three geometrical parameters were evaluated throughout simulation: the canopy/ground distance, the canopy/chimney connection shape and the chimney shape and cross section. The results indicated that the best performance was achieved with curved canopy/chimney connection shape and chimney conic shaped.

Keywords: *Chaminé Solar, Volumes Finitos em Coordenadas Generalizadas, Convecção Natural, Energia Solar, Fontes Alternativas de Energia / Solar Chimney, Finite Volume Method with Generalized Coordinates, Free Convection, Solar Energy, Renewable Energy Sources*

COB884 THERMAL EFFICIENCY OF A SOLAR COOKING SYSTEM WITH STORAGE / EFICIÊNCIA TÉRMICA DE UM SISTEMA DE FOGÃO SOLAR COM ARMAZENAMENTO DE CALOR**Maria Eugênia Vieira, Carlos Antônio Silva Gomes & Raimundo Nonato Pereira Teixeira***Laboratório de Energia Solar Aplicada, Centro de Tecnologia, Bloco 710, Universidade Federal do Ceará CEP 60455-760 Fortaleza, Ceara, Brazil -E-mail: eugenia@les.ufc.br, carlos@lex.ufc.br, nonato@les.ufc.br*

The thermal performance of a solar natural circulation heating system that uses an oil as the working fluid, a flat plate solar collector, and a storage tank has been studied for the ambient conditions in Fortaleza. To determine the system efficiency, each component is modeled separately. To estimate the total mass flow rate through the collector, the total frictional pressure drop is set equal to the pressure gain due to the difference in density in the two vertical portions of the circuit. In the analysis, the flow was considered laminar because of the low velocities expected. The results show the numerical values for total mass flow rate through the circuit and castor oil presented the best performance, that is the highest values for collector heat removal factor, when compared to cotton and soy oil.

Keywords: *Solar cooker, flat plate collector / Fogão solar, coletor de placa plana*

COB885 ANALYTICAL AND EXPERIMENTAL STUDY OF A STILL TYPE SOLAR DISTILLER / ESTUDO ANALÍTICO E EXPERIMENTAL DE UM DESSALINIZADOR SOLAR DE TANQUE

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This work presents a procedure to estimate the thermal efficiency of a still type solar distiller to produce potable water from salty water. At present, the general model is based on the simultaneous solution of the energy balance equations for the water in the tank and the transparent cover. These equations are written as functions of the thermal variables, the ambient variables such as the intensity of solar radiation, ambient temperature, wind speed, and the construction materials and dimensions of the distiller. This numerical model allows the simulation of the thermal performance of the solar distiller so that more units may be developed and built taking into consideration the local ambient variables and resources. The thermal efficiency is calculated as the ratio of the energy used in the evaporation process to the total incident solar radiation.

Keywords: *Solar tank, distiller, desalination / tanque solar, destilador, dessalinizador*

COB887 THERMAL ANALYSIS OF AN EVACUATED TUBE SOLAR COLLECTOR IN FORCED AND NATURAL CIRCULATION FLOW / ANÁLISES TÉRMICAS DE UM COLETOR SOLAR DE TUBO EVACUADO EM ESCOAMENTO NATURAL E FORÇADO

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An evacuated tube solar collector is a heat exchanger that converts radiant solar energy into heat. It is made of an absorber plate placed in a glass tube. The space inside the tube is evacuated to a pressure of 10⁻⁰⁴ to 10⁻⁰⁶ Torr. The evacuation reduces convection losses from the plate, which may be coated with a selective surface. This work presents a numerical model to determine the thermal efficiency of this collector operating in forced and natural circulation flows. In forced flow, the energy

balance equations for the absorber plate and the glass tube are used to estimate the collector heat removal factor. In natural circulation, with water vapor as the working fluid, a model developed for a solar thermal siphon circuit is used. The thermal efficiency values found for both operations under the ambient conditions in Fortaleza were high and indicated the possibility of applications in solar refrigeration systems.

Keywords: *SEvacuated tube, solar collector, solar heat pipe / Tubo Evacuado, coletor solar, tubo de calor solar*

COB1453 ANÁLISE TEÓRICO-EXPERIMENTAL DE UM LEITO DE PEDRAS DE GRÊS-DO-PARÁ PARA FINS DE SECAGEM / THEORETICAL-EXPERIMENTAL ANALYSIS OF A STONE BED ABSORBER WITH GRÊS-DO-PARÁ FOR DRYING PURPOSES

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This work presents a numerical and experimental study to evaluate some parameters of the heat transfer in a stone bed solar collector - The outlet temperature and humidity. The numerical analysis is based on the equations obtained by the energy balance using the concept of lumped formulation and fourth order Runge-Kutta's method applied to this non-linear case. The results are then compared to an experiment and were considered satisfactory for design purposes.

Keywords: *Drying sistem, solar energy, stone bed absorber, Runge-Kutta 's method, lumped formulation.*

TEMA 13 - Energia Nuclear

COB43 REPRESENTAÇÃO DOS SISTEMAS AUTOMÁTICOS DE CONTROLE E DE PROTEÇÃO DE ANGRA I / SIMULATION OF THE ANGRA I CONTROL AND PROTECTION SYSTEMS

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The following automatic control systems for Angra I Nuclear Power Plant (NPP): rod control system, steam generator level control system, feedwater bypass valve control system, pressurizer pressure control system and pressurizer level control system and also the following protection system: overtemperature, overpower, pressurizer low pressure, pressurizer high pressure, pressurizer high water level, low primary coolant flow and low-low steam generator water level were simulated with the RELAP5/Mod2 code. The paper shows the results of three transients: a) a ten percent step load change, b) a five percent per minute ramp load change, and c) pump coastdown. Satisfactory quantitative and qualitative results were obtained when comparing these results with the "setpoint study" and FSAR results.

Keywords: Control System, Protection System, Nuclear Power Plant, Angra I, RELAP5/Mod2 Code Sistema de Controle, Sistema de Proteção, Usina Nuclear, Código RELAP5/Mod2

COB75 COMPORTAMENTO TERMOIDRÁULICO DE VARETAS AQUECIDAS ELETRICAMENTE DURANTE TRANSITÓRIO DE FLUXO CRÍTICO DE CALOR / THERMALHYDRAULIC BEHAVIOR OF ELECTRICALLY HEATED ROD DURING A CRITICAL HEAT FLUX TRANSIENT

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In nuclear reactors, the occurrence of critical heat flux leads to fuel rod overheating with clad fusion and radioactive products leakage. To predict the effects of such phenomenon, experiments are performed using electrically heated rods to simulate operational and accidental conditions of nuclear fuel rods. In the present work, a theoretical analysis of the drying and rewetting front propagation is performed during a critical heat flux experiment, starting with the application of a slope of electrical power from steady state condition. After the occurrence of critical heat flux, the drying front propagation is predicted. After a few seconds, a power cut is considered and the rewetting front behavior is analytically observed. Studies done with several values of coolant mass flow rate show that this variable has more influence on the drying front velocity than on the rewetting one.

Keywords: Critical heat flux, rewetting front, drying front, thermalhydraulics, numerical simulation, Fluxo crítico de calor, frente de remolhamento, frente de secamento, termoidrúlica, simulação numérica.

TEMA 14 - Conservação de Energia

- COB85** **COMPARAÇÃO DOS SISTEMAS DE COLHEITA MANUAL E MECANIZADO ATRAVÉS DA AVALIAÇÃO ENERGÉTICA E FINANCEIRA PARA CULTURA DE CANA-DE-AÇÚCAR (*Saccharum spp.*) / COMPARISON OF MANUAL AND MECHANICAL HARVESTING OF SUGAR CANE (*SACCHARUM SPP.*) BY ENERGETIC AND FINANCIAL EVALUATION**

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The sugar cane crop represents an enormous potential for energy, due to its phytomass excess left on the fields, which is burned as a way to ease the manual harvesting. Most of this energy could be utilized if changes are made in the harvesting practice, such as using mechanical harvesting instead of manual.

The present study had the objective to show the viability of substituting manual harvesting with burning in the fields, by mechanical harvesting (green cane), with a better energy recovery from its residues and net income. For the calculations we used the gross calorific value and the Brazilian currency (Real), at an exchange rate of approximately R\$1=US\$1.

The results showed that this change in harvesting procedure is economical and energetically more efficient. For manual harvesting the energy consumption was found to be 39,725.96 Mcal/ha (166,292.87 x 103 J/ha) at a cost of R\$113.62/ha. For mechanical harvesting the energy consumption was 19,063.32 Mcal/ha (9,799.06 x 103 J/ha) at R\$61.98/ha. With the utilization of the residues it was obtained 312,218.4 (1306,946.22 x 103) and 435,263.2 (1822,011.76 x 103) Mcal/ha (J/ha), 1,304.90 and 1,574.70 R\$/ha, respectively. The social aspects of relocation of the manual labor is not considered in this paper

Keywords: *cana-de-açúcar, biomassa, colheita, mão-de-obra, bagaço, mecanização / sugar cane; bagasse; mechanical-harvesting; manual-harvesting; bionergy; biomass*

- COB760** **NUMERICAL SIMULATION OF THERMAL STORAGE ON ENCAPSULATED PHASE CHANGE MATERIALS**

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Thermal storage on encapsulated phase change materials (pcm) is under consideration. The phase change (solidification/melting) process is approximated by a quasi-stationary model, which is solved together with the one-dimensional transport equation. Results are shown by the evolution of the non-dimensional outlet temperature through non-dimensional time.

Keywords: *Thermal storage, latent heat, encapsulated phase change material*

COB826 ESTIMATIVA DO POTENCIAL DE CONSERVAÇÃO DE ENERGIA EM INTALAÇÕES DE BOMBEAMENTO/ ESTIMATE OF THE ENERGY POTENTIAL CONSERVATION IN PUMPING SYSTEMS

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It's unusual that a pumping sistem works with just one fixed condition of flow and pressure. The processes that work with centrifugal pumps have, in general, a variable consumption and in the case of necessity of changing the flow, in normal systems, is necessary to act in the control valve, which will change the sistem curve because of the introduction of adcional friction losses in the instalation. Meanwhile, it will cause a unnecessary energy consumption. Another way to change the flow of a pumping system is through the variation of the pump speed, using a variable speed driver that has less consumption of energy and presents a series of advantages over the throttling valve, due the agreement between the pump characteristics and the instalation characteristics and the optimization of the project point. Based in this considerations, this work presents a methodology that permits to estimate the real saving energy potential in centrifugal pumps driven by constant speed electrical motors. It's done through the determination and analysis of the grafic characteristics, providing in this way, data for a viability economic analysis with less rises and uncertainty.

Keywords: *Conservação de energia, bombas centrifugas, instalações de bombeamento / Energy conservation, centrifugal pumps, pumping systems.*

TEMA 15 - Mecânica dos Fluidos Ambiental

COB36 ANÁLISE DIMENSIONAL AUXILIANDO NA IDENTIFICAÇÃO EMPÍRICA DO COMPORTAMENTO DE MODELOS NUMÉRICOS / DIMENSIONAL ANALYSIS HELPING IN THE EMPIRICAL IDENTIFICATION OF THE BEHAVIOUR OF NUMERICAL MODELS

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There are several engineering problems in which the development of numerical models still does not have a firm basis on universally accepted concepts. The literature about numerical models from the transient-advection-diffusion equation reveals mismatches of terminology and even of concepts of applied mathematics. Dimensional analysis may help some numerical modelling, similarly to physical modelling. This methodology has been applied to a fluid transport problem and the results clarified the region identification where the numerical model presents a good performance.

Keywords: *Dimensional Analysis, Identification, Behaviour, Numerical, Models. / Análise Dimensional, Identificação, Comportamento, Modelos, Numéricos.*

COB308 CONTROL OF GASEOUS POLLUTANTS EMISSION WITH EGR (EXHAUST GAS RECIRCULATION) AND CATALYTIC CONVERTER

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Study of gaseous pollutant emission from engine tests simulating real work conditions, using spark point manually controlled and exhaust gas recirculation in diverse proportion levels. The objective of this present work is to re-examine the potential of the EGR conception, a well-known method of combustion control, employed together electronic fuel injection and three-way catalytic converter closed-loop control at a spark ignition engine, verifying the performance characteristics and technical availability of this conception to improve pollution control and fuel economy. The pollutant emissions under operational conditions simulations were analysed and compared with the expected by concerning theory and real tests performed by EGR equipped engines by factory.

Keywords: *Exhaust Gas, Exhaust Gas Pollutant Emission, Spark Ignition Engine, Pollution Control, EGR, Exhaust Gas Recirculation*

COB717 CONTRIBUIÇÃO DAS EMISSÕES VEICULARES, NA QUALIDADE DO AR ATMOSFÉRICO DA REGIÃO METROPOLITANA DE PORTO ALEGRE / CONTRIBUTION OF THE VEHICULAR EMISSIONS, IN THE QUALITY OF THE ATMOSPHERIC AIR OF THE METROPOLITAN REGION OF PORTO ALEGRE

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The Diesel vehicles of the fleet of Porto Alegre City were chosen to roall at typical streets of the City. A gas fraction of the exhausted of these vehicles was collected and analysed at the end of the road. Vehicles that employ gasoline and alcohol were analysed according to Padronized Tests.

Keywords: *Emissões, Emission, Air Quality, CO, CO₂, HC, NO_x*

COB737 UMA METODOLOGIA PARA AVALIAÇÃO DA CAPACIDADE DISPERSIVA NA ATMOSFERA DE UMA REGIÃO ESPECÍFICA / AN ALTERNATIVE METHODOLOGY FOR EVALUATION OF ATMOSPHERIC DISPERSION CAPACITY IN A GIVEN REGION

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In the present work a methodology for determination of atmospheric dispersive capacity in the convective boundary layer in a given region during daytime, has been developed. Its main objectives are to define the necessary steps to gather the parametric equations that are dispersed in the literature; and to develop an easy-to-use and efficient set of algorithms. This process has been followed to refine the Gaussian dispersion model which is used to relate a source's emission strength to its resultant, downwind atmospheric concentration. The model uses as input the incoming solar radiation; temperature distribution; and wind speed and direction, as measured in strategic points to characterize the field in terms of typical gradients. The area under study is also characterized in terms of the topography of the region. An application of this methodology was done for the Metropolitan Vitoria Region (RMV), situated in the state of Espírito Santo-Brazil.

Keywords: *Convective Boundary Layer, Solar Radiation, Heat Flux, Atmospheric Stability, Convective Velocity Escala / Camada Limite, Radiação Solar, Fluxo de Calor, Estabilidade Atmosférica, Escala de Velocidade Convectiva*

COB1371 NUMERICAL MODELLING OF FLOW AND DISPERSION OVER COMPLEX TERRAIN / MODELAGEM NUMÉRICA DO ESCOAMENTO E DA DISPERSÃO EM TERRENO COMPLEXO

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Due to the complexity of some topography driven atmospheric flows, it is sometimes not possible to accurately predict pollutant transport on the basis of sparse wind field measurements. A possible solution is the mathematical modelling of both the flow and pollutant transport. In order to overcome shortcomings of the conventional $k-\epsilon$ turbulence model for this kind of flows, a more general model of environmental flows, a modified $k-\epsilon$, is adopted. This non-isotropic model is derived from the algebraic stress model including wall proximity effects. The modified $k-\epsilon$ is implemented in a three dimensional code. Once the flow is resolved, the predicted velocity and turbulence fields are interpolated into a second grid and used to solve the concentration equation. To evaluate the model, various steady state numerical solutions are compared with dispersion experiments which were conducted at the wind tunnel of Mitsubishi Heavy Industries, in Japan. Several cases of dispersion under neutrally stratified atmospheres over flat and hilly terrain are compared and discussed. Vertical profiles of concentration are shown and compared.

Keywords: *Atmospheric dispersion, flow over hills, modified k- ϵ , numerical simulation / Dispersão atmosférica, escoamento sobre montanhas, k- ϵ modificado, simulação numérica*

TEMA 16 - Engenharia de Petróleo

COB240 ANÁLISE DE SENSIBILIDADE APLICADA A AJUSTE DE HISTÓRICO DE PRODUÇÃO / SENSITIVITY ANALYSIS APPLIED TO HISTORY MATCHING

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An important step towards a good reservoir characterization and therefore a good production prediction is obtained with history matching where the reservoir model is corrected until simulation results match observed data. Due to complex reservoir characteristics and high number of parameters, there is no fully automatic history matching model reported in the literature. However there are many techniques that can be used to improve the process. This work aims an automation of some of these techniques by creating indexes to facilitate some decisions and, mainly, by creating a methodology to make an automatic sensibility analysis to quantify the influence of some parameters in the matching process.

Keywords: *Sensitivity Analysis, Reservoir Simulation, History Matching, Parallel Computing / Análise de Sensibilidade, Simulação de Reservatórios, Ajuste de Histórico, Computação Paralela*

COB241 PARALELIZAÇÃO EXTERNA DE SIMULADORES NUMÉRICOS DE PETRÓLEO / EXTERNAL PARALLELIZATION OF NUMERICAL PETROLEUM SIMULATORS

Sergio Henrique Guerra de Sousa & Denis José Schiozer

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One of the most important steps of petroleum reservoir characterization is history matching which requires several simulations to adjust the reservoir model. External parallelization of reservoir simulators is an important tool in the automation of this type of methodology where simulations can be distributed to a network of workstations, significantly reducing the total execution time. This work shows (1) the importance and the advantages of external parallelization in CPU intensive applications and (2) a routine (MPS) that was developed to distribute the runs over a network of workstations using the software PVM (Parallel Virtual Machine). Results are shown for three different networks, varying the number of simulations and workstations. There is a great number of applications of this technique in reservoir simulation. Any application which requires several simulations can benefit from external parallelization. A routine to manage all simulations is very important to make the best use of a network.

Keywords: *External parallel computing, PVM, parallelization, Black-Oil reservoir simulation, computação paralela externa, paralelização, simulação de reservatórios de petróleo*

COB242 OTIMIZAÇÃO DE PARÂMETROS DE PRODUÇÃO PARA MINIMIZAR OS EFEITOS DE CONE DE ÁGUA / OPTIMIZATION OF PRODUCTION PARAMETERS TO MINIMIZE WATER CONING EFFECTS

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Water production control is a difficult task and therefore has been extensively studied. It is characterized by a fast growing in water production, drastically reducing oil production. This control can be made by many techniques, the most common being: (1) changing the water-oil mobility ratio by using polymers and surface-active agents and, (2) using artificial barriers to obstruct the water flux. However, the cost-benefit ratio of these techniques is not always favorable. Sometimes, the only way to control the water coning is by the control of the production parameters. The objective of this work is to develop an optimization routine to find the best values of production rate and completion interval in order to maximize an objective function which represents the net present value of oil production. The methodology used for this optimization is an iterative procedure with separated optimization of production rate and completion interval, resulting in a computer program which uses a reservoir simulator to optimize the objective function by successive simulations. This methodology was tested in two water coning problems found in literature, showing good results.

Keywords: *Cone de Água, Otimização, Simulação de Reservatório, Water Coning, Optimization, Reservoir Simulation*

COB260 MODELING AND PERFORMANCE OF PIG-LIFT

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Artificial lift is used in petroleum production when the energy of the reservoir is not enough to sustain the flow of oil in the well up to the surface with satisfactory economic return. The gas-lift is a widely used method of artificial lift; in some cases, the continuous gas-lift (CGL) is not efficient, and one must implement the intermittent gas-lift (IGL), for which there are different design options. There are some empirical and questionable rules of thumb to choose between the CGL and IGL, but almost no material exists in the literature for the selection among the different intermittent gas-lift designs; furthermore, there are no published models or behavior studies of their dynamics to help in the selection and design of IGL systems. This work presents a model to study the novel IGL WITH PIG. In this system, a foam-pig separates the oil and gas flowing in the well, to prevent fall-back of oil; a double column is used inside the well. This paper presents sample results for some conditions of the petroleum reservoir. This work can aid the engineer in the determination of the optimum values of the operational parameters, and in the choice of the IGL design for particular field conditions.

Keywords: *petroleum, artificial lift, gas-lift, computer simulation, production optimization*

COB261 MODELING AND PERFORMANCE OF INTERMITTENT GAS-LIFT WITH PLUNGER**Odair G. dos Santos, Francisco J. S. Alhanati & Sérgio N. Bordalo***Depto. de Engenharia de Petróleo, Faculdade de Engenharia Mecânica - UNICAMP**Cx.Postal 6052, CEP 13.083-970 Campinas SP, Brasil - E-mail:bordalo@dep.fem.unicamp.br*

Artificial lift is used in petroleum production when the energy of the reservoir is not enough to sustain the flow of oil in the well up to the surface with satisfactory economic return. The gas-lift is a widely used method of artificial lift; in some cases, the continuous gas-lift (CGL) is not efficient, and one must implement the intermittent gas-lift (IGL), for which there are different design options. There are some empirical and questionable rules of thumb to choose between the CGL and IGL, but almost no material exists in the literature for the selection among the different intermittent gas-lift designs; furthermore, there are no published models or studies of their dynamics to help in the selection and design of IGL systems. This work presents a model to study the IGL WITH PLUNGER. In this system, a solid plunger separates the oil and gas flowing in the well, to prevent fall-back of oil. This paper presents sample results for some conditions of the petroleum reservoir, and for variations of the operational parameters. This work can aid the engineer in the determination of the optimum values of the operational parameters, and in the choice of the IGL design for particular field conditions.

Keywords: *petroleum, artificial lift, gas-lift, computer simulation, production optimization.*

COB262 MODELING AND PERFORMANCE OF INTERMITTENT GAS-LIFT WITH CHAMBER**Odair G. dos Santos, Francisco J. S. Alhanati & Sérgio N. Bordalo***Depto. de Engenharia de Petróleo, Faculdade de Engenharia Mecânica - UNICAMP**Cx.Postal 6052, CEP 13.083-970 Campinas SP, Brasil - E-mail:bordalo@dep.fem.unicamp.br*

Artificial lift is used in petroleum production when the energy of the reservoir is not enough to sustain the flow of oil in the well up to the surface with satisfactory economic return. The gas-lift is a widely used method of artificial lift; in some cases, the continuous gas-lift (CGL) is not efficient, and one must implement the intermittent gas-lift (IGL), for which there are different design options. There are some empirical and questionable rules of thumb to choose between the CGL and IGL, but almost no material exists in the literature for the selection among the different intermittent gas-lift designs; furthermore, there are no published models or behavior studies of their dynamics to help in the selection and design of IGL systems. This work presents a model to study the IGL WITH CHAMBER. In this system, a chamber is used to accumulate oil at the bottom of the well. This paper presents sample results for some conditions of the petroleum reservoir, and for variations of the operational parameters. This work can aid the engineer in the determination of the optimum values of the operational parameters, and in the choice of the IGL design for particular field conditions.

Keywords: *petroleum, artificial lift, gas-lift, computer simulation, production optimization*

COB263 MODELING AND PERFORMANCE OF CONVENTIONAL INTERMITTENT GAS-LIFT**Odair G. dos Santos, Francisco J. S. Alhanati & Sérgio N. Bordalo***Depto. de Engenharia de Petróleo, Faculdade de Engenharia Mecânica - UNICAMP**Cx.Postal 6052, CEP 13.083-970 Campinas SP, Brasil - E-mail: bordalo@dep.fem.unicamp.br*

Artificial lift is used in petroleum production when the energy of the reservoir is not enough to sustain the flow of oil in the well up to the surface with satisfactory economic return. The gas-lift is a widely used method of artificial lift; in some cases, the continuous gas-lift (CGL) is not efficient, and one must implement the intermittent gas-lift (IGL), for which there are different design options. There are some empirical and questionable rules of thumb to choose between the CGL and IGL, but almost no material exists in the literature for the selection among the different intermittent gas-lift designs; furthermore, there are no published models or studies of their dynamics to help in the selection and design of IGL systems. This work presents a model to study the CONVENTIONAL IGL. The IGL works in cycles, and each cycle is made of stages that follow transient flow processes. Vertical two-phase flow occurs in the well. This paper presents sample results for typical conditions of the petroleum reservoir, and for variations of the operational parameters. This work can aid the engineer in the determination of the optimum values of the operational parameters, and in the choice of the IGL design for particular field conditions.

Keywords: *petroleum, artificial lift, gas-lift, computer simulation, production optimization*

COB524 EFEITOS DA CORRENTE ELÉTRICA CONTÍNUA NA RECUPERAÇÃO DE PETRÓLEO / EFFECTS OF DIRECT ELECTRICAL CURRENT IN PETROLEUM RECOVERY**Rosane Oliveira Mota***PETROBRAS - E&P-BA, Av. Antônio Carlos Magalhães, 1113, Sala 433**CEP.: 41856-900 Salvador, BA, Brasil - E-mail: rosane@ep-ba.petrobras.com.br***Euclides J. Bonet & Osvaldo V. Trevisan***Departamento de Engenharia de Petróleo, Faculdade de Engenharia Mecânica - UNICAMP - Caixa Postal 6052**CEP.: 13081-970 - Campinas, SP, Brasil - E-mail: trevisan@columbia.dep.fem.unicamp.br*

The aim of this work was to investigate the effects of applying a direct electrical field and to measure its significance in oil recovery through electro-osmosis and/or physical-chemical modifications on clay structure due to the electrochemical treatment. A series of laboratory experiments was conducted with linear porous media saturated with oil and water. Values for the coefficient of electro-osmotic permeability for porous media in different water saturation stages are also presented. Results are presented as graphics such as oil recovery curves, relative permeability curves and production water-oil ratio curves. In the results, it may be noted the beneficial effect of the electrical current in additional oil recovery and in the production water-oil ratio reduction.

Keywords: *Electro-osmosis, Oil Recovery, Direct Current*

COB531 TRANSFERÊNCIA DE CALOR EM OPERAÇÕES DE INJEÇÃO EM POÇOS / HEAT TRANSFER IN WELL INJECTION OPERATIONS**Flávio Medeiros Júnior¹ & Osvaldo Vidal Trevisan²**

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Fluid temperature is an important parameter in production or injection wells. This paper presents an analytical solution, in Laplace space, to the liquid temperature in injection operations. The model proposed for the heat transfer along the column incorporates heat accumulation (in the column and in the annulus) to the heat exchange between the wellbore and the semi-infinite surroundings. The problem was solved by Laplace transforms and the Stehfest's algorithm is used to invert the solution to real domain. Results show that the liquid temperature is very sensitive to the injection flow rate and the short time behaviour is affected by heat accumulation in the column and the annulus.

Keywords: Heat Transfer; Well Completion; Well Operations; Liquid Flow. *Transferência de Calor; Completação de Poços; Operações em Poços; Fluxo de Líquido*

COB1118 MODELO MATEMÁTICO SIMPLIFICADO PARA DEPOSIÇÃO DE PARAFINA EM OLEODUTOS / SIMPLIFIED MODEL FOR WAX DEPOSITION IN OIL DUCTS**Sérgio Balthar Pereira da Silva, Paulo Laranjeira da Cunha Lage e Cirus Macedo Hackenberg**

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A simplified numerical model to predict the wax deposition inside petroleum ducts is developed based on the conservation equations of mass, energy and chemical species. The model considers the radial mass fluxes of all mixture components and the phase change at the duct wall due to heat removal by the surroundings. A thermodynamic model for the phase change at the wall is utilized with melting temperatures and enthalpies for each of the mixtures components given by existing correlations. The model is able to predict the transient behavior of the effective duct diameter along all duct length.

Keywords: wax deposition, heat and mass transfer, deposição de parafina, transferência de calor e massa

TEMA 21 - Termodinâmica**COB65 DESIGN AND DEVELOPMENT OF A CONTINUOUS CORK STOPPERS DRYER****C.M.C.T. Pinho & A.M.S. Santos**

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The drying of cork stoppers is a technological process commonly used in the stoppers manufacturing industry. Until recently no systematic scientific approach had been undertaken in the study of the drying kinetics of cork stoppers. An historical account of the sequence of steps followed in the design and erection of a new continuous dryer commissioned to the university is presented. The short time period required for the implementation of the new dryer lead to a twin path approach of the problem. A fundamental study of the kinetics of the drying process of slim fixed beds of cork stoppers was simultaneously accompanied by a study of the drying of batches of stoppers, as received from the industrial washery process. Data from this preliminary analysis were used in the design of the new dryer whereas data from the fundamental study were used in the final adjustment of dryer working conditions. Analysis of the behaviour of the dryer in the industrial environment showed a satisfactory performance and although the actual energy consumption is two and half times larger than the latent heat of water vaporization, experimental results are of the same order of magnitude of those found in the wood drying processes, which were used as references due to the lack of experimental data on industrial drying of cork.

Keywords: *Cork stoppers drying. Industrial dryers*

COB317 ANÁLISE TERMOCÔNOMICA DA COGERAÇÃO DE ELETRICIDADE A PARTIR DO BAGAÇO DE CANA EM UMA USINA DE SÃO PAULO / THERMOECONOMIC ANALYSIS OF ELECTRICITY COGENERATION FROM SUGARCANE BAGASSE IN A SÃO PAULO PLANT**Suani Teixeira Coelho**

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Despite the advantages of cogeneration process for sugar/alcohol plants, as well as for electric sector and the whole Brazilian society, the protocol signed between the Government of São Paulo State and this industrial segment has not yet achieved its stated objectives. Besides other difficulties, one of the main problems is the sale's price of electricity. This paper intends to contribute to such discussion, by adapting thermoeconomic analysis to cogeneration process in a sugar/alcohol plant of São Paulo. Exergy-based costs of process steam and electricity are evaluated for different configurations, from existing estimates of surplus electricity and corresponding investments. "Equality", "extraction"

and "electricity-as-by-product" methods are utilized, the adopted configurations corresponding basically to Rankine steam cycle (currently commercialized in Brazil). Generation costs are calculated and compared to current electricity purchase's price proposed by the utilities, leading to the discussion of mechanisms to improve a large scale cogeneration program in São Paulo State.

Keywords: *Cogeração; bagaço de cana; exergia; análise termoeconômica/Cogeneration; sugarcane bagasse; exergy; thermoeconomic analysis.*

COB330 CARBONATO-APATITA: ANÁLISE TERMODINÂMICA DA SUA FORMAÇÃO E COMPORTAMENTO DURANTE O SEU AQUECIMENTO

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The paper intended to give the science and technology of hydroxyapatite production and usage the suitable equilibrium diagrams capable to show clearly the conditions under which carbonateapatite can result as a transformation product of the former apatite; that knowledge is highly valuable to understand the behavior of the hydroxyapatite coating metallic implant biomaterials in human fluid body solution. Therefore, free energy of the carbonateapatite at 25°C was estimated from similarity between the formation reaction of the hydroxyapatite from beta-tricalcium phosphate and calcium hydroxide and of the carbonateapatite from beta-tricalcium phosphate and calcium carbonate. The molar entropy and heat capacity at constants pressure of the carbonateapatite were determined through estimation conventional methods everywhere available. Then, potential-pH diagrams of the Ca-C-P-H₂O system at 25 and 100°C have been calculated and drawn using the Computing Software Chemistry for Windows 2.0 from Outokumpu Oy, Finland, as licensed to the COPPE/UFRJ. In the following, activity-pH diagrams have been drawn at these two temperatures and analyzed. The conditions of the stability of the carbonateapatite have been well set up.

Keywords: *carbonateapatite, hydroxyapatite, bone and dental implant material, hydroxyapatite coating on metal implants, then-nodynamic analysis*

COB502 ANÁLISE TÉCNICA E ECONÔMICA DE SISTEMAS DE COGERAÇÃO PARA UM LATICÍNIO DE PEQUENO PORTE / A TECHNICAL AND ECONOMICAL ANALYSIS OF A COGENERATION SYSTEM FOR A SMALL LATICINIO PLANT

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In all part of the world, the necessary improvement of energy conservation and the search of new energy generation technologies became priority at the science, in the engineering and for the gov-

ernment; usually having preoccupation with the future's environment. Then, the rational utilization of the energy were exited cogeneration's technologies. In the last years are getting a great interesting by cogeneration system because the increase of the fuels cost, the hardness to get more efficiency at conventional thermoelectrics, the possibility of reduction of the energy costs like the increase of gain and competitively of your products in world market. This article can make an technical and economic analyzes of use of cogeneration's systems of one laticinio small plant in the Vale do Paraíba area, state of São Paulo. This researches, looking for the utilization of steam and gas turbines. Both results of this economical analyses show models of two technologies turbines that supply gains.

Keywords: *Análise Técnica e Econômica, Cooperativa de Laticínios, Cogeração, Custos de Produção de Vapor, Custos de Produção de Eletricidade, Technical and Economical Analysis, Laticinio Cooperative, Cogeneration, Productive Costs of Steam, Productive Costs of Electricity*

COB535 A SEMI-ANALYTICAL MODEL FOR CYLINDRICAL ICE STORAGE UNITS

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The objective of this paper is to present a simplified semi-analytical model to predict the thermal performance of cylindrical phase-change thermal energy storage units. The physical model is composed of an insulated vertical tank of cylindrical geometry into which is grouped a set of tubes through which a refrigerant passes, arranged in hexagonal form around the seventh central tube. The phase-change material (PCM) used is water and the refrigerant is a water-ethylene-glycol solution at low temperature. During the charging process (late night time) refrigerant circulation provides ice. This ice is to be used during the discharging cycle when water circulating provides cold water for air conditioning application. The semi-analytical model is based upon one-dimensional formulation of the phase-change heat transfer problem associated with an energy balance equation between the turbulent flow and the PCM. These coupled equations are solved by an integral approximation method. Results including solidified mass, thermal energy stored and temperature profiles are also presented and discussed.

Keywords: *Thermal energy storage units, ice storage units, phase-change materials, conjugate heat transfer*

COB541 AVALIAÇÃO TERMOECONÔMICA DE UM SISTEMA DE COGERAÇÃO DE INDÚSTRIA PETROQUÍMICA / THERMOECONOMIC ANALYSIS OF A COGENERATION SYSTEM OF A PETROCHEMICAL POLE

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This paper is a study of a real system of cogeneration at a Petrochemical Pole. The analysed system has five boilers, four steam turbo-generators and one gas turbine operating in a combined cycle with total capacity of 202 MW of electrical power and 2100 t/h of steam for the process. Splitting the cogeneration process into subsystems, the exergy of each one of the energetic fluxes is calculated. It is presented the exergetic balance of each subsystem as well as the global one. The efficiency of second law of the thermodynamic of each subsystem is showed and compared, identifying where and why the losses and irreversibilities occur. The thermoeconomic costs of each one of the fluxes are calculated, and the conclusions about the cogeneration process are obtained.

Keywords: *Exergy, Thermoeconomics, Petrochemical, Cogeneration, Energy, Exergia, Termoeconomia, Petroquímica, Cogeração, Energia*

COB738 ANÁLISE EXERGÉTICA DE SISTEMAS DE COGERAÇÃO E CICLOS COMBINADOS / EXERGY ANALYSIS OF COGENERATION SYSTEMS AND COMBINED CYCLES

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This paper presents a general methodology to evaluate the exergy use in cogeneration and combined cycle plants, as well as to relate the overall exergetic efficiency of the plant to the efficiencies of each module/set of equipment that compose the plant. The objective of this methodology is to quantify the thermodynamic performance of the plant and to characterise the influence of each module/set of equipment of the plant in the overall exergy consumption. The exergy analysis developed for cogeneration and combined cycle plants evaluates the exergy efficiency and the exergy destroyed in each set of equipment, and the overall cogeneration and combined cycle plants performance. The importance of each set of equipment in the overall exergetic efficiency is quantified by the use of the factor f , defined as the relation between the consumed exergy in a particular set of equipment and the consumed exergy in the plant. With the factors f_i (for each set of equipment) and the exergetic efficiencies h_i (for each set of equipment) it is possible to establish an expression that relates the overall exergetic efficiency to the factors f_i and the exergetic efficiencies h_i . This expression is useful to characterise the importance of each set of equipment in the overall exergetic efficiency and to indicate possible ways of optimising the performance of the plant. This methodology is employed to evaluate and optimise the performance of a cogeneration plant composed by a gas turbine, a Rankine cycle and an absorption chiller.

Keywords: *cogeneration, combined cycle, exergy analysis*

COB779 A SIMPLIFIED THEORY TO ASSESS THE BURNING CHARACTERISTICS OF A SLICK OF OIL ON WATER

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An experimental technique has been developed to systematically study the ignition, flame spread and mass burning characteristics of liquid fuels spilled on a water bed. The final objective of this work is to provide a tool that will serve to assess a fuels ease to ignite, to spread and to sustain a flame, thus helping to better define the combustion parameters that affect in-situ burning of oil spills.

Keywords: *In-situ burning, oil spills, mass burning, flame spread, ignition*

COB912 PERSPECTIVA ECONÔMICA DO GÁS DE MADEIRA PARA GERAÇÃO TÉRMICA NO NORDESTE / WOOD GASIFICATION ECO-NOMICAL ANALYSIS FOR THERMAL POWER GENERATION IN NORTH-EAST OF BRASIL

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This paper presents results of wood gasification economic analysis concerning thermal power generation through combined cycles. Comparison is made between the gas production costs and oil barrel price. In short term, wood gasification technology and gas turbine combined cycles association is not economically competitive. In near future, however, the environmental concern, through creation of penalties like the carbon tax, proposed by the European Commission, can make use of power forests more feasible, allowing application of neutral CO₂ emission technologies. One important contribution to solve this issue involves the BIG-GT project (Biomass Integrated Gasification Gas Turbine), sponsored by international organizations associated with local enterprises. The first demonstration plant using this technology will be installed in Brazilian state Bahia.

Keywords: *Wood gasification. Combined cycles. Carbon neutral emission processes. Renewable energy./ Gaseificação de madeira. Ciclo combinado. Energia alternativa. Emissão neutra de carbono*

COB1097 ANÁLISE EXERGÉTICA COMPARATIVA ENTRE UM FORNO ROTATIVO COM PRAQUECEDOR DE QUATRO ESTÁGIOS E UM COM PRAQUECEDOR E PRECALCINADOR / COMPARATIVE EXERGETIC ANALYSIS BETWEEN A ROTARY KILN WITH A FOUR-STAGE PREHEATER AND A ROTARY KILN WITH A PREHEATER AND A PRECALCINER

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This work presents the results of a comparative exergetic analysis of plants of clinker production for the cement Portland manufacturing. The first installation is composed of the rotary kiln with

a four-stage preheater and the other of a rotary kiln with preheater and a precalciner. In this analysis it is utilized the concept of rational efficiency defined by Kotas, considering the exchange of the exergy between the current of the solids and the current of the gases, as well as the transference of the mass between the solids and gases. Through of the calculus of the irreversibilities generated in each step of the process, the Grassmann's diagram correspondent obtained, comprising the burning of the fuels in the rotary kiln burner and in the precalciner.

Keywords: *Exergy; Cement Plants; Rational Efficiency; Exergetic Analysis; Irreversibilities / Exergia; Fábricas de Cimento; Eficiência Racional, Análise Exergética, Irreversibilidade*

TEMA 22 - Radiação**COB53 ESTIMATING ABSORPTION AND SCATTERING COEFFICIENTS AND INTERNAL SOURCE TERM IN A RADIATIVE TRANSFER PROCESS I**

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A reconstruction technique for estimation of inherent optical properties (IOPs) and bioluminescence sources in natural waters from in situ irradiance data is presented. The inverse problem is formulated as a nonlinear constrained optimization problem, assuming that the bioluminescence unknown profile can be represented by a sum of distributed gaussian sources. The objective function is defined as the square Euclidean norm of the difference vector between experimental and computed data. The associated direct problem is tackled with the Hydrolight 3.0 code, which uses the invariant imbedding theory.

Keywords: *Inverse problems, inherent optical properties, bioluminescence sources, invariant imbedding method, radiative transfer equation*

COB234 THERMAL RADIATION IN COMBUSTION SYSTEMS

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A numerical procedure for solving the nongray radiative transfer equation (RTE) in two-dimensional cylindrical participating media is presented. Nongray effects are treated by using a narrow-band approach. Radiative emission from CO, CO₂, H₂O, CH₄ and soot is considered. The solution procedure is applied to study radiative heat transfer in a premixed CH₄-O₂, laminar, flame. Temperature, soot and IR-active species molar fraction distributions are allowed to vary in the axial direction of the flame. From the obtained results it is possible to quantify the radiative loss in the flame, as well as the importance of soot radiation as compared to gaseous radiation. Since the solution procedure is developed for a two-dimensional cylindrical geometry, it can be applied to other combustion systems such as furnaces, internal combustion engines, liquid and solid propellant combustion.

Keywords: *Radiation, participating media, nongray gases, combustion*

COB264 CONSTRUÇÃO E ENSAIO DE UM CORPO NEGRO PARA OPERAÇÃO A BAIXAS POTÊNCIAS TÉRMICAS / CONSTRUCTION AND TESTING OF A BLACK BODY OF LOW THERMAL POWER

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A cavity capable of working as a black body radiator was built and tested. Whereas most commercial systems work with the cavity body fixed to the core of a heated cylinder, the new device is directly heated by means of electric resistors fixed along its external surface. The electric resistors are heated by a highly stable dc-power system, which allows the cavity to reach temperatures of the order of 250°C. Constructed in a cone-type shape, the cavity has the back wall shaped with a large number of small pyramids, forming grooves. Its internal surface is roughly machined, forming a trap of baffles to radiation, which leaves the cavity after multiple reflections through a unique small opening at the top of the cone. The main advantages of the system are its low cost and the simplicity of assembling. Emissivities as high as 0.96 were measured.

Keywords: *Black body, thermal cavity, emissivity, pyrometer, thermal radiation. Corpo negro, cavidade térmica, emissividade, pirômetro, radiação térmica*

COB265 DETERMINAÇÃO EXPERIMENTAL DA EMISSIVIDADE DE UM TROCADOR DE CALOR DE BAIXA POTÊNCIA TÉRMICA / EXPERIMENTAL DETERMINATION OF THE EMISSIVITY OF A LOW THERMAL POWER HEAT EXCHANGER

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The emissivity of a flat plate type heat exchanger was experimentally determined by means of a compared temperature method. Two kinds of surface finishing were studied: naked aluminum, and black painted. In both situations, the plate was submitted to three heating power regimes: 8.7, 24.5 and 47.9W, which correspond to surface temperatures of approximately 45, 70 and 120°C, respectively. The temperature distribution was measured by means of an infrared pyrometer and by thermocouples. By adjusting of the emissivity selector of the pyrometer the plate emissivity was determined.

Keywords: *Emissivity, heat exchanger, natural convection, pyrometer, thermal radiation. Emissividade, trocador de calor, convecção natural, pirômetro, radiação térmica*

COB699 GERAÇÃO DE ENTROPIA EM SISTEMAS RADIANTES DE TUBOS ALETADOS / ENTROPY GENERATION IN TUBE AND FIN RADIATING SYSTEMS

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The entropy generation minimization method is applied to tube and fin radiative systems. The mathematical modeling of the systems lead to a non-linear integro-differential systems of equations, which is solved numerically. The entropy generation in the fin is computed. This is obtained as result

of the thermal analysis of the system which gives the fin temperature distributions and the radiative heat transfer rates. Examples of optimized design are considered and discussed.

Keywords: *Entropia, Irreversibilidades, Minimização, Aletas e Radiação / Entropy, Irreversibility, Minimization, Fin and Radiation*

COB881 ESTIMATION OF MONTHLY DIFFUSE SOLAR RADIATION USING ÅNGSTROM'S EQUATION LINEAR COEFFICIENT / ESTIMATIVA DA RADIAÇÃO DIFUSA MENSAL USANDO O COEFICIENTE LINEAR DA EQUAÇÃO DE ÅNGSTROM

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A method to estimate the diffuse solar radiation using the Ångstrom's equation linear coefficient is presented. The method was validated by comparison with data from the Solar Radiation Station of UNESP, Botucatu, SP, Brazil (22°54' South; 48°27' West). Relative errors ranged from 2.71% to 29.86%, when estimated values were compared with measured data. We concluded that the method permits to estimate monthly diffuse solar radiation, with good precision, under climatic conditions in which monthly frequency of clear, partially cloudy and cloudy days is roughly the same.

Keywords: *Solar Radiation - Diffuse Radiation - Radiation Modeling - Estimation of Radiation - Ångstrom's Models / Radiação Solar - Radiação Difusa - Modelagem de Radiação - Estimativa de Radiação - Modelo de Ångstrom*

COB883 MODELO DE ESTIMATIVA DAS IRRADIÂNCIAS GLOBAL E DIFUSA EM COBERTURA DE POLIETILENO / MODEL TO ESTIMATE GLOBAL AND DIFFUSE RADIATION IN POLYETHYLENE COVERAGE

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This paper describes the results obtained from correlations between global and diffuse radiation inside polyethylene coverage. During 40 days, global (G) and diffuse (D) radiation were measured outside (ex) and inside (in) polyethylene greenhouse (100 mm), for four specter conditions: open sky, partially cloudy, cloudy and the sum of the three previous conditions. The global radiation was measured with pyranometers and the diffuse radiation, with pyranometer below shadow rings. The data acquisition system consisted of a CAMPBELL 21X datalogger and a 486 DX2 microcomputer, programmed to operate in 1 Hz frequency and store average of 5 minutes. The following results were obtained: $G_{in} = 4.13 + 0.79 G_{ex}$; $D_{in} = 45.53 + 0.71 D_{ex}$. The best correlations found to the global radiation ($G_{in} \times G_{ex}$) were, in order: cloudy sky days ($R_2 = 98.53\%$), open sky ($R_2 = 96.45\%$) and partially cloudy sky ($R_2 = 94.07\%$). The best correlations to the diffuse radiation ($D_{in} \times D_{ex}$) were: cloudy sky ($R_2 = 96.52\%$), open sky ($R_2 = 78.93\%$) and partially cloudy sky ($R_2 = 71.78\%$).

Keywords: *global and diffuse radiation; polyethylene greenhouse / radiações global e difusa, estufa de polietileno*

COB1187 GERAÇÃO DO TERMO FONTE A PARTIR DA TRANSMISSÃO DA RADIAÇÃO ÓPTICA EM TECIDOS HETEROGÊNEOS / EVALUATION OF THE HEAT SOURCE THROUGH OF THE RADIATION OPTICAL TRANSMISSION IN HETEROGENEOUS TISSUES

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The application of the optical spectrum on medicine has been increasing. The relevance of optical properties of laser radiation on tissues and their thermodynamic consequences are extremely important to understand and optimize surgical process. In this context, analytical and computational models for photons transport on tissue joined to the heat transport through tissue are required. A simplified model of tridimensional photons transport is proposed with the goal of setting up a methodology of photons flux calculus inside a tissue with high scattering coefficient.

Keywords: *global Laser, Photons Transport, Heat Transport, Finite Element, Tissue/Laser, Transporte de Fótons, transporte de Calor, Elementos Finitos, Tecido*

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Keywords: *Laser, Photons Transport, Heat Transport, Finite Element, Tissue/Laser, Transporte de Fótons, transporte de Calor, Elementos Finitos, Tecido*

COB1425 ANÁLISE DO MÉTODO DE ORDENADAS DISCRETAS: DISCRETIZAÇÃO ANGULAR / ANALYSIS OF THE DISCRETE ORDINATE METHOD: ANGULAR DISCRETIZATION

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This work presents a numerical analysis of different sets of quadratures involved in a discrete ordinate method used to solve the Equation of Radiative Transfer (ETR). Two different quadratures are derived from the classical Gauss and Radau ones, with the imposed condition of satisfying key half-moments of the radiative intensity. This set of quadratures are obtained through a simple translation in the Gauss or Radau full-range scheme $[-1, 1]$ to the half-range $[0, 1]$. These quadratures are compared to cases previously analyzed by Fiveland (1985, 1987) for a slab of isotropic conservative scattering or absorbing-emitting gray medium. The results obtained with the two new set of quadratures, for the net radiative flux and the incident energy to different range of optical thicknesses and the S2, S4, S6, S8, S10, S12 ordinate sets, show a good accuracy).

Keywords: *radiação térmica, ordenadas discretas, meio semitransparente, quadratura / radiative heat transfer, discrete ordinate method, semitransparent materials, quadrature*

COB1427 PREDICTION OF DIRECTIONAL SPECTRAL EMITTANCE OF AN ABSORBING AND SCATTERING CERAMIC MATERIAL AT HIGH TEMPERATURE

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Directional spectral emittance of an absorbing and scattering isotherm ceramic material (Al_2O_3) is predicted using a radiative model based on the discrete ordinates method associated to the control volume technique to solve the radiative transfer equation. The absorption (Q_a) and scattering (Q_s) efficiencies for incident radiation upon spherical particles of aluminum oxide are calculated from the Mie theory for a temperature range from 1200°C to 2020°C, the particle radius lying from 10 μ m to 50 μ m, and a range of wavelengths from 2 μ m to 6 μ m. These calculations are based on literature values of the complex index of refraction ($\bar{n} = n - ik$) at high temperature for the monocrystal of sapphire (Al_2O_3). Independent scattering assumption is used. The limit of independent scattering theory is verified for a particle volume fraction ranging from 0.3 to 0.7. The spectral normal emittance of Al_2O_3 at high temperature is calculated increasing the thickness to identify the 'infinite thickness'. Calculations are performed and analyzed for different particle radius and medium temperatures.

Keywords: *Emittance, semitransparent media, ceramic material, high temperature, discrete ordinates method*

COB1428 ESTUDO DE SENSIBILIDADE DE PARÂMETROS NO ACOPLAMENTO CONDUÇÃO-RADIAÇÃO/ THE SENSIVITY STUDY OF IN COUPLING CONDUCTION-RADIATION

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This paper presents the feasibility of the estimation of radiative and conductive properties from a laser flash method. A sensitivity study of the coupling radiation/diffusion parameters is performed. The solid is emissive, absorbing and scattering semi-transparent. The study allows to detect the parameters that can be estimated simultaneously from the back surface temperature rise. The Levenberg-Marquardt method is used to determine the parameters.

Keywords: *acoplamento, condução, radiação, método inverso, método flash/ coupling, conduction, radiation, ininverse method, flash method*

COB1429 MÉTODO DAS ORDENADAS DISCRETAS ASSOCIADO A FORMA INTEGRAL DA EQUAÇÃO DE TRANSFERÊNCIA DE RADIAÇÃO EM GEOMETRIA RETANGULAR UNIDIMENSIONAL / DISCRETE ORDINATES METHOD ASSOCIATED TO INTEGRAL FORM OF THE RADIATIVE TRANSFER EQUATION IN THE UNIDIMENSIONAL RECTANGULAR GEOMETRY

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Discrete ordinates method is utilized to solve radiative transfer equation in the integral form for analysis of one-dimensional planar enclosure with absorbing, emitting, and either isotropically or anisotropically scattering medium. The main characteristic of the technical is the computing of the average intensity of the control volume. To validate the formulations, one problem test is considered and their results are compared with exact solution.

Keywords: *técnica, radiação, forma integral, ordenadas discretas, retangular technique, radiation, integral form, discrete ordinates, rectangular*

TEMA 23 - Convecção**COB256 CONVECÇÃO NATURAL EM CAVIDADE VERTICAL COM FONTES DE CALOR DISCRETAS MONTADAS EM UMA DAS PAREDES / NATURAL CONVECTION ON A VERTICAL CAVITY WITH FLUSH MOUNTED HEAT SOURCES ON A LATERAL SIDE****Tito Dias Jr., Eduardo Yoshinori Honda, Ricardo Alan Verdú Ramos***Departamento de Engenharia Mecânica - Faculdade de Engenharia de Ilha Solteira - UNESP
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In this work, the natural convection effect on the flow and the heat transfer in a vertical cavity with two discrete heat sources located on the left adiabatic wall is numerically studied. Laminar, two-dimensional and steady flow has been assumed. It has been used the Boussinesq approximation and the physical properties have been considered constant. The finite volumes method has been used to discretize the governing elliptical equations. The numerical solution has been obtained by the SIMPLE (Semi-Implicit Method for Pressure-Linked Equations) algorithm. A grid test was carried out and a more refined mesh was used near the heat sources region and with smooth space progression after that. The influence of the power distribution, spacing between the heat sources and cavity aspect ratio have been investigated. An analysis of the average Nusselt number of the two heat sources was realized to verify the improvement of the heat transfer coefficient.

Keywords: *Convecção Natural, fontes de calor discretas, cavidade vertical, método de volumes finitos / Natural convection, discrete heat sources, vertical cavity, finite volumes method*

COB532 ANÁLISE TEÓRICA E EXPERIMENTAL DA TRANSFERÊNCIA DE CALOR EM PLACAS DE CIRCUITO IMPRESSO FORMANDO CANAIS VERTICAIS ABERTOS / THEORETICAL AND EXPERIMENTAL ANALYSIS OF THE HEAT TRANSFER IN PRINTED CIRCUIT BOARDS FORMING OPEN VERTICAL CHANNELS**Ana Cistina Avelar & Marcelo Moreira Ganzarolli***Departamento de Energia, Faculdade de Engenharia Mecânica - UNICAMP - Campinas
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This paper analyses the influence of steady wind shear (vertical wind profile) on the wind turbines structural stability. The wind speed, in general, increases with altitude (up to about 500 to 1500 m) above the earth's surface. However, for wind turbines, the altitude is limited to about 120 m at the most because beyond this level the cost of tower becomes prohibitive. It should be emphasized that we are talking about the wind turbine's rotor diameter of the order of 15 m or more. Hence, the wind speed at the extreme points of the rotor disc, considering perpendicular to the upwind would certainly be different magnitude, results into wind shear. The latter would cause cyclic load 1/revolution. This paper describes very briefly the equations of blade motion that determine the dynamic stability. This equation then is used to estimate the load due to wind shear. We have assumed a linear shear profile. The effect of it is estimated to calculate the bending moments. A step by step procedure is shown so as to have a real feel of the complexity involved in it.

Keywords: *Transferência de calor, Canais verticais, Convecção natural, Convecção forçada, Placa de circuito impresso / Heat transfer, Vertical channels, Natural convection, Forced convection, Printed circuit board*

COB709 CONVECÇÃO NATURAL EM REGIME TRANSITÓRIO NO INTERIOR DE CAVIDADE POROSA / TRANSIENT NATURAL CONVECTION IN A POROUS CAVITY

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A numerical simulation on transient natural convection occurring in a square porous cavity is reported. The bottom wall of the bidimensional cavity is heated while the upper wall is cooled, both maintained at constant temperatures. The finite volume method was applied. The applicability of the Darcy model was assumed. The transient regime is examined for several intensities of the buoyancy effects due to fluid temperature variations. The transient fluid flow and heat transfer characteristics are studied and compared to other results. Global Nusselt numbers are reported for the heated and cooled walls. Aspects of the fluid flow and temperature fields are illustrated by contour maps.

Keywords: *Convecção natural, regime transitório, cavidade porosa, modelo de Darcy / Natural convection, transient analysis, porous cavity, Darcy model*

COB718 CONVECÇÃO NATURAL TRANSITÓRIA TURBULENTA NUM RECIPIENTE CILÍNDRICO VERTICAL / TRANSIENT TURBULENT NATURAL CONVECTION INSIDE A VERTICAL CYLINDER

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Natural convection of a liquid inside a vertical cylinder is solved numerically. The flow is caused by the uniform heating of the lateral wall. In spite of the practical importance of this problem very few results are available for the turbulent flow, which is the subject of this work. The turbulence model previously used by Ince & Launder, to study the problem of natural convection inside a rectangular cavity, was transformed into cylindrical coordinates and applied to the problem. This low Reynolds number model accepts a laminar as well as a turbulent solution. So, as the flow is initially laminar, it would be necessary in some instance to cause the transition. This difficulty was avoided by considering that in the initial condition the fluid was static but had a high turbulence intensity. This technique was not completely successful because the initial turbulent intensity had a phase effect in the solution.

Keywords: *Convecção Natural - Modelos de Turbulência - Dinâmica dos Fluidos Computacional / Natural Convection - Turbulence Models - Computational Fluid Dynamics*

COB719 CONVECÇÃO NATURAL TURBULENTO DE METAIS LÍQUIDOS EM CAVIDADES FECHADAS / NATURAL CONVECTION OF LIQUID METAL INSIDE A CLOSED CAVITY**Luiz Joaquim Cardoso Rocha & Angela Ourivio Niecele***Departamento de Engenharia Mecânica - Pontifícia Universidade Católica do Rio de Janeiro
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At the present work, natural convection of liquid metal inside a closed cavity is examined, based on the Boussinesq approximation. The upper and lower cavity walls are adiabatic, while the vertical walls are at uniform and different temperatures. When the Prandtl number is low, the transition from the laminar to the turbulent regime occurs for a Rayleigh number approximately equal to 105. Therefore, the laminar and turbulent regimes are examined. The turbulence model selected was the two differential equation low Reynolds number LRN k- ϵ model. The problem was numerically solved by the finite volume method, based on the Power-law interpolating scheme. The pressure-velocity coupling was solved with the algorithm SIMPLEC. The solution obtained was validated comparing with some experimental and numerical results available in the literature. The effect of the Rayleigh and Prandtl number in the flow field was examined.

Keywords: *Convecção Natural - Metal Líquido - escoamento Laminar/Turbulento / Natural Convection - Liquid Metal - Laminar/Turbulent Flow*

COB775 LOCALLY-COUPLED NUMERICAL SOLUTION OF THERMALLY-DRIVEN CAVITY FLOWS**Marcelo J.S. de Lemos***Departamento de Energia, Instituto Tecnológico de Aeronáutica-CTA
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This work reports a numerical investigation on buoyancy-induced flows occurring in enclosures of small aspect ratio. The numerical method used consists of the control-volume approach and a new block-implicit smoothing operator. Governing equations are written in terms of the so-called primitive variables and are recast into a general form. In the proposed method all governing equation are relaxed locally, at the same time, in contrast with commonly used segregated schemes. The effect of the Rayleigh number and aspect ratio on temperature and velocity patterns are presented.

Keywords: *Coupled Solvers, Laminar Flow, Numerical Methods*

COB797 ANALYSIS OF AXIAL FLUID CONDUCTION EFFECTS IN THERMALLY DEVELOPING FLOW IN TUBES**Ana Cristina Rocha de Castro, F. Scofano Neto & R. O. C. Guedes***Departamento de Engenharia Mecânica e de Materiais, Instituto Militar de Engenharia
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This contribution addresses the internal forced convection problem in a circular duct including axial fluid conduction effects. The problem is modeled by taking under consideration the "two-

region" model which avoids the prescription of the inlet temperature profile. The mathematical formulation is handled by the Generalized Integral Transform Technique and special consideration is given to the slug flow condition. The results are focused on the axial distribution of bulk and wall temperatures and Nusselt numbers over a range of suitable Peclet and external Biot numbers.

Keywords: *Forced Convection, Eigenfunction Expansion, Analytical Solution, Slug Flow*

COB798 CONJUGATED HEAT TRANSFER IN PARALLEL PLATE CHANNELS SUBJECTED TO A PRESCRIBED FLUX AT THE WALL

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Conjugated convective-conductive heat transfer in laminar flow inside a parallel-plates channel subjected to prescribed wall heat flux is investigated. The Generalized Integral Transform Technique is used to handle the mathematical formulation and results are presented in terms of the dimensionless parameters governing the problem.

Keywords: *Forced Convection, Thermal Entrance, Eigenfunction Expansion, Conjugate Problems*

COB904 CONJUGATE HEAT TRANSFER TO NEWTONIAN FLUIDS IN DUCTS BY FINITE ELEMENTS

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In this work, we analyse conjugate heat transfer problems to Newtonian fluids in ducts by an SUPG finite element method. The case of prescribed temperature at the outside surface wall is considered, as well as radial and axial conduction effects in both fluid and solid. Heat fluxes are calculated by a post-processing technique and numerical results are presented.

Keywords: *Conjugate convection-diffusion heat transfer, finite element, post-processing method, SUPG-methods / Transferência conjugada de calor por convecção-difusão, elementos finitos, método de pós-processamento, métodos SUPG*

COB1124 CONVECÇÃO NATURAL TRANSIENTE EM CAVIDADES 3D / TRANSIENT NATURAL CONVECTION IN 3D CAVITIES

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The transient heat transfer by natural convection in a fluid confined into a completely filled 3D cavity ($H = 165$ mm, $L = 95$ mm, $W = 65$ mm) is analyzed here. The fluid is initially at a temperature T_{fi} , and at a given time, all walls are heated to T_b , greater than T_{fi} . Heat is propagated by natural convection into the enclosure, until its complete thermal equilibrium. The problem is analyzed by numerical simulations and experimental measurements, for different values of the initial Rayleigh number. The numerical simulations are performed using the finite element method for 3D natural convection flow problems. Temperature profiles during the heating process, the flow visualization of the convective patterns, a discussion of the topology of the flow into the cavity and the mixing problem resulted from the natural convective effects, are presented. Practical relations for the Nusselt number into the cavity are proposed.

Keywords: *Natural convection. Heat transfer. Convecção Natural. Transferência de Calor*

COB1236 NATURAL CONVECTION IN THE EVAPORATOR REGION OF HOUSEHOLD REFRIGERATORS

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The buoyancy induced convection of air in the evaporator region of household refrigerators is investigated numerically. The problem formulation accounts not only for body forces due to temperature gradients, but also to those due to moisture nonuniform concentration. In this way the whole problem is governed by two dimensionless and independent body force parameters, Grashof numbers, related to temperature and moisture concentration nonuniformity. Results were obtained for different combinations of thermal and concentration Grashof numbers, while the problem geometry remained unchanged. For a variety of operating conditions, that is, Grashof numbers, streamline pattern, temperature and moisture concentration fields are shown. Emphasis is given to overall values of Nusselt and Sherwood numbers, that allow for estimation of the sensible heat exchange and rate of air dehumidification between the evaporator and refrigerator cabinet.

Keywords: *Natural Convection, Simulation, Refrigeration, Evaporator*

COB1286 ANÁLISE TEÓRICA DA CONVECÇÃO FORÇADA LAMINAR TRANSIENTE EM DESENVOLVIMENTO SIMULTÂNEO EM PLACAS PARALELAS / THEORETICAL ANALYSIS OF THE TRANSIENT LAMINAR FORCED CONVECTION FOR SIMULTANEOUS DEVELOPING FLOW IN PARALLEL PLATE CHANNELS

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Transient laminar forced convection for simultaneous developing flow between parallel plates is studied by applying the generalized integral transform technique. A fifth kind boundary condition for the energy equation is used and an auxiliary complex problem is generated. The results for the Nusselt

number and bulk temperature are compared with other publications in order to validate the technique used in this work.

Keywords: *Transient Forced Convection Generalized Integral Transform Technique Fifth Kind Boundary Condition*

COB1289 ANÁLISE TEÓRICA DA CONVECÇÃO NATURAL LAMINAR NUMA CAVIDADE POROSA CONSIDERANDO O EFEITO DA POROSIDADE VARIÁVEL / THEORETICAL ANALYSIS OF LAMINAR NATURAL CONVECTION INSIDE A RECTANGULAR CAVITY POROUS CONSIDERING THE EFFECT OF VARIABLE POROSITY

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A numerical study is performed on steady two-dimensional natural convection inside a rectangular porous enclosure with uniform internal heat generation. The boundary conditions were: Two isothermal walls at same temperatures, two horizontal adiabatic walls. The effects of non-uniform porosity are taken into consideration in the momentum equation. The governing equations in terms of the primitive variables are solved by the finite volume method. The coupling velocity - pressure was treated by PRIME algorithm employing staggered grids. The results are presented in terms of the isotherms, stream functions and Nusselt number with and without uniform porosity.

Keywords: *Natural Convection - Porous Medium - Non-Darcian Model - Variable Porosity - Convecção Natural - Meio Poroso - Modelo não Darciano - porosidade variável*

COB1372 FORCED CONVECTION AIR COOLING OF A 1/2 ATR PROCESSOR BOX - AN EXPERIMENTAL STUDY

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Wind tunnel studies have been carried out to evaluate the forced convection air cooling requirements of a 1/2 ATR processor box designed for air-borne applications. Various levels of heat flux are simulated at the PCB level in the box using resistance element heating. Pressure drop, transient heating and cooling curves are analysed and a set of performance curves involving the time constants and steady state excess operating temperatures are obtained.

Keywords: *Processors, Convection, Air cooling, Time constant, Steady state excess operating temperature*

COB1420 VERTICAL PLATE IN RELATIVE MOTION TO A PARALLEL AIR STREAM**M.V. A. Bianchi¹, O. H. G. Branco², J.V.C. Vargas² & R. Viskanta¹**¹ *Heat Transfer Laboratory, School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907-1288 USA*² *Departamento de Engenharia Mecânica, Universidade Federal do Paraná*

Heat transfer from a surface in motion relative to either a stationary or moving fluid occurs in many materials processing applications such as hot rolling, extrusion, drawing, and drying. In this study, an analysis has been carried out to predict convective transport occurring in the laminar air boundary layer on a continuous vertical surface which moves in parallel or in counterflow with respect to the free stream in the presence of gravity. Numerical results obtained with the local non-similarity method based on boundary layer assumptions are compared to numerical results from a complete formulation. Predictions for the local skin friction and heat transfer are made for different configurations of the relative position of the surface and the free stream. The comparison allows for the establishment of criteria on when the use of boundary layer assumptions is an acceptable approximation. New results are presented with the complete formulation using the finite element method.

Keywords: *Moving plate, laminar regime, finite element method*

TEMA 24 - Condução

COB288 TWO-DIMENSIONAL SIMULATION OF HEAT CONDUCTION IN ORDERED COMPOSITES WITH A THERMALLY-CONDUCTING DISPERSED PHASE

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In this paper we extend a finite-element-based methodology to simulate two-dimensional heat conduction in ordered composites with a thermally-conducting dispersed phase. The method of homogenization is employed to derive the continuous cell problem and an expression for the effective thermal conductivity. Finite elements are used for numerical solution of the cell problem. Our formulation is applicable to both ordered and random composites; however, here we only compute the effective conductivity of the former, and validate our results against well-known analytical solutions to the same problem. Future research will extend the current implementation to random composites, which model real composite materials more closely.

Keywords: *Heat Conduction; Finite Elements; Thermal Composites; Ordered Media; Numerical Methods / Condução de Calor; Elementos Finitos; Compósitos Térmicos; Meios Ordenados; Métodos Numéricos*

COB299 SOLUÇÃO VIA TRANSFORMADA INTEGRAL PARA PROBLEMA DE CONDUÇÃO DE CALOR EM CHIPS COM ENCAPSULAMENTO PLÁSTICO / AN INTEGRAL TRANSFORM SOLUTION FOR THE HEAT CONDUCTION PROBLEM IN PLASTIC ENCAPSULATED CHIPS

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In this paper we study the steady-state heat conduction problem involving a plastic encapsulated chip. The two-region problem is solved as a single-region one, by assuming perfect contact between the chip and the encapsulant. The Classical Integral Transform Technique is used for the solution of the present problem, by using a two-dimensional auxiliary eigenvalue problem. The Generalized Integral Transform Technique is then applied for the solution of such eigenvalue problem. Results are presented for a typical test-case.

Keywords: *Integral Transform Technique, Plastic Encapsulated Chips, Heat Conduction / Técnica de Transformação Integral, Chips com Encapsulamento Plástico, Condução de Calor*

COB324 ESTIMADOR DE UMA FUNÇÃO OBJETIVO DE CORRELAÇÃO NA MEDIÇÃO SIMULTÂNEA DE PROPRIEDADES TÉRMICAS / SIMULTANEOUS THERMAL PROPERTIES ESTIMATION USING A CORRELATION OBJECTIVE FUNCTION ESTIMATOR

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This paper describes an experimental technique to measure simultaneously the thermal diffusivity and thermal conductivity of nonmetallic materials. Thermal properties are estimated by using parameter estimation techniques with measured surface heat flux and temperature histories on only one surface of a perspex sample. In addition the golden section optimization technique is used with the parameter estimation for minimizing two different objective functions. Each of the thermal properties is estimated in a different way. The diffusivity estimation uses a correlation function estimator between the heat flux and temperature while a square function error of experimental and estimated temperatures is the objective function used for determining the conductivity. A comparison with the guarded hot plate method indicates a deviation of 2.1% of the thermal conductivity.

Keywords: *Estimação de Parâmetros, Medição de Propriedades Térmicas, Condução, Problemas Inversos, Otimização. Parameter Estimation, Thermal Properties Measurements, Heat Conduction, Inverse Problems, Optimization*

COB905 APLICAÇÃO DO MÉTODO DE ELEMENTOS FINITOS EM PROBLEMAS DE MUDANÇA DE FASE COM PROPRIEDADES FÍSICAS DEPENDENTES DA TEMPERATURA / FINITE ELEMENT METHOD APPLICATION IN PHASE CHANGE PROBLEMS WITH TEMPERATURE DEPENDENT PHYSICAL PROPERTIES

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This work studies a solidification process with temperature-dependent physical properties for the solid region. Is developed a numerical unsteady model based upon an enthalpic approach and the finite element method. The obtained numerical results compare well with an analytical solution for a semi-infinite body and obtained experimental results.

Keywords: *Mudança de Fase/Phase Change; Elementos Finitos/Finite Element; Método Entálpico/Enthalpic Method*

COB1228 ESTUDO DE TÉCNICA PARA SOLUÇÃO DE PROBLEMA INVERSO DE CONDUÇÃO DE CALOR BIDIMENSIONAL / STUDING OF TWO-DIMENSIONAL IHCP TECHNIQUES

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This work treats techniques for solving inverse heat conduction problems (IHCP) related to tools used in machining. The surface heat flux can be estimated from experimental and calculated tem-

perature data. An evaluation of boundary conditions of metal cutting indicates the complexity of the thermal problem and a 3-D analysis is necessary. However, in a first study, the use of a simplified hypothesis enables two-dimensional (2D) analysis initially. The heat source due the machining process was simulated numerically to permit a great flexibility in the analysis of the technique used. The results of the 2D analysis are presented in several graphics. In this case, the linear imposed heat transfer history varies with time and position and the heat appeared to be lost laterally. The evaluation of results indicates the cases that the methods can be applied successfully.

Keywords: *Inverse problems – parameter estimation – heat conduction – two-dimensional – cutting / Problemas inversos – estimação de parâmetros – condução de calor – bidimensional – usinagem*

TEMA 25 - Ebulição e Condensação

COB247 TURBULENT WAKE OF AN AXISYMMETRIC BLUFF BODY

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This work deals with the aerodynamic behaviour of new wind sensor balloons which are to be used to evaluate with high precision the atmospheric conditions before Ariane V launches. Due to the high complexity of the system, we undertook an experimental analysis of a model situation. The diagnostic methods used involved global and local detection by hot wire measurement techniques. The Strouhal number of the vortex shedding remains around 0.2 even in a three-dimensional axisymmetric configuration. A spatio-temporal correlation analysis of the data and the application of the POD reveals a strong influence of the drag transition over the near wake. The periodic component of the near wake shows, in the subcritical range, a high level of coherence which strongly decreases over the transition. The coupling of these results with the shape evolution contribute to a better knowledge and control of the stability in high altitude of these new balloons.

Keywords: *Axisymmetric bluff body, Turbulent wake, Transition, Coherent structures, Hot wire measurement*

COB271 CONDENSAÇÃO PELICULAR SOBRE TUBOS INCLINADOS ANISOTÉRMICOS / FILM CONDENSATION OVER ANISOTHERMAL INCLINED TUBES

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A model is presented for the steady laminar film flow of a newtonian liquid condensing from a steady saturated vapor over the non-isothermal external surface of an inclined tube. The analysis results in a universal and non-dimensional semi-analytical solution in respect to Ra and Ja numbers and the duct inclination. The wall temperature variation must be given as a function of the angular position. Calculations are presented for a cosine local temperature distribution. The results are expressed in terms of the dimensionless local film thickness, local and averaged Nusselt numbers, and the temperature distribution parameter. The film thickness is found to depend significantly on the temperature non-uniformity, whereas the effect on the average Nusselt number depends on the intensity of this temperature variation.

Keywords: *Inclined Tubes, Film Condensation, Condensation*

COB537 A MODEL FOR THE ICE CRYSTAL GROWTH IN LAMINAR FALLING FILMS**Kamal A. R. Ismail & Musa M. Radwan**

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A finite volume numerical code has been developed to numerically approximate the rate of ice crystal growth in a laminar falling film flowing down a cooled vertical plate. The governing energy equation contains the phase energy as the source term. Enhancement of heat transfer due to suspended ice crystals is accounted for in the use of effective values of thermal conductivity, viscosity, thermal diffusivity, and specific heat as function of volumetric concentration of ice crystals in the falling film. Nusselt numbers, overall heat transfer coefficients between the fluid and cooled plate, and ice crystal growth rate were calculated for different film thicknesses with and without axial diffusion. Nusselt numbers and ice crystal growth rate were found to be dependent on film thickness. Axial diffusion effects were found to be negligible for larger film thickness (large flowrate).

Keywords: *Energy storage, heat transfer enhancement*

**COB1137 MODELO NUMÉRICO PARA PREVISÃO DE INSTABILIDADES MORFOLÓGICAS NA SOLIDIFICAÇÃO DE LIGAS BINÁRIAS /
NUMERICAL MODEL TO EVALUATE MORPHOLOGICAL INSTABILITIES
DURING SOLIDIFICATION OF BINARY ALLOYS****Romulo Heringer Ferreira**

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A numerical model is proposed to explore heat and mass transfer during the unidirectional solidification of binary metallic alloys in presence of morphological instabilities. The basic hypothesis adopted in the work is that the most important effect in the transport of energy and chemical species during the solidification is the increasing in the solid liquid interface area. With this hypothesis in conjunction with the linear stability theory proposed by Mullins and Sekerka, as well as the conclusions of Langer and Muller-Krumbhaar related to the criterion of marginal stability, the instability effect was included at thermal and solute balances across the solid liquid interface. The energy and solute transport equations were solved simultaneously for both solid and liquid regions using the finite volume methodology. The present model allows to predict interface velocity, enthalpy and solute fields, as well as the primary dendrite arm spacing.

Keywords: *alloy solidification, heat and mass transfer in solidification, morphological instabilities, dendrite growth / solidificação, instabilidades morfológicas, crescimento dendrítico*

TEMA 26 - Compressores**COB313 ESCOAMENTO DE ÓLEO E REFRIGERANTE PELA FOLGA RADIAL EM COMPRESSORES ROTATIVOS DE PISTÃO ROLANTE / OIL AND REFRIGERANT FLOW THROUGH RADIAL CLEARANCE IN ROLLING PISTON COMPRESSORS****José Luiz Gasche, Álvaro Toubes Prata* & Rogério Tadeu da Silva Ferreira****Departamento de Engenharia Mecânica, Faculdade de Engenharia - UNESP - Ilha Solteira
CEP 15.385-000 - Ilha Solteira-SP, Brasil - E-mail: gasche@feis.unesp.br***Departamento de Engenharia Mecânica - NRVA, UFSC**CEP 88.040-900 - Florianópolis-SC, Brasil - E-mail: prata@nrva.ufsc.br, rogerio@emc.ufsc.br*

In this work, important points associated with the leakage of the refrigerant gas through the radial clearance in rolling piston compressors are discussed. This leakage is the main cause of volumetric efficiency loss. The principal characteristic of this leakage flow is its transient behavior since the chamber compression pressure, the absolute tangential velocity of the piston surface and the radial clearance, all vary with time during the compression cycle. These parameters must be determined by modeling the gas compression process and the piston dynamics, and by knowing the pump geometric characteristics. Another important aspect in this flow modeling is related to the nature of the leaking fluid: a mixture composed by oil and dissolved refrigerant. As this mixture flows through a low pressure region, the dissolved refrigerant separates from the oil, forming bubbles, so that the mixture shifts to a new equilibrium condition, and a two-phase flow is created. Also foam may form in the flow due to the large number of bubbles. Following this discussion, the importance of the inertial forces in the flow is analyzed and a first model to calculate the oil and refrigerant flow through radial clearance is presented.

Keywords: *Compressor (Compressor), Refrigeração (Refrigeration), Refrigerante (Refrigerant), Óleo (Oil), Folga (Clearance)*

COB346 FORÇA AXIAL ATUANDO NUM DIFUSOR RADIAL DEVIDO AO MOVIMENTO SÚBITO DA PALHETA / AXIAL FORCE ON THE FRONTAL DISK OF A AXIALLY FED RADIAL DIFFUSER WITH MOVING BOUNDARY**Carlos F. E. Alves^{1,*}, Washington Braga Filho¹ & Carlos A. Thompson²***¹ Departamento de Engenharia Mecânica, PUC-Rio - Rua Marques de São Vicente, 225
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This paper reports preliminary numerical results of some aspects of the axially fed radial flow between parallel disks. Particularly, the characteristics of the axial force on a situation in which the frontal disk is suddenly moved to a new location (closer or further apart) is studied. The flow is assumed incompressible, laminar and isothermal.

Keywords: *compressor; radial flow; finite volume; moving grid; space conservation / compressores; escoamento radial; volumes finitos; fronteiras móveis; conservação de espaço*

TEMA 27 - Refrigeração e Bombas de Calor

COB72 ANÁLISE DO ESCOAMENTO EM TUBOS CAPILARES ADIABÁTICOS CONSIDERANDO O NÃO-EQUILÍBRIO HIDRODINÂMICO E TÉRMICO ENTRE AS FASES

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This work presents a model to simulate the refrigerant flow through capillary tubes, used as expansion devices in refrigeration systems. The governing and constitutive equations, the boundary conditions and the simplifying assumptions are presented and discussed. The two-fluid model, considering the hydrodynamic and thermal non equilibrium between the liquid and vapor phases, is applied to the two-phase flow region. The pressure profiles and the mass flow rates given by the model are compared with experimental data and a good agreement is shown.

Keywords: *Capillary tubes, two-phase flow, two-fluid model. Tubos capilares, escoamento bifásico, modelo de dois fluidos.*

COB73 EQUAÇÕES CONSTITUTIVAS PARA TUBOS CAPILARES E O SEU IMPACTO SOBRE O DESEMPENHO DO PROGRAMA CAPILAR / CONSTITUTIVE EQUATIONS FOR CAPILLARY TUBES AND THEIR IMPACT ON THE CAPILAR PROGRAM PERFORMANCE

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This work presents a second version of a numerical model to simulate adiabatic capillary tubes. The constitutive equations employed in the first version of the model are replaced by new ones, derived from experimental work on capillary tubes. Comparisons with experimental data reveal that the second version predicts more accurately the refrigerant flow through adiabatic capillary tubes.

Keywords: *Capillary tubes, Expansion, Refrigeration, Tubos capilares, Refrigeração*

COB740 CIRCUITO PARA ENSAIOS DE EVAPORADORES / EVAPORATORS TEST RIG

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This paper describes an experimental apparatus for testing evaporators of residential air conditioning systems. In this test rig it is possible to determine the overall heat transfer coefficient, pressure loss (of air and refrigerant sides) and refrigerating capacity as function of different operating conditions (air flow rate, refrigerant flow rate, evaporating temperature, quality at the evaporator inlet). This test rig can be utilized to characterize the performance of evaporators of room conditioners employing different types of refrigerant fluids and heat enhancement surfaces.

Keywords: *evaporator test rig, room conditioners*

COB874 ESTUDO DO ESCOAMENTO DE REFRIGERANTES ATRAVÉS DE TUBOS CAPILARES - UMA REVISÃO CRÍTICA / A CRITICISM ON THE STUDIES OF THE FLOW THROUGH CAPILLARY TUBES

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Some important aspects concerning the mathematical modelling and numerical simulation of the flow through capillary tubes, as treated by several researchers, are usually not presented in details on published papers. This paper presents the phenomena, parameters and variables that mostly governs the flow, performing some insights into them.

Keywords: *Capillary tubes, two-phase flow, refrigeration, mathematical modelling, simulation*

COB901 VALIDAÇÃO DE UM MODELO PARA SIMULAÇÃO DE SISTEMAS DE AR CONDICIONADO COM TERMOACUMULAÇÃO / VALIDATION OF A MODEL FOR SIMULATION OF THERMAL STORAGE AIR CONDITIONING SYSTEMS

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This work presents a model for computational simulation of direct ice-storage air conditioning systems. The model developed is based on the thermodynamics quasi-steady equilibrium process. The results of the simulation are compared with experimental data obtained in the air conditioning laboratory at EFEI.

Keywords: *Ar condicionado, termoacumulação, modelo, simulação e validação / Air conditioning, thermal storage, model, simulation and validation*

COB1140 MODELO DINÂMICO PARA A LUBRIFICAÇÃO DE PISTÕES EM COMPRESSORES ALTERNATIVOS DE REFRIGERAÇÃO / DYNAMIC MODEL FOR PISTON LUBRICATION IN REFRIGERATION RECIPROCATING COMPRESSORS

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A numerical simulation of the piston movement inside the cylinder of a reciprocating compressor is performed. The compressor considered here is a small hermetic compressor employed in domestic refrigerators. For the problem formulation both the axial and the radial piston motion is considered. In operation, the piston moves up and down along the axis of the cylinder, but the radial oscillatory motion in the cylinder bore, despite being usually small, plays a very important role on the compressor performance and reliability. The forces acting on the piston are the hydrodynamic force due to the pressure build up in the oil film (lubrication effects), the force due to the connecting rod, the viscous force associated with the relative motion between the piston and oil, and the force exerted by the gas on the top of the piston. All corresponding moments are also included in the problem formulation of the piston dynamics in order to determine the piston trajectory, velocity and acceleration at each time step. The results explore the effects of several design parameters and operation conditions on the stability of the piston, its sealing performance and friction losses.

Keywords: *piston dynamics, piston lubrication, sealing, compressor operation / dinâmica de pistão, lubrificação de pistão, vedação, operação de compressores*

COB1284 SIMULAÇÃO DE UM REFRIGERADOR ADSORTIVO REGENERATIVO UTILIZANDO REJEITOS TÉRMICOS / SIMULATION OF AN ADSORPTION REFRIGERATION REGENERATED BY REJECTED HEAT

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This research presents numerical simulation and a later dimensioning technique for a refrigeration system based on solid sorption, taking advantage of the rejected heat of a stationary internal combustion motor for regeneration. The functioning is based on a chemical reaction between two compounds, one in solid form and the other in liquid form or vapor. The choice of the frigorific pair depends on the desired working temperature for evaporation and also the maximum temperature at which the adsorbent can be reactivated. In order to analyze the influence of the frigorific pair, as well as the optimization of the prototypes, it is necessary to construct a mathematical model which represents correctly the operation of a real system. In this model, the heat equations are solved within the

porous medius coupled to the form of heat generation relative to the mass transportation. Computation methods will be used to solve in finite differences.

Keywords: *Refrigeration - solid adsorption - porous medius - active carbon - methanol / Adsorção sólida - carvão ativado - refrigeração - leito poroso - metanol*

COB1423 SISTEMA FRIGORÍFICO A ADSORÇÃO UTILIZANDO CARVÃO ATIVADO-METANOL COM REGENERAÇÃO POR ENERGIA SOLAR / ADSORPTION SOLAR COOLING SYSTEM USING ACTIVATED CARBON-METHANOL

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An analytical model of a new-conception of solid sorption solar cooling system and its numerical simulation are presented. This model accounts instantaneous heat and mass transfers in each component of the machine, during a whole characteristic average day of each month. The innovation of the machine consists in the use of a honeycomb TIM's cover for the solar collector and multitubular configurations for the reactor and the evaporator. The performance of the machine is evaluated utilizing meteorological data for one region of Brazil close to the equator, for the hottest six months. The results are compared with those obtained by modeling the system with a single cover solar collector and those from an experimental study of a prototype with usual components realized in Tunisia. The average net solar COP for the six months was 0.13 for the TIM cover system, corresponding to an ice production going from up to 7 to 10 kg per day per square meter of collector surface, respectively for March and December, with solar irradiations of 20 to 23 MJ/m².

Keywords: *Adsorption, Solar Cooling, Activated Carbon-Methanol, Numerical Simulation / Adsorção, Refrigeração Solar, Carvão Ativado-Metanol, Simulação Numérica*

TEMA 28 - Combustão

- COB306 TERMOQUÍMICA DOS PRODUTOS DE COMBUSTÃO UTILIZANDO PROPRIEDADES TERMODINÂMICAS OBTIDAS DA MECÂNICA ESTATÍSTICA / TERMOCHEMICAL OF COMBUSTION PRODUCTS USING THERMODYNAMIC PROPERTIES OBTAINED OF STATISTICAL MECHANICS**

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This work presents the results of an analytical model and a computer program to obtain thermochemical properties of combustion products in a liquid rocket motors, using the method of statistical mechanic to calculation thermodynamic properties of the species. The equations of statistical mechanics and the technique of minimization of Gibbs free energy are used to calculate the thermochemical functions and the equilibrium chemical composition. These methods are applied to the calculation of equilibrium properties of the combustion products in liquid rocket motors for different propellant pairs, O/F ratios and chamber pressures. The results obtained from this method are compared to those of NASA SP-273.

Keywords: *Combustion products - equilibrium chemical composition - statistical mechanics - minimization of Gibbs free energy - liquid fuel / Produtos de combustão - Composição em equilíbrio químico - Mecânica estatística - Minimização da energia livre de Gibbs - Combustível líquido*

- COB323 INCINERAÇÃO DE RESÍDUOS SÓLIDOS DE SERVIÇOS DE SAÚDE UTILIZANDO O BIOGÁS DE ATERROS SANITÁRIOS / MEDICAL WASTES INCINERATION WITH UTILIZATION OF THE BIOGAS GENERATED FROM SANITARY LANDFILLS**

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This paper takes consideration about the utilisation of the biogas generated from sanitary landfills as a support energy source on medical wastes incineration processes. The data from similar incinerators currently operating in Brazilian cities and data bibliography has used. The results of the present study shows the volume of the biogas necessary for operating system as function of the habitants number.

Keywords: *Incineração - Biogás - Resíduos - Combustão - Energia - Incineration - Medical Wastes - Combustion - Energy*

COB525 CONSIDERAÇÕES SOBRE A RELEVÂNCIA DOS 3T's NA INCINERAÇÃO DE RESÍDUOS ORGÂNICOS / CONSIDERATION CONCERNING ON THE 3T's SIGNIFICANCE IN THE ORGANIC RESIDUES INCINERATION

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We discuss the 3T's (Temperature, Residence time and Turbulence) real importance on the organic compounds incineration, trying to show that the temperature importance over 850°C, after thermal decomposition (Pyrolysis) and partial combustion of the organic compounds, the carbon monoxide combustion defines the high temperature needs. But, around 910°C, 2 seconds of residence time puts the conversion over the four nines (99,99 %) pattern fixed by the present regulation, NB-1265, for incineration performance. If we attend these conditions, the principal goal on incineration of organic compounds is attained by the best turbulence.

Keywords: *Incineração, Importância dos 3T's, ABNT NB 1265, Pirólise, Monóxido de carbono, Incineration, Pyrolysis, 3T's Combustion, ABNT NB 1265, Carbon monoxide*

COB540 SISTEMA DE COLETA E ANÁLISE DE GASES E ALCATRÕES DE GASEIFICADORES / A LABORATORY TYPE TAR GAS AND PARTICULATE SAMPLING UNIT

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A laboratory type tar and particulate sampling unit has been designed for quantitative assessment of contaminant in biomass based producer gas. Development of efficient cleaning system is an important facet of biomass gasification technology.

Keywords: *Isocinetic sampling unit, Tar, Gaseification, Gas cleaning / Amostragem isocinética; Alcatrão; Limpeza de gás; Gaseificação*

COB1113 MODELO SIMPLIFICADO PARA A VAPORIZAÇÃO DE GOTAS DE COMBUSTÍVEL EMULSIFICADO / SIMPLIFIED MODEL FOR VAPORIZATION OF EMULSIFIED FUEL DROPLETS

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A model for the vaporization of emulsified fuel droplets has been developed by assuming transient-diffusive heat transport and constant liquid composition within the droplet. For the gas-phase,

the extended film theory has been used. The model is used to simulate the vaporization of water-in-hexadecane emulsion droplets in order to study the microexplosion phenomena. It has been shown that, although some trends are well predicted, the influence of the initial mass fraction of water on the relative time for the occurrence of microexplosion is wrongly predicted by the model. The reason seems to be the inconsistency of the constant liquid composition hypothesis.

Keywords: *Emulsified fuel, microexplosion, superheated emulsion, droplet vaporization / Combustível emulsificado, microexplosão, emulsão superaquecida, vaporização de gotas*

COB1241 CONTROLE DAS EMISSÕES DE NOX EM MOTORES DIESEL MARÍTIMOS / NOX EMISSION CONTROL IN MARINE DIESEL ENGINES

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In recent years, an increasing awareness of the contribution of marine exhaust emissions to atmospheric pollution has been observed, with particular attention on the emission of nitrogen oxides, NOX. This concern is reflected in the high priority established by the International Maritime Organization (IMO), as well as several countries, in the implementation of restrictions on emissions from marine sources. This paper discusses the principal aspects related to NOX emission control of marine diesel engines. Some of the control methods developed by engine builders are reviewed with respect to their efficiency and related problems on engine operation. Future prospects of each proposed solution are evaluated in view of social demand for more restrictive emissions limits.

Keywords: *Diesel, Combustão, Emissões, Controle, Poluição / Diesel, Combustion, Emissions, Control, Pollution*

COB1243 AN ANALYTICALLY GENERATED GRID FOR DROPLET-STREAM COMBUSTION PROBLEMS

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The present work describes the development of a discretizing grid for the numerical study of droplet stream combustion problems. The small and large length scale phenomena associated with the process are addressed by splitting the physical domain into near and far-field subdomains. Within the inner sub-domain, expressions previously developed for droplet-stream vaporization studies are used allowing the development of appropriate finite-difference expressions and control of grid point distribution. Analytical expressions are developed and applied to the outer subdomain coordinate system in order to match the inner and outer grids along the subdomain interface and to properly address the out-

flow boundary conditions using a regularly spaced grid. The proposed extension of the numerical approach previously used is made necessary by the singularity present in the coordinate transformation which becomes important as high aspect ratio domains are studied. The singularity affects the results leading to nonrealistic velocity profiles at the droplet surface. Quasi-steady and transient results, which indicate interaction effects present over a broad range of interdroplet distances, are also presented.

Keywords: *Combustion, Vaporization, Phase-Change, Numerical Methods, Grid Generation*

COB1247 FRENTE DE CHAMA: MODELAGEM E PESQUISA DAS CARACTERÍSTICAS DETALHADAS / FRONT OF FLAME: RESEARCH AND MODELING OF DETAILS CHARACTERISTICAS

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The present work propose a form of the thermal model equations that not use the boundary conditions on the - "hot" limit. One too apply the exponential form of the chemical kinetics equations. The corresponding algorithm and program are invariant to reagent medium. The numerical results to fuel: $\text{CH}_4 + \text{air}$; $\text{C}_3\text{H}_8 + \text{air}$ are shown.

Keywords: *Frente de chama, modelo térmico, substâncias intermediárias, entalpia / Front of flame, thermal model, intermediate substance, enthalpia*

COB1249 PESQUISA TEÓRICA DOS ESCOAMENTOS QUIMICAMENTE DESEQUILIBRADOS EM TUBEIRAS SUPERSÔNICAS / THEORETICAL RESEARCH OF UNEQUILIBRIUM CHEMICALLY FLOW IN SUPERSONICS NOSSELS

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The present work study the model of the unequilibrium chemically current in supersonic nosel. The advantage of this model is the possibility to calculate the proprieties of the currents as much gaseous as condensed phase. One describe the algorithm and program that are invariant to reagent medium . The numerical results to many fuel are shown.

Keywords: *Tubeiras, escoamento, cinética química, modelagem. / Nossels, current, chemical kinetic, modeling*

COB1410 UNSTRUCTURED ADAPTIVE GRID FLOW SIMULATIONS OF INERT AND REACTIVE GAS MIXTURES

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An adaptive, unstructured grid, flow simulation capability is applied to the calculation of high speed, compressible flows of inert and reactive gas mixtures. In the present case, the flowfield is simulated using the 2-D Euler equations which are discretized in a cell centered based finite volume procedure on unstructured triangular meshes. Interface fluxes are calculated by a Liou flux vector splitting scheme which has been adapted to an unstructured grid context by the authors. Physico-chemical properties are functions of the local mixtures composition, temperature and pressure, which are computed using the CHEMKIN-II subroutines. Computational results are presented for the case of premixed hydrogen-air flow over a 2-D wedge. In such a configuration, combustion may be triggered behind the oblique shock wave and transition to an oblique detonation wave is eventually obtained. It is shown that the solution adaptive procedure implemented is able to accurately define the important wave fronts.

Keywords: *Gas Mixtures, Reactive Flow, Unstructured Grid Methods, Finite Volume*

TEMA 29 - Máquinas Térmicas, Ciclos Termodinámicos e Propulsão

COB334 BANCO DE TRABAJO 2D PARA EL DESARROLLO DE SUB-MODELOS DE MOTORES DE ENCENDIDO POR CHISPA

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A 2D finite volume model has been developed as a workbench for sub-models development for combustion, turbulence and wall interaction in spark ignition engines combustion modeling. In particular different formulation of the eddy break-up model for turbulent premixed combustion have been casted in the 2D framework in conjunction with standard k-epsilon and k-epsilon-RNG turbulence models formulation. The simplified 2D formulation results particularly suited for model assessment. Numerical results have been then compared with experimental results varying the basic operational parameter (i.e. air/fuel ratio and RPM). In cylinder pressure data have been recorded for a 1242 Fiat MPI engine in different operating conditions. Pressure data and calculated heat release rate have been compared with numerical predictions. Even in the 2D simplified approach results seem to be in good accordance with the experiments and the fundamental behaviour of the combustion model is correctly described.

Keywords: *motor de combustión interna - modelo multidimensional de simulación de motor - modelo turbulento - motor de encendido por chispa - análisis de combustión*

COB337 SISTEMA PARA MEJORAR LAS CARACTERISTICAS DE ARRANQUE DE LOS MOTORES DIESEL EN LA ALTURA

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Se presentan los fundamentos teóricos de un sistema para mejorar el arranque de los motores diesel en la altura, que incluye una válvula especial, denominada RND, utilizada para introducir líquidos inflamables a la línea de alta presión del sistema de inyección, y así reducir el período de retraso del encendido durante el arranque. Complementariamente, se propone el método de desconexión parcial de cilindros para evitar que el motor se apague después de arrancar. También, se presentan los resultados experimentales del tiempo de arranque, utilizando líquidos inflamables, en un banco de pruebas con simulación de altura estrangulando la admisión.

Keywords: *Arranque en frío, altura, período de retraso del encendido, velocidad crítica, válvula RND, desconexión de cilindros, líquidos inflamables*

COB518 IDENTIFICAÇÃO DE DETONAÇÃO EM MOTORES DE COMBUSTÃO INTERNA - PROCEDIMENTO EXPERIMENTAL

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This work presents the results of tests aimed at developing a methodology for the correct identification and analysis of knocking in internal combustion engines during laboratory testing. The instrumentation layout, and test methods used are presented, as well as the results obtained for gasoline engines of different capacities. The objectives of the tests included the identification of block vibration frequencies caused by knocking, the determination of the optimum position on the engine block for the knock sensor, and the analysis of the influence of engine speed and ignition advance on the intensity of knocking.

Keywords: *Motores, Detonação, Sensores, Vibração, Pressão*

COB727 SOBRE A ESCOLHA DE SISTEMA DE CONTROLE DO VETOR EMPUXO DE MOTORES OGUETE A PROPELENTE LÍQUIDO / ON THE CHOOSE OF THE THRUST VECTOR CONTROL SYSTEM OF LIQUID PROPELLANT ROCKET ENGINES

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This paper describes an analysis on the suitability of different types of thrust vector control (TVC) system to be applied to liquid rocket engines of open cycle scheme. It provides description of different types of existing Russian engines and the TVC methods that is utilized in these systems. In particular, detailed analysis is conducted on the propulsion system using liquid oxygen/kerosene propellants on three different open cycle configurations, aiming the second stage of VLS-2 launcher. These configurations are: a) one turbopump feeding four fixed combustion chambers, with the attitude control forces provided by four vernier nozzles expelling gases from the turbine; b) one turbopump feeding four fixed combustion chambers, with the control forces provided by four gimbaling combustion chambers fed by independent turbopump; and c) four autonomous gimbaling engines, each one having its own turbopump and combustion chamber.

Keywords: *propulsão líquida, motor foguete, controle de atitude, controle do vetor empuxo, veículo lançador / liquid propulsion, rocket engine, attitude control, thrust vector control, launch vehicle*

COB728 EXPERIMENTOS BÁSICOS SOBRE MOTOR FOGUETE A PROPELENTE LÍQUIDO / BASIC EXPERIMENTS ON LIQUID PROPELLANT ROCKET ENGINE

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The use of the technology of liquid propellant rocket-engine in the next phase of the Brazilian Space Program is a need. This technology includes complex and multidisciplinary nature problems, still new for our country. Considering the broad variety of required specialization, more researchers from industries, universities and research centers should be devoting their efforts to related fields for the success of the Program. Fundamental studies on injectors and atomization, ignition, combustion of spray, combustion under high pressure environment, are some of the fields that need to be conducted more extensively. In this work, an assembly of simple conception, composed by a test module and a small engine, was constructed and tested, in order to demonstrate a practical way to perform basic studies. The preliminary results show that the assembly is operational and allows to conduct several kind of experiments.

Keywords: *Propulsão líquida / liquid propulsion, motor foguete / rocket-engine, propelente líquido / liquid propellant, combustão de spray / combustion of spray*

COB729 PROPULSÃO LÍQUIDA NO BRASIL / LIQUID PROPULSION IN BRAZIL

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The knowledge already accumulated on technology of solid propellant rocket-engine allows Brazil to develop propulsion systems for small launch vehicles. To obtain commercially feasible class vehicles however, the inclusion of stages with liquid propellant rocket-engine becomes a necessary condition. It is a complex technology that involves long-term big volume investment. Therefore, initial planning should be carefully prepared in order to direct the development activities in an effective way. In this work, it is intended to give contribution in this direction, analyzing some fundamental aspects for assimilating the new technology. Initially, main advantages and disadvantages that each of propulsion systems, liquid and solid, adds in a vehicle are discussed. Finally, configuration options for the next Brazilian Launch Vehicle are discussed for directing the activities for capability development.

Keywords: *Propulsão líquida / liquid propulsion, motor foguete / rocket-engine, propelente líquido / liquid propellant, propelente sólido / solid propellant*

COB903 CONFIGURAÇÃO DE SISTEMAS DE COGERAÇÃO CONSIDERANDO A SENSIBILIDADE DO INDICADOR DE VIABILIDADE / CONFIGURATION OF COGENERATION SYSTEMS CONSIDERING THE VIABILITY INDICATOR SENSIBILITY

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Cogeneration has been appointed as an important alternative to supply the increasing demand of electricity in Brazil. Even though this technology presents high thermodynamic efficiency, not always is economically merited, depending basically on the load factor and fuels and electrical energy prices. So it is worthwhile to develop good analysis tools for feasibility studies. In this paper one

presents a improved methodology to evaluate the pay-back time of industrial cogeneration plants, determining the energy balance through convolution of thermal and electrical load curves and allowing to estimate the economic indicator in two scenarios. The difference of pay-back time in these scenarios can be used as risk indicator of a particular cogeneration configuration, assisting the decisor to select the proper capacity and best level of supplementary heat to be adopted.

Keywords: *Cogeração, Modelagem Térmica, Otimização de sistemas Térmicos. / Cogeneration, Thermal Modelling, Thermal Systems Optimisation*

COB1100 A METHOD FOR CALCULATION OF FORCES ACTING ON THE GAS TURBINE BLADES WITH FILM AND EFFUSION COOLING

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Main technical solutions for air cooling gas turbines blades are shortly described in the paper. The analytical procedure, based on the certain assumptions, for calculation of whirl and axial forces acting on blades with film and effusion cooling is given in detail. The analogous procedures for calculation of torque and power are also presented. The procedures are based on the impulse law and on the specific properties of the cooling process and blade surface. The consequences of film and/or effusion cooling on velocity diagram are presented and discussed in detail. For a blade with effusion cooling and for a blade with film cooling are given exemplified calculation of tangential and axial forces. The consequences of film and effusion cooling on the degree of reaction are also analyzed and the results are presented. We can generally conclude that, under introduced assumptions, there is small, but important increase of moment and forces due to film and effusion cooling, compared to no cooled blades.

Keywords: *Gas turbines, Cooling of gas turbine blades, Force on gas turbine blade*

COB1146 COMBUSTION CHAMBERS FOR STARK IGNITION ENGINES FUELED WITH NATURAL GAS

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This paper describes a new four-valve cylinder head for the Hydra research engine. This cylinder head was built for a research project on the new chambers for heavy duty spark ignition engines operating on natural gas, conducted at the Department of Mechanical Engineering, University of British Columbia, Canada. The new four-valve cylinder head will allow the determination of the optimum level of turbulence inside the combustion chamber, which originates from intake-generated swirl and tumble gas motion and their effects on the combustion process in engines fueled with natural gas.

The results of research on the optimization of a "fast, lean-burn" combustion system for spark-ignited natural gas engines that meet emission regulations without the use of exhaust gas clean-up

equipment are also presented. A family of "squish-jet" pistons was developed and tested over a wide range of air-fuel ratios using full-load operating conditions; these results are presented and discussed.

Keywords: *four-valve cylinder head, squish-jet chambers, spark ignition engines*

COB1274 DESIGN OF A RETROFIT FOR HEAVY DUTY DIESEL ENGINES TO LIMIT PARTICULATE MATTER EMISSIONS

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A preliminary design of a Diesel particles filter system for heavy duty vehicles is presented. The system consists of two ceramic catalyzed filters connected in parallel, so that is possible to regenerate one of them while the other is in operation. The regeneration (cleaning) process is carried out through the injection of a hot air flow in inverse direction to the filtering process. The air is heated by a thermal energy storage device (Thermal Inertia Device, TID). The system has a control and monitoring electronic circuit based on a micro-controller.

Keywords: *Regeneration, Monitoring, Diesel Particulate Filtering, TID*

COB1300 POWER GENERATION SYSTEMS USING FLUIDIZED BED COMBUSTION AND GASIFICATION

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The two types of pressurized fluidized bed combustors (PFBC), the bubbling PFBC and the circulating PCFBC plants, are now undergoing further development with the aim to increase efficiency, reduce emissions, improve availability, and thus to facilitate the commercialization of this technology. This paper reviews the progress and highlights the problems in the development of hybrid cycle power plants based on pressurized fluidized bed combustion and gasification. Hybrid cycle power plants show significant improvement in energy conversion efficiency, and essential reduction in SO₂ and NO_x emissions. They have higher efficiency than integrated gasification combined-cycle power plants. The second generation PFBC coal plants target 50 % efficiency.

Keywords: *Pressurized fluidized bed combustor, hybrid cycle power plant, HGCU, emissions control*

COB1301 NO_x-EMISSIONS CONTROL TECHNIQUES FOR COAL-FUELED POWER PLANTS AND GAS TURBINE-BASED COMBINED CYCLES

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Advanced techniques for NO_x -emissions control used in coal-fueled power plants and gas turbine-based combined cycles are discussed. The in-furnace NO_x control reduces the NO_x formation or emissions during combustion by using staged combustion, reburning, flue gas recirculation, low NO_x burners (LNBs), and other methods. The NO_x emissions reduction in the range of 40 to 60% is achieved with LNBs, 20 to 25% with the burners-out-of-service method, 15 to 25% by using overfire air, up to 15% due to low excess air, and 5% by biased firing. In addition, the paper discusses multi-pollutant emissions control methods. The recently developed processes for simultaneous SO_2/NO_x removal feature high removal efficiency for the two pollutant species. Thus, in the S NO_x -process 96% SO_2 and 94% NO_x removal is achieved when burning coal with 3.4% sulfur.

Keywords: *In-furnace NO_x reduction, staged combustion, reburning, multi-pollutant emissions control, low NO_x burners*

COB1430 ANÁLISE TÉRMICA E ECONÔMICA DE TURBINA A GÁS DE CICLO ÚMIDO / THERMAL AND ECONOMIC ANALYSIS OF THE HUMID AIR TURBINE CYCLE

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This work presents thermodynamics simulation and economic analysis of the Humid Air Turbine cycle (HAT) operation. In this cycle hot water from intercooler and recuperator is mixed with air from the compressors in the evaporator, it is then sent to the gas turbine combustion chamber and expanded along with the combustion gases. A computer program was developed to simulate the thermodynamics behaviour on design point given by the specific fuel consumption, thermal efficiency and specific net work as function of turbine entry temperature and overall pressure ratio. After thermodynamics simulation, an economic analysis was carried out for power plant of 30MW with fuel cost of 3,5 US\$/GJ, which presented energy generation cost as a function of the load factor of power plant for different interest rate and design philosophy. The return rate of investment has been calculated taking into account to sell energy at 60 US\$/MWh. The economic parameters have indicated that economic viability of the investment, in scenery where electric energy cost is sold, is over 60 US\$/MWh. In addition, the results of the HAT have been compared to those of Simple Cycle, Combined Cycle, Steam Injected Gas Turbine and Intercooled Steam Injected Gas Turbine.

Keywords: *Thermal Power System, the Humid Air Turbine cycle, Economic Analysis of Thermal System / Ciclos de potência, Ciclos HAT, Análise Econômica de Sistemas de Potência*

COB1431 ANALYSIS AND DIAGNOSIS OF THE OPERATION PERFORMANCES OF A STEAM POWER PLANT

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A new exergetic and exergoeconomic method for the diagnosis of energy systems operation is presented and discussed. The calculation of suitable indicators, showing the deviations of the fuel consumption from the expected one, helps the analyst or the operator identify the machines or the devices responsible for the malfunction and those "victims" of the malfunction itself. The method, applied to a big-size steam power plant, proved to be useful in locating the origin of malfunctions and their effects on the overall performances; anyhow, it is shown that some experience is needed by the operator, because the results must be interpreted in the light of both the knowledge of the plant operation and the theoretic bases of the diagnostic procedure suggested by the authors.

Keywords: *On line diagnosis, exergy analysis, exergoeconomic analysis, computer code*

COB1432 PERFORMANCE AND GAS-DYNAMICS OF PROPULSION SYSTEMS WITH A SEPARATE SOURCE OF ENERGY

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A new improved approach is developed to analyze alternative propulsion systems with an additional power source, such as augmented catalytic, nuclear and electrical propulsion systems. The performance characteristics are calculated in terms of time of flight, power density, characteristic velocities and specific impulses. The effects of propellant density, tankage weight and the stagnation enthalpy of propellants are considered. A simplified model of the thruster gas-dynamics is employed to determine the mass flow rates and the power input to the propellant.

Keywords: *Electrical Propulsion, Nuclear Propulsion, Performance, Gas-Dynamics, Mass Efficiency*

TEMA 31 - Sistemas Hidráulicos e Pneumáticos**COB178 MODELAGEM LINEAR E NÃO LINEAR DE UM SERVOMECANISMO ELETRO-HIDRÁULICO COM VÁLVULA PROPORCIONAL /
LINEAR AND NON-LINEAR MODELLING OF AN ELECTRO-HYDRAULIC POSITION SYSTEM WITH PROPORTIONAL VALVE****Arno Bollmann***Dep. de Engenharia Mecânica, Laboratório de Sistemas Hidráulicos e Pneumáticos - UFSC
Caixa Postal 476 - 88040-900 - Florianópolis SC - e-mail: bollmann@portadig.com.br***Pedro Luís Andrighetto***Departamento de Tecnologia - Campus Panambi - UNIJUÍ
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In this work is presented a comparison between the linear and non-linear modelling results to an electro-hydraulic position system controlled by a proportional hydraulic valve. This system was built and the experimental results are compared with both models simulation to obtain their experimental confirmation and to identify advantages and disadvantages of these modelling strategies.

Keywords: *Hydraulic systems modelling; Proportional valves; Fluid Power Control; Control Valves; Hydraulic position servo system*

TEMA 32 - escoamentos Compressíveis e Incompressíveis**COB236 SUPERSONIC FLOW OVER A SPIKE-NOSED BODY OF REVOLUTION****Algacyr Morgenstern Jr.**

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The unsteady, viscous, supersonic flow over a spike-nosed body of revolution was numerically investigated by solving the Navier-Stokes equations. The time-accurate computations were performed employing an implicit algorithm based on the second-order time accurate LU-SGS scheme with the incorporation of a subiteration procedure to maintain time accuracy. Self-sustained oscillations for a Mach number of 3.0 and Reynolds number of $7.87 \times 10^6/m$ were observed in the numerical computations, for a spike length to shoulder height ratio of 1.74, confirming the experimental result. The numerical result predicted correctly the discrete frequency range as well as the sound pressure intensities. The flow structure is also presented and discussed.

Keywords: *unsteady flow; supersonic flow; spike-nosed body; time-accurate computations; Newton-like subiterations*

COB335 PRESSURE-BASED SOLUTION FOR THE RADIAL STOKES FLOWS: VALIDATION AND PROPERTIES**Jáuber C. Oliveira and Cristina H. Amon**

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A novel pressure-based methodology is proposed and implemented to approximate the solution of the partial differential equations that model radial Stokes flows between two parallel disks. Eigenfunction expansions and Green's function representations are combined to obtain directly the pressure distribution for a variety of inflow boundary conditions. The velocity field is accurately recovered from the pressure distribution. This methodology was implemented numerically and validated with both exact solutions and numerical spectral element results. By exploring the analytical characteristics of the method, we extract additional information on the behavior of the solution in terms of the inflow functions and we prove rigorously the existence and uniqueness of solutions.

Keywords: *pressure-based, radial Stokes flow, Green's functions, eigenfunctions*

COB545 DIRECTED-ENERGY AIR SPIKE INLET AT MACH 10 WITH 15-25 kW ARC POWER**P.G.P. Toro, H.T. Nagamatsu, L.N. Myrabo**

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The use of thermal energy as a means of enhancing flight performance of blunt bodies at hypersonic speeds is investigated. The "Directed-Energy Air Spike" (DEAS) inlet concept proposes the beamed transmission of concentrated energy forward of a moving vehicle in order to change the bow shock configuration from a detached normal (strong) shock wave to an oblique, parabolic-shaped (weak) shock wave. This new approach provides low aerodynamic drag and heating, or also deflects the oncoming air into an annular hypersonic inlet. The compressed inlet air can either be accelerated to produce thrust or decelerated to extract onboard electric power. A 6-in. diameter blunt body model was fabricated and pressure transducers are installed at its surface and equipped with 6-in. long slender plasma torch at the stagnation point. This model has been installed in the RPI 24-in. diameter Hypersonic Shock Tunnel and used to test the Directed-Energy Air Spike concept. Pitot pressures have been measured at the maximum diameter annular region of the blunt body. Surface pressure and pitot rake pressure surveys as well as the Schlieren photographs will be presented for Mach number 10 with 15-25 kW power at the tip of the spike.

Keywords: *Directed-Energy Air Spike (DEAS), Hypersonic Flows, Hypersonic vehicle*

COB693 NUMERICAL SIMULATION OF TWO-DIMENSIONAL BOUNDARY LAYER SEPARATION CONTROL / SIMULAÇÃO NUMÉRICA DO CONTROLE DA SEPARAÇÃO DE UMA CAMADA LIMITE BIDIMENSIONAL

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The control of the separation on two-dimensional boundary layers at low Mach numbers is analyzed by time-accurate numerical solutions of the compressible Navier-Stokes equations. The control strategy is based on the application of a variable suction/blowing in the proximity of the separation. Open-loop unsteady suction/blowing actuators show the sensitivity of the flow to the control strategy. A simple closed-loop proportional control has been implemented, that uses a tangential shear stress sensor for the feedback control, and that controls the normal velocity at the actuator position. Parallel numerical simulations were performed with the AVBP library on a 32-processor Meiko CS-2, and on a 4-processor IBM SP2. Results show the effectiveness of the control approach in stabilizing the flow and suppressing the periodic shedding of vortices.

Keywords: *Active control, boundary layer separation, numerical simulation / Controle ativo, separação de camada limite, simulação numérica*

COB716 OBTENÇÃO DE MODELO DE PERDAS DE PRESSÃO TOTAL EM COMPRESSORES AXIAIS / MODELLING OF TOTAL PRESSURE LOSS IN AXIALS COMPRESSORS

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The paper presents simulations of cascade flows using the two-dimensional Navier-Stokes equations. An implicit, approximate factorization method which allows the simulation of flows regardless of the speed regime is adopted. Spatial discretization of the governing equations uses a central difference algorithm. Boundary conditions are implemented based on one-dimensional characteristic relations for the Euler equations. Numerical tests are performed for flows in axial compressors with DCA profiles.

Keywords: *Navier-Stokes, Compressores Axiais, Simulação Numérica, Escoamento Compressível, Diferenças Finitas Navier-Stokes, Axiais Compressors, Numerical Simulation, Compressivel Flow, Finites Differences*

COB1227 ESTUDO ANALÍTICO DOS FENÔMENOS TRANSITÓRIOS OCASIONADOS POR GRANDES BOLSAS DE AR CONFINADAS NOS SISTEMAS HIDRÁULICOS

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The flow in a hydraulic installation can be affected by various conditions such as starting or stopping the pumps or turbines and the changes in the valve setting. During such conditions, there arise situations in which pressures and velocities in pipes can be determined by mathematical models in order to verify if their extreme values are within the admissible range. One of the reasons for the transient behavior is the presence of air confined during these alterations. When the pipes are not properly designed or if it is not completely full or air bleeding, large amounts of air may be confined in the system. Pockets of air can cause severe transient behavior if such pockets deslocate from one place to the other giving rise to local acceleration and consequently large velocities and pressures. The higher pressure may be of the order of 15 times the static pressure in the system. Thus, this paper considers practical and safe procedure (rigid or elastic models) that permit calculation of transient pressures given that there is no analytical solution available. This study also conducts a sensitivity analysis on the various factors involved in the problem.

Keywords: *air pockets; hydraulic transients; waterhammer; bolsas de ar; transientes hidráulicos*

COB1405 MODELAGEM DA TECTÓNICA DE PLACAS NA CROSTA TERRESTRE / MODELLING OF PLATE TECTONICS ON EARTH'S CRUST

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A simplified modelling of the interaction between the continental lithosphere and the asthenosphere underneath it is proposed; in this model the lithosphere is considered as a rigid slab moving over and onto a viscous layer, that represents the asthenosphere. The asthenosphere, laying underneath the lithosphere, is represented as a fluid of very high viscosity; also the thinner lithospheric layer forming the ocean floor layer has been suppressed, leaving in its place a free surface. The transient Stokes flow resulting from the translation of the rigid slab is modelled and solved by a Boundary Integral equation based on Lorentz reciprocal theorem.

Keywords: *Movimento de placas tectônicas / Plate tectonics, escoamento de Stokes / Stokes flow, Método da Integral de Contorno / Boundary Integral Method*

COB1406 THE GENERATION OF NONLINEAR WAVES BY A PISTON-TYPE WAVE MAKER

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The generation of large amplitude waves by a wave-maker in a canal is simulated with a Boundary Integral numerical code. The code is based on Potential Theory and the free surface boundary conditions, dynamical and kinematical are taken as completely nonlinear. Results allow for assessments of experimental and theoretical work. Short and long waves are generated according to the analytic motions, for the wave-maker, derived in the classic work of Ursell, Dean and Yu 1959, based on linear approximations.

Keywords: *Piston-type Wave-maker, Nonlinear Boundary Conditions, Wave generation*

TEMA 33 - Escoamentos em Meios Porosos

- COB691 RESFRIAMENTO POR TRANSPIRAÇÃO: INFLUÊNCIA DA ESPESURA E COMPRIMENTO DA PAREDE POROSA E DA RADIAÇÃO TÉRMICA INCIDENTE / TRANSPARATION COOLING: THE INFLUENCE OF THE POROUS WALL THICKNESS AND LENGTH AND OF THE INCIDENT THERMAL RADIATION**

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In this work, some theoretical and experimental results related with the air transpiration cooling of a porous wall are presented and analyzed. The channel test has a length of 2 meters and a rectangular section 0,2 high by 0,5 wide. A porous plate with a porosity of 30% and dimensions 0,6mx0,3mx0,003 is installed in the bottom wall of the channel. The Reynolds number at the edge of the porous plate is always greater than 2×10^5 . The analysis show that neither the length nor the thickness of the porous wall modify greatly the cooling efficiency when the air blowing rate is equal or greater than 0,01. On the other hand, the experimental results show that thermal radiation may reduce in more than 50% the transpiration cooling efficiency. Furthermore, the fresh air injection has a little effect on the cooling of the impermeable plate upstream the blowing region.

Keywords: *Transpiration - Porous wall - Cooling - Injection / Transpiração - Parede porosa - Resfriamento - Injeção*

- COB758 ESTUDO DA MOVIMENTAÇÃO DO LEITO DE INERTES EM SECADOR ROTATÓRIO / STUDIES OF INERTS BED DYNAMICS IN ROTARY DRYER**

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Studies of the bed behaviour of a rotary dryer packed with inerts, utilized to drying pastelike materials, was performed as a function of rotation and geometrical parameters of the internal parts of the equipment, like the width, thickness, number and inclination of longitudinal flights, by film recording, made for a better visualization of the bed dynamics, composed by polyethylene and ceramic spheres.

Keywords: *Rotary Dryer; Bed of Inerts Behaviour; Drying in Inert Bed; Pastelike Materials / Secador Rotatório; Comportamento de Leito de Inertes; Secagem em Leito de Inertes; Materiais Pastosos*

COB1093 RECONSTRUCTION OF 3-D PORE STRUCTURE BY THE TRUNCATED GAUSSIAN METHOD USING FOURIER TRANSFORM

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The purpose of reconstructed porous medium is to simulate invasion processes of fluids and determine important petrophysical and reservoir engineering properties such as permeability, capillary pressure and relative permeability curves. In this paper, we improve the truncated Gaussian method for reconstruction of porous media using Fourier transform. The method is based on the idea that an arbitrary complex pore structure can be described by the values of a phase function at each point in the porous media. If the pore structure is statistically homogeneous, it can be described by the porosity and correlation function, which are measured from 2-D binarized image of thin section of the sample. If correlation function of Gauss field is positive-definite, corresponding Gauss field can be found. Since Fourier transform of correlation function is power spectrum of the field and the phase angle does not affect the correlation structures, then the Gauss field can be generated by using Fourier transform. An algorithm, which is a nice split-radix, n-dimensional and fast-Fourier transform is used. At last, the 3-D porous media are generated using the truncated Gaussian method. The result for Fontainebleau sandstone shows that the porosity and correlation functions reproduce well.

Keywords: *Porous media; reconstruction; 3-D pore structure; image analysis; Fourier transform*

COB1094 EXTRACTION OF 3-D PORE NETWORK AND PREDICTION OF PERMEABILITY FOR RESERVOIR ROCKS

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The main purpose of the present work is to determine the 3-D pore structure network by using image analysis techniques and predict the permeability of the porous rock. The skeleton of a 3-D pore structure provides a way of visualizing the graph of the pore network. It is extracted using a thinning algorithm, which preserves connectivity, i.e., the network and original pore structure have the same topology. It gives both visual and quantitative information about the connectivity of the pore space, the coordination number for every node and local hydraulic radius. Once the network of pore structure is obtained, the macroscopic transport properties of the rock such as permeability can be calculated. In this paper, the reconstructed porous media for Berea sandstone is used to extract 3-D pore network. The predicted permeability for 500mD Berea sandstone rock is in good agreement with the experimental value and empirical correlations.

Keywords: *Porous media; skeleton; 3-D pore structure; permeability*

COB1447 NONSATURATED SPHERICAL SURFACE**M.I. Martins Costa***Laboratório de Mecânica Teórica e Aplicada - LMTA,**Departamento de Engenharia Mecânica, Universidade Federal Fluminense, Rua Passo da Pátria, 156, 24210-240 Niterói/RJ, Brazil***R.M. Saldanha da Gama***Laboratório Nacional de Computação Científica, Rua Lauro Müller, 455 22290-160, Rio de Janeiro, Brazil*

This work studies a nonsaturated flow of a newtonian fluid through a rigid porous spheric matrix, using a mixture theory approach in its modelling. The mixture consists of three overlapping continuous constituents: a solid (porous medium), a liquid and an inert gas, included to account for the compressibility of the mixture as a whole. A set of two nonlinear partial differential equations describes the problem which is approximated by means of a Glimm's scheme, combined with an operator splitting technique.

Keywords: *Nonsaturated Flow, Mixture Theory, Glimm's Method*

TEMA 34 - Escoamentos Multifásicos**COB39 FREE SURFACE FLOW IN A HELICAL RECTANGULAR DUCT****Eugênio Spanó Rosa, Antonio Carlos Bannwart & Fernando de Almeida França***Departamento de Energia, Faculdade de Engenharia Mecânica - UNICAMP**Cx.P. 6122 - CEP 13.083-970 - Campinas, SP - Brasil, E-mail: erosa, bannwart, ffranca@fem.unicamp.br*

Free surface flow in rectangular helical ducts is investigated experimentally. A liquid, driven by gravity, describes a descendent trajectory forming a curved free gas-liquid surface due to the centrifugal and gravity forces created by the duct curvature and torsion. The experiments were conducted in two different helical ducts, with liquids' viscosity varying from 1 cP to 150 cP and for duct Reynolds numbers ranging from 40 to 90000 performing a total of 18 experimental runs. The liquid height distributions across the duct were measured using a double wire probe. The results were transformed to an orthogonal system and then integrated across the flow orthogonal cross section to determine the averaged main flow velocity and liquid holdup. The friction factor is determined based on the experimental quantities and a correlation is proposed in the form of correction factors to the existing friction formulae for curved rectangular channels to express the effect of the free surface.

Keywords: *Helical ducts, free surface flow, experimental techniques, friction factor, rectangular channel / Dutos helicoidais, escoamento com superfície livre, técnicas experimentais, fator de atrito, canal retangular*

**COB48 UMA ANÁLISE DA TEORIA QUASE-ESTACIONÁRIA SOBRE A VA-
PORIZAÇÃO DE GOTAS, PARA TEMPERATURAS INTERMEDI-
RIAS IAN ANALYSIS OF THE STEADY-STATE THEORY ABOUT VAPO-
RIZATION OF DROPLETS FOR INTERMEDIARIES TEMPERATURE****Narciso Angel Ramos Arroyo***Departamento de Engenharia Mecânica, UFSC/CTC, 88.010-970 Florianópolis - SC - Brasil; e-mail: arroyo@sinmec.ufsc.br*

This paper show a revision about the steady-state theory developed of Spalding, Godsave, Goldsmith and Penner. It show that the Lewis number can be obtain for the logarithmic relation of the transfer mass Spalding number and the transfer of heat Spalding number. This work show that intermediaries temperature between 310 K and 700 K, the Lewis number is not equal to the unit. It show experimental results for n-heptane drops in these temperatures range.

Keywords: *Combustion, Vaporization, Sprays / Combustão, Vaporização, Sprays*

**COB52 DIRECT IMAGING OF TWO-PHASE FLOWS BY MEANS OF ELEC-
TRICAL CONDUCTIVITY MEASUREMENTS****Paulo Seleglim Jr. & Antonio Moreira dos Santos***Departamento de Engenharia Mecânica, Escola de Engenharia de São Carlos - USP - Av. Dr. Carlos Botelho, 1465, CEP13560-970**São Carlos - SP - Brasil - E-mail : seleglim@sc.usp.br and asantos@sc.usp.br*

In this paper a two-phase flow direct imaging probe is presented. To do so, the electrode configuration is adapted in the sense that an imaged representation of the phase distribution within the probe's sensing volume can be obtained by simply plotting the signals corresponding to peripheral conductivity measurements without numerically reconstructing it from the experimental data. Several transient tests were performed in a two-phase loop aiming to demonstrate the probe's capability in exhibiting not only large structures such as slugs and plugs, but also some finer details as for instance, the wavy or rugged interface in stratified flow and the drainage of the liquid film in the transition between intermittent and annular flow. The methodology proposed in this work is thus fully adapted to on line process monitoring, which is of crucial importance in order to assure ideal exploitation conditions and safety. It constitutes a simple and inexpensive alternative to tomographic imaging techniques.

Keywords: *two-phase flow, imaging, visualisation, conductivity*

COB67 SEARCH FOR FAVORABLE CONDITIONS OF ATMOSPHERIC FLUIDIZED-BED GASIFICATION OF SUGAR-CANE BAGASSE THROUGH COMPREHENSIVE SIMULATION

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A study to search for the most favorable condition of atmospheric fluidized-bed gasification of sugar-cane bagasse has been possible using a comprehensive computer simulator of fluidized bed equipment. A previous version of the simulation program has been improved to provide more precise results. In addition, the prediction of possible particle segregation in the bed has been implemented. "Cold" efficiency has been chosen as objective function. The following conditions have been set as constants: operational pressure, basic geometry of the reactor, bed height, particle size distribution of bagasse, particle size distribution of alumina (used as inert in the bed), and bagasse dry-basis composition. The parameters left as variables were: bagasse moisture and the oxygen ratio (fraction from the necessary oxidant for total or stoichiometric combustion). Future steps toward a more complete optimization are shown. The results are going to be used on studies of power generation systems employing gas turbine concepts.

Keywords: *Fluidized-bed, gasification, simulation, optimization, sugar-cane bagasse*

COB68 SEARCH FOR FAVORABLE CONDITIONS OF PRESSURIZED FLUIDIZED-BED GASIFICATION OF SUGAR-CANE BAGASSE THROUGH COMPREHENSIVE SIMULATION

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An updated comprehensive simulator for fluidized-bed equipment has been employed to perform studies aiming the optimization of sugar-cane bagasse gasification. The present work for pressurized systems follows one where the atmospheric option was focused. Improvements on the calculations of physical-chemical properties provided more precise computations for operations at high pressures. Gasification "Cold" efficiency has been chosen as the objective function. For this first round of studies, the operational pressure was fixed at 2 MPa. The basic geometry of the reactor, the particle size distribution of the alumina (used as inert in the bed), and the bagasse dry-basis composition are assumed as constants. Bagasse moisture and the injected air mass flow (or oxygen ratio) are left as variables. Detailed data of the reactor internal as well as overall operational conditions are discussed. The results are going to be used on studies of power generation systems employing gas turbine concepts.

Keywords: *Fluidized-bed, gasification, simulation, optimization, biomass*

COB71 ANALYSIS OF SCALE REDUCTION EFFECTS IN ANNULAR SOLID-LIQUID FLOWS

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This paper presents and discusses results of solids transport experiments run in two different flow loops (5 in OD x 4 in ID and 8 in OD x 7.5 in ID external pipes), built in PETROBRAS Research Center and University of Tulsa, respectively. The tests represent the annular stratified flow of solid - non Newtonian fluid mixtures for different operational parameters, such as: fluid and solid properties, annular eccentricity and inclination and fluid flow rate. Based on the experimental data, several recommendations are drawn about the usefulness of running reduced scale solid-liquid flow experiments and its applicability to real oilwell drilling operations.

Keywords: *Petroleum Engineering, Drilling, Dimensional Analysis, Similarity Theory, Pilot Plants.*

COB239 UMA ABORDAGEM MULTIESCALA NA SIMULAÇÃO NUMÉRICA DE RESERVATÓRIOS DE PETRÓLEO / A MULTI-SCALE APPROACH IN PETROLEUM NUMERICAL RESERVOIR SIMULATION

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Advances in petroleum reservoir descriptions have provided an amount of data that can not be use directly during the simulations. This detailed geological information must be incorporated into a coarser model during the multiphase fluid flow simulations by means of some upscaling technique. The most used approach are the pseudo relative permeabilities and the more widely used is the Kyte

and Berry method. In this paper it is proposed a multi-scale computational model for multiphase flow that implicitly treats the upscaling without using the pseudo functions. By solving a sequence of local problems on the more refined scale it is possible to achieve good agreement between a coarser grid and a more fine grid, without expensive computations on a fine grid model of the whole reservoir. The main characteristic of this new upscaling procedure is to overcome some practical difficulties related the use of traditional pseudo functions. Results of bidimensional two phase flow simulations considering homogeneous and heterogeneous porous media are presented. Three examples compare the results between this approach and the commercial upscaling program PSEUDO, a module of the reservoir simulation software ECLIPSE of Geoquest.

Keywords: *Upscaling, Multiphase flow, Numerical simulations, Multi-scale computational model*

COB309 DESENVOLVIMENTO DE UM TERMOSSIFÃO BIFÁSICO PARA UTILIZAÇÃO EM FORNOS DE COCÇÃO / DEVELOPMENT OF A CLOSED TWO-PHASE THERMOSYPHON FOR USE IN BAKERY OVENS

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Electricity-powered ovens are largely employed by bakeries in Brazil, which constitutes a misuse of this form of energy. This is even more so considering that hydroelectric energy resources in the country might be coming close to their limit. The present paper describes the design, manufacture, and testing of thermosyphons to be used in bakery ovens using natural gas as the heat source. The design geometrical parameters, working fluid fill ratio, operation limits, and the two-phase flow pattern are discussed.

Keywords: *fornos de cocção, projeto e ensaio de termossifões / bakery ovens, thermosyphon design and testing*

COB343 ESTIMATING THE THICKNESS OF THE LIQUID FILM GENERATED BY Y-JET ATOMIZERS

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Internal mixing twin fluid air blast (Y-jet) atomizers, in which liquid is injected into a mixing chamber with compressed air or steam, are extensively used in industry. It is well known that one of the main design parameters for pre filming blast atomizers is the thickness of the liquid film generated at the discharge orifice. This paper derives an expression for estimating that film thickness assuming that, apart from a small amount of droplets formed by the impact of the liquid on the air stream inside the pre-mixing chamber, the great majority of droplets is generated by the liquid film formed on the pre-mixing chamber wall through the deflection of the liquid jet by the high speed gas stream

flowing through the center core of the pre-mixing chamber. That is, this Atomizer, usually classified as an "internal mixing, blast atomizer" behaves instead as a "pre filming blast atomizer". The results compared well with experiments.

Keywords: *Atomizers, Y-Jet Atomizers, Liquid Films, Droplets and Sprays*

COB505 INFLUÊNCIA DA RAZÃO DE VAZÕES NA TRANSFERÊNCIA DE CALOR DE UM ESCOAMENTO LAMINAR ANULAR DE DOIS LÍQUIDOS IMISCÍVEIS EM TUBOS CURVOS / INFLUENCE OF THE FLOW RATE ON THE HEAT TRANSFER IN THE FLOW OF TWO INMISCIBLE LIQUIDS IN CURVED TUBES

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The present paper reports the influence of the flow rate on the flow and heat transfer in the fully developed region in a steady laminar annular flow of two immiscible liquids inside horizontal and slightly curved tube with constant circular cross section. The liquids interface was considered without thickness, smooth, circular and concentric to the axis of the duct. The liquids properties were taken constant and calculated based on the mean temperature. The finite volume method was used to solve the mass, momentum and energy conservation equations. The influence of the flow rate on the flow, temperature profile and heat loss have been determined.

Keywords: *Curved pipe, annular flow, heat transfer, tubo curvo, escoamento anular, transferência de calor*

COB703 INVESTIGATION OF FLUID DYNAMICS IN PNEUMATIC TRANSPORT WITH SPOUTED BED AND SCREW SOLID FEEDING SYSTEMS

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The use of a spouted bed for feeding solids in a pneumatic transport tube allows for a wide range of operational conditions. However, as the solid flow rates become dependent on the air flow rates, the flow diagrams available in literature for flow regime identification cannot be applied for such a equipment. In present work, fluid dynamic characterization of pneumatic transport with a spouted bed type solid feeding system has been extended by comparing its fluid dynamic behavior with the one provided by using a classical feeder, which allowed for independent variation of gas and solid flow rates. Experimental data of pressure gradients versus air velocities have been obtained using the same transport pipe (4.0 m long and 104.8 mm in diameter) and using both a spouted bed and a screw conveyor as solid feeding devices. Experimental values of the air velocities at the transition from dilute to dense-phase regimes have been obtained for both systems. The data obtained using the screw feed-

er have been compared with data from literature. Also investigated was the validity of using the correlations for predicting the transition air velocities developed for classical feeders for the data obtained using the spouted bed feeder. The results allow the conclusion that the transition point can be predicted using the same criterion for both systems.

Keywords: *Pneumatic transport, solid feeding systems, flow regime identification*

COB886 MASS FLOW IN A TWO-PHASE FLOW WITH BOILING THERMAL SIPHON LOOP / VAZÃO MÁSSICA EM ESCOAMENTO BIFÁSICO COM EBULIÇÃO EM UM CIRCUITO DE TERMOSSIFÃO

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This work presents a model to determine the total mass flow rate in a two phase flow with boiling closed circuit. This system is used to collect solar energy by the formation of vapor bubbles in a solar collector and to release this energy in condensation by heating a second fluid. The model assumes that the total frictional drop equals the pressure gain due to the difference in gravity in the single phase and the two phase vertical parts of the loop. Using the definition of the void fraction, a second expression could be written and the two equations were solved simultaneously for the void fraction and the total mass rate. The results indicated that the two phase flow was bubbly, what was expected considering the relatively low intensity of the solar flux and the experimental values for the temperature difference between the heated wall and the fluid saturation temperature.

Keywords: *Thermal siphon, two-phase flow, mass rate, void fraction / Termossifão, escoamento bifásico, fração de void*

COB1119 ANÁLISE DA ACELERAÇÃO EM SISTEMAS DE TRANSPORTE PNEUMÁTICO VERTICAL EM FASE DILUÍDA / ANALYSIS OF THE ACCELERATION IN VERTICAL PNEUMATIC TRANSPORT SYSTEM IN DILUTE PHASE

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This work presents a model to analysis the gas-solid vertical flow in dilute phase based on one-dimensional, isothermal and steady-state on balances equation. With this model the length of the acceleration region is calculated and the pressure loss can be analyzed. The results from the present model are confronted with experimental data available in the literature, and a good agreement is observed.

Keywords: *Pneumatic Transport/ Transporte Pneumático Dilute Phase/Fase Diluída / Gas-Solid Flow/Escoamento Gás-Sólido Acceleration Region/Região de Aceleração*

COB1120 UM MÉTODO PARA A ANÁLISE DE TRANSPORTE PNEUMÁTICO VERTICAL EM FASE DILUÍDA / A METHOD FOR VERTICAL PNEUMATIC TRANSPORT ANALYSIS IN DILUTE PHASE

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This work presents a model for the gas-solid vertical flow analysis in dilute phase based on one-dimensional, isothermal and steady-state on balance equation. The model is an extension of some significant works. The results from the present model are confronted with experimental data available in the literature, and a good agreement is observed. The model is consistent and it is concluded that energy losses due the solid friction it is not important face the other loss energy sources.

Keywords: *Pneumatic Transport/Transporte Pneumático Dilute Phase/Fase Diluída / Gas-Solid Flow/Escoamento Gás-Sólido*

COB1445 TURBULENCE AND PHASE DISTRIBUTION FOR SOLID / LIQUID TWO-PHASE FLOW WITH NEUTRAL BUOYANT PARTICLES

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Detailed local phase distribution measurements were made for solid/liquid two-phase flows in a horizontal pipe using a state-of-the-art laser Doppler anemometer (LDA) system. The disperse phase consisted of 2 mm neutral buoyant spherical particles. Since these particles had the same density as water particle/liquid slip was eliminated, thus simulating microgravity conditions. The conduit was a 30.6 mm diameter pipe, which was made of a special optically clear material (Fluorinated Ethylene Propylene) with the same index of refraction as water. A set of velocity profiles, turbulence structure and volume fraction distributions were measured for each phase. These experimental results were found to agree quite well with a multidimensional two-fluid model.

Keywords: *Two-Phase Flow, Solid-Liquid Flow, Laser Doppler and Turbulence*

COB1446 AN EXPERIMENTAL ANALYSIS OF PRESSURE DROP AND ENTRAINMENT IN ANNULAR FLOW

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The droplet entrainment and the interfacial shear are the most important phenomena that can exist in annular flow. Many of the available data were obtained for atmospheric condition neglecting high pressure effects where surface tension plays an important role. A unique vapor/liquid Freon experiments were designed and utilized to scale and simulate annular two-phase flow for high pressure data. The results were compared with two correlations available where Ishii and Mishima's dimensionless group was able to scale the data remarkably well. The pressure data obtained agreed well with Wallis and Asali's correlation for interfacial shear.

Keywords: *Two-Phase Flow, Annular Flow and Vapor/Liquid Freon-113*

TEMA 210 - Comportamento Térmico de Edificações**COB743 INTEGRATION OF BUILDING AIR FLOW MODELS OF DIFFERENT RESOLUTION****Cezar Otaviano Ribeiro Negrão***Departamento de Engenharia Mecânica - UFSC, Caixa Postal 476, CEP 88.040-900 Florianópolis, Brasil**E-mail: negrao@nrva.ufsc.br*

Building air flow models, such as those derived from Computational Fluid Dynamics and fluid flow network are investigated and their deficiencies are identified. In the first, the air flow is defined in high resolution, allowing the evaluation of temperature and velocity gradients within enclosures. However, the boundary conditions cannot be well established. Although the later allows computation of air infiltration and ventilation for the entire building, air velocity, pressure and temperature are assumed uniform within spaces. A new modelling approach, which combines the two methodologies and reduces their shortcomings, is proposed. The potential of such technique is demonstrated by a case study.

Keywords: *Building Air Flow Simulation, Computational Fluid Dynamics/Simulação de Fluxos de Ar em Edificações, Dinâmica dos Fluidos Computacional*

COB1435 ANÁLISE DINÂMICA DO COMPORTAMENTO INTEGRADO DE EDIFICAÇÕES E SISTEMAS DE CLIMATIZAÇÃO / INTEGRATED DYNAMIC ANALYSIS OF BUILDING AND AIR CONDITIONING UNITS**Jorge E. Corrêa (*), Cezar O. R. Negrão (**), Cláudio Melo (**)***(*) Universidade Federal do Pará / Centro Tecnológico / Depto. de Engenharia Mecânica**(**) Universidade Federal de Santa Catarina / Depto. de Engenharia Mecânica / NRVA**CEP 88040-900 - Florianópolis - SC - E-mail: melo@nrva.ufsc.br*

This work is concerned with the dynamic modeling of self-contained air conditioning units. Units with air-cooled and water-cooled condensers are modeled. The ESP-r (Environmental System Performance - research) code, when coupled with these models, becomes capable of modeling the energy and fluid flow within combined building and plant systems, under typical operational brazilian conditions.

Keywords: *Simulação, Ar condicionado, Edificações, Energia / Simulation, Air-Conditioning, Buildings, Energy*

TEMA 211 - Transferência de Massa

COB287 AVALIAÇÃO EXPERIMENTAL DA DISPERSÃO DE CONTAMINANTES EM AMBIENTES COM ALTA INSTABILIDADE / EXPERIMENTAL EVALUATION OF CONTAMINANT DISPERSION IN HIGHLY UNSTABLE AMBIENTS

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A highly unstable convective water tank with turbulence structure generated mainly by buoyancy forces is contaminated by an inert dye solution of rhodamine 6G and the dispersion features analysed in two dimensions and in time by image processing techniques using the fluorescence property of that dye when exposed to a high intensity argon ion laser beam. Tests were performed for two different height sources and under different bottom surface heat fluxes showing a strong dependence of maximum concentration behaviour on those parameters. The images produced and the results of thermal analysis are useful for comparison with numerical solutions of the momentum, mass and energy conservation equations applied to a similar ambient.

Keywords: *Turbulence, Concentration Mapping, Image Processing*

COB1115 MODELO DIFUSIVO COM CINÉTICA COMPLETA PARA POLIMERIZAÇÃO EM MASSA VIA RADICAIS LIVRES / DIFFUSIVE MODEL WITH COMPLETE KINETICS FOR FREE-RADICAL MASS POLYMERIZATION

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The present work deals with a free-radical, mass polymerization that can be applied to the reactive phase of a reactive injection molding process in which the kinetics of reaction is much slower than the model filling up time. The simulation of styrene homopolymerization in a cylindrical reactor, using a model that consists of the energy and species conservation equations, allowed the analysis of the importance of thermal initialization and mass diffusion. Two schemes of numerical solution were applied and compared. It has been shown that the changes in diffusion coefficients due to composition and temperature changes are small, making it possible to treat those coefficients as constants.

Keywords: *Mass polymerization, mass diffusion, thermal initialization, reactive injection / Polimerização em massa, difusão mássica, iniciação térmica, injeção reativa*

COB1116 PREVISÃO DA RETENÇÃO GASOSA EM COLUNAS DE BORBULHAMENTO NÃO ISOTÉRMICAS UTILIZANDO UM MODELO TERMOFLUIDODINÂMICO PARA A FASE DISPERSA / GAS HOLD-UP ESTIMATION FOR NON-ISOTHERMAL BUBBLE COLUMNS USING A THERMOFLUID-DYNAMIC MODEL FOR THE DISPERSED PHASE

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Two methods are analysed to extend the applicability of isothermal gas hold-up correlations to non-isothermal conditions using a thermofluid-dynamic model for the bubble formation. The first method is based only on correction of the gas properties and gas superficial velocity to the conditions at the end of bubble formation. The second method introduces a correction factor based on the ratios of bubble mean volumes and frequencies of formation for isothermal and non-isothermal conditions. The gas hold-up estimates using the two correction methods were compared to literature experimental data. From the results, it can be concluded that the second method is able to predict qualitatively the experimental gas hold-up. Model improvements are necessary for a quantitative agreement.

Keywords: *bubble columns, gas hold-up, bubble formation, heat and mass transfer, coluna de borbulhamento, retenção gasosa, formação de bolhas, transferência de calor e massa*

COB1117 TRANSFERÊNCIA SIMULTÂNEA DE CALOR E MASSA NA FORMAÇÃO E ASCENSÃO DE BOLHAS SUPERAQUECIDAS / SIMULTANEOUS HEAT AND MASS TRANSFER DURING THE FORMATION AND ASCENSION OF SUPERHEATED BUBBLES

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A thermofluid dynamic model was developed to study the heat and mass transfer during the stages of formation and ascension of superheated bubbles in a liquid column. The gas phase physical properties and the bubble radius vary along the process, which makes this a free boundary problem. The model consists of the total mass, energy and chemical species conservation equations applied to a spherical bubble with radial symmetry, with gas injection at the bubble center during bubble formation, whose end is predicted using the final formation volume given by the classical Davidson and Schüler correlation. The internal radial convective flux and the interdiffusion term in the energy conservation equation were considered in the analysis. The model is solved numerically by the method of lines using finite volume discretization. The results obtained are analyzed and compared to a previously developed model restricted to the bubble ascension stage.

Keywords: *Contorno livre, bolha superaquecida, evaporação, contato direto / Free boundary, superheated bubbles, evaporation, direct contact*

**COB1306 DETERMINAÇÃO DA DIFUSIVIDADE DE MASSA APARENTE DA
ÁGUA NA SILICA-GEL / DETERMINATION OF APPARENT MASS DIF-
FUSIVITY OF WATER IN SILICA-GEL**

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This work presents a study of sorption rates of the water vapor by silica gel particles which were measured for a pressure range of 100 - 1000 Pa. A single-step thermal method is used to measure mass diffusion. Sorptions/desorptions rates in silica gel samples after a pressure step are monitored through of the measured of the surface temperature by infrared detection. A theoretical simple model is presented, with the overall kinetics controlled by an apparent diffusivity identified by a curve-fitting method. This method consists of the comparison between from experimental findings and the theoretical results for surface temperature. Obtained Results are in good agreement with other publications. This proposed model can be coupled to, in a simple form, complex model for analysis of adsorptive processes.

Keywords: *Kinetic measurements, silica gel, diffusion, adsorption, apparent diffusivity / Silica-gel - adsorção - difusividade aparente - cinética de adsorção*

TEMA 212 - Trocadores de Calor / Heat Pipe**COB321 PROJETO RÁPIDO DE TROCADORES DE CALOR DO TIPO CASCO E TUBOS / SHORT-CUT DESIGN PROCEDURE FOR TUBE-AND-SHELL HEAT EXCHANGERS****Roger J. Zemp e Cristiane Junqueira**

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A new short-cut procedure for the design of tube and shell heat exchangers is presented. Departing from the energy balances, fluid properties and tube diameters/layout, the algorithm computes the main exchanger variables (pressure drops / area), and therefore can be used for the economic optimisation of the exchanger. The advantage of the procedure is that no detailed design is required, so that it can be used in projects where quick designs are required, like synthesis and design of pressure-drop constrained heat exchanger networks. A procedure to obtain a complete exchanger design, fully meeting the heat transfer requirements, based on the optimised conditions, is also proposed. Available pressure drops are fully utilised, leading to cost effective exchanger designs. The procedure makes use of the Bell-Delaware design method.

Keywords: *Projeto rápido de trocadores de calor, perda de carga em trocadores de calor / short-cut heat exchanger design, pressure drop in heat exchangers*

COB325 TROCADORES DE CALOR ALIMENTADOS POR HIDROGÊNIO / OXIGÊNIO ELETROLÍTICO - UMA ANÁLISE COMPARATIVA / HEAT EXCHANGERS POWERED BY HYDROGEN/OXYGEN ELETROLYTIC - A COMPARATIVE ANALYSIS**Maurício Alves da Motta Sobrinho**

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The environmental care and the search for alternative energy sources are some of the main problem for the governments. Solar and wind energy and hydrogen can be solution. This work shows results of a research run by the Hydrogen Group of UFPB for the development of heat exchangers. The performance of two heat exchangers were compared, a tubular and a convective heat exchanger, through the analysis of the internal and external environmental variation, the gas and the electricity consumption. As a result, the convective exchanger showed a better suitability, suggesting that its efficiency can increase after some alterations to be made, mainly at the gas outlet.

Keywords: *Trocador de Calor, Aquecimento de Ambientes, Hidrogênio Eletrolítico, Energia Alternativa / Heat-Exchanger, Environmental Heating, Electrolytic Hydrogen, Alternative Energy*

COB528 AN INVESTIGATION ON THE HEAT TRANSFER IN AN INDUSTRIAL FLUIDIZED BED HEAT EXCHANGER**Paulo Roberto Tardin Jr. and Leonardo Goldstein Jr.***Department of Thermal and Fluids Engineering, College of Mechanical Engineering - UNICAMP
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An industrial size fluidized bed heat exchanger was tested and the results were applied to check the available correlations for the bed-to-tube heat transfer coefficient. The heat exchanger was designed to recover the heat content of the ashes produced in a 1 MW circulating fluidized bed boiler pilot plant burning oil shale, with an horizontal tube immersed in the bed. The solids inlet temperature was about 375°C and the superficial velocity 0.10 m/s. About 75% of the total heat transfer rate from the ash was transferred to the water and the balance to the air stream. The Molerus correlation (1995) has shown the best agreement with the data, with less than 20% deviation.

Keywords: Heat exchanger, Fluidized bed, Heat recovery, Bed-to-tube heat transfer coefficient

COB897 ANÁLISE EXPERIMENTAL DE UM TERMOSSIFÃO BIFÁSICO / EXPERIMENTAL ANALYSIS OF A CLOSED TWO-PHASE THERMOSYPHON**Nelson Múrcia, Maurício A. Zanardi & Newton Galvão de C. Leite***Departamento de Energia, Faculdade de Engenharia - UNESP - Guaratinguetá
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The main objective of this work was to study the performance of a two-phase thermosiphon under normal operation conditions. Four aspects were investigated: the temperature distribution along the axial distance, heat transferred from the evaporator to the condenser, effects of the thermosiphon's inclination and the amount of working fluid. Water was chosen as working fluid due to the suitable temperature range and availability. The results obtained show that the inclination of the tube is an important parameter for low inclination angles, with respect to the horizontal. It was also found that the best fluid charge is about 30% of the tube volume.

Keywords: Thermosiphons, two-phase thermosiphon, charge in thermosiphons, inclination effects in thermosiphons

COB1130 ESTUDO NUMÉRICO DE UM TROCADOR DE CALOR COMPACTO COM ALETAS RECORTADAS E UMA FILEIRA DE TUBOS / NUMERICAL STUDY OF A COMPACT HEAT EXCHANGER WITH OFFSETS AND ONE TUBE ROW**Jurandir Itizo Yamagihara, Paulo Eduardo Batista de Mello***Departamento de Engenharia Mecânica, Escola Politécnica - Universidade de São Paulo
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Heat transfer and flow loss characteristics of a fin-tube compact heat exchanger were obtained numerically. The heat exchanger model has one tube row and utilises the heat transfer enhancement technique known as "offsets", that promotes successive boundary layer break-ups. The heat conduction effect in the fin was taken into account (conjugate heat transfer) and so the cyclic characteristic of the flow in the perpendicular direction, generated by the interruptions that the "offsets" promote over the fin. The influence of the thermal conductivity parameter over the heat transfer was verified. This paper presents correlations for the Colburn factor and friction factor, both function of Reynolds number, for the laminar regime. With the objective of evaluating the heat transfer enhancement obtained with the "offsets", one model with the same dimensions but with plain fins was simulated numerically. With the results, important aspects were discussed, such as enhancement obtained with "offsets", flow loss increase, influence of the thermal conductivity of the fin and indications for a better design.

Keywords: *compact heat exchanger, offset, tube-fin / trocadores de calor compactos, tubo-aleta*

COB1132 CONJUGATE HEAT TRANSFER AND FLOW LOSSES IN COMPACT HEAT EXCHANGER WITH SMOOTH FINS AND TWO ROWS OF TUBES

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The present work refers to a numerical analysis of the local and global heat transfer and fluid flow characteristics of a fin-tube heat exchanger with smooth fins. These investigations aim to provide basic information for the development of heat transfer enhancement techniques applied to evaporator/condenser of domestic air-conditioning systems. Momentum and energy conservation equations were solved by the finite volume method with a boundary fitted coordinate system. The computational model consists of a compact heat exchanger with two rows of round tubes in a staggered arrangement using smooth fins. The numerical simulations were carried out for a steady-state thermally and hydrodynamically developing laminar flow. The influence of channel parameters such as transverse and longitudinal tube spacing on the heat transfer and flow losses were analyzed. The results allow to identify situations in which the fin effectiveness decreases, providing useful information for the application of heat transfer enhancement techniques to this kind of geometry.

Keywords: *compact heat exchangers; fin-tube channels; smooth fins; conjugate heat transfer; finite volume method*

COB1402 OTIMIZAÇÃO DO PROJETO TERMO-HIDRAULICO DE TROCADORES DE CALOR DE PLACAS / OPTIMIZATION OF THERMAL-HYDRAULIC DESIGN OF PLATE HEAT EXCHANGERS

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This work presents a methodology for the thermal-hydraulic design optimization of Plate Heat Exchangers. It is also presented the results of the application to a typical case.

Keywords: *Plate Heat Exchangers, Thermal-hydraulic Design, Optimization. / Trocadores de Calor de Placas, Projeto Termo-hidráulico, Otimização*

COB1484 ESTUDOS PRELIMINARES DE UM TROCADOR DE CALOR TUBULAR ALIMENTADO POR HIDROGÊNIO ELETROLÍTICO/ PRELIMINARY STUDIES OF A HEAT EXCHANGE POWERED BY ELETROLITIC HYDROGEN

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An environmental heating system fueled by electrolytic hydrogen has been developed by the Hydrogen Group at the Chemical Engineering Department of the Paraíba Federal University. This system purposes to replace the heating obtained by pollutant carbonic fuels and can be integrated with fotovoltaic collectors or aero-generators to improve the utilized energy.

The first tests realized with this heat exchange, developed and projected by this group, are presented besides with the system flow chart. The temperature input and the output of the heater dissipation unit using water and Dowtherm® G synthetic organic oil and the room temperature has been analyzed, as a function of the time. Results shown a higher performance when using the organic oil.

Keywords: *Trocador de Calor, Hidrogênio, Eletrólise, Aquecimento de Ambientes / Heat Exchanger, Hydrogen, Electrolyse, Environmental Heating*

TEMA 213 - Máquinas de Fluxo

COB232 ANÁLISE E SIMULAÇÃO DE UMA TURBINA REGENERATIVA TIPO TOROIDAL / ANALYSIS AND SIMULATION OF A REGENERATIVE TOROIDAL TURBINE

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An analysis and a simulation of a regenerative toroidal turbomachine are made in order to evaluate its potentiality as hydraulic turbine. The working principle of this kind of turbomachine is presented and discussed. Formulae developed on the basis of the circulatory theory are presented allowing the calculation of the circulatory velocity and the global pressure coefficient as a function of the main geometric parameters. Based on these formulae, simulation results were obtained for the variation of the flow rate vs. rotating speed with a fixed specific energy and taking the diameter aspect ratio as a parameter. The operating characteristic is similar to that of a Francis turbine of high specific speed. In order to check the simulation model, some experimental results were obtained by means of rig tests performed on an hydraulic regenerative turbine. One verifies that the simulation model is capable of qualitatively reproducing the flow rate vs. rotating speed curve. One concludes in favor of the applicability of the regenerative turbomachine as hydraulic turbine and suggests that new researches have to be made for further evaluations and improvements.

Keywords: *Hydraulic Turbine; Regenerative; Toroidal. / Turbina Hidráulica; Regenerativa; Toroidal*

COB274 SIMULAÇÃO DO ESCOAMENTO ENTRE PÁS DE UMA TURBOMÁQUINA COMO METODOLOGIA DE PROJETO / FLOW SIMULATION INSIDE A BLADE PASSAGE OF A TURBOMACHINE AS A DESIGN METHODOLOGY

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Many theoretical and experimental approaches have been made in order to achieve a standard and reliable turbomachinery design. The present paper describes an underdevelopment methodology that links an initial design software with commercial computational package (CFD) available. The geometry of a turbomachine is generated by the initial software and, after the visualisation, the data are exported to the CFD which solves the flow field inside the blade-to-blade passage. A simulation with a submergible pump impeller is made and the results in terms of velocity, pressure and streamlines distribution are presented.

Keywords: *Turbomáquinas, escoamento, turbulência, simulação numérica, desenvolvimento de projeto. Turbomachine, flow, turbulence, numerical simulation, design improvement*

COB751 USO DE APLICATIVOS COMPUTACIONAIS NA MANUFATURA DE COMPONENTES DE BOMBAS CENTRÍFUGAS / COMPUTER APPLICATIONS IN CENTRIFUGAL PUMPS MANUFACTURING**Sergio Kenji Moriguchi & Douglas Lauria**

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This paper deals with the use of hardware and software computational features and peripherals in an integrated form to design centrifugal pumps. Results of the impeller and spiral casing basic dimensions are determined as design parameters and corresponding drawings files are generated. Computer Aided Engineering technique is used in the equipment data files. The design information expressed in neutral and parametric form enables the direct use of application softwares. This way, it is possible to check and print out drawings and execute components machining. At the work cycle end the use of the computer allows to dimension and manufacture the pump components reducing manufacturing time and costs.

Keywords: *Rotores de bombas centrífugas, Caixa espiral, Bombas centrífugas, CAD, CAM / Centrifugal pumps, Spiral casing, Impeller, CAD, CAM*

COB888 AN UNSTEADY NUMERICAL SIMULATION OF NA OSCILLATING AIRFOIL WITH STRUCTURAL COUPLING**Said Mounisif**

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Unsteady flow-fields of two-dimensional oscillating airfoil with structural coupling are calculated using an implicit finite-volume numerical procedure. The method employs the semi-strong conservation form of the Navier-Stokes equations with pressure and physical contravariant velocity components as dependent variables. The equations describing the airfoil motion are integrated in time using a fourth-order Runge-Kutta algorithm. Numerical experiments are performed about an unsteady viscous flow-field past a stay-vane airfoil, which is free to vibrate in response to the aerodynamic forces.

Keywords: *Fluid-Structure Interaction, Finite-Volume Method, Moving Curvilinear Coordinates*

COB1217 DEVELOPMENT AND TESTING OF A SMALL DARRIEUS-TYPE TURBINE IN TIDAL CURRENTS NEAR THE MOUTH OF THE AMAZON**Danielle R. S. Guerra & André L. Amarante Mesquita**

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Parts of the northern region of Brazil face serious problems with the supply of electric energy. Thousands of residents near the mouth of the Amazon live dispersed on forest-covered flood plains cut by wide rivers and streams. Thus, for them it is necessary that the electric energy be generated on a small-scale, in a decentralized manner, and at low cost. In this context, this paper presents a experimental study on the performance of a Darrieus-type water turbine. The experiments were carried out in situ and the results are consistent with the experimental data available in the literature.

Keywords: *Darrieus runner, tide-energy, electric power*

COB1404 ANÁLISE DO ESCOAMENTO IDEAL EM GRADES REGENERATIVAS TOROIDAIS COM EFEITOS NÃO-INERCIAIS / ANALYSIS OF THE IDEAL FLOW IN REGENERATIVE TOROIDAL CASCADES INCLUDING NON-INERTIAL EFFECTS

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An ideal rotational flow model for regenerative toroidal cascades with thin blades including non-inertial effects is presented. A conformal mapping is applied in order to transform the toroidal cascade surface in a plane cascade. Vortex distributions are employed to simulate the blade perturbation in the transformed plane. The vortex intensity is calculated by numerically solving an integral equation representative of the relative flow tangency on the blades. The resultant blade circulation is related to the absolute vorticity on the physical toroidal surface. This vorticity creates the circumferencial pressure gradient of a regenerative turbomachine and this fact motivates the present research. Illustrative results for the vorticity and the slip factor are presented as a function of the main geometric parameters of the toroidal cascade.

Keywords: *regenerative cascades; toroidal surfaces; non-inertial effects; vorticity. / grades regenerativas; superfícies toroidais; efeitos não-inerciais; vorticidade*

COB1444 ANÁLISE DE CAMADA LIMITE TURBULENTA TRIDIMENSIONAL EM PÁS DE TURBINAS HIDRÁULICAS / TRIDIMENSIONAL TURBULENT BOUNDARY LAYER ANALYSIS ON HYDRAULIC TURBINE ROTOR BLADES

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A numerical analysis has been developed for calculating viscous flows over arbitrary surfaces by solving the tridimensional turbulent boundary-layer equations. The governing equations are written in a general nonorthogonal coordinate system. The inviscid properties are obtained from the sur-

face Euler equations. A simple algebraic model for Reynolds turbulent stresses is used to close the set of equations. The resulting equations are discretized and approximated by a two-point finite-difference numerical scheme. The procedure developed in this paper is validated for some standard test cases and applied for turbine rotor blades.

Keywords: *camada limite/boundary layer; análise numérica/numerical method; escoamento turbulento 3-D/3-D turbulent flow; diferenças-finitas/finite difference, turbomáquinas/turbomachinery*

COB1485 ANÁLISE DOS ESFORÇOS HIDRODINÂMICOS EM COMPORTAS HIDRÁULICAS / NUMERICAL ANALYSIS OF HYDRODYNAMIC FORCES ACTING ON VERTICAL LIFT GATES

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A numerical analysis has been developed for calculating viscous flows controlled by a vertical lift gate and hydrodynamic forces acting on it. The numerical solution is obtained from the incompressible Navier-Stokes equations. The numerical technique is based on a finite element method. A Poisson equation is derived from the pressure-weighted substitution of the full momentum equations into the continuity equation. Turbulence effects are simulated by a k- ϵ turbulence model. The procedure developed here is applied for a vertical lift gate operating in a CESP installation, and the results are compared with available experimental data at various opening positions. Good agreement is obtained for the velocity and pressure distributions.

Keywords: *Análise numérica/numerical analysis; método dos elementos finitos/finite element method / escoamento turbulento/turbulent flow; comportas/lift gates; esforços hidrodinâmicos/hydrodynamic forces*

TEMA 35 - Turbulência e Camada Limite

COB74 ORTLER VORTICES/TOLLMIE-SCHLICHTING WAVES INTERACTION: REASSESSMENT OF PREVIOUS RESULTS WITH A SPATIAL/NONPARALLEL MODEL

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The interaction between Görtler vortices and Tollmien-Schlichting waves is studied with a spatial, non-parallel model based on the Parabolized Stability Equations. A reassessment of previous results obtained with temporal, parallel models is performed showing that the main conclusions obtained with those models are valid but the parallel flow assumption does influence the results. New results not previously available in the literature for Tollmien-Schlichting wave amplitudes of the same order of magnitude as the vortices are also presented.

Keywords: *Görtler vortices, instability, boundary layer, Tollmien-Schlichting waves, vortices de Görtler, instabilidade, camada limite, ondas de Tollmien-Schlichting*

COB246 A NEW LAW OF THE WALL FORMULATION

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The present work introduces a new expression for the velocity profile in the near wall region of a turbulent boundary layer. The new theory uses asymptotic arguments and considerations of the mixing length type to find a local analytical solution which presents the correct asymptotic behavior both close to wall in the laminar sub-layer and in the logarithmic region of the flow. Next, heuristic arguments are evoked to add a damping function to the local solution. This function provides an excellent correction to the original analytical solution, furnishing a solution valid for the whole range of inner scales. The resulting expression is compared with ten other different formulations for the problem. The results are also compared with some experimental test cases.

Keywords: *Law of the Wall, Turbulence, Boundary Layer, Lei da Parede, Turbulência, Camada Limite*

COB248 CHARACTERISTICS OF A TURBULENT-BOUNDARY LAYER WHEN SUBJECTED TO A STEP CHANGE IN SURFACE ROUGHNESS AND TEMPERATURE

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The present work uses asymptotic and Heuristic arguments to develop a theory for the description of turbulent boundary layer flows over surfaces with a step change in roughness and in tempera-

ture. Based on the concept of the displacement in origin, the theory proposes a new expression for the near wall logarithmic temperature profile, which is then used as a boundary condition for a k - ϵ modeling of the external flow. The results are tested for a sea breeze that advances over dry land. Simulations of velocity and temperature profiles, and of skin-friction and of Stanton number profiles are presented.

Keywords: *Turbulent, Boundary Layer, Surface Roughness, Atmospheric Flows, k- ϵ model / Turbulência, Camada Limite, Rugosidade Superficial, Escoamento Atmosférico, modelo k- ϵ .*

COB249 AN ALGEBRAIC TURBULENCE MODEL FOR THE DESCRIPTION OF BUBBLE PLUMES

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The present work advances a new algebraic turbulence model for the description of bubble plumes. The model is based on the eddy viscosity and bubble diffusivity concepts, resorting to dimensional arguments and experimental data to arrive at functional relationships involving only primitive variables of the flow. The model is an improvement over other algebraic models in literature, providing better results at lower computational cost. The results include predictions of the velocity profiles, of the void fraction and of the plume radius. The four constants that appear in the theory are determined through comparison with the data of Milgram and Van Houten(1982) and of Milgram(1983), for depths ranging from 6 to 20 meters. The agreement is shown to be very good.

Keywords: *Multiphase Flows, Turbulence Modeling, Bubble Plumes, Algebraic Turbulence Models, Finite Difference Methods / Escoamento Multifásico, Modelagem Turbulenta, Pluma de Bolhas, Método de Diferenças Finitas*

COB250 FURTHER RESULTS ON THE ASYMPTOTIC BEHAVIOUR OF INTERACTING TURBULENT BOUNDARY LAYERS AND SHOCK WAVES

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The present work makes a critical compilation of some experimental data to corroborate the physical validity of the theoretical asymptotic structure resulting from an application of Kaplan limits to the shock-wave/turbulent, boundary layer interaction problem. The interaction of a shock wave with a turbulent boundary layer is a very complex and rich phenomenon, where the steep pressure gradient imposed to the boundary layer by the shock wave gives rise to an inviscid interaction process in a region which would be otherwise viscous dominated. Thus, in a classical three deck asymptotic model of the compressible turbulent boundary layer (Silva Freire(1989a)), the turbulent region must

change so as to comply to this constraint. In fact, according to the single limit concept of Kaplun, in the interaction region the turbulent region completely disappears. The new arising asymptotic structure consists then of two distinct regions: the wall viscous region and the outer inviscid region. Here, these two regions are clearly identified by a careful processing of some experimental data. Considering some flow measurements, one is capable of evaluating the dominant terms in the Navier-Stokes, from which the asymptotic structure can then be ascertained. With the new asymptotic structure, a simplified theory can then be developed for the inner regions of the flow. The results obtained through the simplified theory are compared with calculations provided by a full Navier-Stokes code and with some experimental data for velocity, pressure and skin-friction. The full N-S code uses a finite difference explicit scheme. In the numerical simulation, the turbulent shear stresses are evaluated through an algebraic model and a half-equation differential model.

Keywords: *Interaction, turbulence, Boundary Layer, Shock Wave, Kaplun Limits. / Interação, Turbulência, Camada Limite, Onda de Choque, Limites de Kaplun*

COB328 LAMINAR-TURBULENT TRANSITION: THE NONLINEAR EVOLUTION OF THREE-DIMENSIONAL WAVETRAINS IN A LAMINAR BOUNDARY LAYER

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This paper presents results of an experimental study of the transition in boundary layers. The experiments were conducted in a low-turbulence wind tunnel. The process was triggered by a three-dimensional Tollmien-Schlichting wavetrain excited by a harmonic point source in the plate. Hot-wire anemometry was used to measure the signal and investigate the nonlinear regime of these waves. It was observed that the three-dimensional wavetrain behaved very differently from two-dimensional ones. In particular, it did not involve the growth of subharmonics or higher harmonics. The first nonlinear signal to appear was a mean flow distortion. This had a span-wise structure consisting of regions of positive and negative mean distortion distributed like streaks, which became more complex as the nonlinearity developed. Elsewhere studies have revealed the existence of streak-structures in turbulent flow. It is conjectured that the current experiments may provide a link between early wave-like instabilities and some coherent structures of turbulent boundary layers.

Keywords: *Laminar-turbulent transition, hydrodynamic instability, boundary layer, hot-wire anemometry, nonlinear systems.*

COB544 SUPERSONIC AND HYPERSONIC LAMINAR BOUNDARY LAYERS

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A new set of self-similar solutions of a compressible laminar boundary layer is used for air as perfect gas and where the viscosity is a power function of the temperature. Modified Levy-Mangler and Dorodnitsyn-Howarth transformations are presented to solve the flow in a thin laminar boundary layer with no external pressure gradients on a smooth flat plate. This results in an explicit relation between the stream function and the enthalpy fields described by a closed coupled system of nonlinear ordinary differential equations. In the present work boundary layer flows with external Mach numbers up to 15 are studied and the skin friction and heat transfer coefficients for a hot wall case are presented. The present solution methodology provides a straight forward way of comparing results using the viscosity-temperature linear relation, Sutherland's law and the relation according to the kinetic theory. Also, the results may provide important data needed for the design of future hypersonic vehicles.

Keywords: *Self-Similar Equations, Compressible Laminar Boundary Layer, Supersonic and Hypersonic Flows*

COB686 SIMULATION AND TESTING OF A SATELLITE SOLAR ARRAY GENERATOR WING DEPLOYMENT

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This work studies the solar panels deployment of the Chinese-Brazilian satellite CBERS. The problem solution demands some deployment tests and the development of two different dynamic simulation models: one more complex related to the laboratory and another one related to orbit conditions. This work begins with a description of the deployment mechanisms, of the test device and of the deployment dynamic problem. The problem formulation is discussed and the use of a computer package for dynamic analysis of mechanisms is justified. The dynamic simulation models, the test results, the adjustment of the model parameters to fit the simulation to the test results, the laboratory and the in-orbit simulation results are presented. The importance of the inclusion in the dynamic models of the solar panel synchronizing mechanisms, of the aerodynamic forces of the solar panels due to the laboratory atmosphere, and of the solar panels initial deformations are discussed.

Keywords: *Satellite, solar array deployment, dynamic simulation model, dynamic of multibody systems, model adjustment*

COB695 UMA SOLUÇÃO PARA A CAMADA-LIMITE DE CONCENTRAÇÃO JUNTO A SUPERFÍCIES LIVRES EM ESCOAMENTOS TURBULENTOS

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This paper presents an analytical solution for the concentration boundary layer along free surfaces in a turbulent flow, obtained by convenient approximations for the turbulent diffusivity in this region and by a particular nondimensionalization applied to the governing equation for the mass transfer. The later produced an equation describing mass transfer at the gas-liquid interface which leads to a general solution for the geometry under study. The analysis of mass flux through the interface by an approximate solution permitted obtaining an expression that involves classical dimensionless coefficients for the problem of mass transfer such as Reynolds, Schmidt and Sherwood numbers. This expression relates the Sherwood number in a traditional form to the other two dimensionless parameters.

Keywords: *Absorção de Gases, Dessorção de Gases, Turbulência Interfacial, Transferência Interfacial de Massa, Camada-Limite de Concentração, Gas Absorption, Gas Desorption, Interfacial Turbulence, Interfacial Mass Transfer, Concentration Boundary Layer.*

COB697 ESTUDO EXPERIMENTAL DE ESCOAMENTOS TURBULENTOS EM DUTOS CURVOS COM GRANDES RAIOS DE CURVATURA

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This work presents experimental results of fully developed turbulent flows in two curved rectangular duct sections with small curvature. Mean velocity and turbulent intensity profiles are measured using Pitot tubes and a hot wire anemometer system along a 3000 mm x 460 mm x 50 mm rectangular duct and also along the central longitudinal positions of the curved duct sections of 1500 mm and 1800/p mm curvature radii, respectively.

Keywords: *Turbulence, Hot-Wire Anemometer, Wind Tunnel, Data Acquisition System, Curved Ducts*

COB762 ANÁLISE NUMÉRICA DO ESCOAMENTO EM DUTOS COM ALETAS TRANSVERSAIS / NUMERICAL ANALYSIS OF FLOW THROUGH TRANSVERSAL FIN DUCTS

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A numerical study was performed on the augmentation of the heat transfer for internal flow through flat plates containing transversal fins. The duct width and the fins spacing were kept constant and 17 fins were affixed along the heated plate side. Two fin heights were simulated and the heat transfer rate was compared with the smooth duct case. Numerical results obtained for the mean heat transfer coefficients and experimental data showed good agreement. Also reported was the grid refinement effect on the numerical solution accuracy.

Keywords: *Dinâmica de Fluidos Computacional/Computational Fluid Dynamics, escoamento Turbulento/Turbulent Flow, Aletas/Fins, Intensificação da Transferência de Calor/Enhanced Heat Transfer.*

COB774 MIXING OF CONFINED COAXIAL TURBULENT JETS IN DUCTS OF VARYING CROSS SECTION**Marcelo J.S. de Lemos Amarildo Milan***Dept. de Energia, ITA-CTA EMBRAER - GEA -EAD/APC**12228-900 - São José dos Campos, SP, Brasil - E-mail: mlemos@tecsat.com.br*

Computations for the mean and turbulent fields for the flow field formed by two coaxial streams confined in a duct of varying cross section are presented. The widely-used marching-forward method of Patankar-Spalding was used for sweeping the computational domain. The standard $k-\epsilon$ presented.

Keywords: *Duct Flow, Turbulence Modeling, CFD.*

COB1011 AN ASSESSMENT OF THE RNG $k-\epsilon$ TURBULENCE MODEL APPLIED TO THE FLOW IN RADIAL DIFFUSERS**César J. Deschamps, Álvaro T. Prata & Rogério T.S. Ferreira***Department of Mechanical Engineering, Federal University of Santa Catarina, 88040-900 - Florianópolis - SC - Brazil**E-mail: deschamps@emc.ufsc.br*

The present work considers the turbulent flow modeling in a radial diffuser with axial feeding using the RNG $k-\epsilon$ model of Orszag et al. (1993). The model has been recommended for flows including features such as stagnation and recirculation regions, curvature and adverse pressure gradients (all of them are not properly taken into account by the standard $k-\epsilon$ model). The flow through radial diffusers possesses all the aforementioned flow features and therefore is a good test case to further assess the RNG $k-\epsilon$ model. Numerical results of pressure distribution along the surface of one of the diffuser disks are compared to experimental data and show that the RNG $k-\epsilon$ model can predict quite successfully the flow.

Keywords: *Turbulence modeling, radial diffusers, valves*

COB1215 UM MODELO ALGÉBRICO DE TURBULÊNCIA PARA ESCOAMENTO EM CAMADA LIMITE SUJEITA A UM FORTE GRADIENTE DE PRESSÃO ADVERSO / AN ALGEBRAIC TURBULENCE MODEL FOR STRONG ADVERSE PRESSURE GRADIENT BOUNDARY LAYER**Daniel O. de Almeida Cruz & Nelson Kuwahara***Grupo de Turbomáquinas Departamento de Engenharia Mecânica do Centro Tecnológico, UFPA**66075-900 Belém-PA-Brasil - gtdem@amazon.com.br.*

In this work a new algebraic turbulence closure model, developed for adverse pressure gradient boundary layer, is presented. A new characteristic velocity which takes into account the effects of the pressure gradient as well as the influence of the shear stress at the wall is also presented. A comparison with experimental data clearly shows that the proposed model is superior to the Cebeci-Smith one in treating separating flows.

Keywords: *Camada Limite, turbulência, separação, modelo algébrico / boundary layer, turbulence, separation, algebraic model.*

COB1221 O PROBLEMA DA CAMADA LIMITE PARA AVALIAÇÃO DE PERDAS: UMA METODOLOGIA ALTERNATIVA / BOUNDARY-LAYER FORMULATION FOR LOSS CALCULATION: AN ALTERNATIVE APPROACH

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In this work, an alternative approach for loss calculation in external flows is proposed, by applying Kaplun limits to the Navier-Stokes equations, obtaining a generalized boundary layer formulation. It is shown that this alternative formulation can be reduced into a 'quasi similar' differential equation that can be solved as an ordinary one. Numerical solutions of this equation are presented showing that it contains the Falkner - Skan equation as a particular case.

Keywords: *Análise assintótica, camada limite, similaridade / asymptotic analysis, boundary-layer, similarity.*

COB1226 COHERENT VORTICES IN SOLID PROPELLANT ROCKET MOTORS USING LARGE-EDDY SIMULATION

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Coherent vortices in solid propellant rockets motors are investigated by numerical experimentation, via full Navier-Stokes solution in two-dimensional configurations and Large-Eddy Simulation (LES) in a three-dimensional one. Particular attention is paid to the vortex shedding phenomena of Kelvin-Helmholtz vortices and their interaction with the chamber's acoustic. The LES results show that streamwise secondary vortices of mixing layers and Dean-Görtler type vortices may be also present in these kind of geometries.

Keywords: *Coherent Vortices - Large-Eddy Simulation - Subgrid Scales Models - Solid Propellant Rocket Motors.*

TEMA 36 - Hidrodinâmica**COB331 ROLL WAVE FORMATION IN NON-NEWTONIAN FLOWS****Geraldo de Freitas Maciel, Jean Paul Vila, Gilbert Martinet & Geraldine Girard***INSA/TOULOUSE. MIP/CNRS, Complexe Scientifique de Rangueil - 31077 Toulouse cedex 4,
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The purpose of this paper is first to determine the criteria for the occurrence of discontinuous roll waves in the non-Newtonian fluids such as debris and dense snow avalanche flows. These are periodic waves separated by hydraulic jumps. Using shallow water equations applied to a Bingham fluid, a flow down an inclined infinite plane is considered. The conditions for the development of such instabilities are discussed to justify the field observations of such waves in these geophysical flows. Special attention is given to the Froude and the Reynolds numbers. The influences of the wavenumber and the fluid cohesion are also addressed. We limited to present the mathematical development of the phenomenon and a few numerical results which should be appreciated by engineers. The numerical model was elaborated using a finite volume technique and the Godunov -VanLeer (2nd order) scheme was applied.

Keywords: *shallow water equations, Bingham fluid, roll waves, numerical simulations / equações de água rasa, fluido de Bingham, "roll waves", simulações numéricas.*

COB507 LIFT FORCE OF A CYLINDER IN A REVERSING FLOW – MEASUREMENTS AND MODELING**Elyas Ferreira de Medeiros, Maurício Pazini Brandão and Richard W. Miksad***Instituto de Aeronáutica e Espaço - Centro Técnico Aeroespacial - IAE - CTA
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Reduced measurements and a semi-empirical equation are presented for the hydrodynamic lift of a circular cylinder in a harmonically oscillating flow. Characteristic loading features associated with vortex shedding and wake returns are clearly shown from the experimental data. The relationship between the flow near the cylinder and the lift is well represented by a model-equation based on added-mass and circulation concepts. This study may help efforts aimed at a better understanding and modeling of the transverse force induced by oscillatory flows on submerged bodies.

Keywords: *Hydrodynamic lift, reversing flow, vortex shedding, lift on cylinder.*

COB726 APPLICATION OF A SAILING YACHT VELOCITY PREDICTION PROGRAM TO A MONOTYPE AND AN OCEANIC SAILBOAT**Mardel Bongiovanni de Conti & Rodrigo César Franceschini de Oliveira***Departamento de Engenharia Naval e Oceânica - EPUSP
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This paper analyses the steady-state performance of an oceanic yacht cruiser and of a monotype sailboat. The first one is here considered with three sails, namely the main, the jib and the spinnaker, and the last one just with a main sail. True wind incidence angle is varied from 0 to 180 degrees. Three wind velocity amplitudes are considered: 9, 15 and 20 knots. The boat velocity and the leeway and heel angles are determined by solution of three non-linear equations. Two of these equations express magnitude equality and phase opposition between aerodynamic and hydrodynamic forces, and the third expresses equilibrium of heel moments. Suggestions for the first guess of the boat velocity, leeway and heel are made, in order to initialize the solution of the non-linear system. Some discussion about the shadow zone, the heel angles on close-hauled, the spinnaker rising effect and the true wind magnitude effect is presented.

Keywords: *Naval Architecture, Yacht Design, Sail Propulsion, Sail Boat Performance.*

TEMA 37 - Aerodinâmico**COB77 DYNAMIC STALL MODELING TECHNIQUES IN WIND TURBINES****Jorge Antonio Villar Alé***Pontifícia Universidade Católica do Rio Grande do Sul - PUCRS**Departamento de Engenharia Mecânica - Eólus - Grupo de Energia Eólica**Av Ipiranga 6681, Porto Alegre, RS, CEP 90.619-900 - E-mail: villar@music.pucrs.br*

Techniques for modeling dynamic stall in Vertical Axis Wind Turbines (VAWT) are analyzed using semi-empirical models. Some existing models, the Boeing-Vertol, MIT and Indicial are reviewed. It is proposed the utilization of a modified ONERA model with improved performance. The model is based on a set of differential equations. The resulting aerodynamic forces are presented with the proposed model, after including modifications that extend the model to operation at low tip speed ratio where the amplitude oscillation of the attack angle is high. The results are compared with experiment showing good agreement.

Keywords: *Dynamic stall, wind turbines, unsteady aerodynamics.*

**COB238 OTIMIZAÇÃO DE INJETORES DE AR EM TÚNEIS DE VENTO/
INJECTOR OPTIMIZATION FOR WIND TUNNEL****Sidney Lage Nogueira***Instituto de Aeronáutica e Espaço- CTIA/IE, CEP 12228-904 São José dos Campos, S.P., Brasil - E-mail, lts@iconet.com.br*

This paper presents the theory of injectors as applied to Wind Tunnels, and the optimization process used to improve the performance characteristics of the Brazilian Transonic Wind Tunnel Project-TTS. The mathematical model includes the utilization of diffuser, blow off, and pressure losses of the configuration, as well as the principles of using the injectors on a different design point. A Pilot Tunnel using injectors device has been installed in the Brazilian Aerospace Technical Center, and the results obtained are also included.

Keywords: *Wind Tunnel, Injectors, Design, Pressure Loss, Testing.*

COB258 ESTUDO NUMÉRICO E EXPERIMENTAL DO ESCOAMENTO AO REDOR DE UM PERFIL AERODINÂMICO NACA 0012 / NUMERICAL AND EXPERIMENTAL STUDY OF THE FLOW AROUND A NACA 0012 AIRFOIL**Cláudio Lindquist, Edson D.R. Vieira, Ricardo Alan V. Ramos & Sérgio S. Mansur***Departamento de Engenharia Mecânica, Faculdade de Engenharia - UNESP - Ilha Solteira**CEP 15.385-000 Ilha Solteira - SP, Brasil. E-mail: mansur@feis.unesp.br*

Velocity measurements in the wake of a NACA 0012 airfoil have been made with hot wire anemometer in a vertical low turbulence water tunnel, which has a test section of 146 ¥ 146 ¥ 500 mm. The drag coefficient of the airfoil have been determined, employing the momentum equation on a control volume that encloses the airfoil. The same problem has been numerically studied using the finite control

volumes method. In this study, a structured non-uniform grid has been used, with a more refined mesh near the airfoil, where pressure and velocity gradients are more pronounced. Navier-Stokes equations solution has been obtained with the SIMPLE method, considering the flow as laminar, two-dimensional and steady. The experimental and numerical results have been compared, showing a good agreement between them. Flow visualization has also been performed, using the liquid dye injection technique.

Keywords: *NACA 0012 airfoil; drag coefficient; water tunnel; flow visualization; numerical simulation; aerofólio NACA 0012; coeficiente de arrasto; túnel hidrodinâmico; visualização de escoamento; simulação numérica.*

COB290 VEHICLE AERODYNAMICAL SIMULATIONS BASED ON RUNGE-KUTTA TIME-STEPPING SCHEMES

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Simulation is an important tool in the development of today's automobile. This technology allows to reduce the time and the cost to complete the design, development and manufacture of vehicles. However, there are no general methods for all situations. This work employs a method to solve compressible and almost incompressible fluid flows using a finite volume explicit Runge-Kutta multistage scheme, with central spatial discretization. The discretization used follows the cell-centered arrangement of the control volume for the flow variables. Numerical tests are carried out for vehicle configurations and airfoils for Mach-numbers ranging from 0.002 to 0.63.

Keywords: *Vehicle, aerodynamics, numerical simulation, finite volume, Runge-Kutta / Veículo, aerodinâmica, simulação numérica, volumes finitos, Runge-Kutta.*

COB746 ANALYSIS OF A JET FLOW LEAVING A TUBE INTERACTING WITH THE WAKE OF A NORMAL FLAT PLATE

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The configuration analyzed in the present paper is constituted by a tube connected with a flat plate normal to the tube axis. Such model is placed inside a wind tunnel and the undisturbed flow is aligned to the tube axis. The main objective of this work is to study the interaction occurring between the flow leaving the tube and the external flow over the flat plate, which is dominated by the wake flow. Pressure distributions on the flat plate surface and along the tube axis were measured, as well as the velocity of the tube internal flow. Using screens with different meshes, the internal flow velocity was varied and a relation between base pressure and tube flow velocity was obtained. Finally, application of this kind of configuration to wind turbine improvement is discussed at the end of this paper.

Keywords: *Internal pipe flow; Aerodynamics; Experimental procedure; Wind energy; Bluff body / Escoamento em tubo; Aerodinâmica; Procedimento experimental; Energia Eólica; Corpos rombudos.*

COB747 AVALIAÇÃO DA INTERFERÊNCIA DAS PAREDES DE UM TÚNEL DE VENTO SOBRE RESULTADOS EXPERIMENTAIS / EVALUATION OF WIND TUNNEL WALL INTERFERENCE ON EXPERIMENTAL RESULTS

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A method for correction of the blockage effect of the wind tunnel walls on the experimental results, based on the panel technique, is presented. The method is valid only for subsonic flows (Mach £ 0,3). Some comparisons with the worldwide adopted method proposed in Rae & Pope (1984) are made and some contributions of the present work are discussed.

Keywords: *Wind tunnel, blockage corrections, panel method, tridimensional flow, complex geometries.*

COB785 UNSTEADY AIRFOIL INVISCID FLOW SIMULATIONS USING UNSTRUCTURED DYNAMIC MESHES

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The efforts for the simulation of unsteady airfoil flows using an unstructured finite volume algorithm are described. The flowfield is modeled using the inviscid equations of gasdynamics, i.e., the Euler equations, which are discretized in a cell centered unstructured grid made up of triangles. Time integration uses an explicit, second-order accurate, hybrid scheme which evolved from the consideration of Runge-Kutta time stepping schemes. Steady state and unsteady calculations for NACA 0012 and NACA 64A010 airfoils at transonic flow conditions are presented. The results obtained are discussed and the implications of using the present time stepping scheme for unsteady calculations are highlighted.

Keywords: *Unsteady flow, unstructured mesh, finite volume method, aerodynamic hysteresis*

COB789 SIMULAÇÃO NUMÉRICA DE PROBLEMAS AEROESPACIAIS NO CONTEXTO DE MALHAS ESTRUTURADAS E NÃO ESTRUTURADAS / NUMERICAL SIMULATIONS OF AEROSPACE PROBLEMS ON STRUCTURED AND UNSTRUCTURED MESHES

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The paper presents comparisons between different algorithms used for the solution of the Euler equations for typical aerospace applications. The schemes considered include a cell centered, unstructured, explicit method and an implicit, unfactored algorithm constructed on structured grids. The unstructured method is based on Jameson and Mavriplis' work and it yields a centered, spatially 2nd-order accurate scheme. The structured algorithm is based on MacCormack's flux vector splitting scheme, but it is only 1st-order accurate in space. The particular applications considered were transonic nozzle flows and supersonic blunt body flows. The aspects emphasized in the present comparison were the final solution quality for steady state applications, the overall easiness of code implementation, and the method's computational efficiency.

Keywords: *Equações de Euler, Esquemas Explícito e Implícito, Comparação de Eficiência Computacional / Euler Equations, Implicit and Explicit Schemes, Computational Efficiency Comparison.*

COB790 SLOTTED TRANSONIC WIND TUNNEL FLOW SIMULATIONS USING THE EULER EQUATIONS

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The paper presents flow simulations relevant to transonic wind tunnel design and operation. A three-dimensional, finite difference, computational code which solves the Euler equations in a general, body conforming, curvilinear grid has been developed and used for these simulations. This code incorporates the capability of including test section wall slots for realistic simulation of a transonic wind tunnel facility. Test cases considered include a tunnel contraction alone and a complete high speed tunnel segment. Both cases with closed and open slots were considered. The results obtained adequately reproduced the expected flow features for the conditions analyzed and indicated that the particular configuration studied holds promise of providing very good test section flow quality.

Keywords: *Transonic Wind Tunnel, TTS Project, Slotted Walls, Inviscid Flow Simulation, Finite Difference Method.*

COB876 SIMULATION OF UNSTEADY TRANSONIC FLOW OVER A FIGHTER WING USING A ZONAL NAVIER-STOKES / FULL-POTENTIAL METHOD

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An improved hybrid method for computing unsteady compressible viscous flows is presented. This method divides the computational domain into two zones. In the inner zone, the Navier-Stokes equations are solved using a diagonal form of an alternating-direction implicit (ADI) approximate factorization procedure. In the outer zone, the unsteady full-potential equation (FPE) is solved. The two zones are tightly coupled so that steady and unsteady flows may be efficiently solved. Characteristic-based viscous/inviscid interface boundary conditions are employed to avoid spurious reflections at that interface. The resulting CPU times are about 60% of the full Navier-Stokes CPU times for unsteady flows in non-vector processing machines. Applications of the method are presented for a F-5 wing in steady and unsteady transonic flows. Steady surface pressures are in very good agreement with experimental data and are essentially identical to the full Navier-Stokes predictions. Density contours show that shocks cross the viscous/inviscid interface smoothly, so that the accuracy of full Navier-Stokes equations can be retained with a significant savings in computational time.

Keywords: *Transonic flow, zonal methods, viscous/inviscid interaction, unsteady flow, finite-difference methods.*

COB908 TRANSONIC TURBULENT FLOW CALCULATIONS OVER THE VLS FOREBODY

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A detailed study of transonic, turbulent flow conditions over the first Brazilian satellite launcher, the VLS, is described. The emphasis of the work is in developing the capability of accurately simulating realistic rocket flowfields and in understanding the behavior of two turbulence models in such conditions. The flowfields over the VLS at zero angle of attack are modeled by the axisymmetric, thin layer Navier-Stokes equations, and turbulence closure is obtained with the implementation of two different eddy viscosity models. A comparison of the characteristics of these two models is performed. Accurate solutions for the transonic flight regime are obtained. Non-reflective boundary conditions are also implemented, improving the representation of far field boundaries and the code's convergence characteristics in most cases.

Keywords: *Transonic Flow, VLS, Turbulence Modeling, Finite Difference Method, Improved Boundary Conditions.*

COB909 MULTIBLOCK SIMULATIONS OF TURBULENT VISCOUS FLOWS OVER THE VLS AFTERBODY REGION

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Axisymmetric, turbulent, viscous flow simulations over the first Brazilian satellite launcher, the VLS, are presented. The emphasis of the work is on multiblock calculations for afterbody flows. The details of the multiblock implementation are presented together with a brief description of the numerical

method. The implementation is validated against previous solutions for forebody flows over the same vehicle and through comparisons with experimental data for afterbody flows. The increased resolution of the multiblock calculations for the afterbody region is evidenced through comparisons with previous single block grid solutions.

Keywords: *Axisymmetric Formulation, Multiblock Methods, Viscous Flow, Turbulent Flow.*

COB1379 CARGAS AERODINÂMICAS SOBRE UM CILINDRO DE SEÇÃO RETANGULAR / AERODYNAMIC LOADS ACTING ON A CYLINDER WITH A RECTANGULAR SHAPE

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The flow around a body with a complex shape possesses much scientific interest, since it presents phenomena that are not fully understood, such as the shadow effect and the blockage effect. In particular, the calculation of the aerodynamic loads on the body is of great technological importance in the analysis and design of vehicles, offshore structures, etc. In a previous work it has been shown that the estimate of the drag coefficient of such bodies is viable when it is assumed that the body is formed of a combination of simpler bodies. The motivation to this work is to find alternative and efficient methods to estimate the aerodynamic loads that act on a cylinder with a rectangular shape and different aspect ratios, for any value of the Reynolds number. The approach adopted here uses fuzzy logic to estimate the loads, as well as genetic algorithms to improve the accuracy of the calculation.

Keywords: *Drag coefficient, bluff body, fuzzy logic, genetic algorithm, interference.*

COB1380 ANÁLISE DO ESCOAMENTO AO REDOR DE UM CILINDRO DE SEÇÃO CIRCULAR / ANALYSIS OF THE FLOW AROUND A CIRCULAR CYLINDER

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Flows around bluff bodies have always attracted scientific interest due to the complex phenomena that occur, such as separation and the resulting wake formation downstream of the body. In this paper we use the discrete vortex method to study the unsteady, incompressible and two-dimensional flow around a circular cylinder immersed in a uniform flow. With the aid of the circle theorem to impose the flow-tangency condition, vortices with a Lamb core are generated along the cylinder surface whose strengths are determined so that the no-slip condition is satisfied. The dynamics of the body wake is computed using the convection-diffusion splitting algorithm, where the convection process is carried out with a lagrangian time-marching scheme, and the diffusion process is simulated using the random walk method. The aerodynamic forces are calculated from the unsteady Blasius equation. Results are presented for a high Reynolds number flow, showing good agreement with experiments.

Keywords: *Método de Vórtices, Teorema do Círculo, Corpo Rombudo, Esteira, Separação / Vortex Method, Circle Theorem, Bluff Body, Wake, Separation.*

COB1441 A NUMERICAL SIMULATION OF TRANSONIC AERODYNAMIC FLOW, USING THE BALDWIN-LOMAX MODEL, LARGE SCALE FIELD AND EULER SIMULATIONS / SIMULAÇÃO DE UM ESCOAMENTO AERODINÂMICO TRANSÔNICO, USANDO OS MODELOS DE BALDWIN-LOMAX, DE GRANDES ESCALAS E DE EULER

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This work presents a numerical simulation study to compute a turbulent compressible aerodynamic flows. The numerical algorithm used is the finite volume formulation for spatial discretization and a stepping time procedure with multi-stages for time discretization. Also, a multigrid procedure is used with aim for speeding up the steady state convergence. The aerodynamic flows solutions around airfoils in transonic state were performed using Euler equations (Euler model), large scale field simulation (LES) and Baldwin-Lomax model. The results achieved are compared with experimental data available for two kinds of airfoils (NACA0012 and RAE2822), in the transonic range for Reynolds number equal to 9.0×10^6 and for large variation of attack angles. Some supersonic results were also obtained and compared with analytical evaluations. All computations were made for the three models, aiming to estimate of accuracy of the solutions and how expensive they are.

Keywords: *Numerical Simulation (Simulação numérica), Turbulence Model (Modelo Turbulento), Compressible Flows (Escoamento Compressível), Airfoils (Aerofólios), Finite Volume Formulation (Formulação de Volumes Finitos)*

TEMA 38 - Métodos Experimentais em Mecânica dos Fluidos**COB58 ANÁLISE EXPERIMENTAL DO ESCOAMENTO AO REDOR DE UM PERFIL DE BASE QUADRADA EM DOIS DIFERENTES ÂNGULOS DE ATAQUE / EXPERIMENTAL ANALYSIS OF THE FLOW AROUND A SQUARE CYLINDER WITH TWO DIFFERENT INCIDENCE ANGLES****Cláudio Lindquist, Edson Del Rio Vieira & Sérgio Said Mansur***Departamento de Engenharia Mecânica, Faculdade de Engenharia - UNESP - Ilha Solteira
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Flow visualization have been performed to study the flow along a square cylinder placed perpendicularly to the main flow. Two different attack angles have been considered ($\alpha = 0$ and $\alpha = 45$ degrees), for Reynolds numbers up to 300. The experimental facilities are composed by a water tunnel of low turbulence intensity and an apparatus for a flow visualization, image capture and processing. A direct dye injection visualization technique has been employed and the images have been captured on two different media, photo-sensible chemical film and video tape with the help of a modern three CCD video camera. Strouhal numbers have been determined by video tape image analysis by frames counting. A sequence of images is shown for $\alpha = 0$ from which the vortices formation and shedding can be seen.

Keywords: *Square cylinder; Strouhal number; flow visualization; water tunnel; image processing; cilindro quadrado; número de Strouhal; visualização de escoamento; túnel hidrodinâmico; processamento de imagem.*

COB59 VORTEX VELOCITY MEASUREMENT BY HYDRODYNAMIC FLOW VISUALIZATION**Edson D. R. Vieira, Cláudio Lindquist, Emanuel R. Woiski & Sérgio S. Mansur***Departamento de Engenharia Mecânica, Faculdade de Engenharia - UNESP - Ilha Solteira
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Since von Kármán's studies of vortex propagation, vortex streets in wakes of bluff bodies have become a subject of interest to engineers and scientists, producing a great number of experimental vortex velocity measurements. In this work, hydrodynamic flow visualization, by direct dye injection technique, has been employed in order to determine the frequency and propagation speed of vortices shed from circular cylinders in the Reynolds number range up to 600. The experimental procedure consisted on changing the Reynolds number of the flow and evaluating the distance between two vortices on a same row from static images captured on negative film by a SLR camera and determining the Strouhal number from images recorded with a 3 CCD video camera. From the distance and the corresponding Strouhal number, vortex velocity against Reynolds numbers have been calculated and depicted. Results regarding the Strouhal number obtained compared well with literature.

Keywords: *Vortex speed; vortex shedding; flow visualization; Strouhal frequency; circular cylinder; velocidade de vórtices; emissão de vórtices; visualização de escoamentos; frequência de Strouhal; cilindro circular.*

COB70 ANÁLISE EXPERIMENTAL DO PROCESSO DE ASPERSÃO DE GOTAS EM UM SISTEMA JATO-PLACA / EXPERIMENTAL ANALYSIS OF THE DROPS ASPERSION PROCES OVER A JET-PLATE SYSTEM

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This article presents the results obtained with the technique of high-speed photography used to freeze the high frequency dynamic phenomena involved in the problem of drop generation by means of a spray nozzle-plate system. The instabilities that characterize jet transition were initially analyzed to validate the method of experimentation. The physical nature of drop formation was also analyzed and the more important physical phenomena were pointed out: the dynamic instabilities over the liquid sheet; the holes formation and the mass accumulation belongs the borders of the holes and liquid sheet.

Keywords: *Experimentation; turbulence; drops; aspersion; transition*

COB268 ANÁLISE DA PROPAGAÇÃO DE PERTURBAÇÕES NO CAMPO DE VELOCIDADES DO ESCOAMENTO EM BANCO DE TUBOS / ANALYSIS ON THE PROPAGATION OF DISTURBANCES IN THE VELOCITY FIELD OF TUBE BANK FLOW

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This paper presents the experimental analysis of the propagation of a disturbance with a fixed frequency, generated, by means of an obstacle, in the incidence velocity of the cross flow through a tube bank and its influence on the pressure and velocity fluctuations inside the bank. The tube bank investigated had square arrangement and aspect ratio $P/D = 1.60$ and air was the working fluid. Measurements were performed with hot wires and pressure transducers. Behavior of fluctuating quantities is described by means of autospectral density functions and the propagation of the disturbance is discussed based on the analysis of cross-correlation functions. The results show that the frequency of the disturbance remains unchanged as it passes through the bank, in spite of the high turbulence intensities and of the fact that flow velocity inside the bank varies with the position. This fact may indicate that external excitations can be transferred to the solid boundaries of the bank.

Keywords: *Banco de Tubos, Turbulência, Anemometria de Fio-Quente / Tube Bank, Turbulence, Hot-Wire Anemometry.*

COB269 ESCOAMENTO TURBULENTO NA SAÍDA DE UM DUTO CURVO DE SEÇÃO RETANGULAR DIVERGENTE - ESTUDO EXPERIMENTAL / TURBULENT FLOW AT OUTLET OF A CURVED RECTANGULAR DIVERGENT DUCT - EXPERIMENTAL STUDY

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This paper presents the experimental study of the turbulent flow in a curved duct which simulates part of a thermal-electrical power plant. Ashes, carried in the power plant by the flow of gases from the furnace, impinge on the pipes of the heat exchanger, which pre-heat water prior of the steam generator, after passing a curved duct, and produce erosion of the pipes of the heat exchanger, leading to failures which stop plant operation. Flow distribution after the curve increase the erosion near the concave wall of the duct. Classical solutions for flow redistribution in curves, like vanes, are not applicable since they could increase operational risks due to the erosion of the vanes. This problem was investigated in a scale model of the curved duct, with, for simplicity, air as the working fluid. Flow visualizations with wool threads on the duct wall, Pitot tube and hot wire measurements were applied. Based on the results, modifications in the test section were made, using boundary-layer control techniques. The results show that flow redistribution after the curve was improved, and the modifications, when implemented in the plant, may lead to safer and economical operation conditions.

Keywords: *Escoamento turbulento; Dutos retangulares curvos; Anemometria de fio quente; turbulent flow; curved rectangular ducts; hot wire anemometry.*

COB276 **MEDIÇÃO DE CAMPOS DE VELOCIDADE EM ESCOAMENTOS COM O EMPREGO DA TÉCNICA DE PROCESSAMENTO DE IMAGENS / FLOW VELOCITY MEASUREMENT USING IMAGE PROCESSING TECHNIQUE**

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One of the great problem for measuring flow field properties, such as velocity and vorticity, using an intrusive or nonintrusive techniques, is the time consuming. Hot-Wire (HW) and Laser Doppler Velocimetry (LDV), apart from their advantages and disadvantages, demand great effort and care for measuring extensive flow field. Highly unsteady flow is another type of problem not solved when using HW or LDV because both are local velocity techniques, that is, resolving the velocity field at each point at a time. Measuring flow properties having spatial and temporal information is now possible due to new techniques appearing since the great development achieved by the laser technology and the fast digital processors. Particle Image Velocimetry (PIV) is one emerging technology with the proposal of solving part of these measuring flow field problems. The paper describes two developing methodologies for measuring low and fast velocities inside an extensive field flow of a tundish model used in metallurgical process.

Keywords: *Processamento de Imagens, Video Velocimetria, Velocimetria por Processamento de Imagens / Image Processing, Video Velocimety, Particle Image Velocimetry.*

COB497 **DESIGN OF AN EIGHT-STAGES CASCADE IMPACTOR FOR THE CLASSIFICATION OF AIRBORNE PARTICLES**

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The work describes the design of a prototype eight-stages cascade impactor, capable of classifying airborne particles with sizes in the range of aerodynamic diameters between 17 and 0.5 microns, while operating with a nominal flow rate of 30 liters/minute. A summary of the theory involved in the project of such devices is also presented. The collection surfaces accommodate 37 mm substrates which may be of different materials (e.g. filter media, aluminum foil), depending on the application of interest. The design is optimized for reducing inter-stage particulate losses, and the instrument may be used in the separation of inhalable PM10 particulate (Particulate Matter 10 microns cut off size). It is also flexible enough for permitting the operation with different sets of nozzle diameters, accepting a diverse selection of cut off sizes.

Keywords: *Aerosol Technology, Instrumentation, Air Pollution, Atmospheric Aerosols, Environmental Assessment / Tecnologia de Partículas, Instrumentação, Poluição do Ar, Aerossóis Atmosféricos, Avaliações Ambientais.*

COB702 UM ESTUDO EXPERIMENTAL DE VÓRTICES ANELARES VIS-COSOS

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Motivated by the role played by vortex rings in the turbulent mixing processes, the present work investigates the stability and evolution of a single vortex ring. A new classification is proposed for vortex rings, which is based on extensive hot-wire measurement of velocities in the vortex core and wake, and on flow visualization. Vortex rings may be classified as laminar, wavy, turbulence-producing, and turbulent.

Keywords: *Vórtice Anelar, Turbulência, Mecânica dos Fluidos, Experimental./ Vortex rings, Turbulence, Fluid Mechanics, Experimental*

COB753 EXPERIMENTAL DETERMINATION OF THRUSTER PLUME HEAT LOADS ON SAC-C 753

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In this paper, a theoretical and experimental study of the impact of the exhausted gas produced by a 2N hydrazine thruster is presented, simulating the thermal conditions attained in space during the operation of a spacecraft propulsion system used for orbit control. For this purpose, two different configurations were examined, either in continuous and pulsed firing regimes. The first configuration consisted of a set of small aluminum plates placed perpendicular to the plume flow field, in order to have

a direct measurement of the heat load on a surface whose normal is aligned with the incident molecular flow field. The second configuration consisted in a fiberglass-epoxy boom placed near the thruster and parallel to its axis, representing a possible configuration for SAC-C (Satélite Argentino de Aplicaciones Científicas). The boom, when deployed, extends into the area of the flow field of the thrusters used for orbit control and may be subjected to high heat loads during the firing.

Keywords: *Plume Impingement, Heat Estimations.*

COB778 LIQUID FILM THICKNESS MEASUREMENT BY ULTRASONIC TRANSMISSION TECHNIQUE

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In this paper is proposed and tested the use of a non-intrusive ultrasonic transmission technique for the measurement of the thickness of a liquid film flowing along a solid wall. The physical principles, as well as the experimental procedures for the method are presented. The tests were performed measuring film thickness inside a cylindrical chamber in which a liquid was tangentially injected, causing a film of liquid containing certain quantities of dissolved gas bubbles to rotate along the wall. The technique was tested using water, and the results were compared with values measured with an electric impedance sensor. In general, there was a good agreement between the values obtained from both methods, though there is a systematic difference due to the fact that the electric sensor is able to measure film thickness almost locally, while the ultrasonic technique averages the values over a larger region. The ultrasonic technique was also tested with a higher viscosity liquid, obtained by adding corn syrup to the water, for which the electric sensor was unable to measure. In this case, the results were compared to an analytical model, which was verified for the previous measurements with water. The results also showed good agreement.

Keywords: *Liquid films, ultrasonic sensors, measurement techniques*

COB799 DETERMINAÇÃO DO COEFICIENTE GLOBAL DE TRANSFERÊNCIA DE CALOR EM RODAS FERROVIÁRIAS / DETERMINATION OF THE OVERALL HEAT TRANSFER COEFFICIENT IN RAILROAD WHEELS

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The objective of this work is to present a determination of a value for the overall heat transfer coefficient to be able to simulate the heating during the braking process in 33 inch (838 mm) railroad wheels. To achieve this objective it was necessary to design and construct a full scale dynamometer

to reproduce the most common braking conditions found in railway operation. The variations in brake power and temperature were measured during standardized tests and were compared to the results obtained from a finite element numerical simulation. Many trial simulations were realized in order to achieve better agreement between the numerical predictions and the experimental results. A value of $25 \text{ W/m}^2 \text{ } ^\circ\text{C}$ was found for the overall heat transfer coefficient when used with 80% of the total generated friction power. The results of this work are important to determine the thermal stresses in railway wheels during braking and this represents the major aim of the Railway Laboratory of the State University of Campinas.

Keywords: *Railroad wheels, railroad braking, wheels failures, brake heating, frenagem ferroviária*

COB906 ANÁLISE EXPERIMENTAL DO PROCESSO DE ASPERSÃO DE GOTAS EM UM SISTEMA JATO-PLACA / EXPERIMENTAL ANALYSIS OF THE DROPS ASPERSION PROCES OVER A JET-PLATE SYSTEM

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This article presents the results obtained with the technique of high-speed photography used to freeze the high frequency dynamic phenomena involved in the problem of drop generation by means of a spray nozzle-plate system. The instabilities that characterize jet transition were initially analyzed to validate the method of experimentation. The physical nature of drop formation was also analyzed and the more important physical phenomena were pointed out: the dynamic instabilities over the liquid sheet; the holes formation and the mass accumulation belongs the borders of the holes and liquid sheet.

Keywords: *Experimentation; turbulence; drops ; asperion; transition.*

COB1211 UM EXPERIMENTO DIDÁTICO EM CONVECÇÃO NATURAL / A DIDACTIC EXPERIMENT ON FREE CONVECTION

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This paper describes a didactical experiment on natural convection along a vertical flat plate at constant temperature. It describes a methodology to determine the heat transfer coefficient based on the use of heat fluxmeters. The effect of radiant exchanges on the heat transfer coefficient is presented. A new type of heat fluxmeter, the "tangential heat fluxmeter", is presented as well the calibration technique. The experiment is very useful to illustrate heat transfer concepts.

Keywords: *convecção, convecção natural, fluxo de calor, fluxímetro / convection, free convection, heat flux, heat fluxmeter*

COB1233 COEFICIENTES HIDRODINÂMICOS EM SEÇÕES SEMI-CIRCULARES EM ESCOAMENTO TURBULENTO / HYDRODYNAMIC COEFFICIENTS IN A SEMI-CIRCULAR DUCTS IN TURBULENT FLOW

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Pressure drop coefficients have been experimentally determined for turbulent flow in smooth semi-circular ducts. The experiments were performed by measuring the pressure distribution along the flow. The flowing fluid was air and the pressure drop coefficients are presented as function of the flow Reynolds number. Results for circular ducts are also presented and compared with Blasius. The agreement was very good.

Keywords: *Perda de Carga - Métodos Experimentais - Mecânica dos fluidos - Trocadores de Calor / Pressure Drop - Experimental Methods - Fluid Mechanics - Heat Transfer.*

COB1273 DIESEL PARTICULATE MATTER EMISSIONS MEASUREMENT BY MEANS OF A PARTIAL DILUTION MINITUNNEL

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A minitunnel is proposed in lieu of a full dilution tunnel, that will allow determination of carbon monoxide (CO, CO₂), unburned hydrocarbons (HC), oxides of nitrogen (NO_x) and particulate matter (PM). The design will permit independent evaluation of emissions from Diesel engines.

Keywords: *Sample, Control, Filters, Particulate Matter, Measurement, Sign, Acquisition.*

COB1296 ANÁLISE EXPERIMENTAL DO AQUECIMENTO DE ÁGUA ATRAVÉS DE MICROONDAS / EXPERIMENTAL ANALYSIS OF WATER HEATING BY MICROWAVE ENERGY

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In the present paper is showed an experimental study. The main object of this study is to improve the microwave power absorption by the water in a resonant cavity. This cavity has a cylindrical geometry and contains a glass (Pyrex) tube in its longitudinal position. Distilled water flows through this tube. The following parameters were varied: water flow mass, glass tubes diameters and the screws position (disturbances) inside the cavity. The results show a strong influence of those parameters about the absorbed power by the water. In this way, it is possible to obtain a situation for the maximum microwave power transferred to the water.

Keywords: *Microwave, resonant cavity, water heating by microwave, thermal optimization: geometry / Microondas, cavidade ressonante, aquecimento de água por microondas, otimização térmica: geometria.*

COB1419 A THEORETICAL AND EXPERIMENTAL STUDY OF THE VORTEX TUBE

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This paper presents a theoretical and experimental study and introduces a mathematical model for a Vortex tube on steady state operation. The internal swirling flow is modeled by a set of ordinary differential equations that are integrated along the radial direction. Experimental temperature measurements from a Vortex tube built in the laboratory are compared to numerical results obtained with the theoretical model, with good qualitative agreement. The temperature variation with respect to the inlet fluid temperature along the radial direction is understood as a result of the distribution of the kinetic energy through the swirling flow, i.e., temperature increase in the periphery and decrease in the core. The theoretical estimation of the flow reversal at the Vortex tube axis agrees well with the internal swirling flow results of Armfield and Fletcher (1991)

Keywords: *Refrigeration, swirling flow, irreversible model, experimental measurements.*

COB1491 OPTIMIZACION EN EL DISEÑO Y CALIBRACION DE REDES DE DISTRIBUCION HIDRAULICA

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In this Work an algorithm that allow design and calibrate water distribution network is developed. The network topology is analysed by graph theory. The conservation equations that establish the state of network equilibrium allow the analytic formulation of the problem as boundary value problem, and the proposed method is applicable for open, closed and combined networks.

Since that in regime state, a network is put to quick changes: pumps starter and stoped, flow rate variations, etc., during design and calibration of this is necessary to know the effect that caused over the variables group, the modification that try out one of this, denominated resolution parameter, so that satisfy the new regime conditions.

The correction of quasilinear equations system that shown the network equilibrium state allow obtain the analytic solution of new problem.

The operation range and the algorithm ductility are shown by mean of application example, the solution obtained is optimal since satisfy exactly the especificated state parameters.

Keywords: *water distribution, calibration, networks analysis, graph theory, optimization.*

TEMA 41 - Mecânica do Contínuo

- COB96** **UMA TEORIA SIMPLES PARA O CÁLCULO DE TENSÕES EM VIGAS INELÁSTICAS SUBMETIDAS A CARREGAMENTOS COMPLEXOS / A SIMPLE THEORY TO PERFORM AN APPROXIMATE COMPUTATION OF THE STRESSES IN SLENDER INELASTIC MEMBERS SUBJECTED TO VARIABLE TRANSVERSE AND AXIAL LOADING**

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The present paper presents a simple theory to perform an approximate computation of the stresses in slender elasto-plastic and elasto-viscoplastic members subjected to variable transverse and axial loading. Theories for inelastic beams found in the literature are restricted to very simple hardening rules (generally a perfectly plastic behavior) which are not adequate to model cyclic loadings. Although the proposed theory is adequate for any kind of elasto-plastic and elasto-viscoplastic constitutive equations with internal variables, a particular set of constitutive equations which accounts for the isotropic and kinematic hardening induced by plastic deformations is considered in the presentation. No matter the non-linearity of the evolution laws adopted for the kinematic and isotropic hardening variables, simple expressions are obtained connecting the stress components with the bending moment, the shear force, the normal force and the plastic strains. The theory allows a low cost analysis of the stresses and strains in many structural elements used in industrial applications. The usefulness of the proposed theory is checked through the simulation of a combination of axial and transversal loading in 316 L stainless steel bars at 600°C.

Keywords: *Theory of beams, Plasticity, Viscoplasticity, Internal Variables/Teoria de vigas, Plasticidade, Viscoplasticidade, Variáveis internas.*

- COB449** **DESCRIPTION OF THE SHAPE MEMORY EFFECT IN THE SETTING OF STANDARD GENERALIZED MATERIALS : A THREE-DIMENSIONAL MODEL**

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A phenomenological model describing the mechanical behavior of solids undergoing stress-induced phase transformations is presented in the setting of three-dimensional media. Pseudoelasticity as well as shape memory effect can be described by the model at hand. Numerical results are presented so as to illustrate the capabilities of the three-dimensional constitutive model.

Keywords: *Plasticity, pseudoelasticity, shape memory effect, martensitic transformation, constitutive model.*

COB676 PLANE DEFORMATIONS WITH UNIFORM STRETCHES**Fernando P. Duda & Luiz C. Martins**

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A complete characterization of plane deformations with constant stretches, as well a constructive method to obtain them, is presented. With these results at hand we arrive at an important kinematical characterization of the Singh-Pipkin family of deformations. Finally, we provide a complete treatment of universal deformations with constant stretches for the Bell's elastic materials.

Keywords: *Deformations with constant stretches, universal deformations, the Singh-Pipkin solution, Bell's constraint.*

TEMA 42 - Método de Elementos Finitos

COB41 NUMERICAL SIMULATION OF FLUID FLOW BY THE CONTROL VOLUME-FINITE ELEMENT METHOD

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A control volume-finite element method (CVFEM) to simulate unsteady, incompressible and viscous fluid flows using nine-noded quadrilateral elements is presented. The mathematical modeling of flows is the Navier-Stokes equations in primitive variables $u-v-p$. The set of non-linear partial differential equations was integrated and after using interpolation functions and the time discretization, the algebraic system of equations was solved by using the frontal method of solution. The obtained results of some benchmark problems compared favorable with available results from the literature.

Keywords: *Finite Element, Control Volume, Navier-Stokes Equations, Primitive Variables, Computational Fluid Dynamics.*

COB76 OBTENCIÓN DE LA MATRIZ DE RIGIDEZ SECANTE EN MECÁNICA NO LINEAL DEL SÓLIDO / DERIVATION OF THE SECANT STIFFNESS MATRIX FOR NON LINEAR FINITE ELEMENT ANALYSIS OF SOLIDS

William Matias & Eugenio Oñate

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In this paper the general non symmetric parametric form of the secant stiffness matrix for non linear analysis of solids using finite element method is derived. A convenient symmetric expression for a particular value of the parameters is obtained. The geometrically non linear formulation is based on a Generalized Lagrangian approach. Detailed expressions of all the relevant matrices involved in the analysis of 3D solids are obtained. The potential of using the secant stiffness matrix for developing new solution algorithms for non linear structural problem is also discussed. Examples of application are given for the non linear analysis of pin joined frames and 2D solids.

Keywords: *geometric nonlinear analysis, secant stiffness matrix, Generalized Lagrangian description.*

COB79 A SIMPLE LOCKING-FREE THREE-NODE SHELL FINITE ELEMENT

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A simple triangular shell finite element with fifteen degrees of freedom for the analysis of general shell structures is presented in this work. The element uses a substitute transverse shear strain field to avoid locking, and is formulated on the basis of RSDS-element (Resultant Stress Degenerated Shell Element) approach, which leads to very simple strain-displacement expressions. The substitute shear strain field is derived assuming constant shear strains along the sides of the element, similar to the MITC (Mixed Interpolation in Tensorial Componentes) procedure. All integrations can be performed using only one point Gaussian rule, leaving the element with one non-communicable zero energy mode, which does not affect the results. This procedure allows the use of symbolic engines to derive analytic expressions for stiffness matrices, reducing computational cost of the analysis by a significant amount.

Keywords: *Finite element method, plates and shells, shear locking.*

COB103 STRESS PREDICTIONS FOR SHORT FLAT BARS WITH PROJECTIONS SUBJECTED TO SHEAR LOADING**M. K. Pipelzadeh & S. J. Hardy**

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The finite element method has been used to obtain stress concentration factor data for flat 'T' shaped components subjected to shear loading with local restraints being applied. This paper presents and describes the stress contours developed as a result of the shear load for a typical geometry. In addition, the stress concentration factor (SCF) data are used to obtain prediction equations using a multiple linear regression model. These equations provide guidelines for the assessment of the SCF by designers. The contours show the localised and large stress gradients in the vicinity of the fillet region. The ratio of the length to depth (or slenderness ratio) of the shank region is generally less than 3:1. For these short components particularly under shear (or bending) loads, primary bending stresses are no longer dominant and the transverse shear becomes an important secondary effect.

Keywords: *Shear loading, stress concentration factor, finite element analysis, flat bars with projections.*

COB109 ELASTIC CONTACT WITH FRICTION AS A CONDITIONAL MINIMIZATION PROBLEM / CONTATO ELÁSTICO COM ATRITO COMO UM PROBLEMA DE MINIMIZAÇÃO CONDICIONAL**Alberto Luiz Serpa^{1,2} & Fernando Iguti²**

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This work presents a study of contact with friction between elastic bodies under the assumptions of infinitesimal elasticity. This is a non-linear problem due to the unilateral constraints (interpenetration of bodies) and friction. The solution can be found using optimization concepts, modelling the problem as a constrained minimization problem. The Finite Element Method is used to model the equations of elasticity. The minimization problem has the total potential energy of the elastic bodies as the objective function, the non-interpenetration conditions are represented by inequality constraints, and equality constraints are used to deal with the friction. Due to stick and slip conditions, equality constraints are present or not according to the current condition. Since the Coulomb friction condition depends on the normal and tangential contact stresses related to the constraints of the problem, it is devised an approach called here as a conditional dependent constrained minimization problem. An Augmented Lagrangian Method is used. This method, when applied to a contact problem, presents Lagrange Multipliers which have the physical meaning of contact forces. This fact allows to check the friction condition at each iteration.

Keywords: *Finite Element, Contact Problem, Mathematical Programming, Augmented Lagrangian / Elementos / Finitos, Problema de Contato, Programação Matemática, Lagrangiano Aumentado.*

COB 155 ANALYSIS OF COLD ROLL FORMING OF THIN SHEET METAL FOR SOME ROLL-STANDS

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The cold-roll-forming of thin sheets is a forming process where initially flat sheet is drawn along through roll stands which may have a complex form. The cold-roll-forming is a three dimensional problem with large transformations, elasto-plastic behaviour with contact and friction. The objective of the model is to have a better knowledge of sheet strains, in order to obtain a product with optimised mechanical and geometrical qualities. The proposed method simulates the cold-roll-forming process by a two dimensional analysis on the sheet cross section resolved by linear finite elements, coupled with a three dimensional analysis of the sheet between adjacent roll stands. Complex profiles were modeled with this method.

Keywords: *Finite Element, Large Deformations, elastoplastic behaviour, Contact, Cold-Roll-Forming.*

COB182 THE PRECONDITIONED CONJUGATE GRADIENT METHOD FOR THE SOLUTION OF SPARSE MATRICES: FINITE ELEMENT METHOD APPLICATIONS

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This paper presents the Preconditioned Conjugate Gradient Method (PCG) for the solution of sparse matrices and its application in the Finite Element Method. The Preconditioned Conjugate Gradient Method was implemented for the solution of a heat transfer problem in an unstructured mesh. The stiffness matrix generated by the Finite Element Method is sparse and banded. The results obtained for a conduction problem were in very good agreement with the analytical results. The performance of PCG is also compared with the unpreconditioned version of the algorithm in terms of CPU time for different computer platforms. This result is of practical importance when dealing with transient problems where saving time is essential as so many iterations are involved. As an example of this class of problems, the authors are implementing the method to study vortex shedding phenomenon using a 2D discrete vortex method including viscous diffusion in an unstructured finite element mesh.

Keywords: *Preconditioned conjugate gradient, finite elements.*

COB194 ANÁLISE DINÂMICA DE PLACAS E CASCAS ATRAVÉS DE ELEMENTOS FINITOS QUADRILATERAIS QUADRÁTICOS COM INTEGRAÇÃO NUMÉRICA CONSISTENTE / DYNAMIC ANALYSIS OF PLATES AND SHELLS THROUGH QUADRILATERAL QUADRATIC FINITE ELEMENTS WITH CONSISTENT NUMERICAL INTEGRATION

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The purpose of this work is a comparative performance study of plates and shells dynamic analysis, considering consistent numerical integration, of the Serendipity and Lagrangean isoparametric quadrilateral quadratic finite element families, obtained both from the Ahmad's formulation; one intends to establish, between both elements, which is the most adequate to start the development of a subparametric hierarchical element, based on the p mesh refinement concept, intending to remove the excessive rigidity characteristic of the Ahmad's element for thin plates and shells problems. One could notice from the obtained results that the Lagrangean family element has a consistently better performance than the Serendipity family element, particularly for thin plates and shells problems.

Keywords: *Finite Elements Method, Numerical Integration, Structural Analysis, Shell, Plate / Método dos elementos finitos, Integração numérica, Análise estrutural, Casca, Placa.*

COB358 MALHAS ADAPTATIVAS DE ELEMENTOS FINITOS: APLICAÇÃO À ANÁLISE DE TENSÕES EM ELASTICIDADE BIDIMENSIONAL / ADAPTIVE FINITE ELEMENT MESHES: APPLICATION TO STRESS ANALYSIS IN TWO-DIMENSIONAL ELASTICITY

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An adaptive remeshing procedure for finite element plane stress analysis is presented. A variant of the Zienkiewicz and Zhu a posteriori error estimator is used to guide a Delaunay mesh generator based on Bowyer's algorithm. The remeshing scheme is designed to create nearly optimal meshes containing a controlled number of elements. The numerical examples presented demonstrate the good performance of the Zienkiewicz and Zhu error estimator and the effectiveness of the remeshing scheme proposed.

Keywords: *Finite Elements, Error Estimator, Adaptive Remeshing, Plane Stress, Linear Elasticity / Elementos Finitos, Estimador de Erros, Remalhagem Adaptativa, Tensões Planas, Elasticidade Linear.*

COB403 STRUCTURAL DYNAMIC ANALYSIS OF NONLINEAR MULTI-BODY SYSTEMS BY A TIME-DISCONTINUOUS GALERKIN FORMULATION

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This work presents a study for structural dynamic analyses of nonlinear multibody systems, by a time- discontinuous Galerkin finite element method. A single-field formulation is used with the displacements approximated as a parabolic function continuous within each time slab, but discontinuous across time levels. Since the resulting system of equations is prone to high frequency oscillations the algorithm presented is well suited for the solution of such problems as it provides unconditional stability, third order accuracy and high frequency numerical damping. For conservative systems the relative difference in total energy at each time step is used as error indicator and an adaptive time stepping procedure is used to select the proper time step size. The solution for a linear oscillator gives access to the applicability of the algorithm to more complex problems and then the scheme is applied to a strongly nonlinear oscillator whose results are in excellent agreement with their analytical counterparts. The scheme allows the freedom to choose whatever initial time step size, since it searches for the best time step size that will provide the desired accuracy.

Keywords: *Structural Dynamics; Adaptive Time Integration; Discontinuous Galerkin.*

COB420 CONTACT PROBLEMS IN PLATES UNDERGOING LARGE DEFLECTIONS, USING A HIGHER ORDER PLATE THEORY

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This work presents an incremental finite element formulation for contact problems of plates undergoing large deflections, with unilateral constraints, such as rigid foundations. A nine node

lagrangian type isoparametric finite element, based on the Lo, Christensen and Wu higher order plate theory, is obtained using this formulation. The penalty method is used to solve the variational inequality that usually arises in contact problems, and the solution depends on the penalty parameter. Using the finite element obtained, bending problems of beams and plates, with their lateral displacements constrained by walls, are numerically solved, and the results are compared with solutions available in the literature.

Keywords: *Contact, plate theories, finite elements.*

COB504 **DINÂMICA DE CASCAS CILÍNDRICAS CONTENDO FLUIDO EM FLUXO CIRCULAR: SOLUÇÃO DO PROBLEMA EM REGIME PERMANENTE / DYNAMIC OF THE CYLINDRICAL SHELL CONTAINING FLUID AT CIRCULAR FLUX: SOLUTION OF THE PROBLEM AT STEADY STATE**

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This work presents the solution and numerical results of the governing equations of a viscous fluid in steady state circumferential motion. To describe the motion of the fluid, Navier-Stokes and Continuity equations are used (Panton, R.L. 1984). The numerical solution is based on the studies of Taylor e Hughes (Taylor e Hughes, 1981), who employed the Finite Element Method for the two-dimension solution of the flow. Three velocity components are considered in a cylindrical coordinate system. To validate the results, the problem of a concentric journal bearing is solved, which shows a predictable pressure and velocities profile.

Keywords: *Fluxo circular, regime permanente, método dos elementos finitos, dinâmica dos fluidos / circular flow, steady state, finite element method, fluid dynamic.*

COB855 **APLICAÇÃO DO MÉTODO DE ELEMENTOS FINITOS COM O AUXÍLIO DE SISTEMA ESPECIALISTA / APPLICATION OF FINITE ELEMENT METHOD AIDED BY EXPERT SYSTEMS**

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This paper presents an expert system to help the tasks of modelling physical problems through the finite element method. The construction of the modelling system is associated with two modules. The first one is an expert system that helps in the numerical model building, and the other one is a model manager that controls the whole process remaining, i. e., the model manager gets the geometry from a CAD modeller, based on ACIS standard, and perform a mesh generation. The user, following the advices received from the expert system, applies the loads and boundary conditions. After that, a finite element package reads this data, and solve the problem using adaptive methods to take accurate results.

Keywords: *Expert Systems, Knowledge Based Systems, Structural Analysis, Finite Element Method, Preprocessor, Modelling / Sistemas especialistas, Sistemas baseados em Conhecimento, Análise Estrutural, Método de Elementos Finitos, Pré-processador, Modelagem*

COB988 **MODELAGEM DA INTERAÇÃO QUASI-ESTÁTICA ENVOLVENDO SÓLIDOS ELÁSTICOS E RÍGIDO-PLÁSTICOS COM ÊNFASE NO FENÔMENO DE CONTATO / QUASISTATIC INTERACTION OF ELASTIC AND RIGID PLASTIC SOLIDS WITH EMPHASIS ON CONTACT PHENOMENA**

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Interaction and contact between solids are relevant phenomena in the context of structural engineering. In this field, loads are transmitted by contact to structures which, in their turn, transmit loads to foundations by contact between bodies. In metal forming computations, such phenomena also play a major role. A good description of the interaction between workpiece and tools is of fundamental importance for a realistic simulation of fabrication processes. Actually, contact mechanics have many applications in structural and mechanical engineering and contact models can be generated by the variational principles of solid mechanics. The present work describes a finite element model, based on a treatment of boundary conditions by penalty functions, developed in order to analyse the quasi-static interaction between a rigid solid and a deformable solid. The model is verified in its simpler version through the analysis of the Signorini's problem without friction. It is extended, in order to take into account the inelastic behavior of the deformable solid in the domain of finite strains, through rigid-plastic constitutive equations. In the extended version the model is verified by the analysis of a metal forming process.

Keywords: *contact mechanics / finite elements / metal forming computation - mecânica de contato / elementos finitos / conformação mecânica computacional.*

COB995 **A-POSTERIORI ERROR ESTIMATORS FOR STRONGLY NONLINEAR PROBLEMS**

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The use of auxiliary linear problems in order to estimate the approximation error of finite element discrete solutions to nonlinear elliptic problems has been one of the most reliable and robust way of assessing the accuracy of a discrete model. There has been an understanding that if an implicit estimator is asymptotically exact for linear problems, then it will be so when being used for nonlinear problems through a suitable auxiliary problem. In this work we prove that statement for a wide class of implicit estimators.

Keywords: *Finite element method, Nonlinear PDE's, A-posteriori estimators.*

COB1160 **A DIRECTIONAL ERROR ESTIMATOR FOR ADAPTIVE LIMIT ANALYSIS**

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We present some results on finite element adaptive mesh-refinement strategies for limit analysis, using a posteriori error estimator based on local directional interpolation error and recovering of the second derivatives of the finite element solution. The abstract framework of the adopted error estimation techniques is discussed. Some possibilities of derivatives recovery are considered, including the proposal of a directional error estimator. We apply the above abstract formulation to finite element models of limit analysis.

Keywords: *Finite elements, limit analysis, error estimator, adaptive mesh / Elementos finitos análise limite, estimativa de erro, malhas adaptadas*

**COB1266 MODELO CONSTITUTIVO PARA DANO EM MATERIAIS FRÁGEIS
I CONSTITUTIVE MODEL FOR DAMAGE IN BRITTLE MATERIALS****Roque Luiz Pitangueira**

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A simple constitutive model which includes heterogeneity and size effects is presented. Distributed and discrete approaches for modeling of damage in brittle materials are discussed. Different implementations of the distributed approach are established, according to the choice of the initial compliance matrix, the treatment of the damage direction variation during the analysis, the approximation of the tangent constitutive relation, and the local damage evolution laws in tension and compression. The implications of the different approximations of constitutive tensors in a tangent formulation are addressed in a numerical example.

Keywords: *Constitutive, Damage, Fracture, Localization, Size effect, Dano, Fratura, Localização, Efeito de Tamanho.*

TEMA 43 - Método de Elementos de Contorno

- COB441** **FORMULAÇÃO H-HIERÁRQUICA ADAPTATIVA PARA O MÉTODO DOS ELEMENTOS DE CONTOURNO EM ELASTICIDADE / ADAPTIVE H-HIERARCHICAL BOUNDARY FORMULATION FOR THE BOUNDARY ELEMENT METHOD APPLIED TO ELASTICITY PROBLEMS**

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The present paper is concerned with the development of the H-Adaptive Hierarchical formulation applied to the Boundary Element Method. An analysis of the refinement is made, comparing two error's estimators. The convergence tax is also tested and commented. Finally, suggestions are made for an implementation of an optimal adaptive strategy.

Keywords: *Numerical Methods, Boundary Elements Method, Adaptive Procedures.*

- COB442** **SEMI-ANALYTICAL SINGULAR INTEGRATION FOR THE BOUNDARY ELEMENT METHOD IN ELASTICITY**

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This paper shows an alternative formulation to compute the value of the singular integral elements in the Boundary Element Method for Elasticity Problems, employing a process called semi-analytical. The expressions to be implemented are discussed and the precision obtained is illustrated with a numerical example.

Keywords: *Numerical Methods, Boundary Element Method, Adaptive Procedures.*

- COB839** **SIMULAÇÕES COMPUTACIONAIS DO COMPORTAMENTO DINÂMICO DE BARRAS DE SEÇÃO LINEARMENTE VARIÁVEL ATRAVÉS DO MÉTODO DOS ELEMENTOS DE CONTOURNO / COMPUTATIONAL SIMULATIONS OF DYNAMIC BEHAVIOR OF LINEAR TAPERED RODS USING BOUNDARY ELEMENT METHOD**

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This job presents the Dual Reciprocity Boundary Element formulation applied to dynamic analysis of tapered rods with linear variation in its transverse section. Some features of Boundary

Element discretization in this case are discussed in this work: the influence of area's ratio; level of refinement; opening angle of rod and internal poles. The performance of numerical displacements are compared with analytical response. Only constant element are used in this analysis carried out here. Houbolt's time stepping is employed to advance the solution.

Keywords: *Boundary Elements; Numerical Methods, Dynamics of Structures, Dynamic Response of Tapered Rods / Elementos de Contorno, Métodos Numéricos, Dinâmica de Estruturas, Resposta Dinâmica em Barras de Seção Variável, Propagação de Ondas.*

COB1222 ALGORÍTMO PARA INTEGRAÇÃO FRACA PRESENTE NO MEC APLICADO A PROPAGAÇÃO DE ONDAS / NEARLY SINGULAR INTEGRAL ALGORITHM IN BEM APPLIED TO WAVE PROPAGATION

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Nearly singular integrals arise in boundary element formulation applied to elastodynamics problems. In this paper is proposed an algorithm to integrate this nearly singular integrals. The method is formulated on subtract the nearly singular parcel from the nearly integration expression and integrate this expression by numerical approach them the nearly singular parcel is algebraically integrated.

Keywords: *Método dos elementos de contorno aplicado a elastodinâmica, Integral fracamente singular, Métodos de integração numérica, Propagação de ondas no contínuo, BEM Applied to Elastodynamics, Nearly Singular Integral, Numerical Integration, Wave Propagation.*

COB1224 UM ALGORÍTMO PARA INTEGRAÇÃO DA SINGULARIDADE NO MEC APLICADO A PROPAGAÇÃO DE ONDAS / AN ALGORITHM FOR SINGULAR INTEGRATION IN BEM APPLIED TO WAVE PROPAGATION

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This work concern on the development of a scheme to integrate the singular expression, present at the boundary element method, applied to elastodynamics problems in frequency domain. The mathematical formulation of the problem is discussed as well as some examples are presented and compared with the other methods implemented to show the method accuracy.

Keywords: *Método dos elementos de contorno aplicado a elastodinâmica, Integração singular, Métodos de integração numérica, Propagação de ondas no contínuo, Boundary Elements in Elastodynamics, Singular Integration, Wave Propagation in continuum.*

TEMA 44 - Método de Diferenças Finitas

COB298 FORMULAÇÃO BIDIMENSIONAL GERAL PARA PROBLEMAS INVERSOS DE CONDUÇÃO DE CALOR / A GENERAL TWO-DIMENSIONAL FORMULATION FOR INVERSE HEAT CONDUCTION PROBLEMS

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In this paper we present a general solution for two-dimensional boundary inverse heat conduction problems, by using the conjugate gradient method of minimization together with an elliptic scheme of numerical grid generation. The direct problem, as well as other auxiliary problems, are formulated in terms of generalized coordinates in a computational domain, where they are solved by finite-differences over a rectangular region. Simulated measurements are used to illustrate the application of the present approach with a practical inverse problem of engineering interest.

Keywords: *Boundary Inverse Problem, Conjugate Gradient Method, Function Estimation, Numerical Grid Generation, Generalized Coordinates.*

COB319 SCYL: UM PROGRAMA PARA A SOLUÇÃO NUMÉRICA EM PARALELO DAS EQUAÇÕES DE NAVIER-STOKES / SCYL: A PROGRAM FOR THE NUMERICAL SOLUTION IN PARALLEL OF THE NAVIER-STOKES EQUATIONS

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The use of parallel computing in Computational Fluid Dynamics problems has greatly increased over the past few years, placing an important and useful tool in the hands of scientists and engineers. This work discusses the implementation of a solution algorithm for the incompressible Navier-Stokes equations using parallel computation techniques. Program SCYL is written in FORTRAN 77 and utilizes the message passing library PVM to distribute and control computations between different computers. After discretization the resulting system of algebraic equations is solved using an iterative procedure. Convergence is accelerated with the use of multigrid. The parallelized code running on a cluster of Pentium processor machines displays good speed-up when compared to the serial version.

Keywords: *Incompressible flow, Navier-Stokes equations, multigrid, parallel computers, PVM / Escoamentos incompressíveis, Equações de Navier-Stokes, Multigrid, Computadores Paralelos, PVM*

COB347 APLICAÇÃO DE TÉCNICAS MULTIGRID EM PROBLEMAS DE DINÂMICA DOS FLUIDOS / APPLICATIONS OF MULTIGRID METHODS TO FLUID DYNAMICS PROBLEMS**Rivânia H. Paulino & Washington Braga***Departamento de Engenharia Mecânica, PUC-Rio, R. Marquês de São Vicente, 225, CEP: 22453-900, Rio de Janeiro, RJ,**E-mail: wbraga@mec.puc-rio.br*

The present work deals with the numerical solution of the Navier-Stokes equations, written in the stream function-vorticity form, by the finite difference method and acceleration techniques using multiple meshes. The classical method (storage of the correction) and the method FAS (Full Approximation Storage) have been tested. The results obtained clearly show that a very efficient computational scheme has been achieved with the multigrid method. For example, when comparing this method with the basic SOR method, relative gains in processing time in the order of 80% have been obtained.

Keywords: *Solução Numérica, Navier-Stokes, Multigrid, Full Approximation Storage / Numerical Solution, Navier-Stokes, Multigrid, Full Approximation Storage.*

COB755 APPLICATION OF THE UNIFIED FINITE APPROACH EXPONENTIAL SCHEME TO THE CAVITY PROBLEM**José Ricardo Figueiredo***State University at Campinas, FEM, DE, 13083-970, Campinas, São Paulo, Brazil*

This paper presents the application of a new discretization scheme for convective-diffusive fluid transport equations to the Navier-Stokes equations. The scheme is a conservative-form discretization constructed within the control-volume approach employing an exponential interpolating curve obtained as the exact solution of an approximated equation that admits a source term, which is computed by incorporating Allen's finite difference approach into the finite volume method. It has been called the Unified Finite Approach Exponential Scheme, UNIFAES. A simple one-dimensional test case shows the scheme's ability to cope with irregular grids. The main test problem considered is the recirculating flow in a cavity due to a moving wall, where UNIFAES demonstrates accuracy superior to the conservative form schemes central differencing and simple exponential scheme.

Keywords: *CFD, Finite Volume, Finite Difference, UNIFAES, cavity problem*

COB764 A TIME SPLITTING METHOD FOR EVOLUTION EQUATIONS MODELLING BENARD CONVECTION / UM MÉTODO DE SEPARAÇÃO TEMPORAL DE VARIÁVEIS PARA EQUAÇÕES DE EVOLUÇÃO UTILIZADAS NA MODELAGEM DE CONVECÇÃO DE BENARD**J. Pontes***PEMM/COPPE/UFRJ, PO Box 68505, 21945--970 Rio de Janeiro, R. J, Brazil jopontes@metalmat.ufrj.br*

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Pattern formation in a thin layer of fluid heated by below is often studied by numerical integration of nonlinear parabolic equations, containing fourth-order space-derivatives in the x and the y directions. A finite-difference semi-implicit coordinate-splitting scheme of first order in time and of second order in space is developed and applied to solving two such equations in finite geometries, namely the Swift-Hohenberg and the Knobloch equations. The construction of the scheme is accomplished by assigning terms to the implicit and to the explicit parts, and by replacing the spatial and time operators by discrete representations. The stability properties of the algorithm are defined at this stage. The scheme is splitted in two equivalent equations, to reduce the storage requirements. The resulting algebraic linear system displays a left hand side operator with a pentadiagonal structure and is solved by gaussian elimination with pivoting. Some results and a criteria to characterize the asymptotic state are presented.

Keywords: *Nonlinear Systems, Bénard Convection, Implicit Methods, Finite Difference Methods / Sistemas não-lineares, Convecção de Bénard, Métodos Implícitos, Método de diferenças finitas*

COB776 CELL-IMPLICIT NUMERICAL COMPUTATION OF FLOW FIELD AND HEAT TRANSFER IN INCLINED CAVITIES

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This paper reports numerical results for incompressible thermally-driven flows in tilted cavities obtained with a point-wise solution scheme. The discretized momentum equations are applied to each computational cell and then, together with the mass-continuity and energy equations, are solved directly for each grid node. The effect of cavity inclination on the thermal field is discussed upon. Flow pattern and mass residual behavior are also reported.

Keywords: *Tilted Cavities, CFD, Numerical Methods, Laminar Flow.*

COB786 COMPARAÇÃO ENTRE VÁRIOS ALGORITMOS DE FATORAÇÃO APROXIMADA NA SOLUÇÃO DAS EQUAÇÕES DE NAVIER-STOKES / COMPARISON OF SOME APPROXIMATE FACTORIZATION ALGORITHMS IN THE SOLUTION OF THE NAVIER-STOKES EQUATIONS

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The Navier-Stokes equations, written in conservative form, are applied to simulate the flow-field in a two-dimensional convergent-divergent transonic nozzle. A finite difference formulation is

used to perform the spatial discretization in a generalized coordinate system. The march in pseudo-time is performed by the implicit Euler method to obtain steady state solutions. Three implicit, approximately factored, difference schemes are described and tested in the present work. These include the standard Beam and Warming algorithm, Chaussee and Pulliam's diagonal version of it, and the Steger and Warming flux vector splitting scheme. Several options for spatial discretization of the split fluxes are studied in connection with the Steger and Warming scheme. The main objectives of the present work are to perform a comparative study of the different algorithms and to assess their cost/accuracy performance characteristics.

Keywords: *Equações de Navier-Stokes, escoamento em bocal, Esquemas Implícitos, Esquemas de Diferenças Centradas, Separação de Vetores de Fluxo / Navier-Stokes Equations, Nozzle Flow, Implicit Schemes, Central Difference Schemes, Flux Vector Splitting.*

COB794 ANÁLISE DO ESFORÇO COMPUTACIONAL DE SOLUÇÕES MULTIGRID DE PROBLEMA CONDUTIVO-CONVECTIVO / COMPUTATIONAL EFFORT ANALYSIS OF MULTIGRID SOLUTIONS OF CONDUCTIVE-CONVECTIVE PROBLEM

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Multigrid methods have been used for predicting flows achieving considerable computational time savings. In the present paper, a multigrid method has been applied to a finite-volume numerical solution of a 2-D conductive-convective problem. Structured and regular grids of different sizes were employed. Internodal interpolation has been achieved through the *Weighted Upstream Differencing Scheme*, which depends upon the computational Peclet number Pe . A study on the effect of the number of distinct grids on the overall algorithm performance is presented. Also reported is a comparative study of the computational effort as a function of Pe .

Keywords: *Multigrid, Laminar flow, Convergence acceleration, Finite-volume, Malhas múltiplas, escoamento laminar, Aceleração da convergência, Volumes finitos.*

COB1018 ANÁLISE DO DESEMPENHO DE DIFERENTES MÉTODOS PARA CALCULAR GRADIENTES EM MALHAS NÃO ESTRUTURADAS DE VORONOI / ANALYSIS OF PERFORMANCE OF DIFFERENTS METHODS TO CALCULATE GRADIENTS IN VORONOI UNSTRUCTURED MESH

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This paper presents an investigation on the solution of the linear systems arising from the numerical discretization of the Navier-Stokes equations through Voronoi grids. Three techniques are utilized and compared for evaluation of the pressure gradients: the minimum squared residue, the

weighted mean between the projected normal gradients (MPGNP) and the modified weighted mean between the projected normal gradients, through a modification of the MPGNP. They are validated, adopting for the case of the incompressible flow in square cavity with sliding upper wall (driven cavity) with slide upper wall. All numerical results are obtained in distinct geometrical grids.

Keywords: *Navier-Stokes, Voronoi grids, pressure gradients / Navier-Stokes, diagramas de Voronoi, gradientes de pressão.*

TEMA 45 - Métodos Estocásticos e Estatísticos**COB802 PREDIÇÃO DE MOVIMENTO DE VEÍCULOS OCEÂNICOS / THE TIME PREDICTION OF OCEAN VEHICLES MOTION****Helio Mitio Morishita***Departamento de Engenharia Naval e Oceânica, Escola Politécnica, USP**Av. Prof. Mello Moraes, 2231 CEP 05508-900, São Paulo, Brasil - E-mail: hmmorish@usp.br*

The study of the time prediction of ocean vehicle motions has always attracted the attention of naval architects due to its potential application to improve the performance of control systems of certain marine operations. The motion of an ocean vehicle is due to random action of wave and wind and it is influenced by its speed and load. Therefore, the vessel dynamics can be adequately modelled as a time variant stochastic system and an attempt to predict its motions can be based on adaptive approach developed to stochastic systems. In this paper the prediction of a ship roll motion based on an ARMA model is analysed. The coefficients of the model are estimated using the recursive prediction error method. The study is carried out using data collected during sea trial of a ship and a potential application is shown in the landing of a helicopter on the vessel.

Keywords: *estimação recursiva, predição adaptativo, movimento de navios, recursive estimation, adaptive prediction, ship motion.*

COB1191 FLUXO DE ENERGIA VIBRATÓRIA ENTRE CHAPAS REFORÇADAS POR VIGAS / POWER FLOW BETWEEN BEAM-REINFORCED PLATES**Acir Edvam Ozelame & Arcanjo Lenzi***Laboratório de Vibrações e Acústica (LVA) Depto de Engenharia Mecânica, UFSC, cp. 476 - CEP 88040-900 - tel. 048 234 0689 - fax 048-234 1519 - Florianópolis - SC, email: arcanjo@emc.ufsc.br***Ayres Elias Sada***CENPES - PETROBRÁS - Ilha do Fundão, Rio de Janeiro, RJ*

This work deals with modal density and coupling loss factors analysis of beam reinforced plates, by Finite Elements. The reinforcing beams were placed parallel and orthogonal direction with respect to the junction line. Experimental results showed good agreement with numerical predictions.

Keywords: *Análise Estatística Energética, Fator de Acoplamento, Placa Reforçada por Vigas, Fluxo de Energia / Statistical Energy Analysis, Coupling Loss Factor, Beam Reinforced Plates, Power Flow.*

COB1195 APLICAÇÃO DA ANÁLISE ESTATÍSTICA ENERGÉTICA PARA A PREDIÇÃO DOS NÍVEIS DE VIBRAÇÃO ESTRUTURAL E DE RUÍDO EM PLATAFORMAS OFFSHORE / APPLICATION OF STATISTICAL ENERGY ANALYSIS FOR NOISE AND VIBRATION LEVELS PREDICTION IN OFFSHORE PLATFORMS**L. C. de Souza, A. Lenzi e E. L. Sztajnbok***Depto. Eng. Mecânica, Universidade Federal de Santa Catarina - UFSC, CEP 88010-970 Florianópolis, Santa Catarina, Brasil**E-mail: lucianosouza@hotmail.com, Fone 048 - 234 0689, Fax 048 - 234 1519*

High Noise and Vibration levels usually existent in offshore platforms can cause severe discomfort and stress problems to their occupants. The vibrations of large machines and equipments transfere large amounts of vibratory energy to the main structure which is propagated throughout the platform generating unpleasant noise levels. This work describes the characteristics of a software, based on Statistical Energy Analysis - SEA, for predicting noise levels at the accommodation area. Results are compared to those measured in operating platforms. An anlysis of some related parameters is also presented.

Keywords: *vibração, ruído, análise estatística energética, plataforma offshore, microstation / vibration, noise, statistical energy analysis, offshore plataform, microstation.*

TEMA 46 - Modelagem**COB21 MODELAGEM E SIMULAÇÃO DO FENÔMENO DE ENDURECIMENTO POR PRECIPITAÇÃO EM BARRAS DE ALUMÍNIO/MODELING AND SIMULATION OF PRECIPITATION HARDENING PHENOMENON IN ALUMINIUM BARS****Cláudia Maria Imbroizi Ajús & Heraldo S. Costa Mattos***Laboratório de Mecânica Teórica e Aplicada, Departamento de Engenharia Mecânica, Universidade Federal Fluminense - UFF, CEP 24.210-24 Niterói / RJ, Brasil - E-mail: heraldo@caa.uff.br*

The present work is concerned with the modeling of the coupling between the aging hardening phenomenon and the elasto-plastic behavior in aluminium bars. Such a microstructural process, caused by the diffusion of precipitates in the solid matrix, has a very strong influence on the yield stress, affecting the hardening behavior. The plastic deformation, on the other side, affects the velocity of precipitation (aging). The coupling between these phenomena is described through a constitutive theory in which an additional variable, related with the parcel of the isotropic hardening caused by aging, is introduced. To check the potentiality of the proposed theory, examples concerning 2024 aluminium bars are presented and analyzed, showing a good agreement between experiments and model prevision.

Keywords: *Elasto-plasticity, aluminium-copper alloys, age hardening, precipitation hardening / elastoplasticidade, ligas de alumínio - cobre, envelhecimento, endurecimento por precipitação.*

COB98 SELEÇÃO DE ESTADOS EM REDUÇÃO DE MODELOS COM REALIZAÇÃO BALANCEADA / STATES SELECTION IN MODEL REDUCTION VIA BALANCED REALIZATION**Edvaldo Assunção***Departamento de Engenharia Elétrica, Faculdade de Engenharia - UNESP - Ilha Solteira CEP 15.385-000 Ilha Solteira, SP, Brasil - E-mail: edvaldo@dee.feis.unesp.br***Pedro L. D. Peres & Paulo A. V. Ferreira***Departamento de Telemática, Faculdade de Engenharia Elétrica e de Computação - UNICAMP CP 6101, CEP 13.081-970 Campinas, SP, Brasil - E-mail: {peres.valente}@dt.fee.unicamp.br***Elder M. Hemerly***Instituto Tecnológico de Aeronáutica - CTA - ITA - IEEF CEP 12228-900, São José dos Campos, SP, Brasil - E-mail: hemerly@ele.ita.cta.br*

This work evaluates the performance of two different techniques for selecting the states to be maintained in the reduced model obtained through balanced realization. The model reduction method via balanced realization is presented, and a criterion that takes into account the reduced model impulse response is proposed. The main advantage of this criterion is that it considers not only the singular values, but also the coefficients of the dynamic system output matrix. An example is presented, indicating the better performance of proposed criterion when compared with the classical one adopted in the balanced realization.

Keywords: *sistemas dinâmicos, redução de modelos, realização balanceada, resposta ao impulso / dynamic systems, model reduction, balanced realization, impulse response*

COB160 HEAT TRANSFER COEFFICIENT AT THE METAL-MOULD INTERFACE IN THE SOLIDIFICATION OF Cu-8%Sn ALLOYS**Marcelo de Aquino Martorano & José Deodoro Trani Capocchi***Departamento de Engenharia Metalúrgica e de Materiais - Escola Politécnica - USP - São Paulo - CEP 05508-900 Cidade Universitária, São Paulo, Brasil - E-mail: martoran@usp.br, jdtcapoc@usp.br*

The heat transfer coefficient at the metal-mould interface during the directional solidification of a Cu-8%Sn alloy was calculated using the whole domain method for the inverse solution of the heat conduction differential equation. The finite control volume method was employed in the numerical procedure to solve the two dimensional differential equation and a least squares procedure was used for the whole domain method. The estimated heat transfer coefficient values are in good agreement with published ones and a sensitivity analysis is carried out to assess the coefficient accuracy. The present method has proved to be satisfactory as regards stability and accuracy.

Keywords: *Heat transfer coefficient; Inverse heat conduction; Mathematical modelling; Metal-mould interface; Solidification*

COB189 UTILIZAÇÃO DA DECOMPOSIÇÃO DE VALOR SINGULAR NA REDUÇÃO DO NÍVEL DE RUÍDO EM SÉRIES TEMPORAIS / NOISE REDUCTION IN TIME SERIES BY USING SINGULAR VALUE DECOMPOSITION**Heraldo Nélio Cambraia***Departamento de Mecânica - Centro Politécnico - UFPR, CEP 81531-990 - Curitiba - PR - E-mail: heraldo@demec.ufpr.br*

This work shows how Singular Value Decomposition (SVD) can help to reduce the level of Gaussian white noise in time series. The procedure here employed consists of using a dynamic to the data by means of an embedding in an Euclidian space, and information about this dynamic are organized in the so called trajectory matrix. The questions about the dimension and noise reduction can be discussed by studying the rank of the trajectory matrix, and the question about the rank of the trajectory matrix by SVD.

Keywords: *Noise reduction, dimension, singular value decomposition.*

COB200 VIBRAÇÕES INDUZIDAS PELO DESBALANCEAMENTO DE UM VENTILADOR CENTRÍFUGO, SOB INFLUÊNCIAS DE UMA FUNDAÇÃO EMBUTIDA E DOS MANCAIS COM FILME DE ÓLEO / FOUNDATION AND JOURNAL BEARINGS CONSIDERATIONS IN THE VIBRATION INDUCED BY UNBALANCED CENTRIFUGAL FAN**Luciana Raquel C. da Silva, Alexandre Augusto Simões***Departamento de Engenharia Mecânica, Escola Federal de Engenharia de Itajubá - EFEI - Itajubá CEP 37.500.000, Brasil - E-mail: simoes@iem.efei.rmg.br*

This paper presents a simplified dynamic interaction analysis of a fan supported by journal bearings and its foundation. The interaction changes the rotor-bearing critical speed and so the fan manufacturer may specify the foundations requirements or an improper foundation would result. The same will occur to the predicted resonance frequencies to the foundation-soil interaction. So this procedure can help the understanding between the fan manufacturer and the designer of the foundation. The simplified model is of minimal time consuming and is convenient during the early project. The bearing data, obtained from computerized solutions of the lubrication equations, and the soil dynamics data are used as input to the model. The unbalance response of the entire system is considered as measured at the bearings.

Keywords: *ventilador, mancal, fundação, foundation, fan.*

COB208 CÁLCULO DE FORÇAS EM MANCAIS MAGNÉTICOS COMPARAÇÃO DE RESULTADOS / FORCE CALCULATION IN MAGNETIC BEARINGS - COMPARISON OF RESULTS

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Magnetic bearings have been regarded as a very good alternative for the support of rotors in various industrial branches, where some of their special characteristics have helped to solve problems in pre-existent technologies and arising new ones. The modeling of magnetic field in these bearings furnishes the correlation between the rotor support forces and the winding current and allows for an improved simulation and design of the device and its control system. Comparisons between finite element analysis, analytical and experimental results are presented.

Keywords: *Mancais Magnéticos, Mapeamento de Campo, Forças de Sustentação do Rotor, Elementos Finitos / Magnetic Bearings, Field Modeling, Rotor Support Forces, Finite Elements.*

COB360 UM MODELO PARA A PREVISÃO DAS TENSÕES RESIDUAIS INTRODUZIDAS PELO PROCESSO DE TÊMPERA EM AÇOS / A MODEL TO PREDICT RESIDUAL STRESSES INTRODUCED BY THE QUENCHING PROCESS IN STEELS

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Quenching is a process associated with phase transformation. It generates internal stresses, which can produce warping and even cracking the body. Hence, it is very important to develop an analysis that permits predictions of internal stresses in steel during quenching. Two types of modification occur when phase transformation takes place under an applied stress. The first type is a kinetic modification and sometimes leads to a different morphology in the phase produced. The second is a mechanical modification related to the progress of transformation, and takes place when plastic deformation occurs under stresses lower than material yield stress. For mechanical modeling, metallurgical and mechanical upsetting of the metal must be incorporated into the model along with the effect on the stresses appearing during cooling. Current work discusses the quenching modeling in uniaxial context. Thermomechanical coupling is considered. A numerical procedure is developed and some numerical results are presented.

Keywords: *Quenching, Residual Stresses, Elastoplasticity, Modeling, / Têmpera, Tensões Residuais, Elastoplasticidade, Modelagem.*

COB371 A NON-EXPLOSIVE RELEASE DEVICE FOR AEROSPACE APPLICATIONS USING SHAPE MEMORY ALLOYS

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Aerospace applications use pyrotechnic devices with many different functions. Functional shock, safety, overall system cost issues, and availability of new technologies, however, question the continued use of these mechanisms on aerospace applications. Release device is an important example of a task usually executed by pyrotechnic mechanisms. Many aerospace applications like satellite solar panels deployment or weather balloon separation need a release device. Several incidents, where pyrotechnic mechanisms could be responsible for spacecraft failure, have been encouraging new designs for these devices. The Frangibolt is a non-explosive device which comprises a commercially available bolt and a small collar made of shape memory alloy (SMA) that replace conventional explosive bolt systems. This paper presents the modeling and simulation of Frangibolt. This analysis may contribute to improve the Frangibolt design.

Keywords: *Shape Memory Alloys, Aerospace Applications, Release Device, Frangibolt.*

COB654 MODELAGEM PARALELA E DISTRIBUIDA DE SÉRIES TEMPORAIS EM SUBESPAÇOS DO ESPAÇO DE ESTADO / PARALLEL AND DISTRIBUTED MODELING OF TIME SERIES IN SUBSPACES OF THE STATE SPACE

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In this paper a procedure using a subspace method developed by Aoki (1990) for multivariate time series state space modeling high performance computing is proposed. The resulting algorithm allows the obtention of the triple of matrices (A; B and C), for the state space model for multivariable time series, using singular value decomposition of the Hankel matrix, obtained from data of the time series we intend to model. This contribution aims the viabilization of applications to large scale systems needing real time multivariate time series modeling.

Keywords: *State space, time series, identification, modeling, state estimation / Espaço de estado, séries temporais, identificação, modelagem, estimação de estado.*

COB701 MODELING OF PIG MOTION UNDER TRANSIENT FLUID FLOW**Eijiro Vianes Campo & Felipe Bastos De Freitas Rachid**

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This paper presents a very simple, from the mechanical and mathematical viewpoints, model to predict pig motion driven by transient incompressible fluid flows. Mechanical and hydrodynamical friction forces, inertia effects of both pig and fluid, operational characteristics of equipment installed in the line as well as other features are properly taken into account. Numerical simulations carried out for a representative problem illustrate the model capability of describing some non-trivial peculiar behaviors related to pig motion.

Keywords: *Pig Motion Modeling; Transient Regime; Incompressible Flow.*

COB851 REPRESENTAÇÃO DA INTERAÇÃO ENTRE ELEMENTOS FLEXÍVEIS E RÍGIDOS NO PROBLEMA DA DINÂMICA DE ROTORES / REPRESENTATION OF THE INTERACTION BETWEEN FLEXIBLE AND RIGID ELEMENTS IN THE ROTOR DYNAMIC PROBLEM**Fernando Ribeiro da Silva & Carlos Frederico Pacheco Furtado**

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The rotor dynamics problems have been developed using the classical methodologies of the structural analysis (the Finite Element Method) with the procedures of the rigid body dynamic. In this work we use an alternative procedure with the generalized technique of Bond Graphs, presenting advantages like modularity and facility to obtain the mathematical model of the global system. We present some results for a typical problem of the rotor dynamics.

Keywords: *Rotor dynamics, Dynamic Systems, Bond Graphs / Dinâmica de Rotor, Sistemas Dinâmicos, Grafos de Ligação.*

COB864 A LOOP-BASED DATA STRUCTURE FOR B-REP SOLID AND WIRE-FRAME MODELS**Angelo Roncalli O. Guerra***Departamento de Engenharia Mecânica, Universidade Federal do Rio Grande do Norte - UFRN- PPGEM
CEP 59072-970, Campus Universitário, CT-DEM, Natal-Rn, Brazil - E-mail: ang@ct.ufrn.br***S. Hinduja & P. T. Ling***Co-authors from the Department of Mechanical Engineering, UMIST, Manchester, UK.*

This paper describes a data structure for representing objects in the B-rep form. The data structure is loop centred, rather than edge centred. Its highlight is the achieved reduction in storage cost when compared with current enhanced edge-based implementations and yet being able to represent non-polyhedral objects efficiently. Since the edges in a loop are explicitly stored, face traversals are relatively straight-forward. The loop based data structure can also represent 2D wireframe based objects. This data structure has been used as the heart of TTM (Techoturn Techmill Modeller) which is an academic solid modeller developed for two very large technologically oriented CAPP systems already published in the literature.

Keywords: *Data Structure, Solid Modelling, CAD/CAM.***COB871 DINÂMICA DE VEÍCULOS COMERCIAIS COM SUSPENSÃO DO TIPO PIVOTAMENTO OSCILANTE E TRAÇÃO 6X4 / DYNAMIC OF COMMERCIAL VEHICLES WITH WALKING-BEAM SUSPENSION AND 6X4 TRACTION SYSTEM****Antônio Carlos Canale***USP - EESC, São Carlos - SP, Brasil - E-mail: canale@sc.usp.br***Hélio Aparecido Navarro***UNESP - IGCE - DEMAC, Rio Claro - SP - E-mail: helio@demac.igce.unesp.br***Nicolas Basile Valtas, José Roberto Saraiva & José Eduardo D'Elboux***Mercedes-Benz do Brasil S.A., São Bernardo do Campo-SP, Brasil*

The aim of this paper is to analyse the response of the commercial vehicle to the forces produced by the transmission system. The calculation model for the ideal distribution of the driving force is presented for bus, truck and tractor-trailer combinations. For the tractor, the forces acting on an accelerating vehicle in case of three-axle with walking beam suspension are considered. The proposed model considers the resistance forces (drag, rolling resistance, translation and rotation acceleration, climbing resistance) and traction system 6x4. The center of gravity of the vehicle, the dynamic driving forces, the dynamic axle load and the resistance forces are determined. This work analyses one of the Mercedes-Benz do Brasil trucks with traction system 6x4. The comparison of ideal and real distribution of driving forces and tire-road friction utilization are presented.

Keywords: *Veículos rodoviários comerciais, modelagem, métodos numéricos em engenharia, suspensão do tipo pivotamento oscilante / Road commercial vehicles, modeling, numerical methods in engineering, walking-beam suspension.*

COB991 UM MODELO NUMÉRICO PARA IMPACTO NORMAL DE UM SÓLIDO PRISMÁTICO RETANGULAR CONTRA UM SOLADO DE BORRACHA / A NUMERICAL MODEL TO NORMAL IMPACT OF A RECTANGULAR PRISMATIC SOLID AGAINST A RUBBER FLOOR

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The aim of this work is the development and implementation of a theoretical-numerical model to represent a impact of a rectangular prismatic solid against a rubber floor. The media are represented by a truss-like discrete model with mass concentrated at nodal position and with correspondent stiffness so that the modeled continuum presents the same coefficients. The results are obtained by direct integration of equations of motion using central finite differences, explicit way. The contact problem is solved using an algorithm that recognizes the situation.

Keywords: *Impact, finite differences, modelling, rubber / impacto, diferenças finitas, modelagem, borracha.*

COB1016 CÁLCULO DE SISTEMAS DE AQUECIMENTO POR INDUÇÃO PELO MÉTODO DOS CIRCUITOS MUTUAMENTE ACOPLADOS / MUTUALLY COUPLED METHOD FOR THE CALCULATION OF INDUCTION HEATING SYSTEMS

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This paper deals with a numerical method based on the couples equivalent circuit for the calculation of axially symmetric induction heating systems. Using a procedure for the calculation of the self and mutual inductances, it is possible to calculate the currents, even in the case of complex configurations and with no limits on the choice of the subdivision elements.

Keywords: *Tratamento térmico; Indução; Método de Cálculo / Heat Treatment, Induction, Calculation Method.*

COB1214 SIMULAÇÃO NUMÉRICA DO COMPORTAMENTO DE "PUFFS" PARA REPRESENTAR A DISPERSÃO DE GASES PESADOS NA ATMOSFERA / NUMERICAL SIMULATION OF BEHAVIOUR OF PUFFS FOR REPRESENT THE ATMOSPHERIC DISPERSION OF DENSE GASES

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The releases of the heavy gases at ground level into the atmosphere can have all kinds of behaviour, that is a release can be instantaneous, continuous or intermittent. In this paper is showing a simple model, that can describe these all kinds of releases. The releases continuous or intermittent are represented in the model as succession of instantaneous releases (the puff model). This puffs are summed up and combined to form continuous or intermittent releases. The heavy gas puff is represented by a bulk mathematics model as a cylinder of heavy gas with homogenous properties profiles of the speed, temperature and density (the composition of puff) in his interior (box model). The puffs sum and combination process is showing for representation of a heavy gas continuous release with constant rate. In the later of the paper the numerical results obtain with the model are compared with the field experimental data available in the literature for continuous releases of the liquefied natural gas (LNG) and the liquefied petroleum gas (LPG).

Keywords: *Gases pesados, dispersão atmosférica, excesso de densidade, modelo de "puff".*

COB1250 SIMULAÇÃO NUMÉRICA DE PROCESSOS EM FORNALHAS PARA SECAGEM DE GRÃOS / NUMERICAL SIMULATION OF THE PROCESS OF FURNACE DRYING CEREALS

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The mathematical model, developed by the authors in previous works, apply to prevent the furnace main features of drying cereals, depending on the functioning regime parameters. The comparison was done with experimental data and the process features behavior were explained. The possibility to prevent the abnormal regime is showed and also its explanation.

Keywords: *Furnace, Modelling, Combustion, Heat Transfer, Hydraulic loss / Fornalha, Modelagem, Combustão, Transferência de Calor, Perdas Hidráulicas.*

TEMA 47 - Redes Neurais Artificiais**COB169 INTELIGÊNCIA COMPUTACIONAL APLICADA À MODELAGEM DE UM TURBO-GERADOR: ABORDAGEM NEURAL E EVOLUTIVA / COMPUTATIONAL INTELLIGENCE APPLIED FOR MODELLING OF A TURBOGENERATOR: NEURAL AND EVOLUTION APPROACHES****Leandro dos Santos Coelho & Antonio Augusto Rodrigues Coelho***Departamento de Automação e Sistemas, UFSC, Caixa Postal 476**CEP 88040.900 Florianópolis, Brasil -E-mail: [lsc Coelho; aarc]@lcmi.ufsc.br*

This paper evaluates the application of computational intelligence methodologies in a nonlinear process identification. The different intelligent methodologies are evolutionary computation and artificial neural networks (feedforward and recurrent topologies). The simulations are realized in the identification of a turbogenerator mathematical model through a step signal, pseudo-random binary sequence, and white noise excitation signals. The performance of the techniques are presented and discussed.

Keywords: *Process Identification, Evolutionary Computation, Genetic Algorithms, Evolution Strategies, Artificial Neural Networks / Identificação de Processos, Computação Evolucionária, Algoritmos Genéticos, Estratégias Evolutivas, Redes Neurais Artificiais.*

COB170 CONTROLADORES NEBULOSO E NEURAL COM OTIMIZAÇÃO EVOLUTIVA: METODOLOGIAS E APLICAÇÃO / FUZZY AND NEURAL CONTROLLERS WITH EVOLUTION OPTIMIZATION: METHODOLOGIES AND APPLICATION**Leandro dos Santos Coelho & Antonio Augusto Rodrigues Coelho***Departamento de Automação e Sistemas, UFSC, Caixa Postal 476 - CEP 88040.900 Florianópolis, Brasil**E-mail: [lsc Coelho; aarc]@lcmi.ufsc.br*

This paper presents, evaluates and compares different intelligent strategies in process control. The design and configuration of the controllers is realized by the following hybrid methodologies: i) fuzzy control with evolutionary optimization of membership functions and, ii) control via Elman recurrent topology with evolutionary training. The evolutionary hybridization of the controllers is realized through the optimization and tuning, which in turn are set by, evolution strategies with self-adaptation mechanisms. Experimental tests are conducted to analyse the control techniques for dealing with a nonlinear system in a liquid-level regulation submitted to reference and load disturbances.

Keywords: *Intelligent Control, Evolution Strategies, Fuzzy Control, Neurocontrol, Level plant / Controle Inteligente, Estratégias Evolutivas, Controle Nebuloso, Controle Neural, Planta de Nível.*

COB282 CAVITATION DETECTION IN HYDROTURBINES USING NEURAL NETWORKS**Shih Man Lin, João Souza Neto, Antonio C. P. Brasil & Danilo Santos**

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This paper refers to the development of a methodology to detect cavitation in hydroturbines using a neural network strategy. Both experimental tests and theoretical analysis were carried out. Initially, the methodology of mapping the cavitation regimes in Francis turbines was proposed and tested. The neural network reproduced satisfactorily the different types of cavitation. A real scale experiment was also performed in a 160 MW Francis Turbine in operation at the electric power station in Ilha Solteira/São Paulo (CESP). Acoustic sensors were used to perform preliminary tests on cavitation radiated noise, in order to detect cavitation for different conditions of turbine operations. The neural network methodology was also proposed to analyze these experimental data. A description of laboratory facilities and some results obtained up to this moment can also be found in this paper.

Keywords: *Cavitation, TurboMachinery, Neural Networks and Neuro-Genetic Systems/Cavitação, Máquinas Hidráulicas, redes neurais e sistemas neuro-genéticos.*

COB410 REDES NEURAIIS APLICADAS AO CONTROLE DE ATITUDE DE SATÉLITES ARTIFICIAIS COM APÊNDICES FLEXÍVEIS / NEURAL NETWORK APPLIED TO ATTITUDE CONTROL FOR ARTIFICIAL SATELLITE WITH FLEXIBLE APPENDAGES**Sebastião E. C. Varotto & Atair Rios Neto**

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This work demonstrates that artificial neural networks can be used effectively for satellite attitude dynamics identification and control. In order to exemplify this application, a satellite with a rigid main body, three reaction wheel and three flexible solar panel was chosen (lay-out similar to Brazilian Remote Sensing Satellite) The main objectives of this work are to test the neural control and analyze the interaction between the control system and the elastic motion of the satellite solar arrays. The equations of motion were derived by the Lagrangian approach for quasi-coordinates (rotational motion) and for generalized coordinates (elastic motion). The identification of neural nets parameters is performed by Kalman filtering algorithm with a local parallel processing version.

Keywords: *Redes neurais artificiais, sistemas não lineares, filtro de Kaman, controle de atitude. Artificial neural networks, non-linear system, Kalman filtering, satellite attitude control.*

COB487 DETECTION OF STATE-SPACE PARAMETER PERTURBATION USING RECURSIVE NONLINEAR ESTIMATORS**Belisário Nina Huallpa & Eurípedes Nóbrega***DMC-FEM-UNICAMP - Brazil - Caixa Postal 6122 - CEP: 13083-970 - email: beli@dmc.fem.unicamp.br, egon@dmc.fem.unicamp.br***Fernando José Von Zuben***DCA-FEEC-UNICAMP - Brazil - Caixa Postal 6101 - CEP: 13083-970 - email: vonzuben@dca.fec.unicamp.br*

The problems of parameter estimation and perturbation detection are central to dynamic system identification. The purpose of this paper is to present a robust numerical tool designed to detect permanent parameter perturbation on nonstationary dynamic systems. The main component of the detection apparatus is a Hopfield neural network operating as a recursive nonlinear parameter estimator. At the first step, the Hopfield neural network is applied to estimate the initial parameter values in the state-space model of the dynamic system. The resulting state-space parameter obtained after convergence are assumed to be the nominal parameter for that application. It is necessary to let the estimation process converge to the nominal values before starting the detection of parameter perturbation. So, after convergence, sensitivity analysis is recursively applied to promptly detect any kind of significant perturbation in each output of the Hopfield neural network, with transient perturbations being discarded. The detection process must be robust and flexible enough to deal with a large range of dynamic behavior, because the shape and magnitude of the permanent perturbation, together with its effect on the dynamic system, cannot be properly anticipated.

Keywords: *Hopfield neural network, state-space models, parameter estimation, permanent perturbation detection / Redes de Hopfield, modelos de espaço de estados, estimação de parâmetros, detecção de perturbação permanente.*

COB643 MODELAGEM DO PROCESSO DE USINAGEM POR FRESAMENTO UTILIZANDO REDES NEURAIS / MODELLING MILLING MACHINING PROCESS USING NEURAL NETWORK PROCEDURE**André L. B. Dos santos, Marcus A. V. Duarte e Carlos R. Ribeiro***Departamento de Engenharia Mecânica - Universidade Federal de Uberlândia
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Usually Taylor's equation is one of the most used models to represent the tool life in machining processes. Unfortunately, the great deal of cutting tools available as well as the large range of cutting conditions together with the complexity of some machining processes, all make the reliability of the results obtained via this equation limited. This work presents a neural network procedure in order to estimate the cutting tool life for milling operation. ABNT 1045 steel bars and triple coated cemented carbide tools were used in order to validate the proposed methodology. The results indicate that the suggested neural network procedure provide a considerable reduction in the erro when predicting the machining time and when compared with those obtained from optimization procedures.

Keywords: *Equação de Taylor, Vida da Ferramenta de Corte, Fresamento, Modelagem Utilizando Redes Neurais, Experimento Ótimo / Taylor's Equation, Cutting Tool Life, Milling, Modelling, Neural Network, Optimal Experiment.*

COB687 IDENTIFICAÇÃO DE MODELOS DINÂMICOS DE SATÉLITES COM GEOMETRIA VARIÁVEL ATRAVÉS DE REDES NEURAIS / VARIABLE GEOMETRY SATELLITE DYNAMICS IDENTIFICATION WITH NEURAL NETWORKS

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The use of neural networks for satellite attitude dynamics identification is addressed in this work. In order to validate this application, a spacecraft with a variable dynamic behavior due to articulated appendages fixed to the body was chosen. The differential equations therefore show the nonlinear dynamic effects to be identified by neural nets. In this work some of the main expressions that allow system modeling through neural nets as well as a least squares based training procedure are presented. A general method for obtaining the inertia tensor and center of mass of an articulated space device, is also explained together with the dynamic and cinematic differential equations. These formulations were used in attitude simulation for neural network system identification and control training's.

Keywords: *Neural networks, satellite attitude, non-linear dynamics, system identification. Redes neurais, atitude de satélites, dinâmica não-linear, identificação de sistemas.*

TEMA 48 - Métodos Analíticos e Numéricos Aplicados

COB186 INTEGRAL TRANSFORM TECHNIQUE IN 2D DRYING PROBLEMS

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Multidimensional drying in capillary porous media is analytically solved for the associated temperature and moisture content distributions. Luikov's model with linear transport coefficients and two-dimensional plate geometry is adopted for description of the simultaneous heat and mass transfer phenomena. The generalised integral transform technique (G.I.T.T.) is employed in the automatically global error-controlled solution of the coupled partial differential equations, and the convergence behaviour of the proposed eigenfunction expansions is illustrated.

Keywords: *Integral Transform Method. Simultaneous Heat and Mass Transfer. Porous Media. Thermophysics. Drying. Luikov Problem. Método da Transformada Integral / Transferência Simultânea de Calor e Massa Meios Porosos Termodinâmica Problema de Secagem de Luikov.*

COB210 OPTIMIZATION OF FORCED DYNAMIC SYSTEM RESPONSE: THE MINIMUM VIBRATION PROBLEM / OTIMIZAÇÃO DA RESPOSTA FORÇADA DE UM SISTEMA DINÂMICO: O PROBLEMA DA VIBRAÇÃO MÍNIMA

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We introduce an optimization model and an approximation method to minimize the maximum vibration amplitude of multi-degree-of-freedom dynamic system. This system is discrete, linear and time-invariant. It is represented by the motion equation in the state-space form and characterized by modes. The presented optimization model corresponds to a global optimization problem. We develop simulated tests involving forced 3-dof-system response. At the end we present the results, discuss applications and next developments.

Keywords: *Dynamic system, the minimum vibration problem, global optimization, heuristic algorithm, vibration analysis / Sistemas dinâmicos, o problema da vibração mínima, otimização global, algoritmo heurístico, análise de vibração.*

COB211 STOCHASTIC GRADIENT PROJECTION METHOD APPLIED TO AN EARTH MARS ORBIT TRANSFER PROBLEM

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A reviewed version of a stochastic gradient projection method is applied to an Earth Mars orbit transfer problem. Suboptimal open loop solutions are obtained by parameterization of the control and reduction of the dynamic optimization problem to one of nonlinear programming in each iteration of the numerical solution. A typical iteration is done by direct search and treated as a stochastic optimal linear parameter estimation problem. Random errors model the level of accuracy expected in the satisfaction of boundary constraints. Search increment determination is then done using a Gauss-Markov estimator in Kalman form. The resulting method is a stochastic version of the projection of the gradient that has the feature of inherently and automatically taking in account different specified errors in satisfaction of constraints. Numerical tests indicate that the method can produce results of quality comparable to that of an indirect numerical method.

Keywords: *Suboptimal control, Stochastic projection of the gradient, Orbit transfer, Earth Mars orbit transfer.*

COB312 MODELO DE LOCALIZAÇÃO INTEGRADA DE TÉRMICAS COM OBJETIVOS MÚLTIPLOS / MODELLING OF INTEGRATED THERMAL POWER PLANTS SITING WITH MULTIPLE OBJECTIVES

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The software LITOM was developed as a tool for the selection of appropriate alternatives for thermal power generation. Both qualitative and quantitative information are taken into account for the identification of the combination of site, fuel and technology. The software furnishes several alternatives sorted according to the criteria established by the user. A brief description of the software is presented in this work along with some results.

Keywords: *Usinas Termoeletricas; Localização; Seleção; Software para Seleção e Localização de Termoeletricas; LITOM / Thermal Power Plants; Siting; Selection; Software for Selection and Siting; LITOM.*

COB314 HOW TO CHOOSE EIGENVALUE PROBLEMS WHEN USING GENERALIZED INTEGRAL TRANSFORMS TO SOLVE THERMAL CONVECTION-DIFFUSION PROBLEMS

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This work presents mathematical aspects of the theory of Generalized Integral Transforms. The main focus is directed toward on how to choose the auxiliary eigenvalue problems when solving thermal convection-diffusion type problems using such integral transforms. A class of problem considered here is mathematically modeled by a linear second order partial differential equation having

general boundary conditions of first, second and third kind; and initial condition. Basic ideas are given why is feasible truncate the infinite system in a sufficient large finite system. Once the analysis is performed, a sample problem is solved using two kinds of auxiliary eigenvalue problems. The Graetz convective-diffusive problem is considered as sample problem. It is solved in the classical manner using an auxiliary eigenvalue problem that leads to degenerate hypergeometric type eigenfunctions. It is also solved using a second auxiliary eigenvalue problem that leads to trigonometric type eigenfunctions. Among physical variables of interest are bulk fluid temperature, local axial Nusselt Number, and average Nusselt Number. Results for bulk fluid temperature and heat transfer are compared each other as well with data found in open literature.

Keywords: *Integral Transform, Eigenvalue Problem, Convection, Diffusion, Heat Transfer.*

COB721 OTIMIZAÇÃO DE UMA SUPERFÍCIE ALETADA UTILIZANDO UM ALGORITMO GENÉTICO / COOLING FINS OPTIMIZATION USING A GENETIC ALGORITHM

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Cooling fins have been usually used to guarantee a suitable heat transfer through a thermal surface. On the other hand, when cooling fins are used, increase the weight and costs of the equipments. It is very hard to obtain the optimal geometry with traditional optimization methods (linear and nonlinear programming). Genetic algorithms have been successfully used to find global solutions in complex spaces without derivative knowledge. This paper presents how a genetic algorithm can be used to find the optimum cooling fin geometry to maximize the heat transfer through a surface. The model is composed by a system of nonlinear equations with implicit boundary conditions.

Keywords: *Aletas ótimas, algoritmos genéticos, transferência de calor, otimização, métodos numéricos / Optimal cooling fins, genetic algorithms, heat transfer, optimization, numerical methods.*

COB768 TRANSIENT LAMINAR FORCED CONVECTION HEAT TRANSFER IN CIRCULAR AND PARALLEL-PLATES DUCTS OF HERSCHEL-BULKLEY FLUIDS

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The transient analysis of the thermal entry region in laminar forced convection heat transfer of Herschel-Bulkley fluids, within both circular and parallel-plates ducts, is analytically studied through the so-called Generalized Integral Transform Technique (GITT). A prescribed constant uniform wall temperature is considered for the boundary condition. Benchmark results for the local Nusselt numbers in regions very close to the duct inlet are established, for various rheological behavior parameters, such as power-law exponents and yield numbers, which are then confronted with the previous results in the recent literature.

Keywords: *Generalized Integral Transform Technique, Transient internal forced convection, Herschel-Bulkley fluids, Parallel-plates channel and circular tube.*

COB898 ANÁLISE DE CONVECÇÃO NATURAL NO ESPAÇO ANULAR DE DOIS CILINDROS CONCÊNTRICOS VERTICAIS / NATURAL CONVECTION ANALYSIS IN ANNULAR CAVITY BETWEEN TWO CONCENTRIC VERTICAL CYLINDERS

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This work deals with the study of heat transfer by natural convection, two-dimensional, laminar in annular cavity between two concentric vertical cylinders with the inner wall maintained at a higher temperature than the outer wall. The top and bottom wall are insulated. The finite element method is used for the solution of the conservation equations, in order to find the local and average Nusselt number together with the distributions of the stream function ψ , dimensionless temperature θ and vorticity w , as function of the thermal and geometrical parameters. Numerical results are obtained for Rayleigh numbers range from 10^4 to 10^5 , radius ratios from 2 to 10, and aspect ratios from 1 to 5. Prandtl number is kept constant at 0.7 in this study.

Keywords: *Natural Convection, Vertical Concentric Cylinder, Finite Element Analysis, Nusselt Number / Convecção Natural, Cilindros Verticais Concêntricos, Método de Elementos Finitos, Número de Nusselt.*

COB1019 PRECONDITIONED ITERATIVE TECHNIQUES FOR LINEAR SYSTEMS DERIVED TO SOLVE THE HEAT CONDUCTION PROBLEM IN VORONOI MESHES

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When practical problems involving fluid mechanics, heat transfer, etc., are solved numerically, systems of linear equations are generated and their matrices of coefficients are generally sparse and large. The present work compares the performance of the conjugate gradient method using the general purpose preconditioners for solving the linear systems resulting from the discretization of the heat conduction equation in unstructured Voronoi meshes. We use the Finite Volume Method. Three preconditioners are tested: Diagonal Scaling, Symmetric Successive Over-relaxation and Incomplete Cholesky Factorization. We analyze them through their distribution of eigenvalues, number of iterations and CPU time.

Keywords: *Preconditioning, Conjugate Gradient, Voronoi diagrams, linear systems, equation of heat conduction.*

COB1138 COMPORTAMENTO DINÂMICO DE VÁLVULAS TIPO PALHETA EM ESCOAMENTOS PERIÓDICOS / DYNAMIC BEHAVIOR OF REED TYPE VALVES IN PERIODIC FLOWS

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In the present work a numerical methodology is developed to simulate the dynamic behavior of reed type valves of reciprocating compressors used in refrigeration. A one-degree freedom model is adopted for the valve motion, and a finite volume methodology is employed to obtain the flow field through the valve. The valve dynamics and the time dependent flow field are coupled and solved simultaneously. The flow through the valve is assumed laminar, compressible, adiabatic and axisymmetric. In presence of the valve motion a numerical methodology was developed to take into account the variation with time of the computation domain. Through a coordinate transformation a moving coordinate system was obtained; this new system was able to expand and compress according to the valve displacement. Results for the force acting on the valve were obtained for a prescribed periodic velocity at the valve entrance. The complex interaction between mass flow rate through the valve and the distance between the reed and the valve seat affected the force on the valve in a non-periodic manner. The present model has proved to be effective and accurate in exploring the valve motion in disc-type valves.

Keywords: *Valve dynamics, compressor technology, none steady fluid flow, moving coordinate / Dinâmica de válvulas, tecnologia de compressores, escoamento transiente, coordenadas móveis.*

COB1381 ANÁLISE DINÂMICA DE ESTRUTURAS ENGASTADAS NO SEMI-ESPAÇO ATRAVÉS DO MÉTODO DOS ELEMENTOS FINITOS INCLUINDO O AMORTECIMENTO GEOMÉTRICO / DYNAMIC ANALYSIS OF STRUCTURES EMBEDDED IN A HALF-SPACE BY THE FINITE ELEMENT METHOD INCLUDING GEOMETRIC DAMPING

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The article compares the accuracy presented by the Finite Element Method using an infinite elements and Boundary Element procedures, based on influence functions to analyse the dynamic response of structures buried or embedded in a visco-elastic half-space. The infinite element shape functions were synthesised to encompass simultaneously the propagation of half-space body and surface waves. The numerical studies are conducted for a two-dimensional rigid rectangular foundation in the frequency domain. It is shown that the FE scheme produces good results, even for deeply buried foundations.

Keywords: *Infinite elements, Soil-Structure Dynamic Interaction, Finite Elements, Boundary Elements / Elementos Infinitos, Interação Dinâmica Solo-Estrutura, Elementos Finitos, Elementos de Contorno.*

TEMA 51 - Cinemática e Dinâmica

COB101 ANALYSIS OF THE DYNAMICS OF A MICROTURBINE USING HIGH SPEED FRAMING PHOTOMICROGRAPHY

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As a result of the rapidly growing field of microsystem technology numerous laboratory specimens of micro devices have been developed, mainly at universities and research institutes. However, many problems still exist in order to close the gap between these prototypes and their industrial mass production. The combination of available design methods and advanced testing setups is one of the reasons. An essential step prior to introduction into the market seems to be high speed framing photomicrography for testing of dynamic phenomena in microactuators. The cinematographic image sequences allow the extraction of position, velocity, and acceleration of moving parts in micro devices. The measured data can be used for identifying material parameters of a dynamic model of the microactuator under investigation. This experimental method in combination with model analysis is demonstrated for the highly dynamic behavior of a microturbine. The rotation and sliding of a microturbine is an extremely fast non-reproducible process considering that the turbine runs with approximately 200000 revolutions per minute. Therefore, the demands on the visualization equipment are very high. The setup for testing consists of a high speed camera, a powerful light source, and a suitable microscope. The extraction of information from kinematic data allows the estimation of parameters in a dynamic model of the microturbine. This leads to the improvement of the design and, consequently, to the improvement of quality and life time of the micro device.

Keywords: *Microturbine, high speed photomicrography, microscopy, dynamic model, parameter estimation.*

COB212 NONLINEAR DYNAMICS OF RODS: MOMENTUM AND ENERGY CONSERVING ALGORITHMS

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The long-term dynamics response of nonlinear geometrically rods undergoing finite bending, shearing and extension is considered in detail. The objective is the design of an unconditionally stable time-stepping algorithm which preserve fundamental constants of the motion namely the total linear and total angular momentums and, for the Hamiltonian case, the total energy. The variational form of the equations of motion is obtained through the Hamilton's principle and its discretized spatial form is achieved by the Finite Element Method. The resulting problem is numerically solved by the new implicit time integration scheme in connection with the Newton-Raphson Method. A numerical simulation is presented in order to assess the principal features of the formulation.

Keywords: *non-linear dynamics, rods, large deformations, conserving algorithms, dinâmica não-linear, grandes deformações.*

COB357 ANÁLISE DE IMPACTO EM UM SISTEMA MULTICORPO BI-DIMENSIONAL / IMPACT ANALYSIS OF A BI-DIMENSIONAL MULTIBODY SYSTEM**Tamotsu Hirata**

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This work presents an impact analysis of a bi-dimensional multibody consisting of a rotating flexible multiple section beam. The impact mechanism between two steel flexible bodies was investigated and the influence of structural stiffness and non linear surface stiffness were analysed. The mathematical model for the impact mechanism is based upon the energy balance method and the equations of motion are written by the bi-dimensional flexible multibody theory with Lagrangean formulation. The numerical simulation was performed using the MATLAB software. The results are presented in terms of time-displacement of the colliding bodies.

Keywords: *Impact mechanism, energy balance method, non linear surface stiffness, rotating flexible-rigid beam, bi-dimensional multibody.*

COB433 ON NONLINEAR VIBRATIONS OF A NONIDEAL 'ELECTROMOTOR-PENDULUM'**Débora Belato, José Manoel Balthazar, Hans Ingo Weber & Dean T.Mook**

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A system consisting of a pendulum with a support-point that is vibrated in a horizontal plane by a DC motor considered as a limited power source, is considered. For low velocities of the motor this system is nonideal, because the speed of the motor is influenced by the response of the system. In this condition, the planar oscillation of the pendulum is analysed as a control parameter is varied. The distinct regions of operation are defined and discussed in its nonlinear characteristics.

Keywords: *Nonideal system; Non-linear Dynamics; Pendulum / Sistema não ideal; Dinâmica não linear; Pêndulo.*

COB455 ESTUDO PRELIMINAR DE TRAJETÓRIAS DE REENTRADA DE UM MICROSATÉLITE RECUPERÁVEL / PRELIMINARY STUDY OF RE-ENTRY TRAJECTORIES FOR A RECOVERABLE MICROSATELLITE**Hanfried Schlingloff, Marcelo Curvo & Jaime Augusto Silva**

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This work deals with reentry trajectory simulation of a small satellite intended for microgravity experiments. The satellite is considered to be orbiting at an altitude of 300 kilometers above the

Earth on a circular orbit with small inclination (2.317°). Conditions at the deorbit point are specified and several trajectory simulations are made. A parametric study for preliminary design analysis is presented. It is seen that the reentry trajectory is very sensitive to the initial conditions established at the deorbit point. Dispersion minimization at impact point and vehicle's total range are considered. Final results are presented as well as a comprehensive analysis of the results obtained.

Keywords: *Fator de Carga, Microsatélite, Órbita, Pré Pára-quadras, Reentrada, Trajetória. / Load Factor, Microsatellite, Orbit, Pre-Parachute, Reentry, Trajectory.*

COB463 INFLUÊNCIA DE PALHETAS FLEXÍVEIS NA DINÂMICA DE SISTEMAS ROTATIVOS – TEORIA E EXPERIMENTO / INFLUENCE OF FLEXIBLE BLADES ON THE DYNAMICS OF ROTATING SYSTEMS – THEORY & EXPERIMENT

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This paper gives a theoretical and experimental contribution to the problem of coupled vibrations among rotor and long flexible blades. The design of a special test rig is presented, which enables a experimental validation of different mathematical models (unidimensional, bidimensional and tridimensional), normally used to describe the flexible blades' behavior in a rotating reference system. The blades are modeled as a particle (concentrated mass) connected to the rotor by means of flexible beams (without mass), using the Newton-Euler's Method. Comparing the results obtained with help of the mentioned test rig, the mathematical model could be validated in the frequency range of 0 to 40 Hz.

Keywords: *rotor dynamics, flexible blades' models, rotor-blades coupled vibrations, test rig/ dinâmica de rotores, modelagem de palhetas flexíveis, acoplamento vibratório, bancada de testes.*

COB666 MÉTODO DE OTIMIZAÇÃO DE PARÂMETROS DE ATRASO PARA ANÁLISE DE FLUTTER / LAG PARAMETERS OPTIMIZATION METHOD FOR FLUTTER ANALYSIS

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The equations of motion for the aeroelastic analysis of an aircraft contain unsteady aerodynamic terms which must be approximated by algebraic forms if they are to be written in the Laplace domain. The most common approximation involves rational functions, and several authors have used the so-called Padé functions. In most of the aerodynamic applications in literature, the numerator coefficients, i.e. the lag parameters, have been a priori specified over the desired reduced frequency limit, based on the engineer's own judgement. An alternative is to optimize these non-linear parameters, via non-linear programming techniques, to improve the approximations. In this work, the lag

parameters of the approximating function were optimised using the Nelder&Mead simplex method. This optimization was implemented in a existing program and the optimized and non-optimized results were compared.

Keywords: *Optimization, simplex, lag parameters, flutter, rational functions, unsteady aerodynamics / Otimização, simplex, parâmetros de atraso, flutter, funções racionais, aerodinâmica não-estacionária.*

COB673 RIGID BODY ROTATION EVOLUTION DUE TO DISTURBING TORQUE WHICH IS KNOWN IN A BODY FRAME

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This paper deals with the problem of rigid body rotation evolution under the action of a torque which depends on the projection of rigid body angular velocity on the body frame only. This is, so called, the rigid body with self-excitation. If the magnitude of the torque is arbitrary, the solution to the problem is known in the simplest cases only. The problem with small self-excitation is considered in the paper. This problem is of great importance from the standpoint of a number of applications in spacecraft and rigid body dynamics. In the case of small torque is it possible to use perturbation methods to obtain complete analytical and geometrical description of the rotation. In this paper the common approach to investigate the problem of rigid body rotation under the action of small torque, which is known in the body frame is described. Using this approach two problems are solved: the problem of maintaining the angular velocity of a gyroscope using the control torque which is quadratic on angular velocity, and the problem of nonsymmetric spacecraft rotation with Electric Propulsion thruster.

Keywords: *Rigid body, torque, perturbation methods.*

TEMA 52 - Vibrações

COB143 METODOLOGÍA PARA LA PREVENCIÓN DE PROBLEMAS DINÁMICOS EN OPERACIONES DE MECANIZADO

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The basis of a methodology for the prediction of chatter vibrations in metal cutting operations are presented in this paper. The methodology uses time-domain simulation of the cutting process. A model for the prediction of cutting forces has been developed. In order to do this, the main existing cutting force models are reviewed, selecting a mechanics of oblique cutting approach for implementing the methodology. The most relevant features of dynamic characterization of machine-tools are then commented on. After this, the existing methods for cutting process dynamic simulation are studied, leading to the conclusion that time-domain simulation is the best approach if effects such as non-linearities of the process are to be taken into account. An extension of the existing models, that allows the three-dimensional dynamics of the process to be taken into account is proposed. Finally, the results obtained during the first stage of the implementation of the methodology are shown.

Keywords: *Mecanizado, Fresado, Chatter, Vibración, Simulación.*

COB166 DETERMINAÇÃO DO COMPORTAMENTO VIBRATÓRIO DO MOTOR DE INDUÇÃO DE GAIOLA POR MEIO DE ELEMENTOS FINITOS / DETERMINATION OF THE SQUIRREL-CAGE INDUCTION MOTOR VIBRATIONAL BEHAVIOR BY FINITE ELEMENTS

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Many others phenomena occur simultaneously in a electric rotating machine besides the classical electro-mechanical energy conversion. One part of the energy amount is converted in losses and dissipated thermally; however, another much smaller, but equally important, is irradiated as noise to environment. In this paper a Finite Element numerical model is used to investigate the squirrel-cage induction motor vibrational behavior. This model allows to calculate the windings and bars currents, the magnetic forces and motor structure dynamic response. Firstly, the Finite Element method is employed to discretize the electromagnetic field equations and the b - method is used to discretize the time derivatives of the field and external circuit equations. The magnetic forces acting on the squirrel-cage induction motor stator are obtained by a method based on the Maxwell's Stress Tensor. From it, the harmonic composition of the magnetic forces is evaluated. The second step in this work consists in proceeding with the mechanical FEM to obtain the natural and forced response of the stator mechanical structure.

Keywords: *Vibrações, Forças Magnéticas, Tensor de Maxwell, Método de Elementos Finitos, Motor de Indução de Gaiola, Ressonâncias. - Vibration, Magnetic Forces, Maxwell's Stress Tensor, Finite Element Method, Squirrel-cage Induction Motor, Resonances.*

COB167 ANÁLISE DAS VIBRAÇÕES DE ORIGEM MAGNÉTICA NO MRC POR MEIO DE SIMULAÇÃO E PROCEDIMENTOS EXPERIMENTAIS / ANALYSIS OF SWITCHED RELUCTANCE MOTOR MAGNETIC CAUSED VIBRATIONS BY SIMULATION AND EXPERIMENTAL PROCEDURES

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The switched reluctance motor (SRM) presents short pitch concentrated windings and doubly salient structure. These characteristics provide this machine with certain advantages like simple and robust motor and converter structures, good efficiency and high speed capability. Despite of this positive attributes the SRM does exhibit higher levels of vibration than most competing drives, like induction and permanent magnet motors. Firstly, in this paper electromagnetic FEM analysis is applied to the SRM magnetic structure in order to obtain the electromagnetic forces pattern. From this the harmonic composition of the radial forces is evaluated. The second step in this work consists in proceeding with the Experimental Modal Analysis (to obtain the natural frequencies); mechanical FEM are also used to evaluate the natural frequencies and the mode shapes which define the dynamic of the mechanical behavior of the mechanical structure of SRM. Finally with Rotational Experiments, the SRM is driven by its converter and is possible to verify the vibrations.

Keywords: *Vibrações, Forças magnéticas, Tensor de Maxwell, Método de Elementos Finitos, Análise Modal Experimental, Motor de Relutância Chaveado, Experimentos Rotacionais, Ressonâncias / Vibration, Magnetic Forces, Maxwell's Stress Tensor, Finite Element Method, Experimental Modal Analysis, Switched Reluctance Motor, Rotational Experiments, Resonances.*

COB216 ISOLAMENTO DE VIBRAÇÕES EM BAIXA FREQUÊNCIA EM UM SISTEMA DE ALAVANCA / VIBRATION ISOLATING IN LOW FREQUENCY SYSTEMS USING A LEVER

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Mechanical vibration has brought discomfort and distress for human beings, and it has contributed a great deal of damage to structural integrity of machines and structures. Consequently, insulating precision equipment from even slight vibration of the base, and reducing its malicious effects, have been the object of constant study and research. In this paper a model is designed to isolate the vibration of the base in low frequencies, by employing the principals of active control, while using a lever system. First the response of the uncontrolled simulated model is obtained. Furthermore the response of the model is obtained by subjecting it to active control utilizing sensors, amplifiers, motor, and a system to convert a rotational position of the motor to longitudinal distance. A new analysis compares the performance of the controlled system with respect to the uncontrolled one. The controlled system is improved by introducing a compensator.

Keywords: *Vibração, Isolamento, Controle Ativo, Compensador / Vibration, Isolating, Active Control, Compensator.*

COB429 USING THE PSEUDO-INVERSE TECHNIQUE TO PREDICT RANDOM EXCITATION FORCES FROM ACCELERATION RESPONSE MEASUREMENTS**Paulo S. Varoto***Depto de Engenharia Mecânica, EESC-USP São Carlos SP, Brasil.***Kenneth G. McConnell***Department of Aerospace and Mechanics, Iowa State University, Ames, IA, USA, E-MAIL: varoto@sc.usp.br*

This article investigates the inverse problem of predicting random forces from acceleration responses using the pseudo-inverse technique. It is shown that a commonly accepted assumption of input signals being uncorrelated is untrue. Under this assumption, only real valued acceleration auto spectral densities are used to solve for the unknown random forces in the pseudo-inverse technique. Experimental results show that acceleration cross spectral densities must be used in addition to auto spectral densities when solving the inverse problem for random forces. These cross spectral densities are complex functions of the excitation frequency and thus, they carry the phase information required to establish the correlation between time variables.

Keywords: *Force identification, random loads, inverse problems.*

COB437 CONTROLE DE VIBRAÇÕES EM EDIFÍCIOS ATRAVÉS DE PÊNDULOS SUSPENSOS / VIBRATION CONTROL IN TALL BUILDINGS USING A SUSPENDED PENDULUM**Luciana do Val de Azevedo, Romulo de Freitas Paixão & Seyyed Said Dana***Pos-Graduação em Engenharia Mecânica - Centro de Tecnologia - UFPB, CEP 58059-900, João Pessoa, Paraíba, Brasil, E-mail contact@ct.ufpb.br*

Excessive vibration in structures can be attenuated by active or passive dissipative mechanisms. Though active controle systems have grown substantially recently, however the passive systems still represent the major ways for reduction of amplitudes in vibration of structures. Their use still brings low cost simplified and relatively easy implemented devices. In this work a study of efficiency of synchronized oscillators acting passively to reduce the amplitude of vibration of tall buildings subjected to random vibration is presented. It is shown that the efficiency of control system designed for optimal work depends principally on the amount of the inherent damping in structural configuration. In the systems with low structural damping the effect of introducing damping by an auxiliary system is high, and the efficiency becomes a considerable factor. In other hand the effect of auxiliary system diminishes when the damping in principal system is already high.

Keywords: *Vibração, isolamento, oscilados sintonizados, Vibration Isolation.*

COB439 CONTROLE ATIVO DE VIBRAÇÕES COM ATUADORES PIEZOELÉTRICOS / ACTIVE CONTROL OF VIBRATION USING PIEZO-ELECTRICS ACTUATORS**Simplicio Arnaud da Silva, Seyyed Said Dana & Clivaldo Silva de Araújo***Departamento de Tecnologia Mecânica, Universidade Federal da Paraíba, Campus I, CEP 58.073-420 - João Pessoa - Pb - Brasil**E. Mail: arnaud@ct.ufpb.br*

Transient noise control has been applied in variety of devices, machines, and structures. In this paper an active control approach that reduces transient noise transmission through a double plate in a circular duct is presented. Two circular pieces of piezoelectric material are used in the plate as an actuator to induce a moment in the plate. The same procedure is applied to use a circular piezoelectric material as a sensor. A special configuration consisting of two circular plates are used as a plant to control transient noise using a dynamic feedforward controller. In the experiment the forward traveling wave is captured by the first plate containing a piezoelectric sensor. This information is used to as feedforward signal. A special electronic circuit is used to perform as the feedforward controller. A transient pressure pulse is used to excite the first plate, and reductions of up to 20 dB are observed at the second plate placed downstream of the first place, when the controller is active.

Keywords: *Controle ativo, Controle de ruído, Piezoeletrico/Active Control, Noise Control, Piezoelectric.*

COB468 **INTERAÇÃO ROTOR-ESTRUTURA DE FUNDAÇÃO ATRAVÉS DE MANCAIS HIDRODINÂMICOS / INTERACTION ROTOR-FOUNDATION STRUCTURE THROUGH HYDRO-DYNAMICS BEARINGS**

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This paper presents a methodology for the analysis of the foundation behaviour and its influence on the whole system (rotor-bearings-foundation), using a mathematical approach to determine its modal parameters such as modal mass, damping factor and natural frequency. The analysis of the complete system is done applying the discretization of the foundation and rotor by finite element method. The evaluation of the foundation modal parameters is done by the analysis of the structure frequency response function, obtained by Fourier Transform. Afterwards the analysis of the system frequency response function is done and analytical results are showed.

Keywords: *Fundação em concreto, Rotor, Parâmetros modais / Concrete Foundation, Rotor, Modal Parameters.*

COB681 **A TIME DOMAIN METHOD FOR INPUT FORCE RECONSTRUCTION**

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This paper addresses the problem of indirect force reconstruction from the dynamic responses of the structure. A time domain method is proposed which is based on the equations of motion in the modal space requiring, as experimental data, the acceleration time responses of the structure when acted upon by the forces to be identified and a set of eigensolutions (natural frequencies, mode

shapes, modal damping factors and generalized masses). After the basic formulation is presented, numerical applications to a simple test structure are shown to demonstrate the effectiveness of the method. Some key points are also examined, such as the effect of the incompleteness of experimental data and measurement noise upon the performance of the method. The numerical results reveal that the method can be accurate and well adapted to real-world applications.

Keywords: *Indirect force reconstruction, force measurement, system identification, inverse problems, vibrations / identificação indireta de forças, medição de forças, identificação de sistemas, problemas inversos, vibrações.*

COB682 ESTIMAÇÃO DE FUNÇÕES RESPOSTA EM FREQUÊNCIA EM AMBIENTES RUIDOSOS / FREQUENCY RESPONSE FUNCTIONS ESTIMATION IN NOISY ENVIRONMENTS

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In this paper, the estimation of frequency response functions (FRFs) from vibration tests is addressed. The main objective of the reported study is to evaluate the performance of some of the currently used frequency response function estimators under experimental conditions in the field, where inescapable uncontrolled perturbations are present in the test environment. A vibration testing procedure was carried out in laboratory, where two random forces were applied simultaneously. The first one played the role of the main test excitation force, which was accounted for in the input-output model used for estimation, whilst the second one was introduced to take into account the uncontrolled inputs, which were not considered in the theoretical model. Under these conditions, the frequency response functions obtained by using the classical estimators H1, H2 as well as three other estimators based on the concept of instrumental variable, Hc, Hx and Hy were compared to the corresponding ones obtained without the uncontrolled input, so as to evaluate the quality of the estimates provided by each estimator.

Keywords: *Estimação, Funções de Resposta em Frequência, Variáveis Instrumentais, Ensaios Dinâmicos / Estimation, Frequency Response Functions, Instrumental Variables, Dynamic Testing.*

COB849 ANÁLISE DO COMPORTAMENTO DINÂMICO DE VIGAS CON-TENDO JUNTAS PARAFUSADAS / ANALYSIS OF DYNAMIC BEHAV-IOUR OF BEAMS WITH BOLTED JOINTS

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This work is devoted to investigation of dynamic behaviour of bolted joints. Both damping ratio and natural frequency of vibration are studied in function of the variation the physicals parameters of the joint, bolt tightening torque and the surface finish. The values of natural frequencies ω_n and displacements amplitudes $q(t)$ for beams studied are calculated using specialized softwares and applied for calculations of damping ratio by method of the logarithmic decrement. The experimental results are analyzed and compared with relation of damping ratio and natural frequency of vibration in the first mode.

Keywords: *Beam; bolted joint; damping ratio; logarithmic decrement; natural frequency of vibration.*

COB955 IDENTIFICAÇÃO DE DEFEITOS TIPO PITTING EM UM MOTORE-DUTOR DE VELOCIDADE / IDENTIFICATION OF PITTING ERROS IN GEARBOXES

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This work presents a methodology to identify the influence of the active involute profile of helical gear caused by pitting on motor-gearbox. Power spectrum density and wave forms were obtained with and without pitting, in order to determine its behavior on motor-gearbox.

Keywords: *Motoredutor, vibração, frequência de engrenamento, pitting e engrenagem. Gearbox, vibration, gear mesh, pitting and gear.*

COB1155 WAVELETS TRANSFORM FOR IDENTIFICATION OF VIBRATING MECHANICAL SYSTEMS

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The paper proposes an identification method for the mechanical and structural systems based on wavelets family. The advantages of using wavelets for system identification are that good localization and hierarchical multi-resolution can be achieved in both time and frequency domain. Consequently, the system model with multiple coupled modes can be identified (by wavelet based identification techniques) more efficient and accurately, especially for wideband (transient) and nonstationary signals. After a presentation of wavelets transform and identification procedure, the paper studies a simulated vibrating system formed by discrete masses, springs and dampers.

Keywords: *Mechanical Vibrations, Wavelets Transform, Multi-resolution, Identification.*

COB1179 CONTROLE DE ESTRUTURAS COM NÃO-LINEARIDADES CÚBICAS E QUADRÁTICAS SOB CARGAS HARMÔNICAS / CONTROL OF STRUCTURES WITH CUBIC AND QUADRATIC NONLINEARITIES UNDER HARMONIC LOADS

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Under extreme environmental loading such as wind, earthquakes and waves, flexible structures like tall buildings, long bridges and offshore platforms tend to develop large vibrations, possibly resulting in extensive damage. This paper studies a methodology for the active control of flexible structures, in order to limiting the amplitude of oscillations to be within safe allowable bounds. The method is based on nonlinear optimal control, using an indicial formulation and state feedback control. General polynomial representation of the control law up to the third order are presented. This methodology is applied to sdof systems with quadratic and cubic nonlinearities, with a computer code implemented to control up to the fifth order. Strongly nonlinear systems subjected to simple harmonic excitations are tested. Numerical results indicate that the control algorithm can be efficient in systems susceptible to chaotic vibrations, escape from a potential well or dynamic jumps.

Keywords: *Active structural control, nonlinear systems, escape from a potential well, chaotic vibrations (controle estrutural ativo, não-linearidades, escape de um vale potencial, vibrações caóticas).*

COB1362 VIBRAÇÕES INDUZIDAS EM MOTORES C.C. POR FALHAS NOS CIRCUITOS ELETRÔNICOS RETIFICADORES DE CORRENTE E DE CONTROLE DE VELOCIDADE / INDUCED VIBRATION IN DC ELECTRIC MOTORS BY CURRENT AND SPEED RECTIFIERS DEFECTS

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This paper presents in a simple way, the technics used to identify defects on the rectifying current electronics circuits and on the speed control of the direct current motors, through the vibration analysis. The system is described both by the DC control firing Cards and the DC control comparator card, explaining about the main faults that can occur in this components. It is also shown a case history where the applying of the vibration diagnostic helped with success to detect the fault. Finally a short conclusion is presented with the main identified frequencies on the vibration spectrums when the circuits fails.

Keywords: *Vibrações, Motores CC, Retificadores, Vibration, Rectifier.*

COB1378 HIGH FREQUENCY MODELS FOR ACTIVE COMPOSITE BEAMS CONTAINING PIEZOELECTRIC SENSORS AND ACTUATORS

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The problem addressed in this paper is that of modeling the dynamic response of laminate, composite beams excited by distributed piezoelectric actuators. In particular, we are interested in the high frequency range, where traditional approximate beam models, such as the Classical Laminate or the First Order Shear Deformation theories, fail in providing accurate representation of the electro-mechanical structural response. To avoid this shortcoming, Reddy's layerwise laminate theory is employed. Through comparisons with exact, wave-dispersion analytical results, it is shown that this approach allows us to properly simulate the high-frequency range of the active beam's dynamic response.

Keywords: *Structural Acoustics - Smart Structures - Composite Structures - Piezoelectric Materials - Vibrations.*

COB1411 ANÁLISE DE SENSIBILIDADE PARA DETERMINAÇÃO DE PONTOS DE MEDIÇÃO DE VIBRAÇÕES OTIMIZADOS / SENSIBILITY ANALYSIS TO IDENTIFY THE OPTIMAL POINTS OF VIBRATION MEASUREMENTS

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The sensibility analysis can be used to simulate and predict the vibratory behaviour of the systems. A particular interest is to obtain relationships among the parameters and the behaviour of the systems. Therefore, this work presents a sensibility analysis of response of the system with respect to the variations of its dynamical parameters, in order to identify the better points of vibration measurements. This technique is very important in monitoring, control and fault detection since it permits to obtain a great quantity of information of the state of the machine with a reduced number of sensors. The analysis was carried out by using a mathematical model developed with the finite elements method. An example of application of this technique in a Francis turbine of vertical shaft is presented.

Keywords: *Modelagem, sensibilidade, vibrações, monitoramento / Modelling, sensibility, vibration, monitoring.*

TEMA 53 - Acústica

COB84 CÁLCULO DO ESPALHAMENTO ACÚSTICO ATRAVÉS DO MÉTODO DE SIMULAÇÃO POR FONTES ELEMENTARES / CALCULATION THE SCATTERING BY THE METHOD OF SOURCE SIMULATION TECHNIQUE

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One method to calculate the acoustic scattering from a body with given surface velocity is described here. The method consists in approximating the scattered field of auxiliary radiators in a way that allows a good agreement between them both. The error due to this approximation can be minimized in several ways. However, in the present contribution only the method of minimal squares was used. In this paper the acoustic scattering due to the presence of one cylinder with variable surface impedance was investigated both theoretically and experimentally using the method of the source-simulation-technique.

Keywords: *Espalhamento acústico, radiação, multipolo, monopolo - scattering, radiation, multipole, monopole.*

COB202 SIMULAÇÕES NUMÉRICAS E ENSAIOS EXPERIMENTAIS DA RESPOSTA ACÚSTICA DE ALTO-FALANTES / NUMERICAL MODELING AND MEASUREMENTS OF THE ACOUSTIC RESPONSE OF LOUDSPEAKERS

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The frequency response prediction of loudspeakers is a problem that have closed form analytical solution only for low frequencies and simple geometry. In this paper it is investigated the use of the finite element method and the boundary element method implemented in commercial software for extend the prediction of loudspeaker response for higher frequencies considering the flexible behavior of the diaphragm. The modeling of a commercial loudspeaker is performed and its frequency response and directivity is calculated. The computational results are compared with measurements realized in a hemi anechoic chamber showing good agreement.

Keywords: *Simulação de Alto-falantes, Método de Elementos Finitos, Método de Elementos de Contorno / Loudspeaker Simulation, Finite Element Method, Boundary Element Method.*

COB414 ONDAS ACÚSTICAS EM CORPOS DELGADOS - UMA FORMULAÇÃO INTEGRAL / ACOUSTIC WAVES ON THIN BODIES - AN INTEGRAL FORMULATION

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This paper presents an advanced boundary element method to deal with scattering of sound waves by curved thin bodies. The formulation employed involves a hypersingular integral equation obtained from the normal derivative of the Helmholtz integral representation formula, considering the thin body of very small thickness as an open surface. The hypersingular integral, interpreted in the sense of Hadamard finite part integral, requires more attention in its numerical treatment, mainly when modelling curved surfaces. A general algorithm to numerically evaluate the hypersingular integral based on the concept of finite part integration is implemented to enable the use of higher-order isoparametric boundary elements, to model curved sound barriers.

Keywords: *Acústica, Corpos delgados, Elementos de contorno, Integral hipersingular. Acoustic, Thin bodies, Boundary elements, Hypersingular integral.*

COB426 MODELAGEM DE TRANSDUTORES PIEZOELÉTRICOS DE POTÊNCIA / MODELING POWER PIEZOELECTRIC TRANSDUCERS

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Two methods are presented for modeling power piezoelectric sandwich transducers, composed of a stack of piezoelectric ceramics terminated at both extremities with steel masses. The piezoelectric ceramics are rings connected by a bolt that passes through their centers and is clamped at both ends to apply tension to the stack. This transducer may be solved by a very efficient analytical method called Chain Matrix, which uses electric and acoustic matrices to describe the interactions between successive layers. Chaining these matrices provides a model of the complete transducer. The second modeling method is based on the finite element method. Both methods allow to calculate the electrical impedance of the transducer to determine the resonant and antiresonant frequencies. To achieve different optimization criteria, parameters of the transducers may be changed and the results rapidly examined. These methods were applied to construct a prototype transducer. Experimental and simulated results showed good agreement. In conclusion, these modeling methods are accurate, constituting a useful tool for designing power transducers.

Keywords: *Chain matrix, finite element method, power piezoelectric transducer, ultrasound, piezoelectric transducer / Matriz em cadeia, método dos elementos finitos, transdutor piezoelétrico de potência, ultra-som.*

COB427 MEDIÇÃO DA VISCOSIDADE DINÂMICA DE LÍQUIDOS POR ULTRA-SOM / ULTRASONIC MEASUREMENT OF DYNAMIC VISCOSITY OF LIQUIDS

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This paper describes an method for measuring the viscosity of liquids using ultrasound. From several signals reflected inside a measurement cell, the density, the attenuation coefficient and the propagation velocity of the liquid can be calculated and related to its dynamic viscosity. The method employs a double element transducer (DET) which consists of a piezoelectric ceramic transmitter and a large aperture PVDF membrane receiver separated by a solid buffer rod. Between the receiver and the liquid there is a reference solid rod. The attenuation coefficients of the liquids are calculated from the measured reflection coefficient for the interface of reference rod and the liquid, and the propagation velocity is calculated from the transit time between this interface and a metal reflector placed at the opposite wall of the chamber. The effect of acoustic diffraction is eliminated by using the DET, because the receiver is somewhat larger in diameter than the transmitter. For testing this method, a sensor was implemented, and measurements of viscous liquids, such as, automotive oils, were conducted at 1.4MHz. The determination of the dynamic viscosity requires the calibration of the measurement system, using a viscometer.

Keywords: *Viscosity measurement, absorption coefficient, ultrasound, instrumentation. / Medição de viscosidade, coeficiente de absorção, ultra-som, instrumentação.*

COB959 AVALIAÇÃO DO RUÍDO QUE O TRATORISTA ESTÁ EXPOSTO EM PREPARO DE SOLO COM TRATOR DE PNEU / VALIATION OF THE NOISE THAT TRACTOR DRIVER IS EXPOSED DURING PERIODICAL SOIL TILLAG OPERATION

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The agricultural wheel tractor is a source of power used to quite a large extent is small and intermediate agricultural in industries from soil tillage to harvest and transportation operation, performing these operations cheaper and more efficiently. During periodical soil tillage operation, this tractor transmit high level of noise to the driver increasing the sound pollution level to search the quantity of noise to with the tractor driver is exposed, it was evaluated the noise levels in plowing, disking and furrowing operation. This work was performed with wheel tractor in a distrofic yellow latosol covered by sugarcane ratoon. The results pointed out noise levels higher than the highest level recommended by legislation to a daily maximum exposure in the three operation accomplished. In both plowing and furrowing operation, the noise levels were equivalent and a little bit higher than the noise in disking operation.

Keywords: *Ruído, Tratorista, Trator de Pneu, Operação - Noise, Driver Tractor, Whell Tractor, Operation.*

COB1192 INFLUÊNCIA DA COMPOSIÇÃO DO TRÁFEGO SOBRE O RUÍDO GERADO POR RODOVIAS BRASILEIRAS TÍPICAS / COMPOSITION EFFECTS ON THE TRAFFIC NOISE OF TYPICAL BRAZILIAN ROADS

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This work deals with a road traffic noise investigation at Florianópolis (SC, Brazil). Seeking to determine the relationship between L10 and Leq levels and traffic composition and volume flow. L10 prediction equation obtained from 149 measurements is compared to equations based on similar works made in other countries. A Statistical analysis indicated good correlation ($r = 0.61$) for L10 predictions and a satisfactory correlation ($r = 0.49$) for Leq predictions.

Keywords: *Ruído de Tráfego, Composição do Tráfego, Road Traffic Noise, Traffic Composition.*

COB1193 PROPAGAÇÃO DO SOM EM LÂMINAS DE ÁGUAS RASAS POR ACÚSTICA DE RAIOS / SOUND TRANSMISSION IN SHALLOW WATERS BY RAY ACOUSTICS

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Due to its vast territorial extension, with extense coast and large hidrographic basins, Brazil still has many unexplored natural resources. The development of SONAR systems would certainly be helpful for underwater mining purposes and to the fishing industry. This work deals with sound propagation analysis in shallow water by Ray Acustics models. The effects of bottom irregularities on the sound propagation are analyzed.

Keywords: *Acústica de Raios, Águas Rasas, Propagação do Som - Ray Acoustics, Shallow Waters, Sound Propagation.*

COB1327 AVALIAÇÃO ACÚSTICA DE DANCETERIA POR MODELO REDUZIDO / ACOUSTIC EVALUATION OF DISCO HALL BY REDUCED MODEL

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An example of the conjugated use of reduced models and digital signal processing to preview the acoustic behaviour of complex shaped halls is here reported. The main concern with the disco hall studied was its very tall, multiplane with cylindrical top glass roof. The roof intersects the main building, which is octogonal, with three cylindrical cavities aside. This is very difficult to numerically simulate, especially for transient response. The 1:20 model built, with patches of absorbing material to correct for absorption of surfaces was used mainly for impulsive response determination. Virtual reality sound files, of voice and music were successfully synthesised by convolution, helping, together with the time frequency representations, to develop the acoustic treatment, which virtually eliminated the observed echoes and room modes, without "drying out" the room response.

Keywords: *Room Acoustics, Reduced models, Signal Processing, Experimental techniques, Time-Frequency Representation. Acústica de Salas, Modelos Reduzidos, Processamento de Sinais, Técnicas Experimentais, Representação Tempo-Frequência.*

COB1384 UNCERTAINTY AND COMPATIBILITY ANALYSIS OF ACOUSTIC POWER DETERMINATION BY INTENSITY AND PRESSURE MEASUREMENT TECHNIQUES

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European Machinery Directive states that all machine producers must declare the noise level, in terms of acoustic power and/or acoustic pressure in a significant point, emitted by each kind of machine on the market. Recently a new standard to perform sound power measurements by intensity methods has been introduced. In this work results of sound power obtained by intensity techniques and traditional pressure measurements inside reverberating room are compared. Measurements have been performed according to two international standards: the first based on acoustical intensity mapping around the source (ISO-9614-1); the second based on averaged pressure measurements inside a reverberating room (ISO 3741). Tests has been performed in two laboratories. The noise source analysed is a range hood. Repeated measurements on different models of range hood by both techniques allowed to obtain an estimate of uncertainty and to perform a compatibility analysis. Also advantages and disadvantages of both techniques for the particular noise source tested are highlighted.

Keywords: *Acoustic intensity, sound power measurements, uncertainty.*

COB1396 PISTONFONE PARA CALIBRAÇÃO DE HIDROFONES EM BAIXAS FREQUÊNCIAS / PISTONPHONE FOR CALIBRATING HYDROPHONES AT LOW FREQUENCIES

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This paper describes the main acoustic parameters related to the development of a non conventional pistonphone for calibrating hydrophones at low frequencies. While in the usual models the internal acoustic field is analytically calculated from the displacement measurements of a stiff piston source, in the model here proposed the calibration curves are obtained by using a standard hydrophone in a comparison calibration process and adopting a comercial loudspeaker as the excitation source. The system is designed for production, testing and field use in the largest possible frequency ranges from 10 Hz to 1 KHz. The hydrophones are placed in a water-air chamber with dimensions established from the application of theoretical models to define the dynamical behaviour of the acoustic means. The initial results obtained from a prototype of the pistonphone are presented.

Keywords: *Acústica - Transdutores - Hidrofone - Calibração - Pistonfone / Acoustics - Transducers - Hydrophone - Calibration - Pistonphone.*

TEMA 54 - Propagação de Ondas**COB191 WAVE PROPAGATION IN DAMAGEABLE ELASTO-VISCOPLASTIC BARS****Felipe Bastos de Freitas Rachid & Saulo Guimarães Machado***Departamento de Engenharia Mecânica - Universidade Federal Fluminense - Rua Passo da Pátria, 156 - São Domingos - Niterói / RJ - Cep. 24.210-240*

This paper presents a theoretical investigation, based on numerical simulations, of the wave propagation phenomenon in damageable elasto-viscoplastic one-dimensional medium. The degradation of the medium induced by inelastic deformations is described by a local continuum damage model in a context of internal variable theory. To solve the hyperbolic governing equations, the Glimm's scheme along with a splitting technique were used. Numerical simulations with and without damage are compared so that the influence of the damage on the wave propagation phenomenon is highlighted.

Keywords: *Wave Propagation; Continuum Damage Mechanics; Elasto-viscoplasticity; Glimm's Scheme.*

COB1194 FLUXO DE POTÊNCIA ENTRE VIGAS UNIDAS EM L EXCITADAS POR FORÇAS TRANSVERSAIS / POWER FLOW BETWEEN L JOINED BEAMS EXCITED BY TRANSVERSE FORCES**Fábio Fiates & Arcanjo Lenzi***Laboratório de Vibrações e Acústica (LVA) Depto de Engenharia Mecânica, UFSC, cp. 476 - CEP 88040-900 - tel. 048 234 0689**fax 048-234 1519 - Florianópolis - SC, email: fafiates@mbx1.ufsc.br arcanjo@emc.ufsc.br***Ernani. Luis. Sztanjbok***CENPES - PETROBRÁS - Ilha do Fundão, Rio de Janeiro, RJ, email: ernani@cenpes.petrobras.com.br*

Beams joined in L are analyzed by the mobility approach. An initial analysis was carried out to determine what waves and coupling types are responsible for the transfer of most of the input energy to the coupled beam. For out-of-plane point excitations, torsional waves were observed to play an important role in power flow between beams by the flexural-torsional waves coupling. Bending waves modeled by Timoshenko's theory leads to greater flow of power when compared to Euler's theory. This is attributed to the larger modal density, and angular and transversal displacements provided by the shear and inertia effects taken into account by Timoshenko's theory.

Keywords: *Fluxo de Potência, Vigas Acopladas, Acoplamento Flexão-Torsão, Método da Mobilidade / Power Flow, Coupled Beams, Flexural-Torsional Coupling, Mobility Approach.*

TEMA 55 - Sistemas Dinâmicos e Modelagem

COB419 DYNAMICALLY COMPENSATED CAMS

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In a cam-follower system the dynamics of the follower-train mechanism cause an actual motion which deviates from the desired one. This effect can be compensated by taking into account the inverse dynamic model of the follower-train in the design of the cam motion law. By considering a constant cam velocity, the follower-train has linear dynamics. However, due to the varying transmission ratio, and due to other nonlinear effects, the whole drive train is a nonlinear system, and nonlinear procedures should be used to fit a motion law. A theoretical analysis with only the linear feedforward compensation, supported by simulation results, has shown the potential of this approach, at least in the case of simple follower-train dynamics: a considerable reduction of the motion error, and a good robustness with respect to errors in the estimated resonance frequency and damping ratio of the follower-train. Experiments with a small driving servomotor, as expected, show different results, due to the non-constant angular velocity. The observed cam angular velocity ripple can be taken into account, in future experiments, to design a complete nonlinear feedforward motion law.

Keywords: *Cams, cam vibration, tuned cams, dynamically compensated cams, feedforward compensation.*

COB639 MODELAGEM AUTOMÁTICA DE SISTEMAS DINÂMICOS VIA GRAFOS DE SISTEMAS E PROCEDIMENTO SISTEMÁTICO / AUTOMATIC MODELLING OF DYNAMIC SYSTEMS USING LINEAR GRAPH AND A SYSTEMATIC PROCEDURE FOR STATE SPACE EQUATIONING

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This paper discusses an approach to automating mathematical modelling of lumped parameters dynamic systems, utilizing linear graphs as system representation, and a systematic procedure for obtaining the equations. It is presented the main characteristics of the associated developed software (acronym MASD) for automatic state space modelling in symbolic form. An application example, an hydraulic system, is presented in order to clarify, more specifically, some characteristics of MASD. A special motivation for this development is its application as an aid for teaching in the dynamic systems area.

Keywords: *modelagem de sistemas/system modelling, grafos de sistemas/linear graphs, manipulação simbólica/symbolic manipulation, procedimento sistemático/systematic procedure.*

COB 658 ANÁLISE DINÂMICA DE VIGAS ELASTO-PLÁSTICAS. UM MODELO ATRAVÉS DOS GRAFOS DE LIGAÇÃO / DYNAMIC ANALYSIS OF ELASTIC-PLASTIC BEAMS. A BOND GRAPH APPROACH

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In this work we show that using the physical models with lumped parameters representing the basic structural elements, we can obtain the mathematical models of the system where the effects of storage and dissipation of energy must be considered. We consider for the model the effects of the dynamic plasticity for which the modeling process depends on the plasticity mechanisms. To validate the results we show the behavior of an Euler beam.

Keywords: *VStructures, Bond Graphs, Dynamic Plasticity, Dynamic Simulation.*

COB664 TRANSFORMADORES CINEMÁTICOS. UMA REPRESENTAÇÃO ATRAVÉS DOS GRAFOS DE LIGAÇÃO / KINEMATIC TRANSFORMERS. A BOND GRAPH REPRESENTATION

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In this paper is presented a procedure for modeling the kinematic of closed-loop mechanisms, known as Kinematic Transformer, by Bond Graph techniques. The main advantage of Kinematic Transformer approach is the assembling of kinematical multi-loop system by means of mathematical connection of Kinematics Transformers obtained to each kinematical single-loop. Bond Graph is a recent technique that permits the modeling of several physical systems through power flow considerations and, to mechanical systems, the dynamic model can be obtained by kinematic model.

Keywords: *Kinematic; Bond Graph; Kinematic Transformer.*

COB877 SIMULATION OF HELICOPTER YAW MOTION AND BLADE ROTATIONAL SPEED DECREASE AFTER TAIL ROTOR SHAFT FAILURE

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After a helicopter accident with typical tail rotor loss characteristics, an alternate possibility was suggested in that the accident occurred due to pilot's loss of pedal control after he suddenly increased the collective pitch near the ground and delayed applying pedals as needed. In order to investigate this hypothesis, numerical flight dynamics simulations were performed. Simple models of the aircraft yaw dynamics and tail rotor aerodynamics were used. For tail rotor aerodynamics, momentum and blade element theories, supplemented by empirical formulae for vortex ring and turbulent wake states, were used. For tail rotor loss simulations, the blade rotational equation of motion was also established. All equations of motion were time-integrated using a fourth-order Runge-Kutta scheme. Simulation results indicated that pedal control would still be available even with a three second pilot delay in applying the pedals, therefore the hypothesis of loss of pedal control was discarded and the hypothesis of loss of tail rotor was maintained.

Keywords: *Helicopter, Simulation, Accident, Tail Rotor.*

COB957 DYNAMIC MODEL FOR CVD PROCESS CONTROL

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This paper presents the development of a lumped parameter dynamic model of a chemical vapor deposition (CVD) reactor for deposition of CdTe film on a GaAs substrate. The model contains the basic elements of the dynamics of the CVD processes, viz., transport delay, diffusion resistance and reaction kinetics. open-loop behavior of the reactor is investigated and simulation results are compared to experimental data to validate the model.

Keywords: *chemical vapor deposition, CdTe, control, dynamic, model.*

COB963 CONJUNÇÃO DE UM CRITÉRIO UTILIZANDO O TEOREMA DE NYQUIST PARA SIMULAÇÃO DINÂMICA DE SISTEMAS MECÂNICOS / THE CRITERION CONJUNCTION UTILISING THE NYQUIST THEOREM FOR THE DYNAMICS SIMULATION OF THE MECHANICAL SYSTEMS

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This paper examines a criterion for simulation of the mechanical systems making use of the Nyquist Theorem for the efficient sample of the displacements signals in the frequency domain. The errors and/or deviation of the displacements signals, utilizing a excitation signal (force), is obtained to part a synthesis of low - peak factor periodic signals are investigated. An exact solution - steady state utilizing this excitation signal, is then simulated. A conjunction of the search criterion using the Nyquist Theorem for making use of efficient samples of the displacements signals in the frequency

domain that measurements is examined. The efficient solution obtained to part of the exact solution utilizing this criterion is then compared with one obtained of the numerical solution considering a generalized acceleration of the Newmark method. Shows that utilizing this search of criterion, the Newmark methods is very efficient if compared with another ones from the literature.

Keywords: *Simulation, Dynamic, Criterion, Nyquist Theorem, Conjunction - Simulação, Dinâmica, Critério, Teorema de Nyquist, Conjunção.*

COB964 AVALIAÇÃO DE MÉTODOS DE INTEGRAÇÃO NUMÉRICA APLICADA A IDENTIFICAÇÃO DE PERTURBAÇÕES EXTERNAS / NUMERICAL VALUATION INTEGRATION METHODS APPLIED TO A EXTERNAL PERTURBATIONS IDENTIFICATION

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In this work the accuracy of numerical integration methods such as: Central Difference method, Houbolt method, Wilson η and Newmark methods have been investigated. These methods were applied on a process of external perturbations (force) identification in dynamic systems using least square estimation method. The results obtained from the application of each method were compared with the results obtained by using the numerical integration Runge-Kutta method of 4th order. In this study, a MDOF system of two degree-of- freedom, which consists of an axis-plain cylindrical journal bearing system, was applied. From the results it can be concluded that the Newmark method has an accuracy closer to the Runge-Kutta method than the other methods investigated.

Keywords: *Avaliação Numérica, Integração, Identificação, Força. - Numerical Valuation, Integration, Identification, Force.*

COB984 OTIMIZAÇÃO DO CONSUMO DE COMBUSTÍVEL DE UM PROCESSO DE DESIDRATAÇÃO UTILIZANDO SECADOR TIPO TÚNEL CONCORRENTE / OPTIMIZATION OF FUEL CONSUMPTION OF DEHYDRATION PROCESS BY CONCURRENT TUNNEL DRYER

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Values for inlet air temperature and truck speed in a concurrent tunnel dryer are obtained in order to minimize fuel consumption per weight of dehydrated fruit. The mathematical model is composed by non-linear ordinary differential equations numerically integrated by an adaptive method. The quality of dehydrated fruit is guaranteed by an equality constraint in the final moisture

content and by an inequality constraint in the maximum temperature of the product throughout the process.

Keywords: *Dryers, fuel consumption minimization, process optimization / Secadores, minimização do consumo de combustível, otimização de processos.*

COB987 AÇÃO DA DINÂMICA DE UMA PESSOA NUM BALANÇO/SIMULATION OF THE DYNAMIC OF A SWINGER

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The pumping of a playground swing from the seated position is modeled as a system of particles. The model consists of four masses attached to each others in a particular fashion. One of these masses represents the legs of the swinger; the others, their body. The methods of Maggi-Kane and Lagrange are employed to get the equations of motion. Based on analysis of the Maggi-Kane's equations it is concluded that the mechanism is driven by two terms: gyroscopic coupling and generalized external torques. Numerical results are presented to simulate the movement when the motion is started up by the oscillation of the legs.

Keywords: *Maggi-Kane's equations, Lagrange's equations, oscillation, gyroscopic coupling, operator split / Equações de Maggi-Kane, equações de Lagrange, oscilação, acoplamento giroscópico, decomposição de operadores.*

COB1343 TRANSFERÊNCIAS ORBITAIS BI-IMPULSIVAS COM LIMITE DE TEMPO / BI-IMPULSIVE ORBITAL TRANSFERS WITH TIME LIMIT

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In this work we consider the problem of two-impulse orbital transfer between coplanar elliptical orbits with minimum fuel consumption but with a time limit for this transfer. This time limit imposes a new characteristic to the problem that rules out the majority of transfer methods. Then, we used the equations presented by D. F. Lawden, modified and solved those equations to develop a software for orbital maneuvers. This software will be used in the next missions developed by INPE. The original method developed by Lawden considers only the case where the initial and final points of maneuver are known. The software developed here extends this method to the case where only one point is known and to the case where the two points are free. The four possible cases were tested with success.

Keywords: *Astrodynamics, Orbital Transfer, Optimal Control, Astrodinâmica, Transferência Orbital, Controle Ótimo.*

COB1344 MANOBRAS COM DOIS E TRÊS IMPULSOS PARA SATÉLITES ARTIFICIAIS / MANEUVERS WITH TWO AND THREE IMPULSES FOR ARTIFICIAL SATELLITES .

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This paper deals with orbital transfer maneuvers. It studies the problem of transferring a spacecraft from an initial to a coplanar final orbit. The control available to perform this task is a sequence of two or three impulses. The main goal is to study what is the best approach for a large set of initial and final orbits. Two methods available in the literature (one for a two-impulse and one for a three-impulse maneuver) are selected and used for comparison. The results show the fuel consumption for each case and produces a map of the regions of optimality for both cases.

Keywords: *Astrodynamics, Orbital Transfer, Impulsive Maneuvers / Astrodinâmica, Transferência Orbital, Manobras Impulsivas.*

COB1345 EFFECT OF VISIBILITY CONSTRAINTS IN ARTIFICIAL SATELLITES MANEUVERS / EFEITO DE VÍNCULOS DE VISIBILIDADE EM MANOBRAS DE SATÉLITES ARTIFICIAIS

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In this work, the effect of visibility constraints due to the use of only one ground station control of a spacecraft during a bi-impulsive transfer between two given non coplanar elliptical orbits is analyzed from the point of view of fuel consumption. This kind of constraint requires special orbital places to apply impulsive maneuvers, where the ground station is able to track the satellite. The increment of the fuel consumption imposed by this kind of constraint is evaluated by subdividing of the true anomalies' intervals at the initial and final orbits. This research takes part on the orbital maneuvers program for the *China-Brazil Earth Resources Satellite (CBERS)* and should be extended for any kind of bi-impulsive orbital transfer.

Keywords: *Astrodynamics, artificial satellites, numerical method, orbital maneuver / Astrodinâmica, satélites artificiais, método numérico, manobra orbital.*

COB1346 DETERMINAÇÃO DE ÓRBITA EM TEMPO REAL ATRAVÉS DO GPS UTILIZANDO O FILTRO DE KALMAN / REAL TIME ORBIT DETERMINATION WITH GPS USING KALMAN FILTER

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In this paper, we discuss a method of preliminary orbit determination in real time for an artificial satellite with a GPS receiver on board. Classical elements are considered as state variables and a sim-

ple dynamic model, based in the classic two-body problem, is used. The observations are formed by range and range-rate measurements with respect to four visible GPS satellites. An extended Kalman filter is used as the estimation technique. The data are simulated through numerical propagation (Cowell's method), which considers special perturbations for the GPS satellite constellation and an user satellite.

Keywords: *GPS system, Kalman filter, orbit determination / Sistema GPS, filtro de Kalman, determinação de órbita.*

COB1347 UTILIZAÇÃO DA SOLUÇÃO DE NAVEGAÇÃO DO GPS PARA DETERMINAÇÃO DE ÓRBITA DE SATÉLITES A BAIXA ALTITUDE / UTILIZATION OF THE NAVIGATION SOLUTION FROM THE GPS TO DETERMINE THE ORBIT OF A SATELLITE IN A LOW ORBIT

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In this work the orbit determination problem of an Earth artificial satellite is analyzed. This problem is solved using the GPS (Global Positioning System). It's assumed that the target satellite will carry a GPS receiver. To perform this mission, one needs to perform the following steps: i) To simulate the motion of the GPS and the target satellites; ii) To calculate all the distances between the GPS satellites and the target satellite; iii) To determine which GPS satellites are visible; iv) To corrupt those data by adding a random error; v) To develop a software that is able to get a navigation solution on each point of the orbit, vi) To develop a new software to get the target satellite state vector (position and velocity) from the navigation solution. This work was motivated by INPE's plans of performing this kind of mission in a near future. It must be emphasized that the goal of this work is not to provide the system maximum accuracy, but a sufficient accuracy to track and control the satellite at a low cost.

Keywords: *GPS, Astrodynamics, Orbit Determination / GPS, Astrodinâmica, Determinação de Órbita.*

COB 1352 CHAOS IN SPACECRAFT ATTITUDE MOTION IN EARTH MAGNETIC FIELD

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The paper deals with spacecraft attitude motion on polar, circular, Keplerian orbit. It is supposed that the spacecraft is equipped by permanent magnet. The model of Earth magnetic field is the dipole aligned with the Earth rotation axis. The spacecraft rotation is considered under the action of the mag-

netic torque only. The model is naive, but it includes the main effect which is important for magnetically stabilized spacecraft design and attitude dynamics analysis. The motion obeys a second-order, nonlinear, nonautonomous equation which depends on one parameter only, namely the magnetic moment of the spacecraft. The goal of the paper is the investigation of global phase picture of the problem for a wide interval of magnetic parameter using the numerical implementation of Poincaré point map method. In course of the analysis, new periodic solutions are found, the evolution of the phase picture and bifurcations of periodic solutions dependent on the magnetic parameter are studied, the values of the magnetic parameter which are dangerous from standpoint of spacecraft stabilization are discussed.

Keywords: *Attitude motion, periodic solutions, chaos.*

COB1353 SYMBOLIC MODELING AND DYNAMIC SIMULATION OF ROBOTIC MANIPULATORS WITH FLEXIBLE LINKS

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The need for fast and precise robots in the industrial environment, capable of attending the productivity and quality demands and that allow a high volume of work, needs the usage of manipulators with flexible links. Besides this, aeronautic applications demand the usage of long and thin arms, which leads to remarkable structural changes. Therefore, the development of manipulators with structural flexibility and its automatic control has become an important research area. The main goal of this work is to model the dynamic behavior of flexible manipulators. It is also presented a comparative study with rigid robots. It is possible to use the model for computer simulations to aid the development of efficient control.

Keywords: *Robotics, Simulation, Industrial Robot, Flexible Robot / Robótica, Simulação, Robôs Industriais, Robôs Flexíveis.*

COB1398 ROTORDYNAMICS AND DIAGNOSTICS OF ROTORS

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A survey of the most updated techniques for modelling rotor systems composed by rotors, bearings and supporting structures, is presented. Some benchmarking test results of several different codes for rotordynamics calculations and oil film bearing coefficients evaluation are shown. Methods for increasing reliability and accuracy in rotordynamic calculations are proposed, because a higher accuracy is needed for model based diagnostic procedures. Finally also a unified approach for fault modelling is presented, which is particularly suitable for fault identification procedures used in model based diagnostics of rotor systems.

Keywords: *Rotordynamics, Model Based Diagnostics, Rotor, Bearing, Foundation.*

TEMA 61 - ANÁLISE MODAL E AJUSTE DE MODELOS

COB91 ANÁLISE TEÓRICA DO USO DE JANELA EXPONENCIAL NA AQUISIÇÃO DE DADOS EM TESTE DE IMPACTO/ THEORETICAL ANALYSIS OF EXPONENTIAL WINDOWING IN IMPACT TEST

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Impact excitation is one of the most common methods for experimental modal analysis. It is versatile, mobile and produces reliable results. In the other hand, when a structure is lightly damped the response to the hammer impact may be sufficiently long that it is impractical to capture the entire signal. To suppress the truncation of response signal a common practice is to artificially force it to decay within the data capture window by multiplying it by an exponential function. However, the application of the exponential window must be considered carefully since it may adversely affect the estimated spectra. The purpose of this paper is to examine the effects of the exponential window over the modal parameters and estimated spectra from the experimental modal analysis developed by impulse excitation technical. Thus, the characteristics of impact test procedure are examined with analytical functions developed for an idealized test and to examine the influence of the exponential window over the closely spaced modes.

Keywords: *Análise Modal, Excitação por Impacto, Janela Exponencial, Modal Analysis, Impact Excitation, Exponential windowing*

COB203 COMPARAÇÃO ENTRE RESULTADOS NUMÉRICOS E EXPERIMENTAIS DA ANÁLISE MODAL DE CONES DE ALTO-FALANTES / COMPARISON BETWEEN NUMERICAL AND EXPERIMENTAL RESULTS FROM MODAL ANALYSIS OF LOUDSPEAKER CONES

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Numerical techniques are a powerful tool for predicting the behavior of structures that can't be modeled in a closed analytical form. However, if the computational model is to be used with confidence, it must be validated by comparison, for example, with experimental measurements. This paper presents the modeling of the vibrational behavior of a loudspeaker cone with modal analysis by the finite element method (FEM) and the comparison with results of experimental modal analysis. The experimental results show the existence of non-axisymmetric modes that can't be calculated by the ideal axisymmetric loudspeaker model and that are well predicted by the tridimensional FEM model. The existence of complex mode shapes in the experimental tests, that implies in non-proportional damping, suggests the limitation of the proportional damping model used by the FEM.

Keywords: *Alto-falantes, Método de Elementos Finitos, Análise Modal Experimental Loudspeakers, Finite Element Method, Experimental Modal Analysis*

COB413 PROBLEMAS EXPERIMENTAIS PARA A ANÁLISE MODAL EM PLACAS DE MATERIAL COMPOSTO**Alessandro B. de S. Oliveira & Fernando J. R. Neves***Departamento de Engenharia Mecânica, Faculdade de Tecnologia - UnB,
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This work is centered on the experimental problems related to modal testing of composite material plates. The results presented show the effects of non uniformity of properties of the plate along its surface. A carbon fiber sandwich plate with aluminium honeycomb core was used in the tests.

Keywords: *Análise Modal, Materiais Compostos, Elementos Finitos, Caracterização Dinâmica, Resposta em Frequência.*

COB445 IDENTIFICAÇÃO DE PARÂMETROS MODAIS DE UMA VIGA NO DOMÍNIO DO TEMPO : TÉCNICA EXPERIMENTAL / MODAL PARAMETERS IDENTIFICATION IN A CANTILEVER BEAM IN TIME DOMAIN : EXPERIMENTAL TECHNIQUE**Luiza Yoko Taneguti & Mario Francisco Mucheroni***Departamento de Engenharia Mecânica, Escola de Engenharia de São Carlos - USP - São Carlos
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In the last decade several methods in time domain have been developed to identify modal parameters of a mechanical structure. Usually these methods require data from the impulse response function or free decay responses. In this paper the Ibrahim Time Domain Method - ITD was used to obtain a unique set of modal parameter of natural frequencies, damping factors and mode shapes from a set of free vibration measurements in a single analysis. The applicability of this method was verified by one experiment using a cantilever beam. A technique for acquisition of the responses at measurement points was used for minimization of the amount of instrumentation required.

Keywords: *Identificação, parâmetros modais, domínio do tempo, método ITD, viga engastada / identification, modal parameters, time domain, ITD method.*

COB452 INVESTIGATION ON THE USE OF THE WAVELET TRANSFORM IN THE SOLUTION OF THE MODEL UPDATING PROBLEM**Mauro J. Atalla, Ph.D.***State University of Campinas, FEM - Department of Mechanical Design, 15083-970 Campinas, SP Brazil. E-mail: mjatalla@vt.edu*

Existing model updating techniques, based on modal data or frequency responses use data experimentally obtained to update the model of the structure with the implicit assumption that the experimental data is correct. However, noise present in the experimental data is known to effect the computation of the updated parameters. In particular, the Fourier transform used to compute the fre-

quency response functions averages the noise over the duration of the signal, smearing its effect over the frequency axis. An alternative to the Fourier transform is the wavelet transform, which has been successfully used in the electrical engineering and computer science fields to filter noise and compress data. This paper investigates the use of the wavelet transform in the solution of the model updating problem, and presents a formulation analogous to the Fourier-based formulation. Numerical results show the feasibility of this approach in updating models based on noisy measurements.

Keywords: *Model updating, Wavelet transform, Ajuste de modelos, Transformada wavelet*

TEMA 62 - Mecanismos

COB80 SIMULAÇÃO DE FLUTUAÇÃO DE VÁLVULA EM MOTORES DE COMBUSTÃO INTERNA / VALVE FLOTATION SIMULATION IN INTERNAL COMBUSTION ENGINES

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This work presents some results obtained with a numerical simulation of the valves behavior in internal combustion's engines. The mathematical model used is simple and consider all the subsystems which influence in valve works, how as: cam, push road, spring, lifter, etc. The governing equations are solved using the finite difference method for a wide range of operational parameters. By monitoring the contact forces between two components in the kinematics chain it is possible to detect the rotation bands which produce the valve flotation. Several graphs are presented to help the designer to avoid such phenomenon.

Keywords: *Internal combustion engines, valve flotation, numerical simulation, cam, lifter. Motores de combustão interna, comando de válvulas, flutuação de válvulas.*

COB181 ANÁLISE DINÂMICA DE MECANISMOS FLEXÍVEIS PLANOS / DYNAMIC ANALYSIS OF FLEXIBLE MECHANISMS

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This work describes a formulation for the dynamic analysis of planar mechanisms with rigid or flexible bodies. The flexible bodies are subjected to small deformations and large translational and/or rotational displacements, and to each one reference and elastic coordinates are associate. The reference coordinates are referred to a global inertial frame, and the elastic coordinates are referred to a proper local floating reference frame. The flexible bodies are discretized by the finite element method, and the joints are modeled by kinematic constraints equations, which leads to a system of differential-algebraic equations of motion. Results for a slider-crank mechanism with a flexible rod are shown and confronted to other similar experimental and numerical results.

Keywords: *Flexible Mechanisms, Multibody Systems, Mecanismos Flexíveis, Sistemas Multicorpos.*

COB1454 OTIMIZAÇÃO NO BALANCEAMENTO DE MECANISMOS ESPACIAIS DO TIPO "RSSR" / OPTIMUM BALANCING OF SPATIAL "RSSR" MECHANISMS

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The Generalized Reduced Gradient method of numerical optimization was successfully applied in obtaining the reduction of moments and forces transmitted by a spatial RSSR mechanism to its base. Such a modification of dynamical behavior of the mechanism, or balancing, was achieved by the addition of counter-weights attached to the movable links in an off-line position. The evaluation of the obtained optimum configuration has been performed by comparing the measured vibration levels of the base of physical models of the balanced and unbalanced mechanism.

Keywords: *Mecanismos, balanceamento, otimização / Mechanisms, balancing, optimization.*

TEMA 63 - Veículos

COB227 DESIGN OF AN AUTONOMOUS VEHICLE FOR DISABLED PEOPLE

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The objective of this work is to study the constructive forms more viable to build an autonomous vehicle for disabled people (AVD) for use indoors. This article presents the dynamic models of two different configurations of tricycle AVDs. The first configuration has rear driving wheels and front steering wheel and the second, front driving and steering wheel. We used these configurations because they have a good psychological impact on people and on user's self-image. The equations of motion governing the behavior of vehicle are obtained with the Newton and Euler's equations. Through the dynamic equations, the analyses of dynamic stability and dirigibility for the configurations are made for different kinds of driving and steering. This work shows that with careful design, the tricycle configuration with rear driving and front steering are more stable and dirigible. Considering the results of stability and dirigibility, a fuzzy controller for navigation, obstacle avoidance and velocity control is design. The fuzzy controller was simulated and the results indicate that it is better use the velocity control only on final approach to goal position.

Keywords: *Autonomous Vehicle for Disabled, dynamic behavior, fuzzy controller, self-image, comfort.*

COB444 DESEMPENHO DE VEÍCULOS PESADOS NA FREAGEM CONSIDERANDO OS REQUISITOS DA REGULAMENTAÇÃO ECE-R13 / PERFORMANCE OF HEAVY VEHICLES DURING BRAKING PROCESS CONSIDERING THE REQUIREMENTS OF ECE-R13 REGULATION

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This paper shows some ECE-R13 requirements for heavy vehicles brake systems, specially the requirements related with brake performance, brake forces distribution and compatibility between towing vehicles and semi-trailers during the braking process. Satisfactory comparison between theoretical values (obtained with mathematical model and computer program utilized for heavy vehicles braking study) and experimental values, from road tests, of braking performance were reached on an heavy vehicle example application, where was utilized the LS 1941 tractor of Mercedes-Benz of Brazil coupled with FNV - CARGA SECA semi-trailer of FNV of Brazil, and will be shown on this work. This work intend to be a contribution to the study of ECE-R13 regulation application on heavy vehicles braking process and for vehicle safety.

Keywords: *braking process, performance, stability, braking regulation, heavy vehicles, vehicular safety / freagem, desempenho, estabilidade, normas de freios, veículos pesados, segurança veicular.*

COB454 PLATAFORMA ORBITAL RECUPERÁVEL PARA EXPERIMENTAÇÃO EM AMBIENTE DE MICROGRAVIDADE / RECOVERABLE ORBITAL PLATFORM FOR EXPERIMENTS IN MICRO-GRAVITY ENVIRONMENT

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To perform experiments in a microgravity environment, a recoverable orbital system is proposed. The system comprises a capsule shaped orbital platform, which after satelization will remain in orbit until the experiments are carried out, being later returned to Earth and recovered at ground.. The proposed system concerns an affordable alternative when compared with usual systems, which are quiet expensive if experiment duration and capability are considered. The system under study is based on a return-on-request concept, innovative for users of small scientific and technological experiments. It is expected that a such system would offer a better opportunity to scientific and academic laboratories in performing low cost microgravity experiments. It also seems to be realistic for the purposes and technological domain of the participating institutions, CTA/IAE and INPE. The present paper summarizes and discusses the specification, concept and preliminary design of the system.

Keywords: *plataforma orbital, plataforma recuperável, microgravidade / orbital platform, recoverable platform, micro-gravity*

COB461 DINÂMICA NÃO LINEAR DE SUSPENSÕES ATIVAS / NON LINEAR DYNAMICS OF ACTIVE SUSPENSIONS

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This paper gives a theoretical contribution to the problem of modeling an independent active suspension using the Newton-Euler's Method, taking into account the constraint equations between the vehicle and the road profile, and including the dry friction between the tyre and the road. After the method's application, one obtains 33 non linear equations: 29 equations which describe the reaction forces among the multiple bodies that composes a quarter of independent suspension, and 4 movement equations, which describe the motion of the car's main mass, the oil flow passing through the servo-valve and the pressions acting on the active damper. These equations are numerically solved and the results discussed for various operation conditions.

Keywords: *Multibody dynamics/ Dinâmica de múltiplos corpos, dry friction/ atrito seco, Newton-Euler/ Newton-Euler, hydraulic systems/ sistemas hidráulicos, output control/ controle de saída.*

COB476 VARIACÃO DO COEFICIENTE DE ATRITO EM SAPATAS FERROVIÁRIAS E SUA INFLUÊNCIA SOBRE O PROCESSO DE FREIAGEM / VARIATION OF THE FRICTION COEFFICIENT IN RAILROAD BRAKE SHOES AND ITS INFLUENCE ON THE BRAKING PROCESS.

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The objective of this work is to present the results of the tests in railroads brake shoes realized in the Railroad Laboratory of State University of Campinas, Brazil. The tests show the influence of parameters do not considered in normal operation of brasilians railroads enterprises: velocity, wear, normal application force, temperature and differences in the materials. The tests followed the Association of American Railroad standard M-926, when possible. The influence of these parameter is analysed and the possible influence on the braking process in a real railroad is discussed. Recommendations are done for the new brake shoes bought by the railroads.

Keywords: *Railroad brake shoes, railroad braking systems, brake heating*

COB491 CONTROLE SEMI-AATIVO DE SUSPENSÕES AUTOMOTIVAS.

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The development of semi-active controled suspensions is, nowadays, an area of research poorly explored for automotive suspension applications. Only a small number of models, which are very simple, has been manufactured by the automotive industry. The semi-active control principle, analized in this work, is based on the adjustment, by an actuator, of the damping coefficient of the damper. The actuator is responsible for opening or closing the damper's dissipative valve. An important drawback for the passive suspensions is that they are optimized for a fixed condition, due to the fixed damping coefficient of its dampers. The semi-active system offers different regulations for different excitation conditions. This means that the semi-active suspension may be optimized for different work conditions. Another advantage of the semi-active suspensions lies in its low energy consumption if compared to the active controled suspensions. Finally, if we compare the passive and the active control suspensions to the semi-active controlled suspensions, as we will see in the following sections in this work, good results for the minimization of the body aceleration can be achieved.

Keywords: *Control, semi-active, suspension, automotive, digital.*

TEMA 64 - Análise Estrutural

COB95 ANÁLISE DAS CAUSAS DO APARECIMENTO DE TRINCAS NA CARROCERIA DE UM TREM METROPOLITANO / CAUSES OF STRUCTURAL CRACKS IN A METROPOLITAN TRAIN

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This work presents the results of a numerical and experimental study on the fixing region of the anchor of the traction system for the metropolitan trains of Porto Alegre. The study is part of an investigation to elucidate the causes of structural cracks detected in the mentioned region. The methodology used in the complete study, static and dynamic numerical analysis and tests and a fracture analysis of the cracked region, are described. The experimental tests, obtained with the instrumentation of the component parts of the traction system, allow the evaluation of the behaviour of the structure when submitted to loads representing passengers and vehicle traction forces. The results of the static and dynamic tests were used as information for the numerical analyses.

Keywords: *Train anchor system, Numerical analysis, Experimental Tests, Structural Cracks. / Sistema de Tração, Análise Numérica, Análise Experimental, Trincas Estruturais, Trem Metropolitano.*

COB465 ANÁLISE DE SENSIBILIDADE E OTIMIZAÇÃO ESTRUTURAL EM PROBLEMAS ELASTOSTÁTICOS LINEARES / SENSITIVITY ANALYSIS AND STRUCTURAL OPTIMIZATION OF LINEAR ELASTIC PROBLEMS

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Structural optimization has features, such as high structural analysis and gradient evaluation costs besides the intense flux of data between analysis and optimization codes, that make it more complex than common mathematical programming problems. This work shows an interior point optimization algorithm and the continuous formulation of the sensitivity analysis taking into account those features, implemented using object-oriented programming techniques.

Keywords: *Optimization, sensitivity analysis, finite elements, object-oriented programming, C++, otimização, análise de sensibilidade, elementos finitos, programação orientada por objetos.*

COB483 ON THE MODELING AND DYNAMICS OF FLEXIBLE SLEWING STRUCTURES. II: SOME COMPARISONS BETWEEN SMALL AND LARGE DEFLECTIONS (CONTRIBUTIONS)

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In this work is studied the dynamical behavior of flexible structures in slewing motion. Nondimensional equations of motion are obtained for large deflections. A small parameter appears multiplying the nonlinear terms in the equations of motion, so the influence of the nonlinearities in the system behavior can be verified. We also analysed the differences between the contributions of small and large deflections nonlinearities on the dynamics of slewing flexible structures. The known Crespo da Silva and Glynn theory for flexible beams is obtained from the one discussed here making some particularizations.

Keywords: *Slewing Flexible Structures, Assumed Modes Method, Large Deflections, Small Parameter, Nonlinear Oscillations.*

COB624 A DOMAIN DECOMPOSITION METHOD FOR STRUCTURAL DYNAMIC PROBLEMS

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We present , for structural dynamic problems, a Domain Decomposition method based on an augmented Lagrangian formulation. This method uses the Inexact Uzawa algorithm to solve the linear system required at any time increment. A three dimensional elasticity dynamic problem is solved by the method and the number of iterations is compared with the unpreconditioned FETI method.

Keywords: *domain decomposition; dynamics; inexact uzawa; parallel processing.*

COB1153 OTIMIZAÇÃO ESTRUTURAL DE PRENSAS EXCÊNTRICAS EM "C" / STRUCTURAL OPTIMISATION OF "C" SHAPED EXCENTRICAL PRESSES

Paulo Carlos Kaminski

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This paper reports the structural optimisation made on C-Shaped Excentric Presses done together with a private enterprise. Its focus is practical and not theoretical and the criterion used on the optimisation was the minimisation of structure building costs of the press, including the reduction of the material (steel) and the elimination, as far as possible, of the components which were difficult to build. The first step was the development of a simplified model in order to define the main stresses the press is exposed to. Then, a global model of finite elements was made. This model was "validated" by experimental data of displacement, press opening. From the global analysis, regions with the highest

levels of stress/deformation were identified and local models of finite elements were created for them. From these models, several alternatives of changes were analysed searching an standardisation of the stress levels and the elimination of the components that were hard and costly to be built. The result achieved was satisfactory, mainly in terms of rationalisation of the components, which will be built without losses in the efficiency of the press, offering a world level competitive advantage to the enterprise involved with the project.

Keywords: *mechanical press, structural optimisation, finite elements / prensa mecânica - otimização estrutural - elementos finitos - solicitações*

TEMA 65 - Localização de Falhas e Manutenção Preditiva**COB432 AVALIAÇÃO DE DANOS ESTRUTURAIS UTILIZANDO O ALGORITMO GENÉTICO / STRUCTURAL DAMAGE ASSESSMENT USING THE GENETIC ALGORITHM**

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The present paper describes an approach for structural damage assessment that has its basis in methods of system identification. Response of a damaged structure differs from that obtained from the original and healthy structure. A refined analytical model that predicts correctly the response of the structure is available. The output error approach of system identification is employed to determine changes in the analytical model necessary to minimize differences between the measured and predicted response. Structural damage are represented by damage variables in which are lumped changes in the stiffness matrices resulting from variations in geometry or material properties of the structure during damage. The design space of the resulting optimization problem is highly nonconvex and has several local optima. In some cases methods of mathematical programming using gradients are not able to detect damage. This work presents a departure from that approach using one stochastic method of global optimization which is the genetic algorithm. Measurements of static deflections are used in the identification procedure. Principal shortcomings in the proposed approach and methods to circumvent these problems are also discussed.

Keywords: *Structural Damage Assessment, Genetic Algorithms, System Identification, Structural Optimization, Avaliação de Danos Estruturais, Algoritmos Genéticos, Identificação de Sistemas, Otimização de Estruturas*

COB450 SUBSTITUIÇÃO DAS CHAVETAS DA COROA POLAR DO ROTOR DA UG-07 DA UHE ILHA SOLTEIRA / REPLACEMENT OF THE MAGNETIC WHEEL'S SPLINES IN THE GENERATOR # 7 OF ILHA SOLTEIRA POWER PLANT

Orlando Marcondes Machado Filho

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In present times, under reduction of the financial investments resources and increase of the demands for electrical power, the improvement of the maintenance actions and increase of the available time in big generators units are a must. Allowing for the maintenance know how and experience of the ABB and CESP, it was possible a new and dared solution for the rehabilitation of a 480 ton's weight generator rotor by the replacement of its magnetic wheel's splines. This solution meant a quality level profit and kept the maintenance time restricted to the original preventive maintenance program of generator unit.

Keywords: *Manutenção - Máquinas Rotativas - Gerador - Chavetas - UHE Ilha Solteira Maintenance - Rotating Generator - Hydroelectric Generator - Splines - Ilha Solteira Power Plant*

COB458 ANÁLISE DE FALHA EM REDUTORES UTILIZANDO TRANSFORMADA DE WAVELET / GEARBOX FAULT ANALYSIS USING WAVELET TRANSFORM

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The Wavelet Transform - WT is a powerful tool used for analysis of non-stationary signals, but it has not been frequently used in this area. A brief mathematical formulation of WT is presented along with various wavelet functions used in this paper. The main feature of WT is to present at the same graphic information of the signal in the time and frequency domain. Therefore it is possible to have different resolutions and simultaneous information of the signal in both domains. A series of simulated signals are generated by computer and processed with the proposed transformation in order to understand how it works. "Doing so we can learn more about the WT concepts such as: scale, level, signal reconstruction and translation". Experimental results from signals measured in a gearbox are presented, when processed with the WT. The analysis of these results showed that WT is more appropriate to locate transients in non-stationary signals than the well known and used Fourier Transform. The WT technique also proved to be possible the detection of transients in the signal, generated by local faults in the gear through time versus scale plots.

Keywords: *Transformada de Wavelet - Redutores - Identificação - Engrenagens - Processamento de Sinais. Wavelet Transform - Gearbox - Identification - Gear - Signal Processing.*

COB480 PREVISÃO DO COMPORTAMENTO VIBRATÓRIO DE SISTEMAS MECÂNICOS / MECHANICAL SYSTEMS VIBRATION BEHAVIOUR PREDICTION

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An important information about mechanical systems is the fact that vibration phenomena is the chief cause and also the consequence of the main wear processes. This information is used to set up a feedback ARMAX forecasting model for machines which have on wear its main source of faults. For evaluating purpose, the ARMAX forecasting model is used for predicting the trend of some simulated cases. Satisfactory results have been obtained.

Keywords: *Machinery prognostics, failure prediction, trend analysis, ARMAX models, predictive maintenance, prognóstico em máquinas, previsão de falhas, análise de tendência, modelos ARMAX, manutenção preditiva.*

COB481 DIAGNÓSTICO DE DEFEITOS EM UM CONJUNTOMOTO-BOMBA BASEADO EM CRITÉRIOS ESTATÍSTICOS / FAULT DIAGNOSTIC IN A CENTRIFUGAL PUMP BASED ON STATISTICAL PATTERN RECOGNITION

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This work analyzes two fault diagnostic methods one based on Euclidean distance and another on Mahalanobis distance. These methods don't require high efforts in learning phase, are easily implemented and present satisfactory results in machinery fault diagnostic. An experimental setup involving a centrifugal pump was designed to analyze these methods. Some faults like unbalance, suction and discharge piping obstructions, wear on rotor blades were studied. Data from healthy and fault conditions were used to evaluate the sensitivity (ST) of the two methods.

Keywords: *Diagnostic, fault, monitoring, pattern recognition.*

COB492 DETECÇÃO E LOCALIZAÇÃO DE FALHAS EM SISTEMAS MECÂNICOS ATRAVÉS DA ANÁLISE DE CORRELAÇÕES / FAULT DETECTION AND ISOLATION IN MECHANICAL SYSTEMS THROUGH CORRELATIONS ANALYSIS

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In the context of model based fault detection and diagnosis, there is a residual generation which can be obtained through redundancy equations. The redundancy equations (analytical redundancy) are based on the use of mathematical models of the process being monitored for faults. This paper presents a new formulation involving the generation of redundancy equations for linear, time invariant, stationary systems, based on correlations functions of the system. The proposed approach is demonstrated using a simulated model of mechanical system

Keywords: *Detecção de falhas, diagnose de falhas, equações redundantes, sistemas mecânicos, funções de correlação / Fault detection, failure detection, fault diagnosis, parity equations, redundancy equations, correlations functions, model based, stationary systems.*

COB983 DIAGNOSE DE FALHAS ATRAVÉS DE OBSERVADORES DE ESTADO EM SISTEMAS COM PARÂMETROS DESCONHECIDOS / FAULTS DETECTION THROUGH STATE OBSERVERS IN SYSTEMS WITH UNKNOWN PARAMETERS

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The application of the deterministic state observer techniques for machine monitoring can be severely restricted because of limitations in accuracy reliability and robustness. The observers can produce large transient or steady-state errors, which can cause frequent false alarms and these limitations in transient and steady-state performance can be described by ill-conditioning factors. This paper

describes a Model-based monitoring system on state observer theory with unknown parameters. A time-domain technique based on Fourier series is used for the parameters identification. The method is based on the orthogonality property of the Fourier series which enables the integration of the equations of motion. These equations are then converted to a linear algebraic model that is solved to obtain the unknown parameters. The goal is monitoring a mechanical system with an automatic system for detection and isolation of the fault using robust observation.

Keywords: *Faults Detection and Isolation, Parameters Identification, State Observers/Observadores de Estado, Falhas*

TEMA 66 - Sistemas não Lineares e Caos**COB466 ANÁLISE DE EFEITOS COMBINADOS DE ATRITO E RESTITUIÇÃO NÃO LINEAR EM ROTORES / COMBINED EFFECT ANALYSIS OF CUBIC STIFFNESS AND DRY FRICTION ON A NONLINEAR ROTOR****I. L. E. Santo & K. L. Cavalca & J. M. Balthazar**

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The nonlinear analysis of a simple Laval Rotor with a non ideal power source crossing its resonance under a Coulomb dry friction action and cubic restoring force of the shaft is done. Dynamical changes on the system response are observed through numerical integration in the case of strong non-linearity and through average method in the case of weakly nonlinearity. Some important constitutive request appear from the studies of the behavior. One could verify that after critical speed the dry friction works as a damping force while the restoring force drives the oscillation to be unpredictable.

Keywords: *rotor, perturbação, método da média, restituição cúbica, atrito seco, rotor, perturbation, average method, cubic stiffness, dry friction.*

COB745 MODELOS REDUZIDOS DA CONVECÇÃO DE RAYLEIGH-BÈNARD / LOW-ORDER MODELS FOR RAYLEIGH-BÈNARD CONVECTION**Miriam Maria de Resende & Paulo Ignácio Fonseca de Almeida**

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Since Lorenz's model for two dimensional Rayleigh-Bènard flow in atmosphere, it has been proposed several low-order models for representing the fluid cellular motion. The present work is a revision of the main low-orders models published. A methodology for the strange attractors simulations in two of them is presented. The bifurcation diagrams based in Nusse & Yorke(1994) method for dynamics explorations is also developed and the evolution of the temperature and stream function fields are related by level curves obtained from the model. The good quality of the graphics results is a credit for going on the methodological numerical investigation.

Keywords: *Modelos dinâmicos reduzidos, escoamento Rayleigh-Bènard/ Dynamics low order models, Rayleigh-Bènard flow*

TEMA 71 - Elasticidade

COB938 STATE SPACE METHODOLOGY FOR ORTHOTROPIC MATERIALS

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The State Space Formulation for linear elasticity is revisited in the realm of two-dimensional orthotropic configurations. The stress and displacement distributions are determined by reducing the boundary value problem of classical elasticity to an initial value problem. The method relies on casting into an initial value formulation the integral transform solution of two-dimensional elasticity.

TEMA 72 - Viscoelasticidade**COB55 NUMERICAL SIMULATIONS OF THERMAL VISCOELASTIC FLOWS BY A STABLE FINITE ELEMENT METHOD****J.H. Carneiro de Araujo & M.A. Silva Ramos***Departamento de Ciência da Computação, Universidade Federal Fluminense Praça do Valonguinho s/no., 24210-000 Niterói/RJ, Brazil***Frey***Laboratório de Mecânica Teórica e Aplicada (LMTA)**Departamento de Engenharia Mecânica, Universidade Federal Fluminense, Rua Passo da Pátria no.156, 24210-240 Niterói/RJ, Brazil*

In the present work, stable finite element simulations of thermal incompressible viscoelastic flows has been performed. The employed method consists of a four-field bubble formulation in terms of extra-stress, velocity, pressure and temperature, which employs a non-consistent SUPG scheme to approximate the advective term of the stress constitutive law and a GLS philosophy for the energy one. Some computational experimentations with Oldroyd-B liquids illustrate the good performance of the numerical procedure.

Keywords: *Viscoelastic Fluid, Finite Element Method, Heat Convection***COB1382 ANÁLISE NUMÉRICA DE SISTEMAS VISCOELÁSTICOS LINEARES TRANSIENTES COM AMORTECIMENTO DESCRITO ATRAVÉS DA REPRESENTAÇÃO INTEGRAL / NUMERICAL ANALYSIS OF TRANSIENT LINEAR VISCOELASTICS SYSTEMS WITH DAMPING DESCRIBED BY THE INTEGRAL REPRESENTATION OF THE CONSTITUTIVE EQUATIONS****Edson Antonio Capello Sousa***Departamento de Engenharia Mecânica, Faculdade de Engenharia e Tecnologia - UNESP - Bauru C.P. 473 - CEP 17033-360 Bauru, SP, Brasil - E-mail: capello@bauru.unesp.br***Euclides de Mesquita Neto***Departamento de Mecânica Computacional, Faculdade de Engenharia Mecânica - UNICAMP - Campinas C.P. 6122 - CEP 13083-970 Campinas, SP, Brasil - E-mail: euclides@fem.unicamp.br*

In the present article the viscoelastic, dissipative properties of a system are described by means of the convolution integral. This representation of the damping mechanism allows the inclusion of experimentally determined properties as well as data obtained from analytical models. This general formulation is applied to describe the transient response of a one-dimensional continuum (a bar). The formulation leads to an integer-differential equation. A numerical algorithm, related to the Newmark algorithm family, is presented to solve this integer-differential equation. Numerical studies using the one-dimensional system are presented to validate the proposed methodology and to show its potentiality. The proposed scheme is readily extended to more general Finite Element models.

Keywords: *Dynamic viscoelasticity, Numerical analysis, Finite Elements*

TEMA 73 - Plasticidade

COB97 **UMA GENERALIZAÇÃO DO TEOREMA DE CASTIGLIANO PARA ANÁLISE DE TRELIÇAS INELÁSTICAS COM DANO /A GENERALIZATION OF CASTIGLIANO'S THEOREM FOR THE ANALYSIS OF INELASTIC TRUSSES WITH DAMAGE**

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The present work is concerned with an extension of the Castigliano's theorem to the case of inelastic damageable trusses (elasto-plastic and elasto-viscoplastic behavior). A general formulation that takes into account any kind of constitutive theory with internal variables is presented. The proposed theory is checked through examples concerning cyclic and monotone loadings in ASTM 6451 aluminium alloy and 316 L stainless steel.

Keywords: *Structural Damage Assessment, Genetic Algorithms, System Identification, Structural Optimization, Avaliação de Danos Estruturais, Algoritmos Genéticos, Identificação de Sistemas, Otimização de Estruturas*

COB459 **STRUCTURAL IMPACT**

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Structural impact is a topic with growing importance among researchers, engineers, industry and regulator bodies. Basic concepts of the phenomenon of impact and the analysis underlying it are introduced in this article, including the influence of the strain rate on the flow stress. The paper finishes with a discussion on various aspects of impact, including joint failure.

Keywords: *impact, joint failure.*

TEMA 74 - Mecânica dos Materiais Compostos

COB18 **MODELAGEM DA EVOLUÇÃO DO DANO EM JUNTAS ALUMÍNIO-EPOXI SUBMETIDAS A SOLICITAÇÕES TRATIVAS / MODELING THE DAMAGE EVOLUTION IN AXIALLY LOADED ALUMINIUM-EPOXY BUTT JOINTS**

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The present paper describes an approach for structural damage assessment that has its basis in methods of system identification. Response of a damaged structure differs from that obtained from the original and healthy structure. A refined analytical model that predicts correctly the response of the structure is available. The output error approach of system identification is employed to determine changes in the analytical model necessary to minimize differences between the measured and predicted response. Structural damage are represented by damage variables in which are lumped changes in the stiffness matrices resulting from variations in geometry or material properties of the structure during damage. The design space of the resulting optimization problem is highly nonconvex and has several local optima. In some cases methods of mathematical programming using gradients are not able to detect damage. This work presents a departure from that approach using one stochastic method of global optimization which is the genetic algorithm. Measurements of static deflections are used in the identification procedure. Principal shortcomings in the proposed approach and methods to circumvent these problems are also discussed.

Keywords: *Structural Damage Assessment, Genetic Algorithms, System Identification, Structural Optimization. Avaliação de Danos Estruturais, Algoritmos Genéticos, Identificação de Sistemas, Otimização de Estruturas*

COB83 **THE HOMOGENISATION THEORY APPLIED TO NET FACESHEETS OF SANDWICH PLATES**

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In order to further increase the efficiency of composite sandwich structures, designers have been using composite facesheets manufactured from a uniform carbon fibre/epoxy net. In the present study, a procedure to approximate this net as a smoothed orthotropic continuum is presented. The smoothing process was accomplished using the theory of homogenisation and the resulting material coefficients are calculated using the Finite Element Method. To validate the procedure, a free-free modal test was completed and its results compared with numerical prediction.

Keywords: *Homogenisation, Optimization and Sandwich Plate.*

COB102 An Integrated Micro/Macro Stress Analysis of Laminate Composites: The Control Volume Finite Element Formulation

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The control volume finite element formulation (CVFE) is described for solving solid mechanics equations for laminate composites. The CVFE is detailed based on the weighted residual method, and comparisons are drawn with the conventional Galerkin Finite Element method (GFEM) to be able to clearly establish the differences between the two methods. An integrated micro/macro mechanical formulation is proposed. First, a micromechanical analysis is performed to obtain the effective properties. The micromechanical model used is the Composite Cylinder Assemblage model (CCA). The macroscopic analysis is based on a variation of the Vanishing Fiber Diameter Theory (VFD). The integrated micro/macro analysis is performed for laminate composites using the concept of "smeared" elements. Punctual, uniform, and linear distributed loadings are considered in the stress analysis of unidirectional metal matrix composite structures. The results are compared to analytical solutions available in the literature. The CPU solution time between the CVFE and FEM are also compared.

Keywords: *Control Volume Finite Element, integrated micro/macro mechanical model, metal matrix composites*

COB138 ANÁLISE DA RESISTÊNCIA DE UM COMPÓSITO EM TRAÇÃO TRANSVERSAL E LONGITUDINAL / ANALYSIS OF COMPOSITE STRENGTH IN TRANSVERSAL AND LONGITUDINAL TENSILE TESTS

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The excellent mechanical behavior, regarding strength and stiffness, makes of the composite material, a choice in structural application. The main objective of this work is the strength data analysis of a unidirectional laminate composite (carbon fiber/epoxy resin), in longitudinal and transversal directions. Several conditions of composite were tested, providing a large amount of experimental results that were studied using statistical considerations, such as media and standard deviation. The Weibull distribution that provides informations about scattering in strength data was also used.

Keywords: *Compósito laminado unidirecional, Compósito fibra de carbono/resina epoxi, Análise estatística, Distribuição de Weibull / Unidirectional laminate composite, Carbon fibre /epoxy resin composite, Statistical analysis, Weibull distribution*

COB217 A FINITE ELEMENT ANALYSIS OF STRESS AND DELAMINATION IN SANDWICH ORTHOTROPIC LAMINATED PLATES

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This work presents a finite element displacement analysis of a laminated composite plate under static bending. The laminate is a symmetric sandwich constituted of three layers with orthotropic mechanical properties. The present theory assumes a piecewise linear distribution of the inplane displacements through the thickness, and as a consequence describes distinct measures of shear for the inner and the outer layers. The numerical results obtained from the finite element simulations were compared with analytical as well as numerical solutions. Fiber failure and delamination criteria were implemented for the analysis of integrity of the laminated plate.

Keywords: *Laminated plates, finite elements, delamination, layerwise theory.*

COB370 HYBRID COMPOSITE PLATES WITH SHAPE MEMORY ALLOY FIBERS

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Intelligent materials can be used on intelligent structures as actuators that may be embedded in structural material (matrix), forming what is called hybrid composites. Actuators made of shape memory alloys (SMAs) have shown a great potential in situations where high force, large strain, and low frequency structural control are needed. This contribution discusses the bending modeling of hybrid composite plates using shape memory alloy fibers. A numerical method is developed and some numerical simulations show the pseudoelastic behavior of these composites.

Keywords: *Composite Materials, Shape Memory Alloys, Intelligent Structures.*

COB830 NOTCHED STRENGTH OF COMPOSITE LAMINATES WITH UNIDIRECTIONAL TAPE LAYERS

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The strength of notched composite laminates with unidirectional tape layers is investigated under the assumption that the failure of the 0^∞ plies governs laminate failure. The failure criterion proposed by Mar and Lin is utilized to define the fracture parameter of a 0^∞ ply. Experimental results obtained from different laminates indicated that under certain conditions the fracture parameter of a 0^∞ ply is essentially constant, regardless of the orientation of the neighboring plies. The 0^∞ -ply fracture parameter is used to compute the laminate fracture parameter, which is subsequently used in the failure criterion to predict the laminate notched strength. The use of this technique significantly reduces the number of tests required to characterize a family of laminates. Correlation between predicted and experimental notched strength showed excellent agreement.

Keywords: *composite materials, notched strength, fracture, laminates, carbon/epoxy*

COB947 TÉCNICAS DE FABRICAÇÃO PARA LAMINADOS COM BORDAS MOLDADAS RESISTENTES À DELAMINAÇÃO / DELAMINATION RESISTANT MANUFACTURING TECHNIQUES FOR LAMINATES WITH MOLDED EDGES

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The strength of composite laminates may be reduced because of delaminations emanating from the free edges. The laminate strength depends on the stacking sequence and the finishing of the free edges. The use of laminates with molded edges leads to a gain in productivity but may have adverse effects on the strength. In this work, fabrication procedures are proposed to reinforce the molded edges producing laminates with high edge delamination strength.

Keywords: *Composites, manufacturing, free edge, tensile strength.*

COB1000 IDENTIFICAÇÃO DE PROPRIEDADES ELÁSTICAS DE MATERIAIS COMPOSTOS A PARTIR DE ENSAIOS DINÂMICOS / IDENTIFICATION OF ELASTIC PROPERTIES OF COMPOSITE MATERIALS FROM DYNAMIC TESTS

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This work consists in the identification of the stiffness properties of composite materials from dynamic tests. Unknown coefficients are identified by a technique of model updating. The used formulation (modal approach) is based on the minimization of the eigensolution residuals (sensitivity method). Errors of generalized masses are considered. This technique allows the simultaneous identification of several properties from a single test. Stiffness properties of extension, bending, twisting and transverse shear are identified. A discussion of the different identification approaches of elastic constants of composite materials from dynamic tests is presented. Results obtained by numerical simulations show the efficiency of the method.

Keywords: *Materiais compostos - Identificação - Vibração - Rigidez - Ajuste de modelos
Composite materials - Identification - Vibration - Stiffness - Model updating*

COB1001 APLICAÇÃO DOS ALGORITMOS GENÉTICOS NA IDENTIFICAÇÃO DE CONSTANTES ELÁSTICAS DE MATERIAIS COMPOSTOS A PARTIR DO COMPORTAMENTO VIBRATÓRIO / APPLICATION OF GENETIC ALGORITHMS FOR THE IDENTIFICATION OF ELASTIC CONSTANTS OF COMPOSITE MATERIALS FROM DYNAMIC TESTS

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This work is placed within the framework of the identification of stiffness properties of composite materials from dynamic tests. More precisely, the used approach is inserted in the general context of model updating. The genetic algorithms method is used as a complementary technique allowing a first estimation of the elastic coefficients, in other words, the initial finite element model is estimated. The refinement of solutions can thus be made by a classic updating method, as for example the sensitivity method. The procedure allows the simultaneous estimation of several properties, from a single test. Properties of extension, bending, twisting and transverse shear effects can be identified. Results obtained by numerical simulation show the efficiency and robustness of the genetic algorithms.

Keywords: *Algoritmos genéticos - Materiais compostos - Identificação - Vibração - Rigidez / Genetic algorithms - Composite materials - Identification - Vibration - Stiffness*

COB1178 BUCKLING AND POST-BUCKLING BEHAVIOR OF LAMINATED COMPOSITE CYLINDRICAL SHELLS

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In the present work an analysis of the stability of layered composite cylindrical shells under axial compression or lateral pressure is carried out using a non-linear shear deformable shell theory. Using general computer algebra routines written in MAPLE, an analytical solution is obtained for the critical load and corresponding critical mode. A modal solution based on the seminal ideas of Koiter's post-buckling theory is employed together with the Rayleigh-Ritz method to obtain the non-linear equilibrium equations governing the post-critical behavior of the shell and the fundamental solution of an imperfect shell. Again these equations are obtained and solved by the use of symbolic algebra. A detailed parametric analysis is presented and the effects of fiber orientation, material properties, number of layers and shell geometry on the critical and post-critical behavior are discussed. It is observed that the shell stability is highly dependent on the laminate characteristics and, from these observations, it is concluded that, in order to exploit efficiently the composite material, a specific laminate should be designed for each application.

Keywords: *laminated shell, composite material, stability, post-critical behavior, limit point and bifurcation point (casca laminada, materiais compósitos, estabilidade, comportamento pós-crítico e bifurcações).*

TEMA 75 - Membranas Placas e Cascas**COB81 ELEMENTOS FINITOS TRI-LINEARES COM INTEGRAÇÃO REDUZIDA NA ANÁLISE DE PLACAS E CASCAS / TRI-LINEAR FINITE ELEMENTS WITH REDUCED INTEGRATION IN THE ANALYSIS OF PLATES AND SHELLS****Sérgio Luiz Schulz & Armando Miguel Awruch***Curso de Pós-Graduação em Engenharia Civil – CPGEC / UFRGS - Av. Osvaldo Aranha, 99 – 3o andar
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The static and dynamic finite element analysis of plates, shells and other structural systems using eight nodes three-dimensional linear isoparametric elements is presented in this work. Some important features are: (a) the element matrices are obtained using reduced integration with control of hourglass modes; (b) an explicit Taylor-Galerkin scheme is used to carry out the dynamic analysis, solving the corresponding equations in terms of velocity components; (c) advantages of vector processors facilities, existing in modern super-computers, were considered. Good results were obtained in terms of accuracy and computational performance.

Keywords: *Placas, cascas, elementos finitos, integração reduzida, supercomputação / Plates, shells, finite element method, reduced integration, supercomputing*

COB172 FREE VIBRATION STUDIES IN CLAMPED PLATES AND SHELLS USING FINITE ELEMENTS**André R. G. de Oliviera & Maher Nasr Bismarck-Nasr***Instituto Tecnológico de Aeronáutica – Divisão de Engenharia de Aeronáutica, 12228-900 – São José dos Campos, SP, Brasil*

The present work deals with a parametric study of free vibration analysis of clamped plates and shells using various finite element models. The different element formulations used are compared in terms of convergence, accuracy, ease of implementation and computational efficiencies. The results obtained are compared with other analytical formulations and experimental findings.

Keywords: *Plates and Shells, Dynamics, Free vibrations, Finite Element Method.*

COB173 FINITE ELEMENT BUCKLING ANALYSIS OF DOUBLY CURVED SHALLOW SHELLS**Juliano Casarin Ozores & Maher Nasr Bismarck-Nasr***Instituto Tecnológico de Aeronáutica – Divisão de Engenharia Aeronáutica, 12228-900 – São José dos Campo, SP, Brasil*

The present work deals with linear elastic stability analysis of doubly curved isotropic shallow shells. The shell analysis uses a two-field variable variational principle with the transverse displace-

ment and Airy stress function as field variables. A finite element formulation that preserves C1 continuity is used for the solution of the problem. Several numerical results are presented and the results obtained are discussed and are compared with previous solutions whenever available.

Keywords: *Plates and Shells, Buckling, Linear Elastic Stability, Finite Element Method.*

COB206 ELASTIC SOLUTIONS IN THE COMPUTATION OF LIMIT LOAD FOR PRESSURE VESSELS / SOLUÇÕES ELÁSTICAS PARA O CÁLCULO DA CARGA LIMITE EM VASOS DE PRESSÃO

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Elastic solutions for thin shells are shown to be a very good alternative for the calculation of limit loads on axisymmetrical pressure vessels in a displacement formulation for the finite element method. In this paper the fundamental relations for the new formulation is presented, followed by the procedure on how to implement them in a technique for limit analysis. The procedure consists of substituting the direct load by its general forces on the calculation of the external work for the Koiter's theorem. The structural problem is reduced to an optimization problem and solved using standard linear programming. The results are presented as 3D collapse mechanisms and upper bounds on the limit load.

Keywords: *Finite Element, Pressure Vessels, Optimization Elementos Finitos, Vasos de Pressão, Optimização.*

COB224 UM ELEMENTO FINITO MULTICAMADAS ADAPTADO A ESTRUTURAS ESPESSAS DO TIPO CASCA / A MULTILAYER FINITE ELEMENT ADAPTABLE TO THICK SHELL STRUCTURES

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A multilayer finite element associated with a model to provide damping in thick shell structures is presented. The displacement components, which are linear by layer, allow a better representation of the shear transverse effects. The validation of the model, based on the comparison with the Classical Laminated Theory, is made on an orthotropic square plate with different ply orientations and different boundary conditions.

Keywords: *Casca, multicamadas, material composto, elementos finitos, shell, multilayer, composite materials, finite elements.*

COB225 ANÁLISE ESTÁTICA NÃO LINEAR DO ENVELOPE BOBINADO DE UM PROPULSOR / THE NON LINEAR STATIC BEHAVIOUR OF A MOTOR'S CASE

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The non linear static behaviour of a motor's case in Aramid/Epoxy is analyzed. The cure process of the Epoxy resin is analyzed numerically and compared with the measurements taken after the fabrication of the envelope. In the non linear analysis, an additional stiffness matrix is considered as a function of the in-plane stresses state.

Keywords: *Análise não linear, estrutura bobinada, material composto, elementos finitos, non linear behaviour, wound structure, composite materials, finite elements.*

COB811 ANÁLISE ELASTOPLÁSTICA DE PLACAS SEMI-ESPESSAS COM NÃO-LINEARIDADES GEOMÉTRICA E MATERIAL UTILIZANDO O MÉTODO DOS ELEMENTOS FINITOS / ELASTIC-PLASTIC ANALYSIS OF THICK PLATES UNDERGOING LARGE DEFLECTIONS USING THE FINITE ELEMENT METHOD

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The finite element method is used to solve elastic-plastic problems of thick plates undergoing large deflections. Hill's variational principle, in its updated lagrangian form, is adopted in the formulation of the problem, since it has shown to be efficient in the modelling of elastic-plastic materials, with isotropic hardening. The behavior of the elastic-plastic plates is modelled using the von Mises yield function and the flow rule associated with von Mises yield function. Due to its invariance with the rigid body rotation and displacements and because it leads to a symmetric stiffness matrix, the co-rotational rate of Kirchhoff stress tensor is used in the formulation. The element obtained from this formulation is the nine node isoparametric quadrilateral Lagrangian finite element. The integration through the thickness of the element is numerically performed by the Gauss-Lobatto quadrature rule, which allows a better representation of the plastic process. This thick plate finite element is used to solve several non-linear elastic-plastic problems of plates and the results obtained are compared with analytical and numerical solutions available in the literature.

Keywords: *Finite elements, plasticity, thick plates, quadrature rule, nonlinearities* *Elementos finitos, plasticidade, placas semi-espessas, regra de quadratura, não-linearidades.*

COB823 ANÁLISE DE CARGAS CRÍTICAS DE CHAPAS PELO MÉTODO DOS ELEMENTOS FINITOS/ANALYSIS OF CRITICAL LOADS OF PLATES BY THE FINITE ELEMENTS METHODS

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This paper presents a determination of critical loads of compression of plates under several conditions of boundary. However, it will be necessary a formulation geometrically nonlinear to obtain differential equations of equilibrium.

The numerical solution of differential equations of equilibrium is obtained by Finite Elements Method (through Weighted Residual). The problem of eigenvalues is solved through the Jacobi Method and the solution of nonlinear system through the Newton-Raphson Method. Several examples are analysed varying boundary geometric parameters. Where possible, comparisons are presented with published results or obtained by commercial program.

Keywords: *Cargas Críticas, Autovalores, Flambagem de Placas e Chapas, Método dos Elementos Finitos / Critical Loads, Eigenvalues, Plates and Shells of Buckling, Finite Elements Methods.*

TEMA 76 - Estruturas

COB88 ESTABILIDADE DE ARCOS SEGMENTADOS DE CONCRETO ARMADO / STABILITY OF PRECAST CONCRETE SEGMENTAL ARCHES

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Segmental arch is a structure made of several straight segments of precast concrete, connected at points belonging to a curve in the form of an arch which circumscribes the structure. This work presents a study of the effects of height to span ratio, number of segments and initial geometric imperfections on the arch stability. The study was carried out with a computational model based on the finite element method. The model takes into account material and geometric non-linearities, and concrete cracking.

It was found that the optimal height to span ratio value is 0,3, the number of segments affects the behaviour of three-hinged arches and that geometric imperfections can drastically decrease the arch load capacity.

Keywords: *segmental arch, reinforced concrete, stability, critical load, limit point and bifurcation point, arco segmentado, concreto armado, estabilidade, carga crítica.*

COB179 FORMULAÇÃO LAGRANGEANA ATUALIZADA PARA ANÁLISE NÃO-LINEAR GEOMÉTRICA DE ESTRUTURAS RETICULADAS PLANAS VIA M.E.F. / UP DATE LAGRANGEAN FORMULATION TO ANALYSE GEOMETRIC NON-LINEAR PLANE FRAMED STRUCTURES THROUGH USING F.E.M.

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This work deals with up dated Lagrangean formulation to analyse geometric non-linear plane trusses and frames, using finite elements. The equilibrium is enforced at the actual position, allowing to compute internal efforts using the true displacement field. Appropriate shape functions are adopted to each type of element, giving therefore the corresponding normal strain component represented by the complete Green-Lagrange tensor. For the truss formulation, all terms are taken into account to derive the global stiffness matrix, while for frames, some terms of higher orders have been neglected. The Lagrangean formulation is used to write the equilibrium at the position giving the final tangent and secant incremental stiffness matrices. Static and dynamic numerical examples are shown to illustrate the accuracy of the proposed formulation.

Keywords: *Structural analysis; Non-linear behaviour / Análise estrutural; Comportamento não-linear*

COB656 ANÁLISE ELASTO-PLÁSTICA DE LAJES UTILIZANDO O MÉTODO DOS ELEMENTOS FINITOS E PROGRAMAÇÃO MATEMÁTICA / ELASTO-PLASTIC ANALYSIS OF SLABS USING THE METHOD OF THE FINITE ELEMENTS AND MATHEMATICAL PROGRAMMING

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A elastoplastic analysis by non-linear Mathematical Programming is developed for thin and thick bending plates, under small deformations. The Finite Element Method is used to discretize the model. The equilibrium equations at the structural level are solved by a conventional Newton-Raphson technique. The elastoplastic constitutive problem is stated for stress variables at Gauss points of the discretized structure as a Mathematical Programming problem. The strength criteria proposed by Johansen and Velasco are used in this work. The tangent consistent matrix is used to update the elastoplastic stiffness matrix. A Newton-like interior point method is used to solve the Mathematical Programming problem.

Keywords: *Lajes de Concreto Armado, Método dos Elementos Finitos, Análise Elasto-Plástica, Programação Matemática / Slabs of Reinforced Concrete, Method of the Finite Elements, Elasto-Plastic Analysis. Mathematical Programming.*

COB657 ANÁLISE ESTÁTICA DE VIGAS LAMINADAS ORTOTRÓPICAS PELO MÉTODO DOS ELEMENTOS FINITOS/STATIC ANALYSIS OF ORTHOTROPIC BEAMS BY FINITE ELEMENT METHOD

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This paper presents a finite element formulation of multilayered orthotropic beams for static analysis. This formulation is developed based on a transverse shear deformation theory which accounts piecewise linear distribution across the interfaces between the layers of the displacement u and satisfies the contact conditions at the interfaces. The element is quite versatile and it can be used to analyse not only thin beams with negligible shear deformation but also thick beams and beams of sandwich construction in which shear effect is important. Numerical examples are worked out to complete the theoretical formulation.

Keywords: *FEM, orthotropic beams, vigas ortotrópicas, multilayered beams, vigas laminadas*

COB661 ANÁLISE DE UM BANCO VEICULAR SUJEITO A GRANDES DEFORMAÇÕES POR COLISÃO / ANALYSIS OF VEHICULAR SEAT SUBMITTED TO LARGE DEFORMATIONS BY COLISION

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This work presents an analysis of a vehicle seat under dynamic load, during a colision. From the deformed seat after the colision, we determine the probable vehicle velocity just before the accident, using simple models, system dynamic tools and some engineering analysis procedures. We describe our methodology and discuss our analysis showing the most important results.

Keywords: *Análise Dinâmica, Colisão de Veículos, Método dos Elementos Finitos, Simulação Dinâmica. Dynamic Analysis, Vehicle Colisions, Finite Element Methods, Dynamic Simulation*

COB831 STRESS STIFFENING EFFECTS ON LAMINATED TIMOSHENKO BEAMS WITH PIEZOELECTRIC ACTUATORS

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The effectiveness of using piezoelectric elements to control the mechanical performance of laminated structures by inducing favorable in-plane stresses is investigated. A finite element formulation is presented for the analysis of laminated Timoshenko beams with an arbitrary number of piezoelectric actuators and/or sensors placed along the length of the beam. Von Kármán non-linear strain-displacement relations are used and ideal linear behavior is assumed for the piezoelectric actuation. It is shown that with proper boundary conditions the piezoelectric actuators induce in-plane stresses that may significantly affect the mechanical behavior of the beam. It is shown that the stress stiffening is more pronounced for slender beams. A configuration with a piezoelectric actuator at the top of a slender beam and a sensor at the bottom is analyzed. It is demonstrated that neglecting the stress stiffening effects may lead to large errors in both the static and dynamic analyses of this widely used configuration. Further, the stiffness of the beam can be electrically tuned to a desired value with interesting applications in active structures.

Keywords: *Piezoelectric, finite elements, stress stiffening, vibration.*

COB832 AXISYMMETRIC ACTUATION OF COMPOSITE CYLINDRICAL SHELLS WITH PIEZOELECTRIC RINGS

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Axisymmetric static and frequency analyses of anisotropic cylindrical shells with one and two perfectly bonded ring piezoactuators are performed. The shell is assumed to be linear elastic and made of laminated composite materials. The electroelastic constitutive relations for the piezoelectric materials are also assumed to be linear. A simple closed-form solution of the equilibrium equations is obtained for the case of a infinite shell with one or two actuators. The finite element method with class C1 continuity elements is then applied to obtain the stiffness and mass matrices required for the static and dynamic analyses of arbitrary cylindrical shells with piezoelectric actuators. Good agreement is reached between the analytical solution found and the numerical procedure implemented. Results indicate that the maximum normalized displacement and its location vary according to the actuator length. Furthermore, a frequency analysis is carried on in a broad range of frequencies to investigate the effect of mass properties on the response of a simply supported cylindrical shell.

Keywords: *Cylindrical Shell, Piezoelectric Actuation, Composite Materials.*

COB837 INFLUÊNCIA DO AMORTECIMENTO INTERNO EM PLACAS SOB AÇÃO DE CARREGAMENTO NÃO CONSERVATIVO / INTERNAL DAMPING IN PLATE WITH NON CONSERVATIVE LOAD

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In the present work, that deals with the dynamic analysis of plates by using the finite elements method, there were used commun elements for structures in bending. In order to work the structures of plates under the action of follower forces and internal damping, it was necessary study plate problems with different boundary conditions, so that loss of stability could be studied. This study proves the destabilizing effect of low internal damping coefficients at plates, for this used graphs and tables for different critical loads values.

Keywords: *Structural Vibration, Plate, Non-Conservative Load / Vibração de Estruturas, Placas, Cargas Não Conservativas.*

COB1357 INFLUÊNCIA DAS JUNTAS SEMI-RÍGIDAS NO COMPORTAMENTO DINÂMICO DE PÓRTICOS PLANOS / INFLUENCE OF SEMI-RIGID CONNECTIONS ON THE DYNAMIC BEHAVIOUR OF PLANE FRAMES

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The behaviour of framed structures with semi-rigid connections subjected to dynamic loads is studied. Attention is given to the effect of joint flexibility on the natural frequencies and correspond-

ing mode shapes, as well as on the dynamic displacements and generalised stresses. The flexible connections are represented by zero-length rotational springs with linear moment-rotation relationship. The mass and stiffness matrices are developed as the sum of the conventional finite element matrices and correction matrices which incorporate the flexibility of the end joints. The problem of forced vibrations is then solved by means of the modal superposition method or, alternatively, by numerical integration of the motion equations. Numerical results are presented and it is shown that the consideration of semi-rigid connections alters significantly the dynamic behaviour of the structure.

Keywords: *Estrutura reticulada, conexão semi-rígida, resposta dinâmica, análise de vibrações. / Framed structure, semi-rigid connection, dynamic response, vibration analysis.*

TEMA 77 - Mecânica da Fratura

COB154 CRACK GROWTH RESISTANCE CURVES IN WOOD MODELLED AS AN ORTHOTROPIC STRAIN-SOFTENING MATERIAL

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This paper depicting resistance curves in wood is based on two concepts. Firstly, the fictitious crack model which takes into account the strain-softening behaviour of the material. Since wood is modelled as an orthotropic (radial R, longitudinal L and tangential T axes) medium, crack propagation along the grain in poplar had been studied using a nonlinear finite element method. Thus load (P)-load displacement (*) curves have been deduced for three specimen geometries submitted to opening mode : the double cantilever beam (DCB), the compact tension (CT) and the single-edge notched in bending (SENB). Three crack configurations had been studied : TL, RL and TR. Secondly, the equivalent crack length concept is used, taking into account the effective length of the fracture process zone. From P-* curves, the estimation of the equivalent crack length makes it possible to plot R-curves. The effects of initial crack lengths and specimen geometries are thus analyzed. The existence of a single - resistance versus crack extension - curve for each crack configuration makes it possible to predict fracture loads confirmed by experimental results. This successful comparison allows future research taking into account the behaviour of other wood species particularly tropical ones.

Keywords: *Equivalent length, Finite elements, Fracture process zone, R-curves, Wood.*

COB184 CONTINUUM DAMAGE PROBLEMS SOLVED BY THE SPLITTING TECHNIQUE IN CONNECTION WITH FINITE ELEMENT METHOD

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Different continuum damage theories for elastic materials have been proposed in the last years. In order to avoid the loss of well-posedness in the post-localization range, some continuum damage theories for elastic materials introduce higher order gradients of the damage variable in the constitutive model. Although such theories allow a mathematically correct modeling of the strain localization phenomena, they are usually considered very complex to handle from the numerical point of view. The present work is concerned with the numerical implementation of a gradient-enhanced damage theory for elastic materials. A simple numerical technique, based on the finite element method, is proposed to approximate the solution of the resulting nonlinear mathematical problems. The coupling between damage and strain variables is circumvented by means of a splitting technique.

Keywords: *Damage Mechanics; Finite Elements; Splitting Technique.*

COB382 OSMOSIS, FILTRATION AND FRACTURE OF POROUS MEDIA**Roberto Suarez Antola***Facultad de Ingeniería, Universidad Católica del Uruguay**8 de Octubre 2738, C.P. 1.600, Montevideo, Uruguay - E-mail: rsuarez@ucu.edu.uy*

Filtration was produced in a small scale physical model of a granular porous medium of cylindrical shape. The same volume flow was obtained either applying a difference in hydrostatic pressure or in osmotic pressure. In the first case a process of sustained erosion ending in an hydraulic short-circuit was observed, while in the second case the material remained stable. This paradoxical strength behaviour is explained using some results from differential geometry, classical field theory and thermo-kinetic theory. The fracture process of a continuous matrix in a porous medium under the combined effect of filtration and external mechanical loads is then considered. The obtained results can be applied to the flexural and compressive strength of wet concrete.

Keywords: *Filtration pressure, osmosis, mechanical failure.*

COB391 ANALYSIS OF FRACTURE IN THIN COATINGS SUBJECTED TO CONTACT LOADING**Sonia A.G. Oliveira¹ & Allan Bower²***¹-Dep. Engenharia Mecânica, Univ. Federal de Uberlândia -UFU, CEP. 38400-900 Cx.P. 593 Uberlândia, MG E-Mail sgoulart@ufu.br**²- Brown University, Providence, RI - USA*

Hard coatings, which are used to protect surfaces that are subjected to contact loading, may fracture or delaminate from their substrates. A simple model of the fracture process is presented. The thin coating is idealized as a brittle elastic layer of uniform thickness, which is bonded to the surface of a half-space. The coating and substrate are assumed to contain microcracks. The solid is loaded by a rigid cylindrical indenter, which slides over the surface of the coating. Methods of linear elastic fracture mechanics are then used to calculate the loads required to initiate fracture in the coating. It is shown that the fracture loads are strongly influenced by the mismatch in elastic properties between the layer and its substrate, the thickness of the layer, the initial crack size and the friction coefficient.

Keywords: *Fracture; Rolling Contact; Coating; Wear / Fratura, Contato, Revestimento, Desgaste.*

COB1003 DETERMINAÇÃO DA CURVA J-R UTILIZANDO UM ÚNICO CORPO DE PROVA BASEADO NO MÉTODO DA NORMALIZAÇÃO DE HERRERA E LANDES/ DETERMINATION OF J-R CURVE USING A SINGLE SPECIMEN BASED ON HERRERA AND LANDES' NORMALIZATION METHOD**Neilor Cesar dos Santos***Coordenação de Mecânica, Escola Técnica Federal da Paraíba - COMEC/DDE/ETFPB, Av. Primeiro de Maio, 720 - Jaguaribe - CEP 58059 900, João Pessoa - PB - Brasil E-mail: neilor@jpa.etfpb.br*

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Herrera and Landes normalization method (Key Curve) to determine the J-R curve was studied. Its applicability was analysed for two HSLA steels: a controlled rolled API 5L-X70 pipelines steel plate, produced with inclusions morphology control, and an ASTM A516-GR65 pressure vessels steel plate. The tests were made at room temperature and three point bend specimens were used. The normalization curve (Key Curve) was analytically determined and the points fit was executed by a power law. The Ramberg-Osgood's functional form relationship was used. The results were confronted with other obtained by the multiple specimens test method. Such procedure brought in to evidence that Herrera and Landes normalization method is suitable to determinate J-R curve for the studied steels.

Keywords: *Integral J, Curva J-R, Método da Normalização, Método de Um Único Corpo de Prova, "Key Curve", J Integral, J-R Curve, Normalization Method, Single Specimen Method, "Key Curve".*

**COB1078 O EFEITO DA ESPESSURA DO CORPO DE PROVA SOBRE OS VALORES DE TENACIDADE À FRATURA DO AÇO ASTM A516-GR65/
EFFECT OF SPECIMEN THICKNESS ON THE VALUES OF THE FRACTURE TOUGHNESS OF THE ASTM A516-GR65 STEEL****José Jefferson da Silva Nascimento & Marco Antônio dos Santos**

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This work is concerned with the thickness effect of the specimen in values of toughness to initial fracture (d_i) and to maximum load ($d_{m\acute{a}x}$, $J_{m\acute{a}x}$). Specimens of the type flexure at three points were tested at the room temperature in a universal machine for testings, hydraulic-servo (MTS 810), under control of displacement with displacement speed of the table equal to $3,33 \times 10^{-3}$ m/s (0,2 mm/min). The thicknesses of the tested specimens changed between 7×10^{-3} m and 20×10^{-3} m. The investigated steel was the ASTM A516-GR65 class. The values of toughness to fracture in the beginning of propagation of crack (d_i) as well as the ones of maximum load ($d_{m\acute{a}x}$, $J_{m\acute{a}x}$), decreased with the reduction of the thickness of the specimen. The behaviour that the steel presents was investigated and discussed.

Keywords: *Pressure vessel steel, d-R Stress curve, Fracture toughness initial, Maximum load toughness.*

COB1270 ADAPTIVE FINITE ELEMENT MODELING OF THREE-DIMENSIONAL ELASTIC-PLASTIC CRACK PROPAGATION**Fernando César Meira Menandro**

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A three-dimensional adaptive elastic-plastic finite element algorithm for crack propagation is developed. The crack propagation algorithm uses theoretical parameters from fracture mechanics to

model crack growth. A maximum energy release rate criterion is adapted to use in three dimensions, combined with a maximum crack tip opening angle criterion. The error estimator adopted is of the flux projection type, which uses the difference between the calculated strains/stresses and a continuous 'smooth' strain/stress distribution calculated also from the obtained solution. This difference is, in general, integrated over the element to give an energy error value. The mesh is then regenerated, targeting an equidistribution of this error value, using a mesh generator which takes the previous mesh to serve as a background grid. New procedures for strain recovery and error estimation, adequate for elastic-plastic problems and for crack propagation problems, are proposed and tested. The proposed algorithm is analyzed qualitatively, and found to perform adequately for the problems of interest.

Keywords: *adaptive finite elements, crack propagation, error estimation, fracture mechanics, plasticity.*

COB1271 INFLUÊNCIA DA EMISSÃO DE DISCORDÂNCIAS SOBRE A TRANSIÇÃO FRÁGIL-DÚCTIL

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In-situ synchrotron observations of loaded pre-cracked silicon single crystals at high temperature allowed for a better understanding of the conditions for dislocation nucleation and development and, consequently, a better comprehension of the origins of the brittle to ductile transition. For a given load rate it can be considered that when the test is accomplished at transition temperature there is a balance between increase of applied stress and increase in the number of dislocations emitted generating a stress field opposed to the applied and causing a retardation of the critical rupture condition given by $K_{ef} = K_{IC}$. Such phenomenon occurs due to the interaction between the stress fields from the crack and the dislocations (shielding). It has been observed that the dislocations are emitted preferably from defects on the crack tip, heterogeneously, which involves the introduction of the crack tip quality as a supplementary parameter. Furthermore, it is shown that in the absence of dislocation emission a variation of the notch curvature radius can occur, which recalls the interest for the crack tip blunting based models. This geometric variation of the crack tip can occur either by plastic deformation, caused by the emergence of dislocations on the crack tip when these are located in preferred planes, or by superficial atomic diffusion which occurs preferably on the highly stressed surface. Experimental results show that, when the crystalline perfection is sufficient, the dislocation nucleation can be inhibited. This supposes that the brittle to ductile transition temperature measurements taken to this date are approximate and that this is not an intrinsic characteristic of the material. Pre-cracked specimens were loaded at high temperature (650 to 800°C) during a period that varied from a few minutes to a few hours and then ruptured at room temperature: the observed toughness increase DK is quantified and depends on the applied load and on the time of heat treatment.

Keywords: *Trincas, transição frágil - dúctil, discordâncias, zona plástica, fator de intensidade de tensões.*

TEMA 78 - Análise Experimental de Tensões

COB1358 ANÁLISE NUMÉRICA E EXPERIMENTAL DE UMA PLATAFORMA DE FORÇAS / NUMERICAL AND EXPERIMENTAL ANALYSIS OF A FORCE PLATFORM

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This paper presents a comparison with numerical and experimental analysis of a force plate. The platform was built with four octagonal steel load cells, each one measures two uncoupled forces, horizontal and vertical. The complete system allows to measure three orthogonal forces and three moments. The load cells were analyzed using the finite element method, the element used was a structural solid element (20 nodes) and the aluminum plates used a structural shell element (8 nodes). Dynamic analysis was developed to determine the lowest natural frequencies with permits to get the working frequency band. The experiment to get the frequency response, was realized bounding an accelerometer in each direction of a force plate connected to Fast Fourier Analyzer. Numerical and experimental results were compared, the resulting linear frequency band is zero to 180 Hz in a conservative form.

Keywords: *Force, platform, modal analysis, numerical simulation, experimental analysis. Força, plataforma, análise modal, simulação numérica, análise experimental.*

TEMA 81 - Metrologia

- COB587** **CORREÇÃO DE ERROS SISTEMÁTICOS DE APALPADORES DE MÁQUINAS DE MEDIR POR COORDENADAS ATRAVÉS DA ANÁLISE DE FOURIER. / SYSTEMATIC ERRORS CORRECTION OF THE COORDINATE MEASURING MACHINES PROCESS THROUGH FOURRIER ANALYSIS**

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One of the most important sources of uncertainties in Coordinate Measuring Machines (CMM) is related with the probes, especially in manual CMM. These probes are mainly mechanical (touch trigger probe or TTP) and suffer from important systematic errors. Due to construction shape, these errors represent a large amount on the machine uncertainty. It is possible to make error corrections eliminating most of these systematic errors. This is not an obvious task, although it can be aided by computer techniques. In this paper a characteristic profile of the behavior of the probe is determined, through Fourier analysis, and it is used to correct the coordinates of the touched points. The measurement were done over a certified standard sphere of Perthen, and the CMM was a microval of the Brown & Sharpe. The final result could be improved up to 40% for circularity. This procedure can be used to other shapes, since one has standards of this same shape. Also the profile is determined for a probe and an equation can be stored for it. An exchange of the probe can be associated to this equation, making it easier to proceed to error corrections when more than one probe (or a setup of this probe) is available.

Keywords: *Máquinas de medir por coordenadas, Análise de Fourier, Incertezas, Metrologia, Apalpadores eletro-mecânicos. / Coordinate measuring machines, Fourier Analysis, Uncertainty, Metrology, Electro-mechanical process*

- COB589** **COMPARAÇÃO ENTRE UM ALGORITMO DE ZONA MÍNIMA DE TOLERÂNCIA E UM ALGORITMO DE MÍNIMOS QUADRADOS / COMPARISON BETWEEN A MINIMUM ZONE CENTER AND A LEAST SQUARE CENTER ALGORITHM**

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The Coordinate measuring machine (CMM) became an important metrology tool in modern manufacturing. They can measure accurately and quickly improving automation conditions. Most of these machines still use least squares center algorithms to calculate circularity and other shape deviations. Recently the American Society of Mechanical Engineering (ASME) printed new Y14.5 and Y14.5.1 standards. They established definitively that minimum zone center (MZC) algorithms should be used instead of LSC ones. In the last years some MZC algorithms had been proposed. In this paper one of these MZC methods, the Voronoi algorithm, is compared with the LSC. The results show that the differences between the methods are negligible when using CMMs with higher uncertainties. However when using better CMMs (with smaller uncertainties), the differences are important.

Keywords: *Metrologia, circularidade, mínimos quadrados, algoritmos, zona mínima de tolerância./ Metrology, Circularity, Least squares center algorithms, Minimum zone center*

COB1007 FONTES DE ERROS NA MEDIÇÃO DA TEXTURA SUPERFICIAL COM ESTILETE E COM SONDA ÓPTICA / SURFACE TEXTURE MEASUREMENT ERRORS SOURCES WITH STYLUS AND OPTICAL PROBES

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Many different systems of roughness measurement are available today. Although the modern instruments are very sophisticated, still exist many sources and kinds of error in surface texture measurement. Most important sources of errors are those related with the measurement instruments as well as the environment they are being used. Only stylus and optical follower instruments would be discussed here. These instruments represent one that are being used in most of the laboratories and industries that handle surface texture measurement. Because of the growing interest in the relationship surface texture/technological function, it is vital to improve the methods in order to find out and eliminate the measurement errors or at least minimise their effects. The scope of this paper is to present the most important sources of errors in surface texture measurement and to propose ways to eliminate or minimize their effects in the measurement results.

Keywords: *Surface Texture - Measurement - Stylus - Optical Follower - Errors / Textura Superficial - Medição - Estilete - Sonda Óptica - Erros*

COB1157 TECHNIQUE FOR ASSESSING THE PERFORMANCE OF CO-ORDINATE MEASURING MACHINES (CMMs)

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A new technique is proposed for assessing the performance of co-ordinate measuring machines(CMMs). This technique comprises a new form of space frame which has the form of a tetrahedron and is referred to as modular space frame as different configurations of tetrahedron can be obtained easily and rapidly. The modular space frame comprises magnetic ball links and a ball plate. The volumetric error data obtained when a CMM measures the calibrated modular space frame can be used to verify whether a CMM maintains the manufacturer specifications. The experimental results have demonstrated that the modular space frame technique has an acceptable repeatability and provides a practical and cost effective mechanical artefact for calibration, verification, periodic reverification and acceptance test of any type of CMM.

Keywords: *Calibration; Verification; Co-ordinate Measuring Machines*

TEMA 82 - Soldagem

COB5 UMA CONTRIBUIÇÃO AO ESTUDO DA SOLDAGEM COM OS ARAMES TUBULARES AUTOPROTEGIDOS / A CONTRIBUTION FROM STUDY OF SELF-SHIELDED FLUX-CORED ARC WELDING

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Eight AWS E71T7 flux-cored steel welding wires were formulated with systematic changes in the Ni-content between 0% - 3,5% and with the addition of 0,5% and 1,0% Mn in the flux. The effects of the above changes and the effects of the welding current and stickout on the economical characteristics of the wire (fusion rate and deposition efficiency) and on the welding bead geometry were examined. The effect of the above wires and the welding parameters on the weld bead hardness were also analysed. The results showed that the welding parameters as well as the wire compositions affected the economical characteristics as well as the weld bead geometry. Otherwire, the effect of the heat input on the weld bead hardness is less significant..

Keywords: *Cored wire; Flow; Stability / Arame tubular; Fluxo; Estabilidade.*

COB7 EFEITO DO MAGNÉSIO SOBRE A GEOMETRIA DA SOLDA E SOBRE AS CARACTERÍSTICAS ECONÔMICAS DE ELETRODOS AWS E7024 / THE EFFECT OF MAGNESIUM ON THE GEOMETRIC AND ECONOMIC CHARACTERISTICS OF THE AWS E7024 ELECTRODES

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Among the different kinds of electrodes, the rutilic types are acknowledged as those which allow the easiest operation and handling. Their mechanical properties, however, are inferior to those of basic and cellulosic electrodes. A recent study has shown that adding magnesium to the coating of AWS E7024 rutilic electrodes improves considerably the impact strength of the welding metal and to reduce the content of diffusible hydrogen. This work attempts to analyse the effect of magnesium on the economic characteristics of rutilic electrodes and also on the geometric characteristics of the experimental welding electrodes. Derived from the AWS E7024 class were developed, with 3.25 mm diam., and exhibiting five different amounts of metallic magnesium (from 0 to 4%). Simple deposition automatic weldings in plane position with current DC+, DC- and AC were performed in 170x50x6 mm ABNT 1020 all-weld metal, using a computerised device. The results obtained were compared using the ANOVA method, and showed that magnesium content does not effect welding geometry neither economic characteristics of consumables.

Keywords: *electrodes, magnesium, welding, rutilic/eletrodos, magnésio, solda, rutílico*

COB9 UM CRITÉRIO PARA AVALIAÇÃO DA ESTABILIDADE DO ARCO ELÉTRICO DE SOLDAGEM EM PROCESSOS GMAW / A CRITERIA FOR EVALUATION OF ARC STABILITY IN GMAW

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This work presents the evaluation of the arc stability in GMAW (Gas Metal Arc Welding) processes by the sound emitted during operation. Using a neural network, the relation between some criteria based on the oscilograms of voltage and current and some characteristics of the sound of the arc allows the recognition of stable or unstable behaviour patterns, and gives an intelligent and simple control of the welding.

Keywords: *Arc stability, GMAW, Arc Welding*

COB12 SELF CALIBRATION AND OFF-LINE PROGRAMMING OF WELDING CELLS

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The objective of GRACO's research is to implement an off-line programming system, which includes welding parameters generation, as well as to integrate the joint location, the seam tracking, and the stand-off control features into a welding monitoring and control system for the GMAW process. The resultant combination is going to provide full off-line programming facilities allied to self-adjusting capabilities for an automatic welding cell.

Keywords: *Automation, Robotic, Off-line programming, Self-calibration, welding*

COB13 APLICAÇÃO DE VISÃO POR COMPUTADOR PARA GUIAGEM DA TOCHA EM UMA CÉLULA DE SOLDAGEM / COMPUTER VISION APPLICATION ON TORCH GUIDANCE IN A WELDING CELL

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A computer vision system is proposed for guiding the welding torch in a robotic welding station. The vision sensing system consists of a laser-emitting diode, a CCD video camera, a frame grabber card and a PC computer. The camera and the laser device are fixed to the welding torch. The laser beam produces a luminous stripe across the welding path and in advance of the torch. By capturing images from the workpieces reflecting the laser stripe an image processing algorithm establishes a welding reference path and compares it with the actual path. A trajectory deviation error is generated

and transmitted to the robot control unit for the necessary action. Provisions for the implementation of a complete visual servo control for the robotic welding station are also discussed.

Keywords: *Computer Vision Guidance; Welding Seam Tracking; Robotic Welding Station; / Guiagem por Visão Computacional; Rastreamento de Trajetória de Soldagem; Estação Robótica para Soldagem*

COB14 USO DE REDES NEURAIS EM SOLDAGEM MIG/MAG SINÉRGICO PULSADO / USE OF NEURAL NETWORK IN PULSED SINERGIC GMAW

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The present work is aimed to optimise the synergic pulsed MIG/MAG weld process' parameters. The experimental methodology was planned using factorial design 34. The welding parameters controlled were the current, trim value, welding speed and stick-out. The results analyses were based on the bead geometry. A Neural Network like back-propagation was used to establish the best weld conditions. The results obtained here shows the practical use of factorial designs in welding experience. The neural network is useful in optimising the welding parameters and it is also showed in this work.

Keywords: *Neural network, Optimisation, Pulsed Welding*

COB15 OTIMIZAÇÃO DE PARÂMETROS DE SOLDAGEM NO PROCESSO GMAW UTILIZANDO ANÁLISE ESTÁTICA E REDES NEURAIS / OPTIMISATION OF GMAW PARAMETERS USING STATISTIC ANALYSIS AND NEURAL NETWORK.

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This work has two main purposes. Firstly, identify operating envelopes for GMAW (Gas Metal Arc Welding) process in commercial sheet steels produced in Brazil with 3,0 mm thickness. Secondly, establish mathematical relations between welding parameters and welding dimensions, besides their performance in welded joints; for doing that, some pre-determined conditions were established: such as shielding gas, electrode diameters and weld position. In this work was also verified if a commercial power source is efficient or not when used in semi-automatic process. The experimental methodology was planned using factorial design. The steel's plates were welded in butt weld position and aided by a machinery tool, which was adapted to operate in the weld speed. The welding controlled parameters were current, tension and travel speed. The analysed parameters were based on the bead geometry and resistance of the weld joint. The mathematical models were determined by multiple regression and neural network which shows to be useful in optimise the welding parameters and the mechanical resistance of welding joint and bead geometry.

Keywords: *Automation, Optimisation, Welding, Factorial Design, Multiple Regression Analysis, Neural Network*

COB25 UTILIZAÇÃO DOS CAMPOS DE TEMPERATURA GERADOS DURANTE A SOLDAGEM À ARCO PARA AUTOMAÇÃO DO PROCESSO/THE USE OF TEMPERATURE FIELDS GENERATED DURING ARC WELDING FOR PROCESS AUTOMATION

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In arc welding process, the thermal energy from the electric arc is responsible for the fusion of the weld pool and for an abrupt thermal cycle in the adjacent unmelted metal. It is expected that the heat supplied by the arc should be sufficient for fusion affecting on minimum the rest of the material. However, one of the greatest problem resulted from the process is the occurrence of residual stresses. To evaluate the extension of the heating effect and looking for the development of a welding automation system, mathematical modeling can be applied. One objection however is that, the existent models are static and usually complex. Rosenthal's model is one of these existent models and despite it is static, it is very simple to apply. This paper presents a study of Rosenthal's model modification to describe the thermal profiles on the base metal produced "during" welding. With the modification, it was possible to verify the more suitable welding parameter to be used as a dynamic manipulated variable in a welding control system, looking forward to a robotics application.

Keywords: *Soldagem robotizada, Modelamento analítico, perfis térmicos, tensões residuais, automação e controle. Robot Welding, Analytical Modeling, Thermal Profile, Residual Stresses, Automation and Control*

COB375 EFEITO DAS DISTORÇÕES SOBRE A DISTRIBUIÇÃO DAS TENSÕES RESIDUAIS NA SOLDAGEM / DISTORTIONS EFFECTS ON WELDING RESIDUAL STRESSES DISTRIBUTIONS

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In the welded steel sheets by shielded metal-arc welding and by oxyacetylene torch, the distortions were recorded and the residual stresses by X-rays diffraction measured. Thus, it was possible to show how the differents forms of distortions affect the macroscopic residual stresses distributions in welding junctions.

Keywords: *welding, residual stresses, distortion.*

COB376 DIFICULDADEDES NA DETERMINAÇÃO DE TENSÕES RESIDUAIS NA SOLDAGEM POR DIFRAÇÃO DE RAIOS-X / DIFFICULTIES IN WELDING RESIDUAL STRESSES DETERMINATION BY X-RAYS DIFFRACTION

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The X-rays diffraction methods are convenient for the welding residual stresses determination, and can be reasonably evaluated with such precision the great stress gradient that occur near the weld beads, presenting results seldom obtained by other experimental procedures. Nevertheless, the X-rays methods are not trivial if discernment and confidence are expected; it is particularly true in the welding residual stresses determination. This paper, tries to present the practical difficulties and possible solutions encountered to solve them. A lot of stress measurements effectuated, by the author, in sheets of differents kinds of steel, welded by shielded metal-arc welding and oxy-acetylene torch are the basis for discussion.

Keywords: *Residual stresses, welding, X-rays diffraction.*

COB556 SELEÇÃO DE PROCESSO DE SOLDAGEM BASEADA EM ANÁLISE CONJUNTA DE CUSTO E QUALIDADE / WELDING PROCESS SELECTION BASED ON COMBINED COST AND QUALITY ANALYSIS

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The diversity of welding processes and their variants makes the choice of process difficult. Both Cost and Quality analysis are a good indicative to consider during the selection, because in the market exigencies of Cost and Quality must be attended in order to be competitive. In fact, the best process will be the one that analysing these factors together result in the best global performance. The objective of this work is to select the best process for a practical case study, using a thin carbon steel sheet as the work-piece normaly used in dredging pipes. The processes considered are: GMAW - short-circuit, spray and pulsed, and GTAW - convencional and pulsed. The results showed that, for the welding set conditions, in terms of Quality, the best was spray GMAW. In terms of Cost, short-circuit GMAW outperformed the others. However, considering both Cost and Quality requirements, the best was short-circuit GMAW.

Keywords: *Welding, Cost, Quality, Thin sheet, Gaseous protection / Soldagem, Custo, Qualidade, Chapa fina, Proteção gasosa*

COB557 UTILIZAÇÃO DA EMISSÃO ACÚSTICA NO ESTUDO DA TRINCA DE REAQUECIMENTO/ACOUSTIC EMISSION UTILIZATION IN STUDY OF REHEAT CRACKING

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The Reheat Cracking phenomenon can occur either in the heat affected zone or in the fusion zone during Post Weld Heat Treatment (PWHT) for stress relief as well as in high temperature operation. An Acoustic Emission Measurement System (AEMS) was used in this work to determine the instant of propagation of reheat cracking. The AEMS was connected to a Modified Implant Test which is applied for simulation of thermal cycles typically. This study were developed using a high strength

low alloy steel commercially produced. Tests varying initial loads and different heat-treatment temperatures, maintaining constant the welding conditions. It was concluded that the AEMS is very adequate for the purpose, where the modes fractures showed a predominance for low-ductility intergranular fracture. For the modes of fracture by creep cavitation were not possible determine with clarity the instant of propagation of reheat cracking.

Keywords: *Welding, Reheat cracking, Thermal treatment, fracture surface, Acoustic emission/Soldagem, Trinca de Reaquecimento, Tratamento Térmico, Superfície Fraturada, Emissão Acústica*

COB660 **MODELAGEM E SIMULAÇÃO DA DINÂMICA DE UM SISTEMA PARA SOLDA DE CHAPAS A FRIO / PRESS JOINING SYSTEM DYNAMICS MODELING AND SIMULATION**

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This paper covers the description and modeling procedure, based on the Bond Graph language, of the Press Joining industrial method for fastening sheet metal parts. The computational simulation of its dynamics and the applications of these results are presented, aiming to show the advantages of using these methodologies in the design of industrial process.

Keywords: *Modelagem Dinâmica, Grafos de Ligação, Simulação Dinâmica, Solda à Frio, Processo Industrial. Dynamic Modeling, Bond Graphs, Dynamic Simulation, Fastening Sheet, Industrial Processes*

COB1261 **AUTOMATIC VOLTAGE TUNING - A MEANS OF ENSURING PROCESS STABILITY AND WELD QUALITY IN GMA WELDING**

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This paper presents a method of attaining process stability and ensuring good weld quality in conventional gas metal arc welding by automatic voltage tuning. The process is first monitored, its stability assessed and, based on the assessment, voltage control commands are issued. The automatic voltage tuning algorithm utilises fuzzy production rules, which use as inputs the values of four monitoring indices calculated from the welding current and voltage waveform features. The main control objective of the algorithm is to ensure that the welding voltage is not too low or unnecessarily high, thereby preventing arc instability, minimising the level of fume and spatter generated, and reducing the risk of defects such as undercut and lack of fusion. The result of this present research work shows that welding procedures can be adapted to give good weld quality and stable welding arcs by trimming the welding voltage to a suitable level.

Keywords: *Gas Metal Arc Welding, Automatic Voltage Tuning, Metal Transfer, Process Monitoring and Control.*

TEMA 83 - Conformação

COB131 DETERMINAÇÃO DE ABERTURAS ENTRE CILINDROS DE LAMINAÇÃO, VIA LÓGICA NEBULOSA / DETERMINATION OF THE ROLLING MILL GAP BY USING FUZZY LOGIC

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In the present work, a method for the determination of the rolling mill gap of flat products by using fuzzy logic was developed. The rolling mill gap is determined by considering the aimed and accumulated deformations, classified as "high", "medium" and "low". The rules to decide the corresponding actions are obtained from the input data. This schedule is non-dependent upon the knowledge of the mechanical properties of the material to be rolled and the characteristics of the rolling process.

Keywords: *Rolling Process, Fuzzy Logic, Laminação, Lógica Nebulosa*

COB161 ANÁLISE COMPARATIVA DE ESTIRAMENTO IN-PLANE VERSUS OUT-OF-PLANE/COMPARATIVE ANALYSIS OF IN-PLANE VERSUS OUT-OF-PLANE STRETCHING

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The limit strains, or the maximum plastic strains that a sheet can support up to the necking point, admitting free deformation on the sheet plane (In plane strains-IP) are quite different of the biaxially stretching operations with spherical punch or pressure (Out of plane strains-OP). The last one, which represents the real industrial operations, are greater than the IP strains, for the same degree of biaxial tension. The main scope of this work is to perform stretch operations IP, using a specially designed device able to input IP strains, and verify if differences between theoretical models and experimental data are based on the fact the stretching operation be IP or OP.

Keywords: *Chapas metálicas, Estiramento Biaxial, Deformações limites. Sheet metals, Biaxially stretching, Limit strains*

COB377 PROCESSO DE FABRICAÇÃO POR CONFORMAÇÃO SUPERPLÁSTICA EM CHAPAS DE TITÂNIO / FABRICATION PROCESS BY SUPERPLASTIC FORMING IN TITANIUM SHEETS

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In this work, activities related to application of superplastic forming technics, in getting pieces with titanium alloy sheets of the type Ti 6Al 4V, are presented and discussed. The results show that the forming process presents no difficulties. But, the whole set of the accessories and the artifice to get good performance of the process involve technics that must be well controlled and improved, depending on the size or complexity of the piece worked. The equipments and devices to prepare the experiments were particularly designed and constructed to the purpose, and suffered constantly modifications to attend improvements and propitiate versatility and producibility during the course of the activities. The gotten pieces showed a good finishing and possibility of a good dimensional precision. The much more interesting result of the experiment was the experience obtained during the development of the process and so, we intend to present its many stages, technical characteristics and the potential application in different industrial segments.

Keywords: *Superplastic Forming, titanium alloys*

COB393 EXPERIMENTAL DETERMINATION OF FRICTION COEFFICIENT AND STRESS-STRAIN CURVE FOR APPLICATION IN METAL FORMING ANALYSES

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The compression test of a ring is customarily used to determine the friction coefficient in metal forming problems. The aim of this work is to develop a procedure to obtain, for metals in large deformation, the stress-strain curve and the friction coefficient through the same ring test. The friction coefficient is evaluated comparing curves obtained by a finite element code with the experimental curves. The stress-strain curve is obtained inverting an analytic solution, calculated by the lower upper-bound approach.

Keywords: *Friction, Stress-strain curve, Ring test, Large deformation*

COB548 NUMERICAL AND EXPERIMENTAL ANALYSES OF FORMING AND PENETRATION PROBLEMS

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In this work the large elasto-plastic deformations taking place in metal forming and impact are analyzed, using numerical and experimental procedures. Initially, the procedures used for remeshing and transference of variables are described. Then, the analyses of two practical problems are performed, using the code METAFOR (METAL FORMing). The first corresponds to a forming operation using alternatively one and two forging stages. In the second one, the penetration of a steel conic head into an aluminum cylinder is analyzed, both numerically and experimentally. It is seen that, for this kind of applications, remeshing is indispensable to obtain adequate final solutions.

Keywords: *Finite elements method (FEM), large elasto-plastic deformations, remeshing*

COB575 ANALYSIS OF METAL FORMING PROCESSES BASED ON A REPRODUCING KERNEL PARTICLE METHOD**Cristina Maria Oliveira Lima Roque, Sérgio Tonini Button***Department of Mechanical Engineering, State University of Campinas, Campinas, SP, 13083-970, caixa postal 6122, Brazil e-mail: crism@fem.unicamp.br***Jiun-Shyan Chen, Chunhui Pan***Department of Mechanical Engineering and Center for Computer-Aided Design, The University of Iowa, Iowa City, Iowa 52242, USA e-mail: jschen@icaen.uiowa.edu*

The excessive plastic deformation during metal forming processes exhibits characteristics of both solid and fluid flow, and conventional finite element methods often break down due to severe mesh distortion. Since 1993, considerable research work in computational mechanics has been devoted to the development of meshless methods. The main feature of these methods is that the domain of the problem is represented by a set of nodes, and finite element mesh is totally unnecessary. This new generation of computational methods reduces time-consuming model generation and refinement effort, and provides a higher rate of convergence than that of the conventional finite element methods. A meshless method based on the reproducing kernel particle method is applied to metal forming analysis. With this method, the model refinement in metal forming simulation can be done simply by inserting nodes without remeshing. Metal forming examples, such as sheet metal stamping and upsetting, are analyzed to demonstrate the performance of the method.

Keywords: *Meshless Method, Reproducing Kernel Particle Method, Metal Forming, Elasto-Plasticity, Large Deformation. Método sem malha, Método RKPM, Conformação Mecânica, Elasto-plasticidade, Grandes deformações.*

COB577 SISTEMA ESPECIALISTA PARA FORJAMENTO A QUENTE / EXPERT SYSTEM FOR HOT FORGING DESIGN**Ângelo Caporalli Filho, Luciano Antonio Gileno, Sérgio Tonini Button***Departamento de Engenharia de Materiais, Faculdade de Engenharia Mecânica - UNICAP CEP 13083-970 - Campinas, S.P. Brasil, E-mail: sergio1@fem.unicamp.br*

Planning hot forging process is a time-consuming activity with high costs involved, because of the trial-and-error iterative methods used to design dies and to choose equipments and process conditions. Some processes demand many months to produce forged parts with controlled shapes, dimensions and microstructure. This paper shows how expert systems can help engineers to reduce the time needed to design precision forged parts and dies from machined parts, with the software APFFQ interfacing Visual Basic v.4.0 and SolidEdge v.2.0. The software was used to design flashless hot forged gears, chosen from families of gears.

Keywords: *Precision Forging, Expert Systems, Hot Forging. / Forjamento de precisão, Sistemas Especialistas, Forjamento a Quente*

COB590 AÇÃO DE CONTROLE SOBRE A ESPESSURA DE SAÍDA DE TIRAS LAMINADAS UTILIZANDO A LÓGICA NEBULOSA / CONTROL ACTION ON THE ROLLED STRIPS THICKNESS USING FUZZY LOGIC

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The thickness of a rolled strip, which must remain within very close limits, is one of the critical parameters in the characterization of its quality. The process of controlling this thickness frequently requires actions which may affect other important characteristics of the strip, such as profile and shape. Two control procedures are commonly used for this purpose, one on the screw-down mechanism and the other on the strip front or back tensions. One or the other may be more adequate, depending on the operational conditions. These control actions have been normally determined and executed in correspondence with the variation of only one of the parameters of the process. In the present work, a method is developed based on the application of fuzzy logic, which allows for the calculation of suitable control actions to adjust the final thickness of the strip, considering the simultaneous variation of any two operational parameters of the process.

Keywords: *Strip rolling, gage control, fuzzy logic, laminação de tiras, controle de espessura, lógica nebulosa*

TEMA 84 - Usinagem

COB31 SISTEMA DE APOIO À DECISÃO NA ESCOLHA DE CONDIÇÕES OPERACIONAIS PARA PROCESSOS DE USINAGEM

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Process planning is an essential activity in the several stages of the manufacturing cycle and has been developing with the use of CAPP systems, particularly for machining processes. This paper presents the model for a prototype system to aid the planning decisions and intending to obtain the machine, the tool and a theoretical specification of the depth of cut, feed and cutting speed of the process. It was considered aspects like machinability of the part material, secondary and auxiliary manufacturing times, and the logistics applied to the flow of parts at the shop-floor through the definition of the used machine to be or not a production neck beyond its machine capacity. As optimization criterion it was proposed a study of the compromise between cost and manufacturing time for the maximum efficiency interval, with the restrictions of the machine-tool-part set. The system has a practical testing module intended to refine the theoretical values of the adopted cutting speed to guarantee its application to the adopted machine and tooling. The system approach is semi-generative, with algorithmic and knowledge based solutions, with a simple and user-friendly interface.

Keywords: *Planejamento de processo, CAPP, processos de usinagem, velocidade de corte, otimização de processo*

COB115 ANÁLISE COMPARATIVA ENTRE USINAGEM DE COMPÓSITO PRFC E USINAGEM CONVENCIONAL DOS METAIS / COMPARATIVE ANALYSIS BETWEEN CFRP COMPOSITE MACHINING AND METALS CONVENTIONAL MACHINING

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In reason of their characteristics the applications of composite materials based on Carbon Fibre Reinforced Plastic (CFRP) growing considerably. So, new manufacturing process and production techniques must be developed to ensure high precision and good surface quality to the components. In function of this manufacturing scenario, is necessary to study the machining process. This work shows practical experiments in turning of carbon fiber reinforced resin to study the performance of different tool materials like ceramics, cemented carbide, cubic boron nitride (CBN), and diamond (PCD). The tests were carried out with cemented carbide tool in various cutting speeds and feeds. For

finish operation were used the PCD tools with positive and negative geometry. During the tests were observed tool wear, machining forces, and main engine power. In function results is done a comparative analysis between CFRP composite machinability in relation ABNT 4340 steel. Finally, the work shows that the cutting conditions optimisation is extremely important in the selection of tools and cutting condition to be used during CFRP manufacturing process.

Keywords: *CFRP Composite, Machinability, Tools, Roughness, Machining Forces, Cutting Conditions/Compósito PRFC, Usinabilidade, Ferramentas, Forças de Usinagem, Condições de Corte*

COB116 ANÁLISE COMPARATIVA ENTRE USINAGEM DE COMPÓSITO PRFC E USINAGEM CONVENCIONAL DOS METAIS / COMPARATIVE ANALYSIS BETWEEN CFRP COMPOSITE MACHINING AND METALS CONVENTIONAL MACHINING

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Keywords: *CFRP Composite, Machinability, Tools, Roughness, Machining Forces, Cutting Conditions/ Compósito PRFC, Usinabilidade, Ferramentas, Forças de Usinagem, Condições de Corte.*

COB120 EFEITO DO ENXÔFRE (UM ADITIVO E.P.) NA LUBRIFICAÇÃO EM USINAGEM / EFFECT OF SULPHUR (AN E.P. ADDITIVE) ON LUBRICATION IN MACHINING

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Several turning experiments were carried out in quenched AISI E52100 steel with average hardness of 60 HRC, using blended ceramic tool material. A 22 kW CNC lathe was used and acoustic emission and electrical current of the main machine motor were monitored in real time, aiming to indirectly determine the end of tool life. When the workpiece surface roughness reached $Ra = 0.6$ mm, the experiment finished and the tool was replaced. This value of Ra was used because it is a typical surface roughness value for grinding and the main goal of hard turning process is to replace grinding process. The results point out that, due to the low value of flank wear allowed to the tool in order to not pass this surface roughness, the 2 monitoring methods used are not suitable for establishing the end of tool life without further signal conditioning.

Keywords: *Hard Turning, Ceramic Tools, Tool Wear, Tool Monitoring, Sensor, Machining, Torneamento de Aços Endurecidos, Monitoramento, Usinagem, Sensores, Ferramentas Cerâmicas*

COB130 MONITORAMENTO DO TORNEAMENTO DE AÇOS ENDURECIDOS USANDO EMISSÃO ACÚSTICA E CORRENTE DO MOTOR / MONITORING OF HARD TURNING USING ACOUSTIC EMISSION AND MOTOR CURRENT

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Keywords: *Hard Turning, Ceramic Tools, Tool Wear, Tool Monitoring, Sensor, Machining, Torneamento de Aços Endurecidos, Monitoramento, Usinagem, Sensores, Ferramentas Cerâmicas.*

COB140 A VIDA DAS FERRAMENTAS NA USINAGEM DA MADEIRA DE "EUCALYPTUS GRANDIS" NOS ESTADOS VERDE E SECO / AISI D-6 STEEL AND STELLITE-1 TOOL LIFE DETERMINATION IN THE "EUCALYPTUS GRANDIS" WOOD MACHINING

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Two tool materials were tested at the same time: the steel AISI D-6 and the stellite-1. The wet and the air dried "Eucalyptus grandis" wood were machined with the following cutting speed: 25,4 - 35,0 - 42,6 and 50,5 m/s. The test was carried out in a molding machine, on which we set up a built tool holder and attached a feeder for the wood beams with stepless regulation speed. With regard to the two tool materials tested over tens of kilometers of cutting lengths, in the wet or the air dried wood machining, it was the stellite-1 tool material that showed a better performance in the wet, as well as in the air dried wood machining. The experimental outcome showed different trends, as to the life of the tools. The plots of the tool life for the air dried wood are bent downwards, that is, for the lower cutting speeds the tool life lasts longer. From a certain value of speed, the tool life falls, while for the wet wood machining the tool life bends upwards, that is, by increasing the cutting speed value a little bit, the tool life decreases, whereas, from a certain value of the cutting speed, the tool life stabilizes.

Keywords: *Wood working, Wood machining, Tool wear / Processamento da madeira, Usinagem da madeira, Desgaste de ferramentas*

COB141 UM SISTEMA AUXILIADO POR COMPUTADOR PARA DETERMINAR O DESGASTE DAS FERRAMENTAS NA USINAGEM DA MADEIRA / A COMPUTER AIDED PROCESS TO DEFINE THE TOOL WEAR IN WOOD MACHINING

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Because of the difficulty in measuring the wear of the saw teeth and other wood cutters and because of the inaccuracy of the use of an optical measuring projector for that purpose, we developed a tool holder with twelve holes to hold the tools in the same direction of the axis, forming an end mill, which would be applied at a molding machine. We also built up a system to measure the tool wear using a coordinate table, two digital electronic measuring instruments, a multiplexer and a computer constituting a profile analyzer. The tool wears were measured for tool machining definite cutting length, for instance 10 km, 25 km, 40 km, and so on. After having obtained the wears which took place along the cutting edge from the vertex with a step of 0,1 mm until its useful length (3,0 to 3,5 mm), we built the edge wear graphs showing the evolution of the tool edge wear. We concluded that the built tool holder and the wear measurement system used were accurate and suitable. With such a system, it is possible to have a great amount of information, in regard to the tool wear inside a computer.

Keywords: *Wood working, Wood machining, Tool wear / Processamento da madeira, Usinagem da madeira, Desgaste de ferramentas.*

COB144 OPTIMIZACIÓN DEL MECANIZADO DE Ti-6Al-4V Y Ni-19Cr-19Fe-Nb

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This paper describes several aspects on the Titanium based Alloys and Nickel based alloys machining technology, its role in the aeronautical industry, as well as their properties, disadvantages and the efforts carried out in the optimization of the conventional machining process (modifying the cutting parameters, tool materials, geometry, and other parameters involved in the process). This paper also describes different aspects related to using coated tools (TiCN, TiN, CrN) in the machining of titanium alloys, in order to protect cutting edges against flank wear.

Keywords: *Mecanizado, Ti-6Al-4V, Ni-19Cr-19Fe-Nb, Aeronáutica, Fresas, Recubrimientos*

COB146 TOOL LIFE OF PCBN AND CERAMIC CUTTING TOOLS WHEN TURNING HARDENED AISI E52100 STEEL

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The paper investigates the tool life of two grades of polycrystalline cubic boron nitride tools (high and low CBN content) and three grades of ceramic tools (mixed alumina, whisker reinforced alumina and silicon nitride-based ceramic) when continuous turning AISI E52100 bearing steel (62 HRC). The tests were conducted over a range of cutting parameters involving roughing and finishing conditions. A tool life criterion was established for an average flank wear of $V_{BB}=0.3$ mm and the surface roughness of the machined surface was monitored throughout the test programme. The results indicated that, in general, longest tool lives were obtained when machining using the mixed alumina and low content PCBN tools, followed by the whisker reinforced alumina, high content PCBN and finally silicon nitride-based ceramic (which presented the poorest performance). Surface finish values as low as $R_a=0.14$ mm were obtained under finishing conditions.

Keywords: *Machining, Hardened Steels, PCBN and Ceramic Tools, Tool Life*

COB152 MEDIÇÃO DE TEMPERATURA EM USINAGEM UTILIZANDO SENSOR INFRAVERMELHO / TEMPERATURE MEASUREMENTS IN MACHINING USING INFRARED SENSOR

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This work describes a technique that uses an infrared sensor to measure the temperature on the machined surface of the workpiece. This temperature is obtained after extrapolation of three measured temperatures below the cutting edge: at 3mm; 6mm and 9mm. The technique was first developed to be used in dry cuts, but was improved to allow measurements when cutting fluid is applied. Results from machining an AISI1040 steel are presented for dry cut and when a mineral oil is used as lubricant.

Keywords: *Usinagem; Temperatura de usinagem; Fluidos de corte / Machining; Machining temperature; Cutting fluids*

COB387 OTIMIZAÇÃO DO PROCESSO DE USINAGEM DE MATERIAIS FRÁGEIS COM FERRAMENTA DE PONTA ÚNICA DE DIAMANTE / OPTIMIZATION OF THE SINGLE POINT DIAMOND MACHINING OF BRITTLE MATERIALS

Carlos Renato Pagotto, Jaime Gilberto Duduch, Juan Carlos Campos Rubio, Renato Goulart Jasinevicius & Arthur José Vieira Porto

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Researches on single-point machining of brittle materials show that critical chip thickness should be of submicrometre order. Condition of cut to obtain crack-free surfaces, however, vary significantly from material to material. According to the geometry of the tool, cutting depths and feed rates can be of the order of a few micrometres. This has implications for the economics of the process. This paper discusses qualitative results of cuts both with round and truncated tool tip. Both showed that the condition of cut are limited by the dynamics of the process rather than geometric factors to obtain low subsurface damage.

Keywords: *Ultraprecision machining, brittle materials, single point diamond tool*

COB392 INFLUÊNCIA DOS TERMOS DE SEGUNDA ORDEM NOS MODELOS MATEMÁTICOS DE MÁQUINAS FERRAMENTAS / SECOND ORDER TERMS INFLUENCE AND MATHEMATICAL MODELS FOR MACHINE TOOLS

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Using the Homogeneous Transformation Matrices, a mathematical model of the volumetric error of a machine tool was developed. Normally, simplifications are made by neglecting the second order terms in the calculations. For verifying if these simplifications are valid even for high-precision machines, a comparison was made using the error of a CNC cylindrical grinding machine. The machine error was calculated with and without the second order terms; negligible differences were found in these two procedures.

Keywords: *Máquinas Ferramentas, termos de segunda ordem, erro volumétrico, modelo matemático / Machine Tools, second order terms, volumetric error, mathematical model*

COB397 ASPECTOS DA SUPERFÍCIE USINADA DO AÇO RÁPIDO ABNT M2 PELO PROCESSO DE ELETROEROSÃO / ASPECTS OF THE INTEGRITY OF MOLYBDENUM HIGH-SPEED STEEL MACHINED SURFACE WITH ELECTRICAL DISCHARGE MACHINING

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This work presents a study of the texture and some. The bits were machined in four grades of finish: Basic, semi-finished, finished and super-finished. Copper and graphite electrodes were used. The surface texture study is restricted to measure the roughness parameters Ra, Rq, Ry and Rt. The surface integrity study is restricted to the following aspects: melt layer thickness, heat affected zone, micro hardness profile and the presence of micro cracks. The methodology used as well as the result in the form of graphs, table and micrographs for all combinations of grades of finish and cutting electrodes are presented. Generally, it is concluded that concerning the superficial texture quality, no preference exists for any of the two types of electrodes. Also, it was found that the bits machined with the graphite electrode had a thinner melt layer than the ones machined with the copper electrode. Additionally, the micro cracks present in the bits machined with graphite electrode were deeper than the ones of the bits machined with the copper electrode. The melt layer surface contains particles which are the cause of the micro cracks.

Keywords: *Usinagem por Descargas Elétricas; Textura Superficial; Integridade Superficial / Electrical Discharge Machining; Surface Texture; Surface Integrity*

COB579 COMPARAÇÃO DA UTILIZAÇÃO DE DIFERENTES SENSORES NO ESTABELECIMENTO DO FIM DA VIDA DE REBOLOS / COMPARISON OF USING DIFFERENT SENSORS TO ESTABLISH THE GRINDING WHEEL LIFE

Amauri Hassui*, Anselmo Eduardo Diniz*, João Fernando Gomes De Oliveira, Juarez Felipe Jr*. & João Jorge De Faria Gomes****

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Dressing is necessary to rebuild the grinding wheel surface, as its grains lose their edges and break. Dressing must be done to avoid the part rejection, mainly due to the surface roughness growth. The establishing of the exact moment to dress the wheel is still a non precise task. Most of the times, the grinding machine operator decides the moment to dress the wheel based on non precise criteria, like the sound made by the wheel during the cut. Lately, many works have been done trying to find out ways to monitor the process, in order to determine the end of tool life in such a way that do not need the presence of an operator. The goal of this work follows this trend. Several experiments were carried out, grinding hardened steel parts, up to the moment that, due to the wheel wear, the roughness part reached values bigger than the expected in precision grinding. During these experiments, the system vibration and the acoustic emission of the process were measured in 2 points of the machine. The main conclusion of this work is that the vibration signal is the best to

follow the increase of surface roughness and, therefore, the most suitable to be used to establish the moment to dress the wheel.

Keywords: *Retificação; Dressagem; Monitoramento; Emissão Acústica;/ Grinding; Dressing; Monitoring; Acoustic Emission*

COB580 INFLUÊNCIA DOS PARÂMETROS DE CORTE NA RUGOSIDADE DE PEÇAS TORNEADAS / INFLUENCE OF CUTTING CONDITIONS IN THE SURFACE ROUGHNESS OF TURNED WORKPIECES

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The main goal of this work is to analyze the influence of feed rate, depth of cut and cutting speed in the surface roughness of turned workpieces made of 4 different steels. The results obtained were compared with those predicted by the literature. In this way, a second goal could be reached, that is to compare the machinability of these steels related to how easy it is to get a good surface roughness, in each one of these steels. Aiming these purposes, workpieces made of 1045 (carbon steel), 4340 (alloy steel), 1212 (easy to machine steel) e 316 (austenitic stainless steel) were turned with 5 different feedrates, 5 depth of cut and 5 cutting speeds. Among the conclusions of these work, it must be noted that several of them do not agree with the previous literature about this subject.

Keywords: *Rugosidade, Torneamento, Condições de Usinagem, Usinagem de Aços / Surface Roughness, Turning, Cutting Conditions, Machining of Steels*

COB581 INFLUÊNCIA DOS PARÂMETROS DE USINAGEM NOS ESFORÇOS DE CORTE DE PEÇAS TORNEADAS DE DIVERSOS AÇOS / INFLUENCE OF CUTTING CONDITIONS IN THE CUTTING FORCES OF TURNED WORKPIECES OF DIFFERENT STEELS

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The main goal of this work is to analyze the influence of feed rate, depth of cut and cutting speed in the cutting forces generated during the turning of workpieces made of 4 different steels. The results obtained were compared with those predicted by the literature. In this way, a second goal could be reached, that is to compare the machinability of these steels related to how easy it is to get low cutting forces, in each one of these steels. Aiming these purposes, workpieces made of 1045 (carbon steel), 4340 (alloy steel), 1212 (easy to machine steel) e 316 (austenitic stainless steel) were turned with 5 different feed rates, 5 depth of cut and 5 cutting speeds. Among the conclusions of these work, it must be noted that the influence of feed rate and depth of cut in the cutting forces are bigger than that predicted by the literature.

Keywords: *Esforços de Corte, Torneamento, Condições de Usinagem, Usinagem de Aços / Cutting Forces, Turning, Cutting Conditions, Machining of Steels*

COB585 APLICAÇÃO DE BROCAS HELICOIDAIS COM AFIAÇÕES ESPECIAIS NA FURAÇÃO DE LIGA DE TITÂNIO / APPLICATION OF TWIST DRILLS WITH SPECIAL POINTS TO DRILLING TITANIUM ALLOY.

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With the development and application of new materials, the manufacturing processes needs to be optimized through the improvement of the geometry and material of the tools and the use of the adequate manufacturing parameters. The objective of this work is to study the drilling process of the Ti-6Al-4V alloy, which represents 45% of the total production of titanium and its alloys, and is heavily used in the aerospace, chemical, maritime, electronic and biomedical industries. For this purpose, the objective of this work concentrate on the selection of the adequate tool point geometry for the manufacturing of Ti-6Al-4V alloy with high speed steel twist drills. Tests with various tool point geometries were done and the behaviour of the tools was observed regarding cutting forces, tool wear, form of the chips and dimensional deviation of the hole. The results show that the “Bickford”, NAS-P3 e “Helical” are the best choice for machining Ti-6Al-4V alloy.

Keywords: *Drilling/Furação; Titanium/Titânio; Twist drill/Broca helicoidal; High speed steel/Aço rápido; Machining/usinagem*

COB586 FURAÇÃO EM LIGA DE TITÂNIO UTILIZANDO BROCAS HELICOIDAIS COM DIFERENTES PERFIS DA SEÇÃO TRANSVERSAL / DRILLING IN TITANIUM ALLOY WITH DIFERENTS TWIST DRILL PROFILES

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Difficult to machine alloys are widely used in many industries. The object of this work is to study the drilling process of the Ti-6Al-4V alloy, which is heavily used in the chemical, maritime, electronic and biomedical industries and primarily in the aerospace industry. Because this alloy is difficult to machine, the selection of appropriated tool geometry and machining conditions is critical. This work concentrates on the selection of adequate drill geometry and machining conditions for the manufacturing of Ti-6Al-4V alloy with high speed steel twist drills. Tests with special twist drills were done and the behaviour of the tools was observed regarding cutting forces, the tool wear, form of the chips and dimensional deviation of the hole. The results show that the profile number 13, for a cutting speed of 11,30 m/min and a feed rate of 0,100 mm/rot, tends to be the best choice, but when dimensional deviation of the hole was considered (work quality ISO IT 9) the use of profile number 9 was superior.

Keywords: *Drilling/Furação; Titanium/Titânio; Twist drill/Broca helicoidal; High speed steel/Aço rápido; Machining/usinagem*

COB588 A INFLUÊNCIA DAS AFIAÇÕES CÔNICA E CÔNICA RADIAL (RACON) EM BROCAS HELICOIDAIS DE AÇO RÁPIDO / THE INFLUENCE OF THE CONVENTIONAL AND RADIUSSED CONVENTIONAL POINT (RACON) IN HSS TWIST DRILLS

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One determinant fact to increase high speed steel twist drill lifetime and improve cutting conditions in steel drilling is the elaboration and development of new geometries to the drill points used in this kind of tool. This article investigates life increment and decrease of forces obtained with the utilization of Racon drill point (radiused conventional) when cutting SAE 4340 and SAE 1045 steels, comparatively to the utilization of the conventional drill point

Keywords: *machining, drilling, drill point, twist drill, racon usinagem, furação, afiação, broca helicoidal, racon*

COB605 ASPECTOS PRÁTICOS DO PROJETO DO FERRAMENTAL NA USINAGEM ELETROQUÍMICA DO AÇO AO MOLIBDÊNIO ABNT M2 / STUDY OF TOOLING DESIGN INFLUENCE ON SHAPE ACCURACY OF ABNT M2 STEEL PARTS ELECTROCHEMICALLY MACHINED

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This paper presents a diagram of the main causes of shape accuracy lose of parts machined by Electrochemical Machining (ECM) process. In addition to a resumed analysis of factors that affect accuracy regarding technical literature, two proposals of electrochemical machining tooling (with opened and with closed chamber) are presented, which were used to machine a circular groove in a square section bar manufactured of ABNT M2 steel (molibdenium alloyed). The prototype and the tooling developed in the laboratory were used to perform the tests, which were run with the Sodium Nitrate in the concentration of 20% in weight as electrolite. Five parts were machined with each tooling and compared in terms of shape accuracy and surface finishing.

Keywords: *Usinagem Eletroquímica; Acuracidade; Ferramental; Aço ABNT M2 Eletrochemical Machining; Accuracy; Tooling; ABNT M2 steel*

COB674 MONITORAMENTO DO ACABAMENTO SUPERFICIAL NO FRESAMENTO VIA VIBRAÇÕES/PREDICTION OF SURFACE INTEGRITY OF MILLING BY MONITORING VIBRATIONS

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With the development of new automated machine tools the need to monitor either tool wear or surface integrity became more critical. The present work uses a CNC milling machine with 15 Kw of power to validate proposal of monitoring system. A uses the vibration as an alternative to control tool wear and surface roughness parameters. The results showed a good correlation between the vibration signals and the parameters considered.

Keywords: *Monitoring, vibration, tool wear, surface roughness, face milling*

COB915 INFLUÊNCIA DO FLUIDO DE CORTE NA USINABILIDADE DE AÇOS / INFLUENCE OF THE CUTTING FLUID ON THE MACHINING OF STEELS

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The influence of the application of synthetic (at 5 and 10% concentrations) and semi-synthetic (at 5% concentration) cutting fluids was investigated during milling of NB 8640 with triple-coated cemented carbide cutting tools. Dry cutting was also performed in order to have a basis for comparisons. Tool life, power consumption, and surface roughness were the parameters considered. In order to evaluate the coolant ability of the cutting fluids the cutting temperature was studied during turning of NB 1020 steel under dry condition and with the application of the fluids. After the tool life tests the worn tools were analysed within SEM. The dry condition showed better tool lives than when a cutting fluid was applied. Although only slightly, the synthetic fluids outperformed the semi-synthetic. This can be attributed to the lower power consumption as well as the lower variation on cutting temperature obtained when cutting dry. Thermal microcracks was present at the tool cutting edges regardless the cooling / lubricant condition used. These cracks led to the development of comb cracks.

Keywords: *Fresamento, fluidos de corte, vida da ferramenta, temperatura de corte, potência de corte. / Milling operation, cutting fluids, tool life, cutting temperature, power consumption*

COB916 ASPECTOS PRÁTICOS DO PROJETO DE UM EQUIPAMENTO DE USINAGEM ELETROQUÍMICA / PRACTICAL CONCERNS OF AN ELECTRO-CHEMICAL MACHINING EQUIPMENT DESIGN

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The present work aims to the develop a electrochemical machining equipment to be used in research. Prior to the project specification, it is presented an explanation on the nature of the electrochemical process. After detailing the project and building the equipment, the machine was tested for drilling high speed steel. The holes were analysed considering not only the remove material rate but also the overcut and taper accuracy. Additionally, the findings are related to those presented in the literature and possible reasons for the differences found are discussed.

Keywords: *Electrochemical machining, overcut and taper: / Usinagem Eletroquímica, sobre-corte e conicidade.*

**COB917 FRESAMENTO DE AÇOS INOXIDÁVEIS AUSTENÍTICOS NB 316 /
MILLING OF NB 316 AUSTENITIC STAINLESS STEEL****Rodrigo Pizzi, Wisley Falco Sales & Alisson Rocha Machado***LEPU - DEEME - UFU, Uberlândia, MG, Brasil - E-mail: alissonm@ufu.br.***Alexandre Mendes Abrão***DEM - UFMG, Belo Horizonte, MG*

Austenitic stainless steels are considered difficult to machine materials due to their high ability to workharden and large chip-tool contact length produced, which generate high cutting forces and elevated temperatures, promoting high tool wear rates. The present work compares the machinability of two AISI 316 austenitic stainless steel one of them has suffered small alteration on its chemical composition (within the range allowed in its specification) and manufacturing process with the aim of improving its machinability. Tool life, power consumption, surface roughness and cutting temperature after milling operations with coated carbide tools were the parameters considered. The steel with the alterations mentioned performed better than the standard AISI 316 steel.

Keywords: *Aço inoxidável austenítico, fresamento, vida da ferramenta, potência de corte, temperatura de corte / Austenitic stainless steel, milling, tool life, power consumption, cutting temperature*

**COB918 DETERMINAÇÃO DA EFICIÊNCIA DE QUEBRA-CAVACOS COM AS
PRINCIPAIS CONDIÇÕES DE CORTE / DETERMINATION OF CHIP-
BREAKER EFFICIENCY WITH THE MAIN MACHINING CONDITIONS****Wisley Falco Sales, Wilson de Souza Paulino & Alisson Rocha Machado***LEPU - DEEME - UFU - Uberlândia, MG, Brasil. E-mail: alissonm@ufu.br***Emmanuel Okechugwu Ezugwu***South Bank University, Londres, Inglaterra. E-mail: ezugwueo@vax.sbu.ac.uk*

The development of the new generation of tool materials capable to withstand very high cutting speeds, the constant appearance of expensive and high strength work materials as well as the frequent use of automated manufacturing systems does not allow the formation of long continuous chips during machining. Experimental techniques, mathematical models and engineering systems are powerful tools available in order to achieve complete control of the swarf produced during machining. More frequently CAD systems are employed to develop new designs of chipbreakers. In the present work four different chipbreakers were tested during dry and wet cylindrical turning of ABNT 5140 steel with coated cemented carbide inserts under various cutting conditions. The chips were collected after each test and their chip thickness (h') measured in order to determine the chip thickness ratios and the shear angles. This allowed an analysis of the behavior of these parameters with the cutting conditions to be done.

Keywords: *Usinagem, torneamento, controle do cavaco, geometrias de quebra cavacos / Machining, turning, chip control, chipbreaker geometry*

COB926 ESTUDO DO COMPORTAMENTO DE DISCOS ABRASIVOS, EM OPERAÇÕES DO TIPO “CUT-OFF” POR MERGULHO BASCULANTE, SUBMETIDOS A DIVERSAS CONDIÇÕES DE CORTE / STUDY OF THE DIVING CUT-OFF OPERATION BEHAVIOR UNDER SEVERAL CUT CONDITIONS

Eduardo Carlos Bianchi*, **Adriano Rogério Cagnin***, **Eduardo Martins de Castro ***, **Odilson Coimbra Fernandes ***, **Ivan De Domenico Valarelli ***, **Paulo Roberto Aguiar ****

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The cut-off operation is a common practice. The foreign competition, through the economy globalization, is forcing the Brazilian industry to attend the international quality and performance standards. One way for the national industries become more competitiveness (improving the productivity and decreasing the production costs) it is by the detailed knowledge of the cut-off operations with abrasive wheels. This work shows a research about the abrasive wheels behavior, under several cutting conditions. The results are discussed in function of the cutting speed, downfeed of the abrasive wheel and average of tangential cutting force.

Keywords: *Operação Cut-off, condições de corte, otimização, corte abrasivo, força tangencial de corte*

COB929 DETERMINAÇÃO DA PRESSÃO ESPECÍFICA DE CORTE PARA DEZ ESPÉCIES DE MADEIRA BRASILEIRA / ANALYSIS OF THE SPECIFIC CUTTING FORCE FOR TEN BRAZILIAN WOOD SPECIES

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The objective of this study is to measure the values of the specific cutting force “KS”, unitary specific cutting force for a cross-sectional area of 1mm² “KS1”, both constant, material attributes and dimensionless coefficient “1-Z” that represent the parameters which affect the cutting performance for the parallel direction to the grain (90-0); analyzing the results obtained, for ten different density, native and cultivated wood species in Brazil. The following cutting parameters were studied: cutting thickness (h), tool rake angle (α) and cutting speed (Vc), in an orthogonal cutting situation for three different moisture contents (water soaked, air dried and kiln dried).

Keywords: *Madeira, usinagem, pressão específica, rendimento, otimização. Wood, machining, specific cutting force, performance, optimization*

COB930 ANÁLISE DA INFLUÊNCIA DAS CONDIÇÕES DE USINAGEM DE MADEIRA SOBRE A FORÇA PRINCIPAL DE CORTE / ANALYSIS OF THE INFLUENCES OF THE MACHINING CONDITIONS OF WOOD ON THE PRINCIPAL CUTTING FORCE

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The objective of this study was to verify the influence that parameters related to the wood machining process have over cutting performance, by analysis of the parallel cutting force in orthogonal cutting situation. The parameters analyzed were: the rake angle of the tool, the cutting thickness and cutting speed. Ten species of native and cultivated wood were studied under three different conditions of moisture (soaked, air dried and kiln dried).

Keywords: *Experimentação, Força de Corte, Madeira, Usinagem / Experimentation, Cutting Force, Wood, Machining*

COB934 REVISÃO BIBLIOGRÁFICA SOBRE DESGASTE EM FERRAMENTAS DE CORTE PARA USINAGEM DE ALTO DESEMPENHO / A REVIEW ON THE WEAR OF CUTTING TOOLS APPLIED TO HIGH PERFORMANCE MACHINING

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The development of the cutting tools is due to the evolution and introduction of new materials, which permit that tool wear rates can be each time smaller and consequently tool life extended. A good evidence of this fact is that the machining conditions are becoming much more severe and the increasingly use of components made of materials in the hardened state, instead of in the annealed one. High speed steel, cemented carbide, cermet, ceramic, PCBN and PCD, as tool materials, will have their characteristics analysed, based on the recent literature, as well as their wear mechanism. The several different types and wear mechanisms, which are mainly related to the machining conditions, will affect directly the productivity. Therefore, the knowledge of wear patterns has a great effect upon the production processes based on machining, which contributes to further improve the performance and tool life.

Keywords: *Materiais de Ferramenta, desgaste de ferramenta, ferramentas de cerâmica, ferramentas de PCBN, ferramentas de PCD / Tool materials, tool wear, ceramic tools, PCBN tools, PCD tools*

COB948 A DRESSAGEM DE REBOLOS CONVENCIONAIS E SUPERABRASIVOS APLICADOS EM RETIFICAÇÃO DE PRECISÃO - UMA REVISÃO BIBLIOGRÁFICA / THE DRESSING OF CONVENTIONAL AND SUPERABRASIVE WHEELS APPLIED TO PRECISION GRINDING - A REVIEW

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The main objective of the grinding process is to obtain high quality components. As the operation is performed, the grinding wheel loses its sharpness. Thus, the dressing operation becomes part of the grinding operations, with great importance too. The dressing operation modifies the wheel surface (sharpness). The sharpness between two consecutive dressing operations is mainly related to the dressing parameters employed. On the other hand, the sharpness during the entire wheel life time is related to the dres-

sing tool and mainly to its wear rate. Some solutions have been employed to solve this problem, such as the dressing tools using diamonds with constant cross section, instead of the single point one. Several different researches on new dressing methods are analysed at the present work. Research and knowledge about the several different dressing methods allows a better fitting between the new dressing tools and the requirements found in each grinding operation.

Keywords: *Métodos de dressagem, retificação, agressividade, rebolos convencionais e superabrasivos / Dressing methods, grinding, sharpness, conventional and superabrasive grinding wheels*

COB950 **APLICAÇÃO DO SISTEMA ATAC NA OTIMIZAÇÃO DOS PARÂMETROS DE USINAGEM E SELEÇÃO DE FERRAMENTAS/APPLIED OF ATAC SYSTEM IN OPTIMIZATION OF MACHINING PARAMETERS AND TOOL SELECTION**

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The proposal of this work is to present and discuss a system, which besides to manage a database is able to execute functions which allow the tool selection and optimizing of the machining parameters, and to determine in industrial plant the maximum production condition. Utilized then, the structure of a machining database, enlarged by algorithms for optimization of cutting conditions and tool selection. The principal way to start the choice procedure of the optimized tools and cutting conditions, is made through a piece code which is under test. This code is defined for a codification and classification system based in Group Technology. The optimization routines and search of the stored data in the system utilizes the piece code to select the most probable solutions for the problem and through all existent sequence of priorities in the codification system files are achieved. By suitable storing in a database of the results and their fast recovery, reliable informations can be estimated for different pieces under similar situations. This allows to obtain initial values for future tests.

Keywords: *Database, Machining, Optimizing, Tool Selection, Process Planning*

COB1009 **CARACTERÍSTICAS DE DESGASTE E AVARIAS EM FERRAMENTAS CERMET NO TORNEAMENTO DE AÇO ABNT 1045 WEAR AND BREAK-AGE CHARACTERISTICS ON CERMET CUTTING TOOLS IN TURNING AISI 1045 STEEL**

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In spite of the technological evolution of the cutting tool materials which took place in the last years, and their greater range of application, as is the case of CERMET tools, it still occurs some break-

age and wear that contradict the usual expectations concerning their application, which reduces the reliability of the recommended data obtained through wear measurements. The present work is concerned with turning of ABNT 1045 steel with last generation CERMET tools, and it reveals the presence of permanent adhesion on the tool/part interface, and the occurrence of macrochipping of the tool edges. In the first case, it is estimated that there is a source that intensifies the temperature, whereas in the second case it is believed that there is a disintegrating effect of the unused tool edges due the mechanical action of the chips. Based on physical, metallurgical and mechanical analyses of these occurrences, this work aims to contribute for the elucidation of apparently non-typical characteristics of wear and breakage, as well to discuss the risk of incorrect selection of cutting tools based on generalized recommendations.

Keywords: *CERMET, Turning, Cutting Tools, Wear / Torneamento, Ferramentas de Corte, Desgaste*

COB1026 ESTUDOS PARA DETERMINAÇÃO DAS CARACTERÍSTICAS DE UMA GUIA E SEU DIMENSIONAMENTO / Studies for Determination of the Guideways' Characteristics and Its Design

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The guideways are elements that influence directly the precision of manufacturing. This paper recommends techniques to increase this precision, using guideways combing sliding/rolling to the turn process. It's necessary to know the error that occur in this process and also to specify the profile of the surface of the guideways to decrease the wear and the probability of surface fatigue.

Keywords: *Machining, precision, guideways, tribology, wear*

COB1027 ESTUDO DO COMPORTAMENTO DE REBOLOS DIAMANTADOS, COM LIGANTE RESINÓIDE, NA RETIFICAÇÃO DE CERÂMICAS AVANÇADAS PELA GEOMETRIA DO CAVACO GERADO / STUDY OF THE BEHAVIOR OF DIAMOND GRINDING WHEELS WITH BONDED RESIN, IN THE GRINDING OF MODERNS CERAMICS BY THE GEOMETRY OF THE CHIP GENERATED.

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The aim of this work is to study the behavior of the plan tangential grinding process with diamond grinding wheels. The analysis of the grinding performance was done regarding the cutting surface wear

behavior of the grinding wheel for ceramics workpieces. The results discussion emphasized the wear mechanism of the grinding wheel cutting surface and the cutting phenomenology of the grinding process.

Keywords: *Retificação de cerâmicas avançadas, rebolos diamantados, desgaste de rebolos, relação G*

COB1028 ESTUDO DA RUGOSIDADE SUPERFICIAL DE EIXOS DE LIGAS LEVE PARA UTILIZAÇÃO EM MANCAIS AEROSTÁTICOS / STUDY OF AXLES SURFACE FINISH OF LIGHT ALLOY FOR UTILIZATION IN AEROSTATICS BEARING

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The objective of this work is to study the possibility of producing aluminum axles in order to utilize them in aerostatic bearings, using the turning process. Therefore it analysis the roughness produced by the two types of insert tungsten carbide, in several condition of machining.

Keywords: *Aerostatic Bearing; Surface Finish, Surface Roughness on Turned Aluminum Mancais Aerostáticos, Acabamento Superficial, Rugosidade Superficial no Torneamento de Alumínio*

COB1030 INFLUÊNCIA DA GEOMETRIA TEÓRICA DO CAVACO NA POTÊNCIA DE CORTE, NO ACABAMENTO SUPERFICIAL E NO DESGASTE DE REBOLOS / INFLUENCE OF THE TEORICAL GEOMETRY OF THE CHIP IN THE CUTTING POWER, IN THE SURFACE FINISH AND IN THE WHEEL WEAR

Odilson Coimbra Fernandes, Eduardo Carlos Bianchi, Carlos Elias da Silva

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Grinding operations are influenced by a large number of variables. These make it difficult for the operator to choose the ideal working conditions in order to attain the desired objective. An experimental study of the influence of geometry of the generated chip, with respect to the cutting power, surface finish and wear of the grinding wheel manufactured using three types of vitrified bonding material and two types of abrasive grain, was made. Six types of grinding wheel and sample ground work pieces made of ductile steel (ABNT 1020) and fragile steel (ABNT 1045 quenched) were used. By using a tangential grinding process, the cutting speed parameter was maintained constant and the work piece speed and the grinding wheel penetration were varied, in order to work with two constant values of the equivalent chip thickness. Also, for all the cases the same grinder dressing was used. The results are presented in tables which consider different entry parameters, varying the type of grinding wheel and test piece material. The wear of the grinding wheel is discussed based on tables of the G ratio. Finally, a comparison was made between output variables, involving the six tests simultaneously, for each value of the equivalent chip thickness.

Keywords: *Grinding; Chip geometry; Grinding wheel wear, Vitrified bond; Abrasive grain*

COB1083 ROSQUEAMENTO POR USINAGEM EM FERRO FUNDIDO NODULAR / CUTTING TAP IN GLOBULAR CASTING IRON**Walter Lindolfo Weingaertner & Hewerson Ranière da Silva***Laboratório de Mecânica de Precisão – Departamento de Engenharia Mecânica UFSC
Cx. P. 476 - EMC - CEP 88.040-600 Florianópolis, Brasil***Franz Tikal & Christian Vollmer***Instituto für Produktionstechnik und Logistik - IPL/GhK, Kurt-Wolters-Str. 3 Plz. 34.125 Kassel – Deutschland -
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The Institut of Production Technics and Logistic from Germany has developed a German Society of Research-Project, whose topic was the investigation of the behavior of coating taps with a determinated geometry in casting iron from types GGG 40 and GGG 60. Two parameters were varied: the type of cutting fluid introduction (external or through the tool) and the tool spin angle (15o or 40o). The used cutting speeds have created a new limit for the high speed cutting tap tools, mainly in GGG 40. This work shows how these researches were made and which parameters must be considered for the right analysis of this manufacturing process.

Keywords: *macho de rosquear, ferro fundido, introdução de fluido de corte, ângulo de hélice, velocidade de corte Cutting Tap, casting iron, cutting fluids introduction, tool spin angle, cutting velocity*

COB1084 ASPECTOS TECNOLÓGICOS DO DESENVOLVIMENTO DA FURAÇÃO POR ESCOAMENTO / TECHNOLOGICAL ASPECTS ON THE DEVELOPMENT OF THE FLOWDRILLING**Walter Lindolfo Weingaertner, João Carlos Oliveira Lopes, Daniel Carlos da Silva, Otacílio Cardoso Duarte Filho, Cristiano Rafael Schramm, Gerson Ismael de Souza, Manfred Molz***Laboratório de Mecânica de Precisão - EMC - UFSC. Campus Universitário Trindade - CP 476 EMC,
Florianópolis - SC, E-mail :***Franz Tikal, Roland Heiler***Instituto für Produktionstechnik und Logistik - IPL - GhK, Kurt-Wolters-Str. 3 - 34 125, Kassel – Deutschland,
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Flowdrilling is a relative new manufacturing process for bush forming. A cemented carbide tool with special geometry is used on standard drilling machines to produce bushes in thin metal sheets, without chip removal. After the drilling process a cold forming tap is used to generate the thread in these bushes by plastic deformation. A threaded bush is then used like a sheet metal joint in many applications. This work is about new research topics which have been developed in a cooperation between the Laboratório de Mecânica de Precisão/UFSC, from Florianópolis - Brazil, and the Institut für Produktionstechnik und Logistik/GhK from Kassel – Germany. These topics are concerned about the deformation process of the sheet material, development of new materials for the tools, microstructure analysis of the sheet material and development of some applications of this technology.

Keywords: *Furação por escoamento, rosqueamento por conformação, deformação, materiais, chapas metálicas. Flowdrilling, flowtapping, deformation, materials, sheet metal*

COB1087 PROJETO CONCEITUAL DE UMA RETIFICADORA PARA OBTENÇÃO DE SUPERFÍCIES COM QUALIDADE SUB-MICROMÉTRICA

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This paper presents the conceptual design of a plain grinder which will work with workpieces in steel or not, working in a range under 1 mm, like metallic reflective surfaces. At first, the design process looks for the machine tool requirements and their evaluation. After this, based on a function structure, a detailed study of all machine components is made, generating a final conception of the grinder.

Keywords: *Precision Grinding, Conceptual Design, Function structure, QFD.*

COB1088 DESENVOLVIMENTO DE UMA RETIFICADORA PARA A USINAGEM DE LIMAS ENDODÔNTICAS

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This paper shows the conceptual project and the functional model conception of a machine tool for the grinding of root canal files type hedström. Initially there is a brief look on the reamers characteristics for the determination of the grinding process kinematics, so to determine a pre-conception. After that, through QFD, a classification of the project specifications for the machine is obtained, which combined with its functions structure, determines the grinder conception. To prove that the grinding process for obtaining reamers is proper for the small dimensions of the work piece (less than 1 mm in diameter), a functional model is set.

Keywords: *Retificação de pequenos diâmetros, projeto conceitual, estrutura de funções, modelo funcional.*

COB1089 USINAGEM A VERDE DE CERÂMICA AVANÇADA

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In the last 30 years, the interest in ceramic materials increased as a result of significant advances in their development and usage, mainly because ceramics are superior to other materials in terms of sta-

bility at elevated temperatures and under wear conditions. However, the same properties that make ceramics so attractive for special uses, such as its hardness, preclude the most traditional machining techniques. The green machining method is a solution for this problem and shows many advantages in terms of flexibility and economy. This paper shows the green machining of advanced ceramics parts using an innovative method with diamond wire.

Keywords: *Usinagem a verde, fio diamantado com movimento alternante, usinagem de cerâmica, usinagem abrasiva*

COB1090 BROCAS HELICOIDAIS: INFLUÊNCIA DOS ERROS DE AFIAÇÃO NA QUALIDADE DOS FUROS / TWIST DRILL: INFLUENCE OF THE INCORRECT SHARPENING ON THE HOLES QUALITY

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Due to their complex geometry and elevated level of difficulty to obtain symmetry of the drill (point angle, clearance angle, relief angle and chisel edge angle), twist drills often present geometric errors derived from the sharpening operations. This geometric errors affect directly the drill performance during cutting. This work identifies the main errors and develop studies of their influence on the drilling operation.

Keywords: *Furação, Brocas helicoidais, Erros geométricos, Geometria, Qualidade dos furos / Drilling, Twist drills, Geometric errors, Geometry, Holes quality.*

Cob1417 ESTUDO DO COMPORTAMENTO DE DIAMANTES NATURAIS E SINTÉTICOS, UTILIZADOS NA FABRICAÇÃO DE PONTAS ESCARTÁVEIS EM ODONTOLOGIA / STUDY OF NATURAL AND SYNTHETIC DIAMONDS'S BEHAVIOR, UTILIZED TO MAKE DISPOSABLE BURS

Eduardo Carlos Bianchi *, **Fabio Andreassa Guedes Cezar ***, **Eraldo Jannone da Silva ***, **Paulo Roberto de Aguiar ***, **Ana Rita Rodrigues Bianchi ****, **César Antunes de Freitas ****

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Eight distincts abrasives diamonds were used to made diamonds burs. Each diamond burs was researched to assign the best type of diamond to be used in rotatory dental diamonds instruments. In the tests, glass was grinding, while the tangential force of cut was taken in real time by computer. The best type of diamond was that could remove more material until a determined maximal tangential force of

cut was hit. The economics and health aspects have also been pondered. Thus, the best type of diamond was that proved at the same time the best conditions to remove material and the least price, enabling the fabrication of disposable diamonds burs.

Keywords: *Tipos de diamante, pontas diamantadas, instrumentos dentários diamantados, diamond, diamond burs*

TEMA 85 - CAD/CAM**COB119 PROBLEMAS NA INTEGRAÇÃO DE SISTEMAS CAD/CAE/CAM NO PROCESSO DE INJEÇÃO DE PLÁSTICO/ SYSTEMS INTEGRATION PROBLEMS ON CAD/CAE/CAM IN THE PLASTIC INJECTION PROCESS****Carla Cristina Amodio Estorilo & Kazuo Hatakeyama***Departamento de Pós-graduação em Tecnologia/PPGTE, Núcleo de Pesquisa em Engenharia Simultânea/NUPES, Centro Federal de Educação Tecnológica do Paraná - CEFET/PR**CEP 80230-910 Curitiba - PR, Brasil - E-mail amodio@nupes.cefetpr.br - E-mail kazuo@nupes.cefetpr.br*

Permanently changing markets situations require quick and flexible reactions on the part of companies. This calls for new strategies and new manufacturing philosophies. At the same time, however, these characteristics of flexibility and innovation increased the complexity of managing work processes.

This paper reviews important aspects of the evaluation of technological innovation. It presents the systems evaluation CAD/CAE/CAM that can be used in order to access the degree of technological innovation for any given project.

This computational tools with; Computer Aided Engineering (CAE), numerical simulations and computational tools are incorporated in the productive process through the establishment of a multidisciplinary environment (concurrent engineering) with adequate task management.

Keywords: *new strategies, new manufacturing philosophies, concurrent engineering, Computer Aided Engineering (CAE), numerical simulations, computational tools. / novas estratégias, nova filosofia de manufatura, engenharia simultânea, simulação numérica, ferramentas computacionais.*

COB124 DESENVOLVIMENTO DE UM BANCO DE DADOS DE TOLERÂNCIAS VISANDO A INTEGRAÇÃO COM UM SISTEMA "CAD" / DEVELOPMENT OF A TOLERANCE DATABASE TO BE INTEGRATED TO A CAD SYSTEM**Nilson L. Maziero, João Carlos E. Ferreira & Everton Gubert***Universidade Federal de Santa Catarina, Departamento de Engenharia Mecânica, GRUCON Caixa Postal 476, 88040-900, Florianópolis, SC - E-mail: jcf@grucon.ufsc.br*

This paper describes a methodology used for organizing and maintaining a tolerance database, and its integration to a CAD system. The information search can be carried out by the user either through the CAD system or independently, and he/she has the following options : (i) from examples of couplings applications, (ii) from the specification of fit and precision of the coupling; and (iii) as a function of the specific components. The retrieved information can be automatically transferred to the graphical representation of the CAD software.

Keywords: *Tolerâncias, CAD/CAM, Projeto para a Manufatura e Montagem / Tolerances, CAD/CAM, Design for Manufacturing and Assembly*

COB359 DETERMINAÇÃO AUTOMÁTICA DOS PARÂMETROS DE USINAGEM E GERAÇÃO DO PROGRAMA NC NUM SISTEMA CAD/CAPP/CAM / AUTOMATIC DETERMINATION OF MACHINING PARAMETERS AND NC PROGRAM GENERATION IN A CAD/CAPP/CAM SYSTEM

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Described within this paper is a technique for determining the optimum machining parameters for turned components modeled in a CAD/CAPP/CAM system. This technique considers initially the area of good chip control, given by a pair of values of feed and depth of cut, which is usually found in catalogs of tool manufacturers. Then, the restrictions for machining, such as cutting forces, clamping rigidity and spindle power are considered within the area of good chip control. The pair which leads to the minimum machining cost is selected as the optimum machining parameters. Finally, the NC program for machining the given part is generated through a commercial CAM software.

Keywords: *CAM, Parâmetros de Usinagem, Otimização, CAPP, "Features"/CAM, Machining Parameters, Optimization, CAPP, Features*

COB379 SIMPRONC - SIMULADOR DE PROGRAMAS NC: EDIÇÃO E SIMULAÇÃO GRÁFICA/SIMPRONC - NC PROGRAM SIMULATOR: EDITION AND GRAPHIC SIMULATION

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GRACO - Grupo de Automação e Controle, Departamento de Engenharia Mecânica, Faculdade de Tecnologia, Universidade de Brasília, CEP 70.910-900, Brasília, Brasil., alvares@enm.unb.br, fabricio@enm.unb.br,

This work presents a simulation system of NC program developed in GRACO. The simulator is called SIMPRONC and is composite of routines of program edition, graphics simulation and report forms. The simulation is executed on screen and the draw can be printed. Some data of process planning can be found in the report forms, like cutting speed, rpm, time elapsed and tools changes.

Keywords: *1- CNC, 2- Graphic Simulation, 3- CAD/CAM, 4- G Code, 5- NC Program, 1- CNC, 2- Simulação Gráfica, 3- CAD/CAM, 4- Código G, 5- Programa NC*

COB473 A CAD SYSTEM TO CONCEPTUAL PHASE OF DESIGN

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This work is concerned about the conception of computer programs to aid the process of mechanical design. Today it urges the development of systems that works further than the traditional

areas dedicated by CAD systems (Computer Aided Design) that are the area of draft. CAD systems must aid in the conceptual phase of design. This paper presents the development of a software system as a solution to this problem in design field. This program uses design methodologies that are presented in literature. It was developed in visual object oriented language, and it was split into 3 modules with tasks of: design process management, requirements determination and conception development. This system is directed towards educational application, working as a auxiliary tool in undergraduated courses in mechanical design field.

Keywords: *Conceptual Phase of Design, Product Design, Computer Aided Design, Expert Systems*

COB547 IMPLEMENTAÇÃO DE UM SISTEMA COMPUTACIONAL PARA OTIMIZAÇÃO DO CORTE DE RETÂNGULOS / IMPLEMENTATION OF A COMPUTATIONAL SYSTEM FOR THE RECTANGLES CUTTING OPTIMIZATION

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This work presents a proposal of procedure to solve the optimization problem involved in uni-dimensional and bidimensional cutting of rectangle pieces from large stocks. It tries to define one algorithmic structure of an interface where the definition and solution of cutting pattern can be reached and applied to the production line.

Keywords: *CAD & CAM, Computational System, Cutting Stock Problem, Optimization, Encaixe, Otimização, Problema da Ordenação de Cortes, Sistema Computacional*

COB569 2D DIMENSION-DRIVEN DESIGN SYSTEM BASED ON THE HISTORY OF OPERATION EXECUTION USING AN ATMS SYSTEM

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In this paper we present a 2D parametric CAD system that uses the execution history of geometric modelling operations and the dependency among these operations to provide the system the capability of obtaining an solution even when the set of geometric constraints is not complete. This can be achieved using the implicit information that are present in drawings as default values. The execution history of operations gives the precedence order of values to the system, which is an essential information to decide whether or not to replace a chosen value. The system stores information about the dependencies among the executed operations in an Assumption-based Truth Maintenance System (ATMS) avoiding problems with cyclic dependencies and allowing the visualisation of model modifications due to operations changes. In the first section an overview of different approaches to the dimension-driven design is given and after that basic concepts and the system description is presented.

Keywords: *computer-aided design, parametric CAD, dimension-driven design, geometric constraints, truth maintenance systems*

COB570 **MODELADOR DE SÓLIDOS CSG PARAMÉTRICO UTILIZANDO DIMENSÕES RELATIVAS / PARAMETRIC CSG SOLID MODELER USING RELATIVE DIMENSIONS**

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A complex solid, according to a CSG representation, is represented by a combination of several primitive solids. When a complex solid is created, it is necessary to apply transformations - translations and rotations - for positioning the solids such that the desired configuration will be obtained. It is possible to modify this solid modifying the value of a primitive solid's dimension. However, the transformations used for positioning will be maintained constant. In this work we will propose a parametric representation based on relative dimensions for representing the positioning transformations. We will define relative dimensions and an algorithm to validate the relative dimensions will be presented. We will present some relative dimension's properties that will allow the definition of some heuristics for the solution searching in the parametric problem.

Keywords: *Parametric CAD, Solid Modeling, CSG, Dimension Representation, Assembling*

COB573 **SISTEMAS CAD/CAM APLICADOS ENTRE DIFERENTES FORNECEDORES / CAD/CAM SYSTEM IN DIFFERENT SUPPLIERS**

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Traditionally the western companies buy its components, parts, and so on in a lot of suppliers. These suppliers are based in the same country which companies or no. In recent years the global sourcing concept have been discussed like a great innovation against the traditional supplier concept. During last years, "keiratsu", the Japanese concept has been discussed. The suppliers are organized in hierarchy in "keiratsu" concept. The new Brazilian VW truck and bus factory allow that the suppliers work within the company. Of a total 1,400 workers when the factory reaches full speed, just 200 will be VW employees. This article study data interchange in traditional and new VW system and propose the use of STEP (STandard for the Exchange of Product data model) and Simultaneous Engineering.

Keywords: *STEP, CAD/CAM, Global Sourcing, Suppliers, Simultaneous Engineering / STEP, CAD/CAM, Fornecimento Global, Fornecedores, Engenharia Simultânea*

**COB584 INDICADORES DO GRAU DE AUTOMAÇÃO DA MANUFATURA /
AUTOMATION MANUFACTURING FOREFINGERS****Rogério Monteiro & Geraldo Nonato Telles***UNICAMP Faculdade de Engenharia Mecânica FEM - Departamento de Engenharia de Materiais, DEMA campus UNICAMP CP 6051 CEP 13083-970 Campinas - SP - Brasil, E-mail: monteiro@fem.unicamp.br*

The large technologic advance permitted at the enterprises to use recourses more developed strategies increasing the flow velocity in Manufacturing Systems. Nowadays, factories are gaining a profile very flexible..with capacity to produce greater variety of products as in little quantity, because the enterprise improves its agility. We observe increase competition too, in the international market where small competition advantages are fundamental to insure the organization survive. This increase competition together with fast changes environment requiring the businessman to get the maxim information about process and as all organization. Actually, grow the interest by indicators capable to show the level of organization of enterprise, the degree of automation of activity and the level of flexibility the manufacturing systems. The objective this article is present various models of automation and to compare their characteristics and applicability in real environment.

Keywords: *Manufacturing Flexible Systems, Indicators of Automation, Flexibility, Productivity. Sistemas Flexíveis de Manufatura, Indicadores de Automação, Flexibilidade, Produtividade.*

**COB603 APLICAÇÃO DE UM SISTEMA CAD PARA GERAÇÃO E
SIMULAÇÃO DE PROGRAMAS PARA FRESADORAS CNC / CAD
SYSTEM GENERATION AND SIMULATION FOR CNC MILLING MACHINE
PROGRAM****Alexandre Dias da Silva, Fábio Manuel Sá Simões, Fábio Ferreira Guimarães & Alonso Andrade de Paula***Departamento de Engenharia Mecânica, Universidade Federal de Uberlândia - UFU CEP38400-902 Uberlândia -MG ;E-mail: fmsimoes@ufu.br ; adiass@ufu.br*

This work presents the development of a system that rationalizes the program generation for CNC Milling Machine, being capable of simulating the cutting process. The interface consist basicaly of routines elaborated with Autolisp language, utilizing a very popular CAD platform (Autocad). It is possible to integrate the project phase of a product with the automatic generation of the program for the machine in a single environment. By simulating the relative movement between the part and the cutting tool, it is possible to have a 3D visualization of generation of the projected elements solid model before its manufacturing.

Keywords: *Integração CAD/CAM; Máquinas CNC; Usinagem; Simulação 3D / CAD/CAM Integration; CNC Machine; Machining; 3D Simulation*

**COB1040 GERAÇÃO DE SEQUÊNCIAS DE USINAGEM A PARTIR DE
GEOMETRIAS CRIADAS EM CAD / TOOL PATH GENERATION FROM
GEOMETRIES CREATED IN CAD****Leandro Costa de Oliveira, Álvaro Michellotti, Elvino Lima & Rodrigo Pivetta***Depto. de Fabricação e Projeto de Máquinas, Centro de Tecnologia, Universidade Federal de Santa Maria CEP 97105-900 Santa Maria - RS, Brasil - E-mail: leandro@inf.ufsm.br*

With the purpose optimizing programming of Computer Numerical Controlled lathes, the development of a system for automatic generation of CNC programs based in CAD/CAM concept was performed. Thus, the software AutoCAD was chosen on account of its extensive use in industry and academics. In this software, using AutoLISP language, its was developed a routine that selects entities in the drawing that determines the contour to be executed, was realized. Next, the same routine saves the data of selected entities in DXF format. Starting from this data, another program, implemented in Turbo Pascal, analyses the drawing geometry and produces the CNC program automatically. In this step are distinguished two types of pieces treated in different forms for two algorithms: the growing-geometry pieces and the diverse-geometry pieces. After generation of programs, they are verified in a simulator for later use in the lathe. In this work, two examples are presented in details, verified in a simulator and tested in lathe EMCO Compact 5 CNC, of NAFA - CT, UFSM. The results obtained prove the efficiency of system in the face of proposed problem.

Keywords: *CAD/CAM, Programação CNC, Usinagem CNC / CAD/CAM, CNC Programation, CNC Machining*

TEMA 86 - Metalurgia do Pó**COB8 RELAÇÃO ENTRE LIMITE DE RESISTÊNCIA A FADIGA E LIMITE DE RESISTÊNCIA A TRAÇÃO DE MATERIAIS SINTERIZADOS****Ernani Sales Palma***Departamento de Engenharia Mecânica - UFMG, Av. Antonio Carlos, 6627 - Campus Pampulha, 31.260-901 - Belo Horizonte-MG E-Mail:ernani@vesper.demec.ufmg.br*

The influence of porosity on the relationship S N /s RES for sintered iron and steels are investigated. Data are presented for tensile and fatigue properties in the porosity range 3-14%, in the as sintered conditions. It is observed that the relationship S N /s RES decreases by increasing porosity. This becomes more evident in the sintered steels than in iron. Finally, with exception of Fe, it was shown that experimental results do not fit in the results obtained from a empirical equation take of literature.

COB362 NITROCIMENTAÇÃO POR PLASMA DE FERRO PURO SINTERIZADO / PLASMANITROCARBURIZING OF PURE SINTERED IRON**Elenice C. Borba, Ana M. Maliska, Antônio R. de Souza & Aloísio N. Klein***LABMAT/Laboratório de Materiais - Depto de Engenharia Mecânica / UFSC, CEP 88015-100, Florianópolis, SC - BRAZIL**Fone: (55) 048 231 9268 - Fax: (55) 048 234 0059. <http://www.labmat.ufsc.br>**E-mail: elenice@labmat.ufsc.br, E-mail: ana@labmat.ufsc.br, E-mail: rogerio@labmat.ufsc.br, E-mail: klein@labmat.ufsc.br*

The microstructure of the material produced by powder metallurgy in presence in the nitrocarburizing atmosphere is investigated. In order to study the influence of the amount of carbon in the atmosphere for the formation of the treated layer, sintered powdered iron was nitrocarburized in 90N 2 - 10 H 2 atmosphere containing CH 4 in the range from 1 up to 2%. The formation of the surface layer was analysed by plasma nitrocarburizing of pure sintered iron. The samples were treated at 3 Torr, 540 and 570°C, during 1-3 hours, using a dc discharge. The nitrocarburized layers were examined by standard optical and scanning electron microscopy (SEM), X-ray diffraction and electron probe microanalyse (EPMA). Results have shown that the thickness of compound layer is very sensitive to the temperature rises, with microstructural modification. It was also detected a micropore formation in the outermost compound layer as a result of increasing treatment time.

Keywords: *Nitrocimentação por plasma, Sinterização, Fase-e, carbonitreto/ Plasma nitrocarburizing, Sintering, Phase-e, carbonitrites*

COB608 PROCESSO DE OBTENÇÃO DE COMPOSTOS INTERMETÁLICOS DE Ti E Al UTILIZANDO ONDAS DE CHOQUE / PROCESS OF OBTAINING INTERMETALLIC COMPOUNDS OF Ti AND Al BY USING SHOCK WAVES**Arnaldo Ferreira e João Edison Minnicelli***Departamento de Engenharia Mecânica e de Materiais, Instituto Militar de Engenharia - IME, Praça General Tibúrcio 80, 22290-270, Praia Vermelha, Rio de Janeiro, RJ - Brasil*

Elemental powders of Ti and Al were mixture and, by employing the flyer plate technique, experiments were performed in order to determine the threshold chemical reaction between the powders, and to obtain compacts that allow to characterize the reagents compacted by shock wave. Different proportional mixtures between Ti and Al were used, as an attempt of obtaining improved reactions and better compaction of the materials. The experimental parameter that was varied was explosive quantity, increasing the amount of energy imparted to the powder material. The intermetallic compound TiAl was also mechanically mixture with Ti and Al powders, in order to compare the compacted material. Analysis by X-Ray diffraction and Scanning Electron Microscopy were performed to determine the chemical changes during the compression by shock waves. Successful consolidation was obtained and was improved by strong bonding between individual particles. The main parameter that is significant during the process of chemical reaction and the experimental results are presented and discussed.

Keywords: *Dynamic Consolidation; Shock Waves; Shock-Induced Chemical Reactions; Ondas de Choque; Metalurgia do Pó*

COB1020 ESTUDO DA DENSIFICAÇÃO DO AÇO INOXIDÁVEL 316L SINTERIZADO EM REATOR DE PLASMA / DENSIFICATION STUDIES OF 316L STAINLESS STEEL SINTERED IN A PLASMA REACTOR

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This study shows the consolidation behavior of AISI-316L Stainless Steel sintered in a plasma reactor. Three thermal cycles were followed varying the sintering temperature and time. The final densities obtained here for the 316L-SS sintered by this novel technique were equal or higher than the densities of known steels sintered by conventional routes. Nevertheless, plasma sintering allows a better atmosphere control, as well as energy saving, since only the sintering parts are heated up by the ionized plasma. The main results include densities of the order of 7.39; 7.43 and 7.64 g/cm³ for sintering conditions of 1050°C and 1150°C during 60 min., and 1270°C during 150 min.

Keywords: *Plasma; Sinterização, Processo / Plasma; Sintering; Process*

COB1045 COMPORTAMENTO À TRAÇÃO DE FERRO E AÇO SINTERIZADOS NITRETADOS POR PLASMA - PARTE II / TENSILE BEHAVIOR OF PLASMA-NITRIDED SINTERED IRON AND STEEL - PART II

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The micromechanisms involved in the tensile fracture of sintered materials submitted to thermochemical treatments have as yet not been clearly established. For this purpose, a scanning-electron fractographic analysis was performed on tension-ruptured sintered specimens of iron and low-alloy molybdenum steel, either nonnitrided or previously plasma nitrided. In order to investigate the effect of some typical microstructures, three different treatment atmospheres were employed, the nitrogen content being varied and a carbon-bearing component being introduced. Results show that nitriding generally favors the operation of fracture micromechanisms of low energy absorption in the near-surface regions. The nature of these mechanisms, their frequency, location and extent, depend on the base material, nitriding atmosphere and, in some cases, also on local porosity features.

Keywords: *Plasma Nitriding, Sintered steel, Sintered Iron, Tensile Test, Fracture Micromechanisms. Nitretação por Plasma, Aço Sinterizado, Ferro Sinterizado, Ensaio de Tração, Micromecanismos de Fratura*

COB1046 COMPORTAMENTO À TRAÇÃO DE FERRO E AÇO SINTERIZADOS NITRETADOS POR PLASMA - PARTE I / TENSILE BEHAVIOR OF PLASMA-NITRIDED SINTERED IRON AND STEEL - PART I

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Two tool materials were tested at the same time: the steel AISI D-6 and the stellite-1. The wet and the air dried "Eucalyptus grandis" wood were machined with the following cutting speed: 25,4 - 35,0 - 42,6 and 50,5 m/s. The test was carried out in a molding machine, on which we set up a built tool holder and attached a feeder for the wood beams with stepless regulation speed. With regard to the two tool materials tested over tens of kilometers of cutting lengths, in the wet or the air dried wood machining, it was the stellite-1 tool material that showed a better performance in the wet, as well as in the air dried wood machining. The experimental outcome showed different trends, as to the life of the tools. The plots of the tool life for the air dried wood are bent downwards, that is, for the lower cutting speeds the tool life lasts longer. From a certain value of speed, the tool life falls, while for the wet wood machining the tool life bends upwards, that is, by increasing the cutting speed value a little bit, the tool life decreases, whereas, from a certain value of the cutting speed, the tool life stabilizes.

Keywords: *Plasma Nitriding, Sintered steel, Sintered Iron, Mechanical Properties. Nitretação por Plasma, Aço Sinterizado, Ferro Sinterizado, Propriedades Mecânicas.*

COB1050 DESENVOLVIMENTO DE LIGAS SINTERIZADAS À BASE DE FERRO, FÓSFORO E NÍQUEL PARA APLICAÇÕES DE ENGENHARIA / DEVELOPMENT OF PHOSPHORUS AND NICKEL, IRON BASED SINTERED ALLOYS TO APPLY IN ENGINEERING

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In this work the possibility of sintering of iron based alloys with variable contents of nickel and the content of phosphorus kept constant in 0,5% has been examined. This investigation has the aim of developing iron based alloys for use in engineering where the introduction of nickel and phosphorus in a matrix of iron produces materials with a more adequate density and improved strength. The absence of carbon has the objective to make these products be recompactable, with the advantage of an improved final density and a better dimensional control. This fact can avoid the inconvenient of an excessive fragility and abrasivity that could be caused by the simultaneous presence of carbon and phosphorus. The mechanical properties of the mentioned alloys were analyzed. By these results, it was show that, despite the presence of porosity, a reasonable compromise between hardness and tensile strength was obtained and this was better performed for alloys with a nickel content of 4% and 5%.

Keywords: *desenvolvimento, ligas ferrosas sinterizadas, Propriedades mecânicas. Development, iron based sintered alloys, mechanical properties*

COB1461 PROCESSAMENTOS ALTERNATIVOS PARA A OBTENÇÃO DE PASTILHAS SUPERCONDUTORAS DO SISTEMA (Bi,Pb):Sr:Ca:Cu:O / ALTERNATIVE PROCESSING TO OBTAIN SUPERCONDUCTING PELLETS OF THE (Bi,Pb):Sr:Ca:Cu:O SYSTEM

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This work is about the obtaintion and characterization of samples of the Bi:Pb:Sr:Ca:Cu:O ceramic system. The powder was prepared by two processes: oxide/carbonate mixture and oxalate coprecipitation. These two processes were used in order to stablish the most favorable process to the 110 K phase formation. The characterization techniques were Inductively Coupled Plasma, Sedigraphy, X-ray diffraction and scanning electron microscope. The sinterization was made by conventional and an alternative techniques. The alternative one consists in applying an electrical current simultaneously to the temperature action. The expectation was that this technique would accelerate the reactions and, consequently, to promote higher volume fraction of the 110 K phase. The pellets were structural, electrical and magnetically characterized by X-ray diffraction, SEM, electrical resistivity and magnetic susceptibility. In the analysis of the electrical and structural characterization of the pellets made by both processing methods, we could not find any difference between them. But, the magnetization measurements indicated that there are numerous phases with critical temperatures bellow 110 K, in addition to a higher fraction of 2223 phase, in the pellet made by coprecipitation of oxalates. The alternative sintering process promoted only some alterations in the behavior of the electrical resistivity as a function of the temperature.

Keywords: *Ceramic Superconductors, superconductor pellets, chemical process, Bi:Sr:Ca:Cu:O. / Supercondutores cerâmicos, pastilhas supercondutoras, processo químico, Bi:Sr:Ca:Cu:O*

TEMA 87 - Materiais Compostos, Poliméricos e Cerâmicos

COB112 ANÁLISE DE IMAGENS TOMOGRÁFICAS DE MATERIAIS COMPÓSITOS E METÁLICOS / ANALYSIS OF TOMOGRAPHIC IMAGES OF COMPOSITE AND METALLIC MATERIALS

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X-ray computed tomography (XCT), originally developed for medical purposes is becoming increasingly applied to several applications where it is necessary the interpretation of the internal structure of an object nondestructively. Due its qualitative and quantitative nature, XCT technique established to be a promising tool of nondestructive materials evaluation, and digital image processing emphasizes its applicability. A problem related to this technique are the artifacts, presents in high density material image, mainly metallic materials. One of most common artifacts are caused by beam hardening effect. This phenomenon occurs because the photons at lower energies are preferentially attenuated. Then, the effective energy of the beam shifts upwards as the beam travels through the medium. This work describes the use of digital filtering technique in metallic material images (basically aluminum), for beam hardening correction. Low-pass filter (frequency domain) and median filter (spatial domain) have been used. The results are demonstrated through graphical analysis of the images and measuring area of known defects, like holes in aluminum sample.

Keywords: *Tomografia Computadorizada de Raios-X, Processamento Digital de Imagens, Ensaios Não Destrutivos / X-ray Computed Tomography, Digital Image Processing, Nondestructive Materials Evaluation*

COB117 CHARACTERISATION OF CARBON/CARBON COMPOSITE MATERIALS FOR BRAKE DISCS

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The purpose of this work was to measure the hardness, the density, the interlaminar shear and bending strengths, as well as the flexural modulus of Carbon/Carbon (C/C) specimens extracted from the brake disks of a supersonic aircraft and a F1 racing car. Two kinds of hardness tests were adopted: (i) Rockwell L and (ii) Micro Vickers. For the flexural modulus the methods of sonic resonance (non destructive) and three point bending (destructive) were used. The interlaminar shear and the bending strengths were obtained by three point bending only. The repeatability of the results for the aircraft brakes (solid disk) was in the range of 3% to 22%. For the F1 brakes, in which the disks had ventilation holes (i.e. cylindrical ducts distributed along the radial direction), the variations were in the range of 13% to 25%.

Keywords: *Composite brakes, Mechanical Properties, Carbon / Carbon Composites.*

COB118 DESIGN OF A TEST FIXTURE TO EVALUATE THE TRANSVERSE SHEAR STRENGTH OF COMPOSITE MATERIALS**Flaminio Levy Neto & Willian Mota Balduino**

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This experimental investigation is concerned with the design, manufacture, and operation of a test fixture to evaluate the transverse shear strength of unidirectional composite rods. Fifteen specimens of carbon/carbon (c/c) composite were tested to failure, using an Instron machine to apply a compressive load on the new apparatus. The results are presented and analyzed in the paper.

Keywords: *Carbon/carbon composites, Transverse Shear Strength*

COB363 MOLDAGEM POR INJEÇÃO APLICADA À RECICLAGEM DE PET DE GARRAFAS DE REFRIGERANTES / INJECTION MOLDING APPLIED TO POST-CONSUMER PET RECYCLING**Sandro Donnini Mancini, Maxwell Nascimento Bezerra & Maria Zanin**

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Post-consumer PET soft-drink bottles, after size reduction, washing and drying were submitted to multiple injection processing. Tensile, impact and differential scanning calorimetry (DSC) were made in samples of this recycled PET. The results of tensile and impact properties are related to crystallinity (which increased when the followed recyclings are made) and processing, after comparison with the results of the same tests in samples made by extrusion.

Keywords: *Injeção, PET, Extrusão, Reciclagem / Injection, PET, Extrusion, Recycling*

COB384 DESENVOLVIMENTO DE UM PROCESSO PARA FABRICAÇÃO DE PEÇAS EM MATERIAL COMPOSTO PARA APLICAÇÕES AUTOMOBILÍSTICAS / DEVELOPMENT OF A MANUFACTURING PROCESS TO PARTS IN COMPOSITE MATERIAL FOR AUTOMOTIVE APPLICATIONS**Araujo, Geraldo Accetturi de**

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This work presents the development of a new composite part production process for the automotive industry and describes its impact on the current industry demands, such as: market globaliza-

tion, shorter project and production times, lower production costs, higher production variability (smaller batches, according to customer demands) and the need for a faster product line exchange with higher quality levels. Facing this new reality, the T.R.V. (Vacuum Resin Transfer) process, a new technology which concerns resin impregnation under vacuum, will be stated as a composite part production process. The T.R.V. process is patent pending at INPI - The Brazilian Institute for Industrial Property - and is the result of the engineers and technicians experiences, who used scientific principles for this development at an important automotive industry in Brazil.

Keywords: *Composites, automotive manufacturing process, materiais compostos, processos de fabricação*

COB546 OPTIMIZATION OF FILAMENT WOUND PARTS USING NON-GEODESIC WINDING

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The basis of the filament winding process is the high-speed precise lay-down of continuous reinforcements in prescribed patterns. The possibility to orient the fibres in the most appropriate directions makes filament winding a very attractive process for the manufacturing of high performance components. However, the fibre paths cannot be freely chosen; in order to obtain an accurate fibre placement, the fibres may not slip on the surface during winding. Thus, the selection of slip-free paths in such a way to obtain a part with optimal strength and minimum weight, is the most important step in the design of filament wound parts. This paper describes two design optimization methodologies based on non-geodesic winding. A first methodology concerns the optimization of individual paths and a second methodology concerns the coverage optimization of "tube-like" parts. Both methodologies have been implemented in a computer integrated environment. Experimental validations are included and the results discussed.

Keywords: *Composites, Design, Filament winding, Optimization, Non-geodesics Compósitos, Projeto, Otimização, Enrolamento filamentar, Não-geodésicas.*

COB561 AVALIAÇÃO DA ESTABILIDADE TÉRMICA DE PC, PBT E DA BLEND A PC/PBT PARA FINS DE RECICLAGEM / THERMAL STABILITY EVALUATION OF PC, PBT AND PC/PBT BLEND FOR RECYCLING PORPOSE.

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The aim of this paper is to show the studies that have been made with engineering thermoplastics and blends in order to see the thermal stability to commercial recycling process. This is important today because there is a increasing in the application of different concentration of reutilized material by the processing industry; so, the evaluation of the degradation degree and how this affect the end product's properties must be made. For this purpose, the following materials and techniques were utilized: polycarbonate (PC), polybutylene terephthalate (PBT) and it's blend (PC/PBT); melt flow index, dilute solution viscosity, and thermogravimetric analysis.

Keywords: *Reciclagem, termoplástico, degradação térmica, índice de fluidez, estabilidade térmica, termogravimetria. Recycling, thermoplastics, thermal degradation, melt flow index, thermal stability, thermogravimetric analysis*

COB564 ESTUDO DO EFEITO DO "SIZE" EM FIBRAS DE CARBONO UTILIZANDO A TEORIA DE WEIBULL / THE STUDY OF SIZE EFFECT OF CARBON FIBERS BASED ON WEIBULL THEORY

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The mechanical properties of T300 carbon fibers (with and without sizing) have been measured at lengths of 1,0, 2,5, 5,0 and 10,0 cm, and the usefulness of the Weibull treatment in correlating the results tested. Other failure modes for carbon fibers have also been observed, based on Weibull distribution, such as the "clamp effect" on expected tensile strength of fibers at small gauge lengths.

Keywords: *Fibras de carbono, tensão de ruptura, módulo de elasticidade, distribuição de Weibull, efeito garra, size, carbon fibers, tensile strength, young modulus, Weibull distribution, clamp effect*

COB567 RESISTÊNCIA AO CISALHAMENTO DE UNIÕES AÇO ZINCADO / EPÓXI / AÇO FOSFATIZADO / SHEAR STRENGTH OF ZINCATED STEEL / EPOXY ADHESIVE / PHOSPHATIZED STEEL JOINTS

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The effects of sheet thickness (1.5 and 2.0 mm), cleaning state of the surface of the steel sheets (in a condition without cleaning and by using Metal Ethyl Ketone as a cleaner), and test time after bonding (24 and 96 hours) on the shear strength of galvanized steel / epoxy adhesive / phosphatized steel joints have been analyzed. The results showed that the sheet thickness and the cleaning state of the steel sheets had no effect the shear strength; for these conditions the shear strength was about 9.7 MPa. On the other hand, the test time after bonding had a significant effect on the shear strength; the

shear strength for the 24 h test time after bonding was 9.4 MPa and 10.4 MPa for 96 h. In all cases the standard deviation was very low: maximum of 5%.

Keywords: *Metal/adhesive joints, Shear strength, Steel, Epoxy*

COB571 SIMULAÇÃO DO PERFIL DE TEMPERATURA NO DISPOSITIVO DE ALTA PRESSÃO PARA SÍNTESE DE MATERIAIS SUPERDUROS / SIMULATION OF TEMPERATURA PROFILE IN HIGH PRESSURE DIVECE OF SUPERHARD MATERIAL SYNTHESIS

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A computational model to analyse the synthesis process of carbonado type synthetic polycrystalline diamond was performed through numerical simulation. In this model it is possible to analyse temperature distribution in a part of chamber in both steady and nonsteady states. The simulation results allowed an understanding of the influence of temperature profile in chamber as well as the effect of increasing voltage in the temperature distribution during the synthesis process.

Keywords: *Diamante policristalino, carbonado, distribuição de temperatura, simulação de perfil, análise numérica. Polycrystalline diamond, carbonado, temperature distribution, profile simulation, numerical analysis*

COB978 SINTERIZAÇÃO DE COMPÓSITOS Fe-NbC COM ADITIVOS DO SISTEMA Fe-Cu-P: ESTUDOS DILATOMÉTRICO E MICROESTRUTURAL / MICROSTRUCTURAL AND DILATOMETRIC CHARACTERIZATION OF Fe-NbC COMPOSITES SINTERED WITH Fe-Cu-P ADDITIVES

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NbC was added to iron to investigate an alternative approach for the production of hard phase composites by mechanical alloying. The powders were mixed in toluene using an attrition mill during 8 h. The slurry was then dried out and the powder was mixed to 0.8 wt.% graphite and 4 wt.% Cu₃P-Fe as the sintering additive. Two different compositions were investigated, corresponding to eutectic points of the ternary Cu-Fe-P phase diagram. Next, the samples were uniaxially pressed and sintered in a H₂ atmosphere. Different sintering profiles were followed based on data gathered by differential thermal analysis. This work shows the dilatometric behavior of the sintered materials and the microstructural analysis carried out by scanning electron microscopy and energy dispersive spectroscopy. The results confirmed the potential of the Cu₃P-Fe as a sintering additive. Nevertheless, further experiments are required to achieve similar levels of densification to those obtained with the Fe₃P additive.

Keywords: *Sinterização, Compósitos, Moagem, Sintering, Composites, Attritor*

COB1034 INFLUÊNCIA DE ALGUNS PARÂMETROS DO PROCESSO DE MOLDAGEM A VÁCUO NA QUALIDADE DAS PEÇAS ACABADAS / INFLUENCE OF SOME PARAMETERS OF THE VACUUM MOULDING PROCESS IN THE QUALITY OF THE FINAL COMPONENT

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This work is the result of an experimental investigation about the damage mechanism on both unsaturated polyester plastic (ALPOLIT LP 8242) and fiber glass made reservoirs. The reservoirs were obtained through the vacuum moulding process and the reinforcements were based on choppy roving blanket type (300g/m²). The material is submitted to both tensile and three-point bending efforts under two conditions: dry and wet. The two techniques used to analyze the mechanical fracture were optics microscopy and micrography. For both test conditions, it is highlighted the die cracking, the non-adhesive behavior between the die and the fiber and the breakage of the fibers.

Keywords: *materiais compostos, fibra de vidro/poliéster, propriedades mecânicas, característica do dano / composite materials, fiber glass/polyester, mechanical properties, absorption moisture, characteristic damage*

COB1035 ESTUDO DO COMPORTAMENTO MECÂNICO E FRATURA DE RESERVATÓRIOS OBTIDOS PELO PROCESSO DE MOLDAGEM A VÁCUO / STUDY OF THE MECHANICAL BEHAVIOR AND FRACTURE OF RESEVOIRS MOLDED BY VACUUM MOULDING PROCESS

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Keywords: *materiais compostos, fibra de vidro/poliéster, propriedades mecânicas, característica do dano / composite materials, fiber glass/polyester, mechanical properties, absorption moisture, characteristic damage*

COB1067 BENEFICIAMENTO DO QUARTZO NATURAL BRUTO: CONSTRUÇÃO DE INSPECTOSCÓPIO E ORIASCÓPIO/PROCESSING OF RAW NATURAL QUARTZ: CONSTRUCTION OF INSPECTOSCOPY AND ORIASCOPY

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Raw natural quartz is mainly used by electronic industries in resonators and pre-defined frequency generation high precision devices. Quartz crystals with adequate quality and size are significantly found only in Brazil, including Minas Gerais state. The present paper aimed the implementation of a laboratorial infrastructure to aid the qualification of natural quartz. In a first phase, an equipment that determines the optical axis of the crystals in order to allow its posterior precise orientation with X-ray techniques was constructed. This equipment, named inspectoscopy, aid also the inspection of raw crystals about macro-defects as color, cracks, twins and inclusions. In a second step, an oriascopy was constructed. This equipment allow the initial determination of X and Y axis and the detection of electrical twins in conveniently etched quartz plates. The oriascopy also allows to determine if the crystal is right-handed or left-handed. The development of this phase was associated to sulfuric acid etching techniques. The precision cutting of the plates used a diamond-wheel cutting machining. Both inspectoscopy and oriascopy are operational and the obtained results are satisfactory.

Keywords: *Quartz, inspectoscopy, defects, chemical etching, cutting.*

TEMA 88 - Propriedades Mecânicas dos Materiais

COB30 ANÁLISE FRACTOGRÁFICA E PROPRIEDADES MECÂNICAS DE TRAÇÃO DE UM AÇO IF AO TITÂNIO *FRAC TOGRAPHY AND MECHANICAL PROPERTIES BY TENSION TESTING OF Ti-ADDED IF-STEEL*

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In recent years, there has been significant interest in properties and development of interstitial-free (IF) steels. These steels, because of their improved formability and deep drawing capability offer a number of advantages for stamped components in automotive applications. IF steels generally exhibit more consistent mechanical properties compared to conventional aluminium killed deep drawing quality steels. The carbon contents of IF steels are well below those of steels which form pearlite after hot rolling and annealing. The objective of this work is to analyse by comparison the influence of mechanical properties on the mechanism of fracture of Ti-IF steel. It was observed that the most significant fracture mechanism was the coalescence of microvoid, and the shape of the "dimples" confirmed the high elongation values of this material.

Keywords: *IF Steel, ductile fracture, microvoid coalescence, mechanical behavior, ductility/ Aço IF, fratura dúctil, coalescência de microvazios, comportamento mecânico, ductilidade.*

COB33 INFLUENCE OF THE NUMBER OF SPECIMENS IN THE REFERENCE TEMPERATURE DETERMINATION - INITIAL APPROACH / *INFLUÊNCIA DO NÚMERO DE CORPOS DE PROVA NA DETERMINAÇÃO DA TEMPERATURA DE REFERÊNCIA - ABORDAGEM INICIAL*

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The ASTM E08.08 subcommittee is preparing a new standard, currently in the draft version #13, to determine the reference temperature T_0 for ferritic steels in the transition region. The minimum number of valid experimental results in the data set, to be analyzed by this proposed standard, for a given temperature T , is six. In this work this assumption (six results) is verified by comparison among the results obtained, in terms of $T-T_0$, with different number of toughness values (subsets) taken from a given large set that fits perfectly the Weibull three-parameter probability distribution. The conclusion is an indication of the way to be followed to determine the minimum number of experiments/results necessary to obtain at least 90%, 95% or 98% of the possible $T-T_0$ values near the target one (that of the whole set from which the subsets are taken)

Keywords: *Fracture Mechanics, Transition, Reference Temperature, Reliability / Mecânica da Fratura, Transição, Temperatura de Referência, Confiabilidade*

COB121 FABRICAÇÃO E CARACTERIZAÇÃO DE FERRAMENTAS DE CORTE DE Si₃N₄ / MANUFACTURING AND CHARACTERIZATION OF TOOLS OF THE Si₃N₄

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Silicon nitride based ceramic cutting tools were developed in Brazil. Ceria and aluminium nitride were used as sintering aids. The samples evaluations were performed using specific mass determination, X ray diffraction, microhardness testing, fracture toughness by indentation method and microstructural examination via scanning electron microscopy. After samples evaluation, some pressureless sintering silicon nitride based ceramic cutting tools were made. A piece of cast iron was machined using these cutting tools. For the purpose of comparison, a commercial hard metal cutting tools was also used to perform the same machining.

Keywords: *Sintering, tools, silicon nitride, ceria, aluminum nitride / Sinterização, ferramentas, nitreto de silício, céria, nitreto de alumínio*

COB151 DETERMINATION OF THE VISCOPLASTIC CHARACTERISTICS OF A POLYESTER RESIN MIXTURE

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It is aimed the identification of typical basic behaviors of a mixture of two types of polyester resins for a broader characterization of mechanical and optical properties to be used in photoplastic studies. The first step shown in this paper refers to the identification of viscoplastic behavior at different temperatures through a tension test with multiple relaxations, using specimens with different proportions of the types of resin. Proportional parts in weight of a flexible resin (Resapol 10.069) and a rigid one (10.116) are mixed and cured with hardeners, and out of this material specimens are machined. A temperature control chamber to be used with a polariscope has been specially designed and constructed to be adapted to the universal testing machine used. This chamber is of very low cost, works at a temperature range 0~80°C, with accurate means of temperature control. These experimental studies intend to incorporate the obtained results into a theoretical-computational model in development. The model aims the broad description of the mechanical and optical properties and behavior of the resin mixtures, which will allow the design of experimental-numerical simulations of specimens/parts with complex geometry and/or loading, through the use of prototypes made with the model material developed.

Keywords: *Mechanical Properties, Resins, Viscoplasticity, Temperature Control, Relaxation / Propriedades Mecânicas, Resinas, Viscoplasticidade, Controle de Temperatura, Relaxação*

COB364 PROPRIEDADES MECÂNICAS DE UM AÇO MICROLIGADO EM ALGUMAS CONDIÇÕES MICROESTRUTURAIS / MECHANICAL PROPERTIES OF A MICROALLOYED STEEL IN SOME MICROSTRUCTURAL CONDITIONS

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The purpose of this work is to analyze the mechanical properties of a titanium and niobium microalloyed low carbon steel, an API 5L X65, in some microstructural conditions: as received and from the thermal treatment (quenching and austempering from the intercritical annealing at two temperatures: 1043 and 1083 K). Tension, crack tip opening displacement and Vickers hardness tests have been conducted in order to analyze the strength, ductility, fracture toughness, and hardness. The as received condition, with a ferrite and perlite microstructure, presented tensile strength of 617 MPa, elongation of 25.4%, reduction in area of 74.3% and fracture toughness of $dm=0.35\text{mm}$. The quenching in oil from the intercritical zone showed a microstructure composed basically of ferrite and martensite, and presented, for the 1083 K, good levels of tensile strength (637 MPa), elongation (29.7%), reduction in area (70.6%), and fracture toughness ($dm=0.45\text{mm}$); this condition is optimized when comparing to the as received condition, and for the 1043 K, high tensile strength levels (690 MPa), but low values of reduction in area (61.2%) and fracture toughness ($dm=0.27\text{mm}$). The austempering in 643 K, from the intercritical zone (1043 K), showed a microstructure composed of ferrite and bainite and presented good levels of tensile strength (598 MPa), elongation (28.5 %), and fracture toughness ($dm=0.44\text{mm}$), and very high levels of reduction in area (81.7 %), indicating a better relationship among the mechanical properties when comparing to the quenching condition from the same intercritical temperature (1043 K), and also an optimization in relation to the as received condition, in spite of the decrease in the tensile strength.

Keywords: *Mechanical properties, Microalloyed steel, Intercritical annealing. Propriedades mecânicas, Aço microligado, Tratamento térmico intercrítico.*

COB690 ANÁLISE TÉRMICA DA INFLUÊNCIA DOS SKIDS NO AQUECIMENTO DE PLACAS EM FORNOS DE REAQUECIMENTO DE SOLEIRA MÓVEL/THERMAL ANALYSIS OF SKIDS INFLUENCE UPON SLABS REHEATING PROCESS IN WALKING BEAM FURNACES

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The following paper presents a mathematical model to simulate the reheating process of slabs in a walking beam furnace. The detrimental influence of the skids upon the temperature profile homogeneity (skidmarks) is evaluated relative to the main characteristics of this specific furnace. Also, a simple solution to the skidmark problem is proposed: a staggered arrangement of the beams of the soaking zone, allowing the cold areas to not be shielded from radiation. The results of this improvement show a large reduction of the skidmarks, providing better product quality and significant energy saving.

Keywords: *Skidmarks, Reheating Furnaces, Metalurgical Quality, Energy Saving, Fornos de Reaquecimento, Qualidade Metalúrgica, Economia de Energia*

COB1082 PROPRIEDADES MECÂNICAS DE UMA LIGA Al-Li / MECHANICAL PROPERTIES OF AN Al-Li ALLOY

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In this work the mechanical properties of a 2090 Al-Li alloy were determined for different thermo mechanical treatments. These treatments correspond to the alloys in the conditions of solution treated and aged at different times, with and without previous deformation. The results of tension tests have shown an increase in the strength of the material (yield and ultimate stresses) with the aging time. The best results were obtained for samples which were pre-deformed before aging. The ductility was greater for the solution treated material and decreases for the aged alloy. An improvement in the ductility occurs for the pre-deformed samples before aging.

The changes observed in the tensile properties are related to the different precipitates formed during the aging treatment as well as to the increase in dislocation density due to the pre-deformation before aging.

Keywords: *Mechanical Properties, Aluminum Alloy, Precipitation, Tension Test, Dislocations.*

COB1401 INFLUENCE OF THE NUMBER OF SPECIMENS IN THE REFERENCE TEMPERATURE DETERMINATION; THE MONTE-CARLO APPROACH / INFLUÊNCIA DO NÚMERO DE CORPOS DE PROVA NA DETERMINAÇÃO DA TEMPERATURA DE REFERÊNCIA: MÉTODO MONTE-CARLO

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This work verifies the assumption of six results to determine the master curve for ferritic steels, as stated by the draft #13 of the ASTM E08.08 subcommittee, using the Reference Temperature approach. The Monte-Carlo Method was used to select the analyzed subsets representing the experimental results taken from an infinite 'universe' that fits perfectly the so-called Weibull Three-Parameter probability distribution. This verification becomes important due to the large results scatter in the transition and no defined reliability level in that assumption. A direct approach to address this problem defining an 'universe' represented by a finite set of results was presented in the part I of this work. It showed the necessity of a new approach to consider the infinity possible results given by an experiment. The reliability of the master curve obtained with a given subset of experimental results is indicated as well the minimum number of experimental results necessary to have a confidence level of 90%, 95% or 98% in the obtained Reference Temperature value and the respective Master Curve.

Keywords: *Fracture Mechanics, Transition, Reference Temperature, Reliability Mecânica da Fratura, Transição, Temperatura de Referência, Confiabilidade*

TEMA 89 - Fratura e Fadiga

COB26 COMPORTAMENTO À FADIGA DE JUNTAS SOLDADAS DE LIGAS DE ALUMÍNIO / FATIGUE OF ALUMINIUM ALLOY WELDED JOINTS

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The design of welded joints coupled with the presence of weld defects can impair severely the fatigue resistance of fabrications subjected in service to cyclic loads. Traditionally the design of welded structures has been based on the use of SN curves, defined experimentally, which do not take into account the presence of weld defects. New means of fatigue behaviour prediction are thus needed. For this purpose a comparative analysis of fatigue prediction models, based on analytical and experimental methods, was carried out, taking into account, in particular, the initiation phase. The methodologies proposed by Neuber, Glinka and Heuler were compared.

The models were validated by an experimental programme carried out with welded 6061-T651 aluminium alloy.

Keywords: *Fatigue, stress concentration factors, fatigue initiation, fatigue propagation, failure, fatigue cracks*

COB361 ANISOTHERMAL ANALYSIS OF THE DAMAGE LOCALIZATION IN METALLIC BARS SUBMITTED TO CYCLIC LOADINGS

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The present paper presents a mechanical model to study the thermomechanical coupling effects on low cycle fatigue life of metallic materials. The ASTM standard for low cycle fatigue testing establishes that the gradient of temperature during a test must not exceed ± 2 K. For high inelastic amplitudes and/or high frequencies it is recommended the use of cooling devices in order to maintain the specimen temperature in the established range. Experimental curves obtained in such controlled conditions are often used to predict the lifetime of real structures, assuming the hypothesis of isothermal processes. In real problems without cooling devices, such assumption may lead to inadequate predictions if small safety factors are adopted. Simple numerical simulations of 316L stainless steel bars are presented and analysed showing that the hypothesis of isothermal processes may be inadequate when cyclic inelastic deformations are involved. The results show that part of plastic work is transformed into heat, resulting in a temperature rise that affects substantially the mechanical behaviour of the material.

Keywords: *Low-Cycle Fatigue, Thermomechanical Coupling, Damage Mechanics, Modelling*

COB390 UMA ANÁLISE DO COMPORTAMENTO À FRATURA DE AÇOS ESTRUTURAIS MICROLIGADOS UTILIZADOS EM APLICAÇÕES ÁRTICAS

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The fracture toughness behaviour of four microalloyed structural steel, with different composition and process routes was evaluated for artice applications. CTOD three point bend tests were carried out at a range of temperatures between +10°C and -110°C in HAZ of submerged arc butt welded specimens. Microstructural analysis and hardness (HV) profiles measurement were also carried out to complement the mechanical tests. The results show that all the four steels can work at -50°C and withstand a CTOD value in excess of 0.2 mm

Keywords: *Fracture Toughness, Microalloyed Steels, Weld Microstructures, Welding and HAZ Properties.*

COB558 COMPORTAMENTO DOS POROS NO LIMITE DE FADIGA DE ALTO NÚMERO DE CICLOS EM MATRIZ MONOFÁSICA / BEHAVIOR OF POROUS IN LIMIT ENDURENCE HIGH CICLIC IN THE MICROSTRUCTURE MONOPHASIC

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Fatigue life curves were get up adopting two criterion: one fracture and other of infinit life. The scattering of results of the same tension of the make necessary of analysis statistic. Actually the industry aeronautic and automotive analyse of test fatigue assumed that distribution of logarithmic life is normally. Four groups of diferent size were evaluated with the same porosity. The result showed that porous with small area increase of fatigue limit up 59.9% in comparison with the group higher size porous. There is coalescence of porous without reach of critic size crack.

Keywords: *Sintered, Fatigue, Fracture, Porosity, Crack / Sinterizado, Fadiga, Fratura, Porosidade, Trinca.*

COB618 PROPRIEDADES MECÂNICAS MONOTÔNICAS E CÍCLICAS DE UM AÇO MICROLIGADO AO TI E NB NAS CONDIÇÕES COMO-FORNECIDO E NORMALIZADO / MONOTONIC AND CYCLIC MECHANICAL PROPERTIES OF A TITANIUM AND NIOBIUM MICROALLOYED STEEL IN AS-RECEIVED AND NORMALIZED CONDITIONS

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The purpose of this work is to analyze the monotonic and cyclic mechanical properties of the API 5L X65 steel, a titanium and niobium microalloyed low carbon steel, in two microstructural conditions: as-received -CF- and normalized (from 1193 K)-N1-. Tension and low cycle fatigue tests have been conducted in order to analyze the tension properties [yield strength (σ_y), tensile strength (σ_t), fracture stress (ρ), reduction in area (RA), and strain hardening exponent (n)] and low cycle fatigue properties [fatigue strength coefficient and exponent (σ'_f and b), fatigue ductility coefficient and exponent (ϵ'_f and c), and cyclic strain hardening exponent (n')]. It was observed that the N1 condition showed better behavior, in the range $0.4\% < \Delta\epsilon / < 1\%$, when comparing to the CF condition. In high cycle fatigue, for low levels of strain, the CF condition presented better behavior when comparing to the N1 condition, in spite of the values of σ'_f for these conditions, they are practically the same and equal to 1075 MPa, due to the big difference between the fatigue strength exponent: $b = -0.074$ for the CF condition and $b = -0.110$ for the N1 condition. The CF condition presented cyclic softening for all strain range, and the N1 condition presented cyclic softening for $\Delta\epsilon / 2 < 0.8\%$ and cyclic hardening for $\Delta\epsilon / 2 < 0.8\%$. The *Incremental step (IS)* method was very efficient for obtaining the cyclic stress-strain curve for the CF condition, when comparing to the conventional method (by using several specimens). However, for the N1 condition the results from *IS* method were not satisfactory.

Keywords: *Mechanical properties, Low cycle fatigue, Microalloyed steel. Propriedades mecânicas, Fadiga em baixo ciclo, Aço microaligado.*

COB933 PROPRIEDADES MECÂNICAS DE FADIGA DE BAIXO E ALTO CICLO DE UM AÇO Cr-Mn-N / LOW AND HIGH CYCLE FATIGUE MECHANICAL PROPERTIES IN A Cr-Mn-N STEEL

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In the present work, the low and high cycle fatigue mechanical properties in a Cr-Mn-N austenitic stainless steel used for application in drill collars were investigated. The temperature dependence of the tensile properties was determined and it was found that the yield strength, ultimate strength and elongation values decrease significantly with the temperature. The low and high cycle fatigue testing were carried out at room temperature according to ASTM E606 and ASTM E466 standards, with $R = -1$. At high temperature, the low cycle fatigue properties were estimated from monotonic properties obtained in the tensile testing. The results showed small influence of temperature in the fatigue life in the short-life range and great influence in the long-life range. Near fatigue limit a great scattering of data was observed. The obtained fatigue limit was 452 MPa which represents 47% of the ultimate tensile strength of material.

Keywords: *Low cycle fatigue; high cycle fatigue; austenitic stainless steel / Fadiga de baixo ciclo; fadiga de alto ciclo; aço inoxidável austenítico*

COB940 PROPAGAÇÃO DE TRINCAS DE FADIGA EM JUNTAS SOLDADAS POR SAW NO AÇO C-Mn 516-70N/FATIGUE CRACK PROPAGATION IN WELD JOINTS OF C-Mn.516-70N STEEL**Isabel Cristina Ramos Antunes, Nazareno das Neves & Herman Jacobus Cornelis Voorwald***Departamento de Materiais e Tecnologia, Faculdade de Engenharia - UNESP - Guaratinguetá CEP: 12.500-000 Guaratinguetá - E-mail: voorwald@feg.unesp.br*

In this paper the fatigue crack propagation in weld metal, deposited with submerged arc welding on carbon-manganese steel is investigated. Five combinations flux-wire were studied, with fatigue samples subjected to cyclic loading. Experimental and theoretical results were compared using Paris equation, and was also possible to identify the best combination regarding fatigue crack propagation.

Keywords: *Fadiga, Aço, C-Mn 516-70N, Propagação de trincas, Equação de Paris/ Fatigue, C-Mn 516-70N steel, crack propagation, Paris equation*

COB1023 ANALYSIS OF THE DAMAGE IN LOW CYCLE FATIGUE**Rodrigo Rossi & Marcelo Krajnc Alves***Departamento de Engenharia Mecânica, UFSC, Trindade, CEP 88010-970 Florianópolis, Brasil, E-mail: Krajnc@gr103.grante.ufsc.br*

We present, in this work, a theory and propose an algorithm for the analysis of the damage of low cycle fatigue in mechanical components. A return mapping type of algorithm is used in the integration of the fully coupled elastoplastic and damage equations. The damage theory used in this work, proposed by Lemaitre (1992), is well-founded in the framework of thermodynamics of irreversible process. The model takes into account a non-linear isotropic and kinematic hardening rule. The algorithm proposed for the integration of the set of evolution equations is based on the algorithm presented by Benallal et al (1988) and uses the Newton-Raphson method in order to solve not only the set of local nonlinear equations but also the set of global nonlinear equations. A Galerkin finite element method is employed in the discretisation of the problem where a Quad9 element has been implemented. A two-dimensional plane stress problem, concerning a plate with a hole, is solved with the objective of illustrating the evolution of damage variable.

Keywords: *damage, fatigue, low cycle fatigue, material degradation*

COB1152 MODELOS DE CONFIABILIDADE PARA A PREVISÃO DA VIDA À FADIGA / MODELS FOR FATIGUE RELIABILITY ANALYSIS**Jorge Luiz de Almeida Ferreira & José Luiz de França Freire***Departamento de Engenharia Mecânica - PUC-Rio, Rua Marquês de São Vicente, 225 - Gávea, Rio de Janeiro, RJ, CEP 22.453-900*

The present work describes two analytical models for fatigue reliability analysis. These models are developed under the assumption that cumulative fatigue damage and its critical value follow a lognormal or a Weibull distribution. To verify the predicted results the Monte Carlo analysis was used. From this analysis it was verified that the interference statistical model, based on a lognormal distribution, describes better the behavior of the fatigue's reliability.

Keywords: *acumulação de Dano, confiabilidade / cumulative damage, fatigue reliability.*

TEMA 810 - Reologia

COB 513 PREDICTIONS OF A FLOW-TYPE SENSITIVE CONSTITUTIVE EQUATION FOR CONTRACTION FLOWS

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A new constitutive equation for incompressible materials is obtained by assuming that the stress tensor is an isotropic function of two kinematic quantities, namely, the rate-of-deformation tensor and the relative-rate-of-rotation tensor. A representation theorem is employed to obtain the most general symmetric form of this function. The arising coefficients are assumed to be functions of the second invariants of the two tensors only. Because the second invariant of the relative-rate-of-rotation tensor is an indicator of the flow strength, the equation is thus sensitive to the latter. Forms of these functions are proposed, which lead to the constitutive equation the capability of fitting closely and independently data for shear viscosity, first and second normal stress coefficients, and extensional viscosity. This constitutive equation is used in conjunction with the equations of mass and momentum conservation to obtain the partial differential equations that govern the steady, axisymmetric flow through a 4:1 abrupt contraction. These differential equations are integrated using the finite volume method to obtain velocity, pressure and flow-type fields. The effect on flow pattern of parameters related to normal stresses and extensional viscosity is investigated. Among other results, it is observed that the vortex size increases when either the normal stresses or the extensional viscosity slope are increased. However, when both the normal stresses and the extensional viscosity slope are increased simultaneously, the vortex size increase is milder.

Keywords: *viscoelastic liquids, abrupt-contraction flows.*

COB 154 ABRUPT-EXPANSION FLOWS OF BINGHAM MATERIALS

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Flows of viscoplastic materials through abrupt axisymmetric expansions are important in a number of manufacturing and packaging industrial processes. Depending upon the expansion ratio and Reynolds number, an axisymmetric jet is observed in the flow core, whereas elsewhere the material is almost stagnant. The conservation equations that govern this flow are solved numerically with the aid of a finite volume technique. The material is assumed to behave as a Generalized Newtonian Liquid, with a Bingham-type viscosity function. To handle numerically this viscosity function in a complex flow, the bi-viscosity model has been used. The effect of expansion ratio, Reynolds number and yield stress on the flow pattern and effective cross section area is investigated.

Keywords: *Abrupt-expansion flows, Bingham materials.*

TEMA 811 - Solidificação**COB372 INFLUÊNCIA DA ADIÇÃO DE SILÍCIO NA QUALIDADE SUPERFICIAL DE UM PISTÃO DE ALUMÍNIO FUNDIDO/ ADICTION OF SILICON INFLUENCE OF SUPERFICIAL QUALITY ON PISTON OF THE ALUMINUM CASTING****Celso Riyoitsi Sokei ***, **Elaine Alves Pedrosa ***, **Helder Augustus Trevisso da Silva ******Depto. Eng. Mecânica-FEIS/Unesp Ilha Solteira-SP-Brasil E-mail: Celso@dem.feis.unesp.br****Depto. Eng. Mecânica-EESCUSP-São Carlos-SP- Brasil*

In the casting process of metal and alloys, the main objective is to produce good quality pieces, i.e. without defects. If they are present, it is absolutely necessary to eliminate or minimize them, or else the piece quality and strength may be seriously impaired. One of the most commonly found defects occurring during the casting process of metals is the shrinkage, i.e. the contraction of the piece. In the case of aluminum alloys, it has been proved that shrinkage can be minimized either by changing the alloy composition with silicon addition or altering the mould design. In the present work, shrinkage suppression obtained by experimentally varying the silicon addition in aluminum alloy is presented. Also, the minimum percentage of silicon is determined, in order to maintain good ductility and mechanical strength. Such results compare well with the literature.

Keywords: *Fundição, Ligas de Alumínio, Defeitos, Pistões/Casting, Aluminum Alloys, Defects, Pistons.*

TEMA 812 - Metalurgia Física

COB22 ASPECTOS FÍSICO-QUÍMICOS DA DECOMPOSIÇÃO SPINODAL bm → bt OBSERVADA EM LIGA DE TITÂNIO BETA METAESTÁVEL/ *PHYSICO-CHEMICAL ASPECTS OF THE SPINODAL DECOMPOSITION IN A BETA TITANIUM ALLOY*

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A beta titanium alloy Ti-5.0Al-2.0Sn-4.0Zr-4.0Mo-2.0Cr-1.0Fe (by weight) was solution treated and followed by quenching. In the supersaturation condition this alloy was reheated at 0.5o C/s and 5.0o C/s in order to study the sequences of phase transformation on the anisothermal conditions. In the first stages of heating, a little modification was observed on the morphology microstructures before the precipitation of intermediary phases. Different zones of the matrix present a darker contrast as a consequence of fluctuations in the chemical composition. Chemical microanalysis obtained by EDS in transmission electron microscopy revealed that those darker zones were weakened in Mo, Cr and Fe solute elements. Morphological analysis in electron microscopy revealed no interface between rich and poor zones of matrix. Electron diffraction patterns taken from it showed scattered spots in the same lattice. The results indicate that solute separation, has no interface and identical lattice for different zones, thus we conclude that spinodal decomposition occurs really in beta titanium alloy at low temperatures.

Keywords: *Spinodal decomposition; Decomposition in b-Ti; Phase transformation in b-Ti; Decomposição spinodal*

COB23 ESTUDO DA CINÉTICA DE CRESCIMENTO E DA ESTABILIZAÇÃO DE GRÃOS EM LIGAS DO SISTEMA CU-ZN-AL / *THE STUDY OF THE KINETIC OF GROWTH TO STABILIZE THE GRAIN GROWTH IN THE CU-ZN-AL SYSTEM*

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The study of the microstruture evolution is of fundamental importance for Cu-Zn-Al shape memory alloy. The growth of grain degrades the shape memory effect by the displacement of temperatures where the transformations are observed. The degradation can be softened by the control of grain boundary migration or precipitation as a consequence of the diffusion process. The process control can be obtained by the increase the activation energy, which is produced by addition of the alloy

elements. In this study was used a Cu-Zn-Zn alloy without the addition of elements. Based on the area criterion of the ASTM standard, the statistic measurements of a grain size were made in samples treated at different temperature of the ageing or annealing treatments. The kinetic of the grain growth was studied by an Arrhenius empirical law and the activation energy for this process (EA) was estimated by $\ln(D) \times 1/T$ diagram. At lower temperatures, results of the activation energy follow either theoretical or experimental results. Moreover, for higher temperatures of the thermal treatments a change in the slope of the $\ln(D) \times 1/T$ diagram was observed. This anomalous behavior was associated with a secondary recrystallization as a consequence of the intermediary thermomechanical treatments. On the morphological view point, the secondary recrystallization was characterized to produce an anormal grain size with many boundary faces. Important conclusions about grain growth mechanisms were obtained. After these results, a selection of some of the elements will be made to increase the activation energy (EA) in order to stabilize the grain size.

Keywords: *Grain growth ; Kinetic of growth ; Activation energy ; Secondary Recrystallization. Cinética de crescimento*

COB1012 FENOMENOLOGIA DO EFEITO MEMÓRIA DE FORMA NAS LIGAS $b\text{-CuZnSn}$ / FENOMENOLOGY ON $b\text{-CuZnSn}$ SHAPE MEMORY ALLOYS

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The shape memory effect on a copper based ternary alloy with 32.9wt.% and 4.0wt.%Sn (copper balance) was obtained on a induction furnace and submitted to thermal treatments to retain the b-phase. The microstructural characterization of parent and martensitic phases was done by optical microscopy and the crystalline structure by means of X-rays diffraction. The phase transformation temperatures were determined by resistivity. The influence of thermal cycling and of grain diameter were analysed in relation to these characteristic temperatures.

Keywords: *Efeito Memória de Forma, Elasticidade Enantiomorfa, Transformações de Fase, Metalurgia Física / Shape Memory Effect, Enantiomorphous Elasticity, Phase Transformations, Physical Metallurgy.*

COB1013 ESTUDO DAS LIGAS $b\text{-CuSn}$ COM EFEITO MEMÓRIA DE FORMA / ON $b\text{-CuSn}$ SHAPE MEMORY ALLOY

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Certain copper based alloys are very susceptible to enantiomorphous phase transformations (nucleation and growth with a well determined habit plane). The great majority of these alloys exhibits the typical behavior of shape memory effect alloys and, in particular, the enantiomorphous elasticity (rubber-like), having a good potential to industrial applications. The physical properties and microstructural characterization have been done by optical microscopy and x-rays diffraction analysis

and measurements of resistivity. Hardness Vickers tests have been done to clarify the effects of aging at room and 100°C temperatures.

Keywords: *Ligas com Efeito Memória de Forma, Elasticidade Enantiomorfa, Transformações de Fases, Martensita / Shape Memory Effect Alloys, Enantiomorphous Elasticity, Displacive Phase Transformations, Martensite.*

COB1014 ESTUDO COMPARATIVO DAS LIGAS COM EFEITO MEMÓRIA DE FORMA $bb\text{-CuZnAl}$ e $bb\text{-CuZnSn}$ / ON $b\text{-CuZnAl}$ e $b\text{-CuZnSn}$ SHAPE MEMORY EFFECTS ALLOYS: COMPARISON STUDY

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Two ternary copper based alloys with nominal compositions (in weight %) of 32.9%Zn-4% Sn and 7.0%Zn-17.7%Al (balance Cu) with shape memory effect were characterized in relation to their microstructural and physical properties. These alloys presented transformation temperatures that are function of composition. The alloys were done on a induction furnace using quartz crucibles. The little ingots were submitted to thermal treatments of homogenization, "betatization" and solubilization. The microstructures of each treatment were analyzed. The material was hot milled in shapes of plates and quadratic section wires and presented the two-way shape memory effect. The microstructures of the EMF alloys were studied by means of optical metallography and X-rays diffraction. The phase transformation temperatures were measured by resistivity. Thermal cycling were discussed.

Keywords: *Efeito Memória de Forma, Transformações de Fase, Ligas a Base de Cobre e Transformações Martensíticas / Shape Memory Effect, Phase Transformations, Copper Based Alloys, Martensite Transformations.*

TEMA 91 - Projeto e Teoria de Sistemas Mecânicos**COB19 DESIGN OF A FEEDING SYSTEM FOR AN AUTOMATIC SAWING MACHINE TO CUT ALUMINIUM PROFILES****Victor Martins Saraiva**

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The author presents an alternative design solution for an automatic feeding/handling system for a sawing machine to cut aluminium profiles. The major problems arose from the need to handle profiles of widely differing shape, and also from the need of compatibility with the rest of the machine, previously designed, mainly concerning space availability. The Total Design approach has been used to carry out this project. The final design proposal is a combination of pneumatic, electric and electronic systems and components, essentially consisting of a pneumatic gripper driven by a servo-motor.

Keywords: *Sawing Machine, Aluminium Profiles, Design Process.*

COB86 ESTIMATIVA DE CUSTOS DE PRODUTOS NO PROJETO CONCEITUAL - METODOLOGIA PARA SELEÇÃO DA ESTRUTURA FUNCIONAL E ALTERNATIVA DE CONCEPÇÃO / ESTIMATE OF COSTS PRODUCTS IN THE CONCEPTUAL DESIGN - METODOLOGY FOR SELECTION OF THE FUNCTIONAL STRUCTURE AND ALTERNATIVE OF CONCEPTION**Cristiano V. Ferreira, Fernando A. Forcellini & Nelson Back**

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In the conceptual design of a product must be a constant worry about the decision taking effect over the product's costs during its life cycle stages. The selection stages of the best product functional structure and the more adequate alternative solution of the conceptual design are fundamental for its success (AKAO, 1990). In the work, it will be presented an estimating model of products' costs, which aims to provide subsidies for decision taking and make possible the selection of a functional structure and a product alternative solution, more adequate to the target cost.

Keywords: *Cost, Estimative, Methodology, Product, Design, Custo, Estimativa, Metodologia, Produto, Projeto.*

COB165 ANÁLISE, SIMULAÇÃO E PROJETO DE UM MECANISMO SEPARADOR DE GRANULADOS BIFÁSICOS POR VIBRAÇÃO / ANALYSIS, SIMULATION AND PROJECT OF A GRAINY SEPARATOR MECHANISM**Adyles Arato Júnior & Cassiano Bíscaro Pereira**

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Grains transport by forced mechanic vibration in vibrating courses or pools is often used in agro-industries, mining and feeding companies. The design of a two-phase grain sharer by mechanical vibrations was stimulated by the necessity of some recycling companies. Using a mathematical model of the process a simulation code of a two-phase grain sharer pool has been developed. In a preliminary analysis the most important variable involved in the process has been detected, followed by a proposition of a mechanical model to satisfy the system' dynamics. With the help of the mechanical model, the accelerating condition in the vibration surface could be obtained, just by simulating the grain sharer process, and employing the optimal aspect ratio for a grain sharer pool design.

Keywords: *Granulados, Separação de granulados, Vibrações, Projeto, Análise, Simulação Grainy, Grainy separation, Vibration, Project, Analysis, Simulation*

**COB197 MODELAGEM E DIMENSIONAMENTO DE UMA MÁQUINA COLHE-
DORA DE CAFÉ POR SUCCÃO AERODINÂMICA / PHYSICAL-MATHE-
MATICAL MODEL ELABORATION AND PROJECT PROCESS OF A COFFEE
HARVESTER MACHINE BY BY AERODYNAMIC SUCTION**

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The high costs involved by commercialisation and operation of harvester machines currently used at coffee cultivation, the possibility of tree damages by their continuous use, and the agricultural mechanisation necessity becomes interesting the development of a simple and portable coffee (Coffea arabica L., Coffea canephora Pierre) harvester machine. This equipment should be not only able to do the fruit's crop in a shortest time than manual harvest system, but capable to operate between the coffee trees lines independently of lines space and kind of ground too. Without special exigencies of specific earthwork or appropriate line distance, the machine implementation cost should be only the acquisition price. This present work explain the problem physical-mathematical model elaboration and prototype project process.

Keywords: *Agricultural machines, Coffee, Coffee cultivation, Harvest machine, Coffee harvest machine, Máquinas agrícolas, Café, Cultivo de café, Colheita, Colhedora.*

**COB218 EVOLUÇÃO TECNOLÓGICA NO DIMENSIONAMENTO DA TER-
CEIRA UNIDADE GERADORA PARA A UHE COARACY NUNES**

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This work has the finality to show the project's philosophies, technologic advances, dimension's calculation methods and the results obtained from an International bid for COARACY NUNES Hydropower Station, third generation unit (Kaplan Turbine with vertical shaft and 30 MW) and comparing its obtained results with the two operating units, installed in 1975 (Kaplan Turbine with vertical shaft, and 20MW per unit).

Keywords: *Turbina Kaplan, Coaracy Nunes, Evolução Tecnológica, Estado da Arte, Filosofia de Projeto.*

COB219 FILOSOFIA DE PROJETO E AVANÇO TECNOLÓGICO NO DIMENSIONAMENTO DOS EQUIPAMENTOS ELETROMECAÑICOS PARA A EXPANSÃO DA UHE TUCURUÍ

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This work has the finality to show the project's philosophy, calculation methods and the achieved results on the design of TUCURUI Hydropower Station, second stage construction, composed by 11 (eleven) generation units (Francis Turbine with vertical shaft 382 MW per unit and Generator with 395 MVA per unit) and also to show the technologic advances obtained comparing its results with the 12 (twelve) units (Francis Turbine with vertical shaft a 320 MW per unit, and Generator with 350 MVA per unit), operating since 1984 and the cost reduction due to the use of some equipments installed in the first stage construction as: overhead travelling crane, travelling crane, trashrack machine, etc.

Keywords: *Turbina Francis, Tucuruí, Evolução Tecnológica, Estado da Arte - Projeto.*

COB222 AVALIAÇÃO DOS PARÂMETROS ENVOLVIDOS NO DESENVOLVIMENTO DE UMA MÁQUINA COLHEDORA DE CAFÉ POR SUÇÃO AERODINÂMICA / PARAMETER'S EVALUATION OF A COFFEE HARVESTER MACHINE BY AERODYNAMIC SUCTION

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The present work has like main objective the necessary parameter's evaluation to development of simple and portable coffee (*Coffea arabica* L., *Coffea canephora* Pierre) harvester machine by aerodynamic suction. The parameter's evaluation was done by means of the physical-mathematical model

elaboration, prototype design and assembly, which was field tested at coffee harvest time. The results showed the coffee grains need flow velocity near 270 m/s for efficient suction, and the leaf's are injured close by 60 m/s flow velocity band. These results permit the follow conclusions: a) the main objective, the harvest machine project parameters identification and quantification, was successfully performed; b) the proposed physical-mathematical model was appropriated, anticipating the velocity flow value necessary for efficient coffee grain suction; c) the methodology used at this study can be adopted in others harvest machines project development process, with distinct target objectives, like different fruits, fibres (such as *Chorisia speciosa* fibres), leaf's, or flower's with commercial value.

Keywords: *Agricultural machines, Coffee, Coffee cultivation, Harvest machine, Coffee harvest machine, Máquinas agrícolas, Café, Cultivo de café, Colheita, Colhedora.*

COB223 PROJETO DE CONJUGAÇÃO DE OPERAÇÕES PARA IMPLIMENTO AGRÍCOLA / DESIGN OF COMBINING EQUIPAMENT FOR AGRICULTURAL OPERATION

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According to the ASAE (1982), the combined tillage operations are those realized simultaneously utilizing two or more different types of tillage tools or implements to simplify, to control or to reduce the number of pass over a field. These systems have not been the study purpose having a small quantify of researchs about this subject in Brazil. By this evidence, was developed this research to study the influences of an combining equipment over several parameters and design.

Keywords: *Combined tillage, design, agricultural equipment*

COB349 MANCAIS AEROSTÁTICOS PARA EIXOS - ÁRVORES DE MÁQUINAS FERRAMENTAS

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The main characteristics and design methods for machine tool spindles aerostatic journal bearings with orifice restrictors are presented. The load capacity and stiffness of front bearing and spindle nose characteristics obtained in a sensed test rig as functions of the supply pressure, spindle overhang and the distance between bearings are analysed and compared with the literature.

Keywords: *Aerostatic bearings, machine tool, spindles, journal bearing, orifice restrictor, stiffness, test rig, spindle nose*

COB451 DETERMINAÇÃO TEÓRICO-EXPERIMENTAL DE ESFORÇOS DINÂMICOS EM BOMBAS INJETORA DISTRIBUIDORA DIESEL / THEORETICAL AND EXPERIMENTAL ANALYSIS OF DYNAMIC STRAINS IN DIESEL FUEL INJECTION PUMPS

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In this work the driving shaft of an injection pump is modeled as a flexible rotor using the Finite Element Method. Strains acting on the shaft due to each one of the mechanisms that are coupled to it (driving gear, hydrodynamic bearings, vane type pump, regulator gear and cam) are extensively studied so that the mathematical model faithfully reproduces the dynamic loadings of the injection pump. Theoretical and experimental analysis are conducted in three distinct operating conditions: injection pump operating at 2600 rpm, 2000 rpm, and 1500 rpm. The driving torque and the loading of hydrodynamic bearings, obtained by means of experimental mechanical tests, are used as parameters for comparisons.

Keywords: *método dos elementos finitos, diferenças finitas, rotores - dinâmica, modelos matemáticos. finite element method, finite difference method, dynamics, mathematical modelling.*

COB456 DESIGN OF A RECOVERY SYSTEM FOR SMALL ORBITAL PAYLOADS

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Small returnable orbital payloads or spacecrafts needs safe, efficient and affordable recovery systems. Systems based on parachutes are the most reliable choice, due to its proven reliability and low cost. The present work deals with the preliminary design features of a high performance ground recovery system for small orbital payloads based on parachutes. The proposed system comprises a three stage parachute system with an air-bag as ground impact attenuator. The paper shows and discusses the specification, concept and design of the system.

Keywords: *recovery system, orbital payloads, returnable spacecraft, parachute, impact attenuator sistema de recuperação, carga-útil orbital, satélite retornável, pára-quedas, atenuador de impacto*

COB471 UMA FERRAMENTA COMPUTACIONAL PARA UTILIZAÇÃO DO QFD NO DESENVOLVIMENTO DE PRODUTOS / A SOFTWARE TO APPLY QFD IN PRODUCT DESIGN

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QFD as a whole can be described as a systematic process which translate the consumers needs into the language necessary to develop goods. This paper presents a computational program developed to execute the task necessities to complete one of the first matrix of QFD, it is called "The House of Quality Matrix". It was implemented under a visual objected oriented language (Visual Basic), and it has a modular structure, that means this system can be used by other softwares. The program is a prototype and the necessary tests to validate it has not been executed yet. This computer program has a educational characteristic, so, it can be used as a tool in courses related to mechanical design, quality, and correlated fields, nevertheless it is useful in industries and commercial environment when it is necessary to training people in QFD.

Keywords: *Quality, Consumer Needs, House of Quality, Quality Software / Qualidade, Requisitos do Consumidor, Casa da Qualidade, Ferramentas Computacionais para Qualidade*

COB472 METODOLOGIA DE ANÁLISE DE VIDA EM UMA TRANSMISSÃO CONTINUAMENTE VARIÁVEL PARA BICICLETAS / METHODOLOGY OF LIFETIME ANALYSIS FOR A CONTINUOUSLY VARIABLE TRANSMISSION OF BICYCLES

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The traction drives continuously variable transmission operate in the high-contact-stress. The achievement of a given number of stress repetitions without failures can only be assigned a probability. Most drives are rated against the 90% probability of surviving the number of stress repetitions associated with the rated number of hours of operation at the rated speed and load. A contact fatigue life analysis for traction drives based on a modified Lundberg-Palmgren fatigue theory and numerical simulations of the Man+Continuously Variable Transmission+Bicycle system for three different types of route and two value of power are used to predict the life of this transmission on a bicycle

Keywords: *Bicicleta, Transmissões, CVT, Fadiga, Teoria de contato/Bicycle, Transmission, CVT, Fatigue life, Stress analysis.*

COB482 INFLUÊNCIA DA GEOMETRIA DOS SELOS DE FLUXO PLANOS NAS PERDAS POR ATRITO E NO SALTO DE PRESSÃO AXIAL / INFLUENCE OF PLAIN SEAL'S GEOMETRY IN FRICTION LOSS AND AXIAL DROP PRESSURE

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The main objective of this work is the development of a Software (Visual Basic 3.0) to analyse the influence of the seal geometry in its friction loss : volumetric flow and pressure drop across the seal. The Software is based on the evaluation of the friction factor, which is calculated using an expression corresponding to the Moody Diagram. The Software results are the seal length, pressure drop,

volumetric flow and the data to build diagrams that makes clear the influence of seal geometry in friction loss. These diagrams show the variation of pressure drop and volumetric flow with the seal length and with the seal clearance. So, it is possible to obtain data that can guide the choose of a better geometry corresponding with the situation the user wishes. For example, a geometry that minimize the friction loss.

Keywords: *Selos de fluxo, salto de pressão, vazão volumétrica, fator de atrito / Plain seals, drop pressure, volumetric flow, friction factor*

COB 627 ANÁLISE DOS RECIPIENTES COMPOSTOS SECCIONADOS E INTEIRIÇOS USADOS PARA A GERAÇÃO DE ALTA PRESSÃO / ANALYSE OF SEGMENTEDS AND ENTIRES COMPOUNDS VESSELS USED TO OBTAIN THE HIGH PRESSURE

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In scientific and technological work two kinds of apparatus are normally used to obtain high pressure up to 7 GPa: cylindrical pistons or conic pistons. These setup allows pressures much higher than the limited rupture of materials which piece are made of. This is possible due to application of a special device called compound vessel. The present work analyses the construction, under normal working pressure, the junction between sector are kept closed and the junction surfaces have normal stress close to zero. The obtained correlation permits the determination, after fabrication and under loading, of stress and strain states of internal sector of the segmented rings compound vessel. It was necessary to design a special profile for the side surface of the sectors to obtain this proposed condition.

Keywords: *Alta Pressão, Recipiente Composto / High Pressure, Compound Vessel.*

COB640 ENGENHARIA CONCORRENTE: PERSPECTIVAS PARA O SETOR ESPACIAL/ CONCURRENT ENGINEERING: PERSPECTIVES FOR THE BRAZILIAN SPACE SECTOR

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The development cycle of a satellite launch vehicle is a task that requires considerable maturity and commitment of the design team. The increasing complexity of the tasks involved and the frequent design changes do create the need for attempts to reduce the development cycle period as well as to implement their rational management. Although one may consider the aerospace industry as a

highly developed one, it keeps its structure in a sequential manner, where the events quite often do not relate to each other, thus preventing the aerospace industry to benefit from effort and rework minimisation. This paper presents a retrospective analysis of the management and design tools recently used in the Brazilian aerospace projects and suggests the utilisation of some concurrent engineering tools which could enhance the performance and productivity of future projects.

Keywords: *Concurrent engineering, Project management, Design teams, Design tools, Engenharia Simultânea*

COB 641 AN ORGANISATIONAL FRAMEWORK FOR DEVELOPING HIGH TECHNOLOGY PRODUCTS -EXPERIENCES OF A BRAZILIAN AERONAUTICAL COMPANY

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This paper relates the Integrated Product Development (IPD) approach with the need of having an improved organisational framework and proposes an integrated management approach to companies which develop complex products. It describes the degree of complexity for developing an aircraft, emphasising the market demand to decrease the development cycle time and operational costs as well as to increase the customer satisfaction and the embedded product quality. The effectiveness of a design that involves complex technologies is highly affected by the project and process management approach. This paper describes some experiences of a Brazilian Aeronautical company, revealing the main pitfalls to move from a functional to a matrix organisation, envisioning a team-based working philosophy. It also describes the required evolution of the product development process to cope with market needs. It concludes the analysis proposing a management framework that balance the organisational aspects with the modern product development process.

Keywords: *Integrated Product Development/Desenvolvimento Integrado do Produto, Concurrent Engineering/Engenharia Simultânea, Aircraft Design Process/Processo para Projetar Aeronaves, Design Management/Gerenciamento de Projeto*

COB672 THE DESIGN OF A STABILIZED GONDOLA FOR A GAMMA RAY TELESCOPE - PROJECT MASCO

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This paper describes the mechanical structure and the attitude control system of the gondola that carries the MASCO experiment. This is a gamma ray telescope that flies suspended by a balloon at an altitude of 40 km. The gondola is a truss structure that shall survive the landing loads and fulfil

several requirements concerned with the mechanical interfaces and constraints of the transportation, launching and recovery. An attitude control system has the objective of pointing and stabilizing the telescope moving the gondola in azimuth and the telescope in elevation. There are several targets to be observed during the flight and the telescope must hold the attitude for more than one hour towards each one. Several types of sensors and actuators are employed. The system is computer controlled and the control software comprises several modes of operation according to the phase of the mission and the angular distance from the target.

Keywords: *Balloon-borne experiment, Gamma ray telescope, Structural design, Attitude control system. Balão estratosférico, Telescópio, Raios Gama, Projeto estrutural, Sistema de controle da atitude*

COB952 ESTUDO DA CONFIABILIDADE NO PROCESSO DE PROJETO RELIABILITY STUDY IN DESIGN PROCESS

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An engineering design consists of comprehensible design requirements and it should outline possible solutions, assess them and select the best alternative. Today's designer must be skilled and have a vast knowledge and a command of all external and internal influences around him and must always aim at achieving an efficient and competitive product at a low cost. The use, however, of one of the several well-known methodologies such as: Asimov; Pahl&Beitz; VDI 2221; among others, facilitates the designer's job. On the other hand, is it worth having an efficient and competitive product that is not available at one specific moment of its lifespan? The temporal quality or life of a certain system is directly related to its availability, which is a direct function of the reliability and maintainability; aspects normally raised in specific areas such as in the nuclear, aeronautics and electronics areas. An assessment of the different design approaches raised show, however, that neither of these models focuses clearly on the specific use of the reliability in the several design stages, which proves the need of a deeper study of such aspect in the design process.

Keywords: *Confiabilidade, Disponibilidade, Processo de Projeto / Reliability, Availability, Design Process.*

COB960 IDENTIFICAÇÃO DE PARÂMETROS UTILIZANDO FILTRO DE KALMAN / PARAMETERS IDENTIFICATION USING KALMAN FILTER.

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A parameters estimation tecnics of mechanics systems in the time domain was investigated. For that, was utilized a mass-spring-viscous damper system with one freedom degree which oscillating around the equilibrium point. Were processed simulations with the Schroeder's sequence harmonics phased. Was analised relationeds points with the discretization system and was compared the results with the simulations theoretics results. Were commented the conjunction efficiency between

Kalman filter and the instrumentals variables estimator with that results obtained by instrumentals variables and the least square methods also.

Keywords: *Kalman Filter, Instrumentals Variables, Estimation, Conjunction, Dynamics Systems Filtro de Kalman, Variáveis Instrumentais, Estimação, Conjunção, Sistemas Dinâmicos*

COB962 CONCEPÇÃO, PROJETO E OTIMIZAÇÃO DE UMA MÁQUINA PARA BENEFICIAMENTO DE AMENDOIM / CONCEPTION, PROJECT AND A MACHINE TOOL BETTERMENT TO SHELL PEANUTS

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This project has the goal of showing an alternative method of peanuts shelling to small and medium producers. This is one of the procedures that takes very much manual work in northeastern Brazil nowadays. For this reason it was developed a electrical mechanical device based on a manual device in order to shell peanuts. Satisfiable results were brought out considering shelling capacity, grain breakage and grain and shell separation when compared to manual device.

Keywords: *Conception, Mechanical device betterment, Machine toll, Grain improvement, Peanut. / Concepção, Otimização, Máquina, Beneficiamento, Amendoim.*

COB1002 PROJETO CONCEITUAL DE UM REATOR PILOTO PARA PROCESSAMENTO DE MATERIAIS METÁLICOS POR PLASMA / CONCEPTUAL DESIGN OF A PILOT REACTOR FOR METALLIC MATERIALS PLASMA PROCESSING

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This paper presents the development of the conceptual design of a pilot reactor for metallic materials plasma processing. The users and design requirements of the reactor were established based on the results obtained from researches developed at the Materials Laboratory / Plasma Division / UFSC, with emphasis on plasma sintering of metallic materials. To these informations were applied organization and classification methodologies, such as the quality function deployment QFD, to define and establish the order of priorities of design specifications. Based on these specifications and using a functional analysis method, a functional model was developed, containing the following main partial functions: vacuum generation; energy supply; gas mixture supply; process containment; structural function; process control. This functional model promotes an electrical discharge environment in abnormal regime having the processing components as the cathode, in wich a set of parameters, such as pressure,

temperature, gas flows, voltage and current are controlled during the process cycle, in order to reproduce the route that ensures the desired properties in the final product. From the functional model was built a morphological chart to generate alternative conceptions and these conceptions were submitted to a selection procedure to define the most suitable conceptual solution for the reactor.

Keywords: *Projeto de reator; Plasma; Sinterização; Metodologia de projeto / Reactor design; Plasma; Sintering; Design methodology*

COB1313 GARRA MECÂNICA FLEXÍVEL PARA MANIPULAÇÃO DE OBJETOS COM DIVERSAS GEOMETRIAS / MANIPULATION OF NA OBJECT WITH VARIOUS GEOMETRIES BY THE ELASTIC MECHANICAL HAND

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This work has the proposal to make a design, to manufacture a prototype and evaluation the operational conditions of a flexible mechanical robot hand destined to grip in the "tweezers way" and to grasp object with various geometrical forms, like the correlated movements of the human hand. Some different configuration of the elastic fingers were evaluated in terms of the manipulations capabilities. An experimental and theoretical evaluations of the effector positions were performed, respectively, by the prototype model and the large deformation beam model. It was concluded that the results of the work were successful.

Keywords: *Elastic mechanical hand, manipulation capability, End effector position, Design.*

COB1320 ANALYSIS AND DESIGN OF A MACHINE FOR STEEL WIRE INDENTATION

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The Theory of Elasticity is applied to the Mechanics of the Contact on this paper, the equations for knowing the magnitude of the forces in the indentation process are developed. The pressures, that are generated upon producing the notches, are calculated based on the mechanics of the contact and the boundary conditions as well as the properties of the material. The purpose is to apply these equations for the designing of the Indentation machine. The equations that describe the behavior of the stress in the edges of the notches of the indenter roller are used to compare the stress when its angles changes.

Keywords: *Mechanics of contact, Theory of Elasticity, Elastic half-space, Indentation, Finite Element.*

TEMA 92 - Controle de Sistemas

COB107 MAXIMUM ACCELERATION TRAJECTORIES FOR SUPERSONIC FIGHTERS

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This work presents the application of the finite difference indirect method (also called relaxation method) to solve the Two-Point Boundary-Value Problem (TPBVP) originated by the determination of supersonic fighters' maximum acceleration trajectories, when stated by the Pontryagin Maximum Principle. In spite of the problem's complexity, the method fitted well.

Keywords: *Finite Difference, Flight Mechanics, Optimal Control, Performance Prediction, Trajectory Optimization/ Diferenças Finitas, Mecânica do Vôo, Controle Ótimo, Predição de Desempenho, Otimização de Trajetórias*

COB136 CONTROLADOR DE MÁQUINAS-FERRAMENTAS DE ULTRA-PRECISÃO / CONTROLLER OF ULTRAPRECISION MACHINES TOOLS

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This paper describes the use of a new parallel computer architecture, aimed at complex real time control applications, such as ultraprecision machine tool controllers. Its implementation is based on the TMS320C40, a Digital Signal Processor from Texas Instruments, allowing for fast inter-processor communication and high performance computing. Standard commercial controllers present sample times around 10 ms. Using the new architecture, sample times lower than 25 μ s and positioning precision of 10 nm or better are possible. The controller software is based on the classical theories for analog proportional, integral and derivative control. Current work is on the porting of the controller software to the new architecture. Preliminary results have demonstrated its feasibility.

Keywords: *Controller, TMS320C40, Parallel Architecture, Ultraprecision, and Machine Tool*

COB168 IDENTIFICAÇÃO E CONTROLE DE PROCESSOS ATRAVÉS DE ALGORITMOS GENÉTICOS E ESTRATÉGIAS EVOLUTIVAS / IDENTIFICATION AND CONTROL OF PROCESSES VIA GENETIC ALGORITHMS AND EVOLUTION STRATEGIES

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In this paper, several evolutionary computation paradigms in process identification and control are utilized. The following methodologies are addressed: i) genetic algorithms (with floating point representation), ii) hybrid algorithms composed by genetic algorithms with simulated annealing, and iii) evolution strategies (without and with self-adaptation mechanisms). Experiments in identification were conducted in mono-tank level and temperature processes. Experimental control tests were evaluated in a non-linear level process, composed of coupled twin-tanks, which was submitted to reference change and load disturbance. In this control implementation, the evolutionary computation paradigms are utilized for tuning of the design parameters of a monovariable PID controller.

Keywords: *Genetic Algorithms, Evolution Strategies, Process Identification, Process Control, Practical Application / Algoritmos Genéticos, Estratégias Evolutivas, Identificação de Processos, Controle de Processos, Aplicação Prática.*

COB221 MOTION CONTROL OF A BIAxIAL MACHINE TOOL USING A VERSATILE CROSS-COUPPLING CONTROLLER / CONTROLE DE MOVIMENTOS DE UMA MÁQUINA-FERRAMENTA BIAxIAL USANDO UM ALGORITMO COM EIXOS ACOPLADOS

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This work deals with a type of cross-coupling controller applied to control the machine tool biaxial table motions. A special algorithm was created to perform well any kind of trajectory, linear and non-linear with constant or varying curvature radius and corners. There is no need to make any previous adjustments. It utilizes information from the interpolator and axial positioning errors to calculate the instantaneous radius and curvature centre of the trajectory and also, the contour error. Moreover, it is able to change the proportional, integral and derivative gains of the control law, according to the kind of path. It can be put to work together with the machine axial controllers, helping them. The system is simulated using a non-linear machine model which includes friction, backlash, cutting forces and the ballscrew elasticity. The response results are compared with those of common PID's in order to analyse the effectiveness of this controller over the system.

Keywords: *machine tools, cross-coupling motion controllers / máquinas-ferramenta, controladores de movimento com eixos acoplados*

COB228 ALTA PRECISÃO DE MOVIMENTO E MEDIÇÃO ATRAVÉS DE RECURSOS MECATRÔNICOS / HIGH MOTION AND MEASUREMENT ACCURACY BY MECHATRONICS

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The purpose of this work is to show by two examples, that mechatronic techniques, i.e., the combined use of conventional mechanical technology with control, sensing, actuation technology and technology related to the electronics and application of computer, it is possible to obtain devices and measuring processes of higher accuracy, or with the same accuracy of conventional one but with a lower cost. One example deals about a controlled type air bearing that by using a piezoelectric actuator, a non-contacting sensor and a controller can actively reduce rotation errors of the axis due to disturbance forces or profile error of bearing parts, achieving an infinite static stiffness and nanometer order motion accuracy. The second example is about a method to measure roundness of objects with a accuracy higher than that of the rotary mechanism used in the measurement.

Keywords: *Mechatronics, air bearing, active bearing, motion accuracy, measurement accuracy / Mecatrônica, mancal a ar, mancal ativo, precisão de movimento, precisão de medição.*

COB365 SIMULAÇÃO HÍBRIDA INTEGRADA COMO FERRAMENTA DE ANÁLISE DE PROCESSO E COMO ACEITAÇÃO DA PRODUÇÃO / HARDWARE-IN-THE-LOOP SIMULATION AS PROCESS ANALYSIS TOOL AND PRODUCTION ACCEPTANCE TEST

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It is described the application of a Hardware in the Loop Simulation as an analysis tool of a process with strong nonlinearities. Besides, the main result is the assembly of the test bench such that the components of the process can be tested and qualified based on its global performance. The process is the control system of a rotating missile which uses on-off actuators. It implies the existence of a limit-cycle besides coupling between maneuver planes. The dynamic of the process is very complex which impairs the use of linear techniques of analysis. Thus, the best option is a simulation loop where the real components are present: controller, actuator and sensor. Only the flight dynamic is simulated in an analog computer. After the preparation of the test environment, the bench can be used to verify the quality of the production of the control loop components.

Keywords: *Simulation, Hardware in the Loop Simulation, Control System, Limit-Cycle.*

COB421 PROPOSTA DE UMA FERRAMENTA AUTOMÁTICA DE PROGRAMAÇÃO DE CPs A PARTIR DE MODELOS MFG/ A PROPOSAL OF AN AUTOMATIC TOOL FOR PROGRAMMING PCs FROM MFG MODELS

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The use of Programmable Controllers (PC) is one efficient way to realize the automation of industrial plants. In this context, is very important the existence of a tool to program the controllers in a

rational, systematic and efficient mode. In this context there are several works that confirm that Petri net is a efficient technique to model and analyse discrete event systems and, its derivation, the Mark Flow Graph (MFG) is a technique suitable to realize the control strategies. In the current paper, we introduce an approach based on analysis and validation of the MFG model of the control system (with a MFG simulator, for example) that is translated to an appropriate program language of commercial controllers such as STEP5 (that is a program language used in Siemens' PC). The focus is on the translator tool concept. With this tool is possible to develop structured STEP5 programs to PC that ensure the inexistence of bumping and deadlock problems.

Keywords: *Programmable controllers, Programming Language, Sequential control, Petri nets, Mark Flow Graph.*

COB422 AUTOMAÇÃO DE UM SISTEMA DE RAMPA PARA EMBARQUE E DESEMBARQUE DE VEÍCULOS EM NAVIOS/ AUTOMATION OF A RAMP SYSTEM FOR SHIP LOADING AND UNLOADING OF VEHICLES

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When do not exist a special port infrastructure, the most common way to realize the access of vehicles in ships is trough a ramp system. One alternative to improve the efficiency of this system is trough techniques of task automation. This paper approach this problem through the application of a methodology for Event Driven Systems design based on Petri nets. At first, a conceptual model of the system is generated by using PFS technique (Production Flow Schema). Then, the dynamic behavior of the system is described by a flow of tokens in oriented graphs called MFG (Mark Flow Graph). Through a gradual refinement and interpretation procedure a detailed and consistent representation of the control strategies is obtained. Validation of the control strategies in the present case were carried out through simulation analysis. Finally, the resulting control strategy model is translated to an adequate language of programmable controllers. The overall tests were carried out in a prototype model of the ramp system.

Keywords: *Simulation, Hardware in the Loop Simulation, Control System, Limit-Cycle.*

COB652 ANÁLISE E EXPERIMENTAÇÃO DE UM PROCESSO "FAN-AND-PLATE": ESTUDO DE CASO DE CONTROLE ROBUSTO VERSUS ADAPTATIVO/ ANALYSIS AND EXPERIMENTATION OF A FAN-AND-PLATE PROCESS: CASE STUDY OF ROBUST VERSUS ADAPTIVE CONTROL

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The development of a small scale laboratory process can help disciplines to meet the practical requirements in studying control concepts. The fan-and-plate prototype, a nonlinear control system, was implemented in the Process Control Laboratory/UFSC and did not present a good closed-loop performance when classical controllers, such as PI and PID, were utilized in the experimentation. In order

to assess the applicability of such process, in the context of a school laboratory, a complete study and analysis of advanced control techniques are needed. The implementation of predictive and robust control strategies was carried out and adequate results have served as a base for this evaluation.

Keywords: *Laboratory education, self-tuning control, robust control, nonlinear analysis, systems engineering / Ensino em laboratório, controle auto-ajustável, controle robusto, análise não-linear, engenharia de sistemas*

COB678 O USO DE CONTROLE H• NA ATENUAÇÃO DAS VIBRAÇÕES LATERAIS EM ROTORES FLEXÍVEIS

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This work studies the problem of applying active control to lateral vibration suppression in flexible rotors. Due to the inherent uncertainties that appear when formulating the rotor model and the fact that the rotor dynamical characteristics vary with the angular velocity, the use of robust H^∞ (Glover and McFarlane, 1989) controllers is proposed and implemented. Such controller is discussed, analyzed and evaluated using a case study, where numerical simulations are done in order to test robustness, stability and performance.

Keywords: *Robust Control - Rotor dynamics - Vibrations control - H• controller – Magnetic Control*

COB679 MODELING, EXPERIMENTAL IDENTIFICATION AND LQG/LTR CONTROL OF A MULTIBODY SYSTEM WITH FLEXIBLE APPENDAGES

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This work shows simulational results of control using the LQG/LTR technique. The system used was a multibody structure composed by a hub and two flexible appendages made of aluminum which are linked to a DC motor and represents a satellite like structure. The model used was obtained through the Lagrangian approach and the model discretization was done by the assumed modes method. An experiment assembled in the dynamical laboratories of ITA (Instituto Tecnológico de Aeronáutica) was used to validate the analytical model. The experimental set up has four kinds of sensors available. One accelerometer in the tip of one of the aluminum beams, two strain-gages located in known points of the beams, one tachometer signal which is provided for the DC motor and a potentiometer which measures the hub angular position. A modal analysis of the system is shown and the experimental results are used to validate the analytical model. To control this system a LQG/LTR technique was employed. This kind of control technique is suitable for systems like this one that have some uncertainties due, for example, model discretization. The aim of the control is to drive the hub to an desired angular position. The results of behavior of the closed loop system with a reference trajectory are also shown.

Keywords: *Flexible structures, Multibody system, Modal analysis, Modeling, Position Control*

COB688 REGULAÇÃO AUTO-AJUSTÁVEL DE NÍVEL COM BASE EM ESTRATÉGIAS DE CONTROLE PREDITIVO: ESTUDO DE CASO / SELF-TUNING REGULATION OF A LEVEL SYSTEM BASED ON PREDICTIVE CONTROL STRATEGIES: CASE STUDY

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Predictive control algorithms with different controller design were compared when applied to a practical control problem. A case study of a laboratory scale level process has been used to evaluate the control algorithms. The design of each monovariable adaptive control law utilizes predictive control and are based on minimum variance strategy. Advanced control techniques and identification of process models are useful in industrial applications. A level control system was used to compare four types of controllers: D. W. Clarke & P. J. Gawthrop (1975), A. A. R. Coelho et al. (1988), K. Furuta et al. (1989) and C. M. Lim (1990). Experimental tests were carried out to evaluate servo and regulatory behaviour, features the flexibility of each controller and closed-loop stability.

Keywords: *Process control, Identification algorithms, Level control, Predictive control, Control equipment, Minimum variance control / Controle de processos, Algoritmos de identificação, Controle de nível, Controle preditivo, Equipamento de controle, Controle de variância mínima*

COB724 THERMAL CONTROL SIMULATION OF A WIDE FIELD IMAGER FOR SPACE APPLICATIONS

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This paper presents the results of the simulation of the active thermal control system of a Wide Field Imager (WFI) camera to be used on board of a low orbit satellite for earth resources observation. The objective of the simulation study was to verify if the active thermal control system could maintain the temperature of the optical unit, where the CCD sensors are located, inside the specified operational temperature range. Simulated results show good agreement with measured temperature values during a thermal vacuum test. In orbit simulation results show that the active thermal control can maintain the CCD sensors' temperature inside the specified operational range.

Keywords: *Energy; Simulation; Thermal Control; Temperature; Mathematical Modeling.*

COB803 DESENVOLVIMENTO DE UM CONTROLADOR ADAPTATIVO PARA MANIPULADORES FLEXÍVEIS COM INCERTEZAS DE CARGAS / DEVELOPMENT OF AN ADAPTIVE CONTROL TO FLEXIBLE MANIPULATORS WITH UNCERTAINTY PAYLOADS

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This article deals with the modeling and control of light weight flexible manipulators. Several adaptive control strategies are compared with respect to the ability to handle abrupt payloads changes. The dynamic model of the a one-link flexible arm is obtained by Hamilton's Principle, using a floating reference frame. With a floating reference frame the linearized equations of motion become uncoupled. These equations of motion have the advantage that optimal placement of actuators and sensors become straightforward. The performance of these controllers have been investigated through numerical simulations.

Keywords: *Flexible Manipulators, Robots, Adaptive Control, Pole Placement, Flexible Links / Controle Adaptativo, Alocação de Pólos, Estruturas Flexíveis, Manipuladores Flexíveis..*

COB834 CONTROLE MULTIMALHAS DE COLUNAS DE DESTILAÇÃO/ MULTULOOP CONTROL OF DISTILLATION COLUMNS

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This work presents an application of the Modified Biggest Log Modulus Tuning method (BLTM) to a distillation column. The original BLT method, developed for tuning multiloop PI controllers, is partially modified by proposing that initial adjustments of the SISO controllers can be made by the use of the ISE-IMC-PID approach instead of the classical Ziegler-Nichols method. The simulation results obtained using rigorous mathematical model representation of the distillation column show the convenience of this method by yielding reasonable settings with a small amount of engineering and computational efforts.

Keywords: *Multiloop control, Controllers tuning, BLT method, Modified BLT method, Distillation column*

COB969 DIGITAIS DE BAIXO CUSTO / STABILIZATION IN LOW COST DIGITAL PIEZOMETRIC POSITIONAL SENSORS

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This paper presents a new piezometric positional sensor stabilising system which is based on a software platform, instead of the conventional viscous and/or magnetic damping effects. The software has been designed to be used both in IBM-PC compatible micro-computer, using DOS environment, or in dedicated micro-processor circuits. A complete comparative analysis, by means of a case study, with the viscous and magnetic damping has been made and the results have shown the software damping system - SDS - using advantages. A resolution of 0.5 degrees, with a 0.5 s time response and 99% repeatability has been reached by the SDS.

Keywords: *damping, pendulum, position, sensor, magnetic, viscous, amortecimento, pêndulo, posição, sensor, magnético, viscoso*

COB1154 AN INTEGRATED CONTROL STRUCTURE FOR SURGICAL ASSIST ROBOTICS FOR LAPAROSCOPY

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Minimal Access Surgery, commonly known as keyhole surgery is revolutionising surgery and has been established as a major complement to open surgery. Its growing popularity in recent years, with both patients and surgeons, is due to the numerous advantages it offers over conventional surgery. These include small access wounds (typically 5 or 10 mm in diameter), no forceable retraction of tissue or organs, shorter recovery times and smaller scars. However, these must be balanced by the increased complexity leading to longer operating times and the need for even skilled surgeons to undergo special training in minimal access techniques. The problems of Minimal Access Surgery can be reduced by using robotic systems and intelligent control and interface techniques. In this paper, the authors describe a fully integrated control structure, with three different command and control input systems, which is used to control a compact six degree of freedom surgical assist robot.

Keywords: *Telemanipulator; Surgical Robotics; Endoscope; Voice control; Integration*

COB1190 VARIABLE STRUCTURE CONTROL APPLIED TO LINEAR HYDRAULIC ACTUATORS

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The work presented in this paper is concerned about robust control design applied to robots with hydraulic actuators. A cascade structure is used to decouple the mechanical dynamics from hydraulics. Once a linearizing control for the hydraulic part is obtained, a sliding mode outer-loop control is applied to guarantee closed-loop performance.

Keywords: *Hydraulic actuators, cascade control, variable structure, sliding modes, robustness / Atuadores, hidráulicos, controle em cascata, estrutura variável, modos deslizantes, robustez*

COB 1332 INTERAÇÃO DO SISTEMA DE CONTROLE E A ESTRUTURA FLEXÍVEL DE UM SATÉLITE DURANTE TRANSFERÊNCIA ORBITAL / INTERACTION BETWEEN CONTROL SYSTEM AND FLEXI- BLE STRUCTURE OF AN SATELLITE DURING ORBIT TRANSFER.

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In this paper, the interaction between the attitude control system and the flexible structure of an artificial satellite during orbit transfer maneuvering has been investigated. The satellite was modeled by a rigid central body with one or more flexible appendages. The dynamics equations were obtained by a Lagrangean approach. The flexible appendages were treated as a clamped-free beam and its displacement was discretized by assumed-mode method. In the satellite transfer maneuver a typical Hohmann procedure and a burn-coast-burn strategy were used, the attitude was controlled by on-off controller. As a result, it was verified that if any jet fire cycling near the fundamental frequency of flexible appendages, a possibility of the interactions between control system and flexible structure can exist which could damage the performance of control system. Therefore, as security, in the control system design a bandwidth with one decade below of first natural frequency of the flexible structure should be used.

Keywords: *Estruturas Flexíveis, Sistemas de Controle, Transferência de Órbita / Flexible structures; Control Systems; Orbit Transfer*

COB1338 DYNAMICS AND DESIGN OF AUTONOMOUS ATTITUDE CONTROL OF A SATELLITE USING FUZZY LOGIC

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Fuzzy logic has rapidly become one of the most successful of today's technologies for developing sophisticated control systems. With its aid, complex requirements may be implemented in very simple, easily maintained and low cost controllers, suitable for small satellites. The increase of satellite autonomy is a continuing goal for improving its performance and reducing its operations costs. One approach to this autonomy is to use fuzzy logic in the controller, specially under modeling uncertainties, which has several features that make it a useful tool for maneuver automation. This current analysis investigates the use of a fuzzy logic controller to the acquisition and control of rotation of a spin stabilized satellite. It is possible to control the satellite motion around its spin axis through the correct switching of two magnetic coils within specified ranges by fine tuning the fuzzy control set domains and by adapting them automatically to reduce error tolerance. Such controller is currently under development and its effects on the satellite dynamics and control will be discussed and compared with a classic controller in this work. Several advantages were found under this approach, including simplicity, flexibility and robustness.

Keywords: *Fuzzy Logic Control; Satellite Attitude Control; Operational autonomy / Controle Nebuloso; Controle de Atitude de Satélites; Autonomia Operacional*

COB1339 SIMULAÇÃO DIGITAL EM TEMPO REAL DE UM SISTEMA DE CONTROLE DE ATITUDE MAGNÉTICO AUTÔNOMO DE UM SATÉLITE ESTABILIZADO POR ROTAÇÃO/REAL TIME DIGITAL SIMULATION OF AN AUTONOMOUS GEOMAGNETIC ATTITUDE CONTROL SYSTEM OF A SPIN STABILIZED SATELLITE

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This work discuss the project and the real time simulation of the Attitude Control Systems-ACS of satellites with geomagnetic attitude control. It has the first Brazilian Scientific Applications Satellite-SACII as application, that will have an autonomous attitude control and will be spin-stabilized with active spin rate and precession control through magnetic torque coil interactions with the geomagnetic field. The work: 1) shows how to use system integrated development tools such MATRIX or MATLAB; 2) shows the mathematical model development with the system dynamics and the controller project and analysis; 3) shows the system closed loop real time simulation process through language C software codification, and 4) shows the simulations done so far.

Keywords: *Simulation/Simulação, Tempo Real/Real Time, Controle de Atitude/Attitude Control*

COB1342 UTILIZANDO O MATLAB PARA O CONTROLE DE UM SIMULADOR DINÂMICO EM TRÊS EIXOS/ USING MATLAB TO CONTROL A THREE AXIS DYNAMIC SIMULATOR

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This work presents the description of an interface software between MATLAB and a three axis dynamic simulator Contraves 53M2-30H. The host computer is an IBM-PC which communicates with the simulator by means of a dedicated interface specially built for this purpose. A software written in C enables to command the simulator exactly in the same way as if it the command keyboard of the simulator controller were used. An additional set of routines that are not built in the simulator controller like multiple rate or position reads was also developed. Based on both sets of routines it was developed an interface software with MATLAB that enables the user to access all the control functions of the simulator directly from the analysis environment of that software.

Keywords: *Real Time, Interactive Software, Attitude Control, Physical Simulation, Hardware in the Loop Tempo real, Software Interativo, Controle de Atitude, Simulação Física, Hardware em malha*

COB1492 MODELAGEM, SIMULAÇÃO E RESULTADOS DE UM EXPERIMENTO DE CONTROLE DE UMA UNIDADE TÉRMICA/MODELING, SIMULATION AND RESULTS FOR A THERMAL UNITY CONTROL EXPERIMENT

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This work shows the development of an experiment implemented at a Control Systems Laboratory focusing Mechanical Engineering students. The objectives to be achieved with this equipment

are to reinforce the importance of good dynamic models and to point out the limitations of the control system design in the absence of a compatible dynamic model. The thermal unit is an aluminum box with removable internal chicanes to modify internal air flow, and covered by an acrylic window, where, through the use of heaters and a small fan, internal prescribed temperatures must be maintained at given levels. As the thermal unit has a distributed parameter system behavior, lumped parameter models allow just mean temperature control very far from the control objective. The paper begins calling attention to the question of control education for Mechanical engineers, shows the design and simulated and experimental control results achieved with lumped parameter models to describe the thermal unit behavior and analyzes modifications to be introduced in the experiment in order to get more realistic results.

Keywords: *Control systems, Thermal control Systems, Laboratory experiments, Mechanical Engineering Education*

TEMA 93 - Instrumentação

COB108 TORQUÍMETRO ELETRÔNICO PARA MEDIDA DE TORQUE EM EIXOS MECÂNICOS ROTATIVOS

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A low cost, small wireless static and dynamic torque measurement strain gage based instrument was designed and implemented. This approach is specially suited for rotating shafts of ships, industrial & household machines and land vehicles. Strain associated to this measures is often very low, so we propose a method using semiconductor piezoresistor strain gages to obtain higher sensitivity with a simple compensation for apparent strain due to local temperature changes in shaft.

Keywords: *Torsion -Measurement, Semiconductor Strain Gages, Telemetry, Temperature Compensation.*

COB 153 MEASUREMENT OF RESIDUAL STRESSES BY THE INCREMENTAL HOLE-DRILLING TECHNIQUE USING THE TRANSMISSION FUNCTION METHOD

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Residual stress state may exist in a large variety of mechanical parts of industrial mechanisms and is very common. The origins of this residual stress state are numerous and are mainly due to material elaboration processes and to body part shaping. Residual stress state must be well known in order to be able to make a proper calculation of mechanical resistance of the body part. Several experimental methods exist so that residual stress state determination can be performed. Those methods are surface ones (X-ray diffraction technique) or destructive and restricted to uniform stress states (hole-drilling technique). Methods suitable for determining stress gradient have been derived from hole-drilling technique but usually complex calculations are requested for this purpose. The method presented here is based on a normalized unique experimental strain variation function called Transmission Function. Once determined, this function allows easy step by step calculation of the stress gradient.

Keywords: *Residual Stresses, Hole-Drilling Technique, Stress Gradient, Incremental Method, Transmission Function*

COB190 DELIMITAÇÃO DO CAMPO DE UTILIZAÇÃO DE UM GERADOR PERIÓDICO DE PRESSÃO / DELIMITATION OF THE FIELD OF APPLICATION OF A PERIODIC PRESSURE GENERATOR

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This presents recent results obtained for the characterization of a Periodic Pressure Generator developed for the dynamic calibration of pressure sensors and transducers in the range of up to 35 mbar, using a sinusoidal excitation signal. Continuing previous research on this pressure generator, the calibration procedures, and the dynamic characterization of the pressure generator were now done with the aid of a dynamic signal analyzer. Use of the analyzer showed that the operating range of the generator is larger than the results first presented indicated. On the other hand the reliability of the calibration procedure was increased, while the procedures themselves were simplified by the use of the analyzer.

Keywords: *Instrumentação; Calibração; Metrologia Dinâmica; Sensores, Pressão / Instrumentation; Calibration; Dynamic Metrology; Sensors; Pressure*

COB259 DESENVOLVIMENTO DE UM RADIÔMETRO ELIPSOIDAL DE ALTA SENSIBILIDADE / DEVELOPMENT OF A HIGH-SENSITIVITY ELLIPSOIDAL RADIOMETER

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The main objective of this work is the development of a high-sensitivity and low-cost ellipsoidal radiometer for measurement of total radiation. The ellipsoidal cavity has an appropriate geometry and high-reflectivity surface so that all incident radiation is focused on a hemispheric sensor connected to a differential thermocouple. From the generated thermoelectric voltage it is possible to evaluate directly the incident radiation power through a calibration procedure conducted using a black-body cavity. We achieved a radiometer sensitivity that is three times larger than the similar instruments in the market. It is also worth noting that all material used in this instrument can be purchased anywhere with low cost. The main application for the radiometer is the measurement of total radiation in furnaces and other high-temperature industrial equipments.

Keywords: *Thermal radiation, total hemispherical radiation, thermal radiometer, ellipsoidal radiometer, differential thermocouple. Radiação térmica, radiação total hemisférica, radiômetro térmico, radiômetro elipsoidal, termopar diferencial*

COB352 CALIBRAÇÃO SEMI-AUTOMÁTICA DE BALANÇAS PARA TÚNEIS DE VENTO EMPREGANDO REDES NEURAS ARTIFICIAIS/ SEMI-AUTOMATIC CALIBRATION OF WIND TUNNEL BALANCES USING ARTIFICIAL NEURAL NETWORKS

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This work is concerned with a semi-automatic calibration procedure using artificial neural networks for wind tunnel balances. The adopted structure is suited to a large variety of wind tunnel balances, from one to six degrees of freedom. The proposed procedure was applied to a pyramidal balance with six components, installed at the windtunnel TA-2 of Centro Técnico Aeroespacial. The estimates of the aerodynamic loading that appear on the test model are obtained directly as the output of an artificial neural network.

Keywords: *Neural Networks, Non-Linear Identification, Instrument Calibration, Windtunnel, Balance, Redes Neurais, Identificação Não-Linear, Calibração de Instrumentos, Túnel de Vento, Balança.*

COB527 WO-PHASE FLOW TOMOGRAPHY USING A 8-ELECTRODE ELECTRICAL CAPACITANCE SENSOR

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This paper describes an electrical capacitance tomography (ECT) system for imaging of two-phase flows. The capacitance sensor was built with eight electrodes around an insulating pipe. In the proposed capacitance measurement system, when an electrode is an emitter, the seven other electrodes are receivers, leading to a parallel reading tomography type. For a 8-electrode sensor, there are 28 independent readings. In order to improve the measurement system time response, a new electronic transducer was developed that supports excitation frequency up to 10 MHz. The proposed ECT system was tested for both stratified and annular air-water flows. A linear back projection algorithm was used to reconstruct the cross section image of the two-phase flow from the measured capacitance values. The reconstructed flow images obtained using this algorithm were compared to the real two-phase flow distributions. Filtering techniques were applied to the back projection algorithm in order to improve the reconstructed flow image quality. Limitations and possible future improvements of this technique are also discussed.

Keywords: *Two-phase flow, Tomography, Capacitance sensor*

COB629 QUALIFICATION TESTS OF THE EMB-145 AIRCRAFT MAIN LANDING GEAR

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This paper presents the procedures, solutions and results found during the certification drop tests of the newest EMBRAER commercial aircraft, in order to define the gear dynamic behavior while absorbing and dissipating the airplane landing energy. Combined free drop conditions, referring to dif-

ferent landing weights and vertical sink speeds have been reproduced in the Aerospace Technical Center by using a machine composed by a tower and a drop carriage. The specimen has been attached to the carriage and dropped from different heights to the ground, allowing the assessment of landings of variable severity. The gear attachment has observed the same conditions verified on the actual aircraft assembling. The dynamic characteristics obtained during the tests have been correlated with theoretical drop test curves previously simulated on computer. The results have verified the requirements defined in the Brazilian Airworthiness Certification Regulations and used by the Industrial Fostering and Coordination Institute, the official airworthiness authority.

Keywords: *Landing gear, drop test, certification.*

COB649 SOME COMMENTS ON DISPLACEMENT MEASUREMENTS USING ACCELEROMETERS

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Some problems in measuring displacements using analog double integration of acceleration data are discussed in this paper. The main problem in using analog double integration is due to the nonlinear phase response of the double integrator and its transient response that can induce great errors. These errors are unacceptable when the purpose of the measurement is to verify structural integrity, since damage is dependent on the peak and valleys of the waveform. In order to quantify some of these errors, several displacement measurements were made using simultaneously double integration of acceleration data and a LVDT. These results indicate that accelerometers should not be used to measure displacements unless the double integration errors are considered and appropriately corrected.

Keywords: *Measurements, accelerometers, displacements, integration/ Medições, acelerômetros, deslocamentos, integração*

COB662 TRANSDUTOR CAPACITIVO PARA MEDIDAS DE FRAÇÃO DE VAZIO EM ESCOAMENTOS BIFÁSICOS. PARTE I: MODELAGEM E SIMULAÇÃO / CAPACITIVE TRANSDUCER FOR VOLUME FRACTION DETERMINATION IN TWO PHASE FLOW. PART I: MODELING AND SIMULATION.

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This paper shows the dynamic modeling and simulation of a two phase flow capacitive transducer. This device, coupled to AC bridge, is used to flow measurements in petroleum industry and it

has good characteristics of electrical sensitivity and low cost. A mathematical model for the capacitive transducer and the complementary electrical circuit was developed and simulated with a commercial simulation program aiming the specification of its components and the analysis of the system behavior under several solicitations.

Keywords: *Sistemas Dinâmicos, Instrumentação, Medidores de Vazão, Transdutores Capacitivos, Medidas em escoamentos Bifásicos. Dynamic Systems, Instrumentation, Flow Meters, Capacitive Transducers, Two Phase Flow Measurements*

COB663 TRANSDUTOR CAPACITIVO PARA MEDIDAS DE FRAÇÃO DE VAZIO EM ESCOAMENTOS BIFÁSICOS. PARTE II: CONSTRUÇÃO DO PROTÓTIPO E TESTES EXPERIMENTAIS / CAPACITIVE TRANSDUCER FOR VOLUME FRACTION DETERMINATION IN TWO PHASE FLOW. PART II: PROTOTYPE CONSTRUCTION AND EXPERIMENTAL TESTS.

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This paper shows the construction and calibration procedures of a two phase flow capacitive transducer. This device, coupled to AC bridge, is used to flow measurements in petroleum industry and it has good characteristics of electrical sensitivity and low cost, but it is very sensitive to the ambient pressure and temperature fluctuations and to magnetic fields too. We show how to insulated this transducer and keep it stable under these adverse conditions.

Keywords: *Sistemas Dinâmicos, Instrumentação, Medidas de Escoamento, Transdutores Capacitivos, Medidas em Escoamentos Bifásicos. Dynamic Systems, Instrumentation, Flow Meters, Capacitive Transducers, Two Phase Flow Measurements*

COB890 A LOW-COST PROBE TO MEASURE THREE MEAN VELOCITY COMPONENTS

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This paper presents the development of a low cost multihole probe to measure three dimensional flow-fields. Details of the construction of this probe are presented as well as the material used to construct the probe. The calibration method avoids the difficulties of nulling or pressure balancing, as the flow quantities are related to the hole pressures by calibration. Experimental procedures and results are demonstrated.

Keywords: *Flow Measurement / Four-Hole Probe / Five-Hole Probe*

COB972 SISTEMATIZAÇÃO DA ANÁLISE DE ERROS NA MULTIPLEXAÇÃO AUTOMATIZADA COM TRANSDUTORES PIEZOELÉTRICOS CONVENCIONAIS / SYSTEMATIZATION OF THE ERROR ANALYSIS IN THE AUTOMATED MULTIPLEXATION EMPLOYING CONVENTIONAL PIEZOELECTRIC TRANSDUCERS

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In this work is presented a systematization of the error analysis due to the multiplexation in conventional piezoelectric transducers. The multiplexation can minimize instrumentation costs, but it is not common in these transducers. In the use of the multiplexation, measurement errors are increased. The analysis of these errors is more complicate because the conventional piezoelectric transducers quantify the output sign in electric charge. In this works is realized an error analysis employing equivalent electrical circuit models and parameters provided by manufacturers. The results demonstrate that the multiplexation can be advantageous but recommendations must be followed.

Keywords: *Automed Measurement, Measurement Error, Piezoelectric Transducers, Acceleration Measurement, Multiplexion, Automação da Medição, Erro de Medição, Transdutores Piezoelétricos, Medição de Aceleração, Multiplexação.*

COB973 ANÁLISE COMPARATIVA ENTRE ERROS METROLÓGICOS DECORRENTES DA MULTIPLEXAÇÃO AUTOMATIZADA OBTIDOS EM ANÁLISES TEÓRICA E EXPERIMENTAL / COMPARISON BETWEEN MEASUREMENT ERRORS FROM THE AUTOMATED MULTIPLEXION OBTAINED IN EXPERIMENTAL AND THEORETICAL ANALYSIS

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In this work is realized a comparison between results from experimental and theoretical analysis, in the automated multiplexation. In some applications, simultaneous measurements of several mechanical magnitudes is necessary. The multiplexation can reduce instrumentation costs, allowing the use of only one conditioning unit for several transducers. But multiplexers have not ideal behaviour, so measurements errors are introduced in measurement chain. Analysis of these errors is critical due to lack of informations found in bibliography and provided by manufacturers. In this works is realized a theoretical analysis in multiplexers with relay and semiconductor switches. This analysis employed electrical equivalent models and parameters provided by manufacturers. The experimental analysis aimed to measure parameters of instruments and compare them with values supplied by manufacturers. By this way, it is evaluated the suitability of the electrical equivalent models. This works presents the modeling in the usual form and the results of experimental analysis.

Keywords: *Data Acquisition Systems, Automated Measurement, Measurement Error, Multiplexation, Experimental Research, Sistemas de Aquisição de Sinais, Automação da Medição, Erro de Medição, Multiplexação, Pesquisa Experimental.*

COB1278 RESPOSTA DINÂMICA DE SENSORES DE TEMPERATURA ATRAVÉS DO DESMASCARAMENTO EM MEIO LÍQUIDO

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This work presents a comparative study between two methods for the generation of a step function temperature signal to be used in the dynamic calibration of temperature sensors in liquid. The classic method, in which the sensor is rapidly immersed in a fluid at different temperature, is compared with the unmasking method. In this method the sensor is placed in the fluid, but is isolated from it by a mask pressurized internally. An especially designed rotating tank was used in these tests. The results obtained have shown that, at least for a given type of sensor, the unmasking method presents better results than the immersion method.

Keywords: *Calibração Dinâmica, Tempo de Resposta, Sensores de Temperatura, Medição Transiente de Temperatura.*

COB1341 CONTROLE DE UM MULTIPROGRAMADOR VIA MATLAB / CONTROLLING A MULTIPROGRAMMER USING MATLAB

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This work presents the software for the command of an interface between a Multiprogrammer STD-85MP (a data acquisition system) and the MATLAB software. The communication between the multiprogrammer and the host computer (in this case an IBM-PC) is done through a GPIB bus. Many different routines have been developed, at least one for each kind of multiprogrammer card available. The implemented routines in the form of MEX-files were developed in FORTRAN. The syntax of the commands follows the syntax used in MATLAB. The objective of this implementation is to simplify the development of software for the control of experiments in the Physical Simulation Laboratory of the Space Mechanics and Control Division - DMC of INPE. This tool facilitates the development of software at the same time that it brings the experiment data into the powerful analysis and graphical environment of MATLAB.

Keywords: *Physical Simulation, Software, Device Driver, Hardware in the Loop/Simulação Física, Software, Acionador de Dispositivos, Hardware na Malha*

COB1448 DESENVOLVIMENTO DE UM SENSOR POROSO CAPACITIVO PARA MEDIÇÃO DE UMIDADE NO SOLO / DEVELOPMENT OF A POROUS CAPACITIVE SENSOR FOR MEASURING OF GROUND HUMIDITY

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In this study was developed a capacitive sensor to measure the relative water mass present in the soil. The sensor is based in the ground water diffusion into dielectric material, where the capacitance of the sensor is representing the ground relative water mass variation. The low influence of the ground conductivity and temperature in de measurements using this method justify the use of this techniques. Many geometrical dimensions were used in the preliminary measurement tests and the sensor with the best geometrical characteristics was built. Two sensors were used in the experiments. In the first, the dielectric was built with gypsum and the second with porous stone. These instrumens were experimented and calibrated with a balance to measure the ground relative water mass variation. Plots, for electric tension versus ground relative water mass and capacitance versus ground relative water mass were designed.

Keywords: *Ground Humidity (Humidade de solo). Humidity Measurement (Medição de humidade). Capacitive Sensors (Sensor capacitivo). Irrigation (Irrigação). Instrumentation (Instrumentação).*

TEMA 94 - Automação e Robótica**COB16 PREDICTIVE SENSOR GUIDED ROBOTIC MANIPULATORS IN AUTOMATED WELDING CELLS****Adolfo Bauchspiess¹ & Sadek C. Absi Alfaro²***GRACO/UnB – Automation and Control Group / University of Brasília**1Electrical and 2Mechanical Engineering Depts. - 70910-900 - Brasília / DF - BRAZIL**E-mail: bauchspiess@graco.unb.br, sadek@graco.unb.br*

This paper presents an on-line tracking optimization scheme for sensor guided robotic manipulators by associating sensor information, manipulator dynamics and a path generator model. Feedback linearization-decoupling permits the use of linear SISO prediction models for the dynamics of each robot joint. Scene interpretation of CCD-camera images generates spline fitted segments of future trajectory. In the sensor vision field the proposed optimization criteria minimizes the error between state variables of the prediction model and the state variables of the spline trajectory generator. These techniques, allied with separation of disturbance rejection and path-tracking performance by the proposed feed-forward Following Model Predictive (FMP) servo-controller design, permits very high path tracking dynamics (and consequently small errors). Experimental results on implementation of a CCD-camera guided hydraulic robot and a welding robot demonstrates the practical relevance of the proposed approach.

Keywords: *Robotics, Predictive Control, Sensor guided Manipulators, Welding Automation***COB17 PATH GENERATION FOR A REDUNDANT SENSOR GUIDED UNLOADING CRANE****Adolfo Bauchspiess¹ & Sadek C. Absi Alfaro²***GRACO/UnB – Automation and Control Group / University of Brasília**1Electrical and 2Mechanical Engineering Depts. - 70910-900 - Brasília / DF - BRAZIL**E-mail: bauchspiess@graco.unb.br, sadek@graco.unb.br*

The path generation for a redundant sensor guided coal unloading crane is discussed in this paper. After using much of task specific knowledge to restrict the possible Tool Center Point trajectories to a feasible subspace two approaches are analyzed to optimize the dig head trajectory in this subspace: a Fuzzy Logic and a Dynamic Programming based trajectory generation. Experimental results are presented for a CCD-camera guided hydraulic manipulator tracking an optimized unload trajectory.

Keywords: *Trajectory Planning, Robotics, Fuzzy Logic, Dynamic Programming.***COB28 LINEARIZAÇÃO EXATA DE UMA MESA POSICIONADORA PARA OPERAÇÃO SÍNCRONA EM UMA CÉLULA DE SOLDAGEM ROBOTIZADA****Adolfo Bauchspiess, Getúlio Menezes Bento, Milton Siqueira**

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At GRACO/UnB a two degrees of freedom positioning table is being developed for the already operating MIG/MAG welding cell. This cell comprises today a Migatronic MBH240 welding equipment and an ABB IRB2000 welding robot. The integration of the positioning table with the welding cell requires synchronous movements, preferentially managed by the robot control system (S3 - from ABB). Conception, project and simulation of the closed loop controlled positioning table using non linear control techniques are discussed in this paper. Exact Linearization decouples and linearizes both degrees of freedom of the system. So it is possible to independently track reference paths for each joint. The dynamics of the decoupled and linearized table is established by a state space controller. A state observer is used to reconstruct the states that cannot directly be measured. Robustness of the proposed approach can be seen from results for different loading conditions.

Keywords: *Exact Linearization, Non Linear Control, Robotics, Welding Automation*

COB62 AUTOMAÇÃO HIDRÁULICA E PNEUMÁTICA EMPREGANDO A TEORIA DE SISTEMAS A EVENTOS DISCRETOS / FLUID POWER AUTOMATION USING DISCRETE EVENT SYSTEMS THEORY

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This paper discusses the design of automatic systems composed of hydraulic & pneumatic components. For a practical case of a discrete plant, the main modeling tools available for the designers on hydraulic & pneumatic systems and automation are compared. The analysis emphasizes: a) the complement between modeling tools that describe function and behavior; b) the use of Grafcet diagram (IEC 848) for modeling discrete event systems; c) the possibility to use the supervisory control theory of discrete event systems to solve logical problems during the design stages of conception, verification, and modification.

Keywords: *Fluid power, automation, discrete systems, Grafcet ; hidráulica, pneumática, automação, sistemas discretos*

COB195 SIMULATION OF ROBOT CALIBRATION PROCEDURES USING MODEL OPTIMIZATION UNDER OFF-LINE PROGRAMMING

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In this paper techniques are described which allow the robot calibration process to be simulated. This allows pre-test planning and optimisation to be studied resulting in an improvement in

overall system performance. By introducing random errors the repeatability characteristics of both the robot under test and the measurement system are simulated. This gives the opportunity to study different numerical optimisation routines for the efficient identification of geometric parameters used to describe the kinematic model of the robot. The overall result is an improved and optimised kinematic model giving considerable improvement in the absolute accuracy of the robot.

Keywords: *Kinematic model, robot calibration, absolute accuracy, numerical optimisation, geometric parameters*

COB220 **SOBRE O PROBLEMA DE OTIMIZAÇÃO DE TRAJETÓRIAS DE ROBÔS MANIPULADORES NA PRESENÇA DE OBSTÁCULOS / ABOUT THE PROBLEM OPTIMIZATION OF TRAJECTORY PLANNING OF ROBOT MANIPULATORS IN THE PRESENCE OF THE OBSTACLES**

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This paper presents two different strategies for the problem of off-line optimal trajectory planning of robot manipulators in the presence of fixed obstacles. The first strategy is related to the situation where the task imposes the trajectory to contain a given number of points. The second strategy corresponds to the case where only the initial and final points are given. The optimal traveling time and the minimum mechanical energy of the actuators are considered together to build a multiobjective function. The obstacle avoidance is expressed in terms of the distances between potentially colliding parts. A simple numerical example involving a Cartesian manipulator arm with two-degree-of-freedom is described for the two strategies.

Keywords: *Robot manipulator, Trajectory planning, Obstacle avoidance / Robôs Manipuladores, Planejamento de Trajetórias, Presença de obstáculos*

COB351 **PROPOSIÇÃO DE UMA LEI DE CONTROLE PARA ROBÔS DO TIPO SCARA / A CONTROL LAW PROPOSITION TO SCARA MANIPULATOR ROBOTS**

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SCARA (Selectively Compliant Articulated Robot Arm) manipulators have many applications at the present, mainly in the industrial domain. Generally, for all manipulators it is necessary fast and well smoothed answers, with the minimum possible undesirable vibrations. However, due to non linear effects, mainly in friction form that exists in the actuators dynamic (motor gear in most cases), there are several difficulties to track trajectories with rapidity and precision. In this work we propose a control law projected to overcome these difficulties and to provide more quality in precision, stability, answer time and absence of undesirable vibrations, independently of the amplitude level in terms of commanded final positions.

Keywords: *Robot, modeling, actuator, friction, control. Robô, modelagem, atuador, atrito, controle.*

COB353 PSEUDO-ODOMETRY FOR LEGGED ROBOTS

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This paper discusses the problem of position and attitude determination for legged robots control architectures. The proposed approach is a geometric method providing a module equivalent to the odometry module found on wheeled mobile robots. This pseudo-odometry module is part of a walk supervisor architecture. The system is capable of fast adaptation to a wide variety of situations using rule-based reasoning to solve the problem of force distribution and react to walk events. The main modules of this architecture are briefly described and the pseudo-odometry method is detailed. Finally, we show a numerical example of position and attitude determination.

Keywords: *Legged robots, walking robots, odometry, autonomous robots, robot localization.*

COB354 DYNAMIC PERFORMANCE OF VARIABLE STRUCTURE HYBRID CONTROL OF MANIPULATORS

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this paper it is studied the implementation of a variable structure algorithm in the position/force hybrid control of robotic manipulators. The time and frequency responses of the system are calculated and its properties are studied. Moreover, the effect of the controller sampling frequency and the system stability are analysed through a linearization procedure.

Keywords: *Robotics, Manufacturing Systems, Intelligent Control, Variable Structure Systems, Force Control*

COB355 TRAJECTORY CONTROL OF REDUNDANT MANIPULATORS

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This paper presents the fundamental aspects of the theory of the generalized inverses matrices and explores their application on the control of redundant manipulators. Redundant manipulators have

some advantages when compared to classical arms because they allow a trajectory optimization, both on the free space and on the presence of obstacles, and the resolution of singularities. Nevertheless, for this type of manipulators the kinematic control adopts algorithms that use generalized inverses matrices. Consequently, the concepts associated with the control by generalized inverses are tested through several experiments that reveal the difficulties that often arise. In this perspective, it is studied the control of redundant and hyper-redundant manipulators namely through the analysis in points of singularity, showing that we may get non-optimal arm configurations.

Keywords: *Kinematics, Redundant Manipulators, Pseudoinverses, Robots, Singularities*

COB399 CINEMÁTICA E DINÂMICA DA PERNA DE UM ROBÔ HEXÁPODE / KINEMATICS AND DYNAMICS OF ONE LEG OF A SIX-LEGGED WALKING MACHINE

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The moving mechanisms of the mobile robot are classified into the wheel system, the crawler system, and the leg system, of which the leg system provides the widest range of movement. The evolution of legged vehicles has progressed significantly in recent years. These vehicles offer the potential of increased mobility for traversing rough terrain. This paper describes the kinematical and dynamical analysis of one leg of a six-legged locomotor. The architectures of this leg and its design is presented. The dynamical analysis is based in the method of Lagrange. The equations of motions are generated using the mathematical symbolic program MAPLE*.

Keywords: *robotics, walking machines, kinematics, dynamics, gait, mechanisms, legs, machine design*

COB400 MODELAGEM E CONTROLE DE UM ROBÔ HEXÁPODE / MODELING AND CONTROL OF A SIX-LEGGED WALKING MACHINE

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The evolution of legged vehicles has progressed significantly in recent years. These vehicles offer the potential of increased mobility for traversing rough terrain. This paper describes the kinematical analysis of a six-legged locomotor. The architectures of these legs and its design is presented. The kinematical analysis (direct and inverse kinematics) is made using the mathematical symbolic program MAPLE*.

Keywords: *robotics, walking machines, kinematics, dynamics, gait, mechanisms, legs, machine design / robótica, máquinas andantes, cinemática, dinâmica, modo de andar, mecanismos, pernas, projeto de máquinas.*

COB485 DESENVOLVIMENTO DE UM SISTEMA DE INFORMAÇÃO PARA PIPEFA / DEVELOPMENT OF AN INFORMATION SYSTEM FOR PIPEFA

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This paper presents concepts and tools for information system design of production planning and control system of an experimental platform. In the first phase of the methodology for the specification of database schema (requirements analysis), the CIMOSA model, that covers the function, information, resource and organizational aspects of an enterprise, is proposed. In the second phase (conceptual design), is proposed the EXPRESS language or PDN-Object model to specify the database schema.

Keywords: *Modelagem de sistema de informação, modelagem de empresas, CIMOSA, EXPRESS, PDN-Object / Information system modeling, enterprise modeling.*

COB486 FERRAMENTAS PARA CONCEPÇÃO DE SISTEMAS AUTOMATIZADOS UMA APLICAÇÃO À PLATAFORMA INDUSTRIAL PARA PESQUISA, ENSINO E FORMAÇÃO EM AUTOMAÇÃO (PIPEFA) / TOOLS FOR CONCEPTION OF THE AUTOMATION SYSTEMS AN APPLICATION IN AN AUTOMATION INDUSTRIAL PLATFORM

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This work will describe methodologies for integration of elements of the Automation System of Production. This ideas will be applied at several posts of the Industrial Platform to Research, Teaching and Formation (PIPEFA), implemented at UNICAMP into a project of scientific cooperation to the LIISI in France. The objective of the PIPEFA platform is development of methods and tools for automation of small and middle size industry.

Keywords: *Automação Industrial, Modeling, Modular Platform, PLC programming, GRAFCET.*

COB591 PROJETO AUTOMATIZADO DE MANIPULADORES MECÂNICOS FLEXÍVEIS / AUTOMATED DESIGN OF FLEXIBLE MANIPULATORS

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Industries have suffered with the high operational cost of old industrial robots which are heavy, slow and have low productivity. There is a compromise between weight and rigidity which is the key for the success in the use of industrial manipulators. The ratio of payload to robot weight used to be around 5% and nowadays robots are reaching 10% using lightweight structures. It is proposed a computer tool that based on CAD designs can dynamically simulate a robot manipulator of industrial complexity. The method used is to integrate motion equations using RBSM ("Rigid Body Spring Models") and finite differences. Geometric nonlinearities originated from the manipulator's mechanism are computed in a stable and economical manner. Stress levels and oscillatory motion can, therefore, be analysed and the robot's architecture is rebuilt in the CAD. Another module to be developed for this Flexible Robots CAD is the controller simulator where control actions and actuator dynamics are introduced and analysed by the designer.

Keywords: *Robô Flexível, Diferenças Finitas, Projeto Automatizado, Robô-CAE/ Flexible Robot, Finite Differences, Automated Design*

COB592 PARALLEL CONTROL OF A TWO-LINK FLEXIBLE ARM

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The need for lightweight, fast and accurate robots is evident. Increasing complexity is observed in the mechanisms of control and dynamic models with structural flexibility added. The nonlinear stiffness of the harmonic drive reducer poses very high frequencies that are difficult to control. Joint and link flexibility originate a complex algorithm that may simulate the arm, but cannot be used for control due to real-time control cycle limitations. Economical models can be obtained condensing degrees of freedom. Parallel processors are available which can process complex algorithms with good accuracy in short time. Transputers are used in a parallel controller, developed over an industrial robot platform. A new control strategy is proposed and referred to as Nonlinear Integrated Tabular control (NIT). It allows the calculation of robot tip position in real-time and also active control of oscillations. A test rig was built to confirm results obtained in the analytical simulation. It consists of a two-link elbow arm with flexible joints and a flexible forearm.

Keywords: *Flexible Robots, Elbow Arm, Nonlinear Control, Parallel Controller, Transputer./ Robôs Flexíveis, Braço Cotovelar, Controle Não-Linear, Controlador Paralelo, Transputer.*

COB612 SISTEMA MECATRÔNICO PARA SOLDAGEM MULTIPASSES MONITORADO POR VISÃO COMPUTADORIZADA / A VISION ASSISTED MECHATRONIC SYSTEM FOR ARC WELDING

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The industrial companies which use extensively the arc welding process seek to improve the productivity of the process through the use of automated systems which yield high quality and repeatability. When the welding process is made in a multipass fashion, used for instance, in high thickness plates, the performance requirements for the automated systems are even tighter. Some companies which can afford it, solve this problem with a robotic welding unit, constituted by one or more anthropomorphic robots with six degrees of freedom in general, indexing tables and the welding unit itself. Medium sizes companies however, do it with a lower cost mechanical solution which has a displacement unit that drives the welding torch at a constant speed through the plates to be welded. This solution puts a heavy load on the operator who is required to monitor constantly the welding process for welding pass tracking as well as for adjustments of some welding parameters, for instance, the height of the torch. As compared with these two possible approaches, this paper presents an alternative, mechatronic approach for the multipass arc welding process which adds the essential monitoring features to the latter, with a cost that is far less to the former.

Keywords: *Soldagem a Arco (Arc Welding) Visão por Computador (Computer Vision), Mecatrônica (Mechatronics), Automação da Manufatura (Manufacturing Automation).*

COB642 CARACTERÍSTICAS MECÂNICAS DE UM SISTEMA MÓVEL COM DESLOCAMENTO POR SALTOS / MECHANICAL CHARACTERISTICS OF A MOBILE SYSTEM WITH ADVANCEMENT BY BOUNCES

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This paper is a contribution to the study of a mode of locomotion allowing robots to displace on artificial or natural soils without loss of speed. In order that, a progression by bonds is suggested. The main two problems posed concern jump trajectory to go from a position to the following and the damping to platform reception on the ground.

Keywords: *FKeywords: Damping, jump, mobile robot, robô móvel, salto*

COB645 ANÁLISE DE VARIAÇÃO NA POSIÇÃO E ORIENTAÇÃO DA PLATAFORMA DE STEWART TIPO 3-3 EM FUNÇÃO DE ERROS NOS ATUADORES / 3-3 STEWART PLATFORM POSITION AND ORIENTATION VARIATION ANALYSIS FUNCTION OF ACTUATORS ERRORS

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In many manipulator tasks the accuracy in positioning of the end-effector is very important. The traditional serial manipulators do not have the required level of accuracy. An alternative is using the par-

allel structure. A well-known parallel structure is the 3-3 Stewart Platform. The question we pose is: given an error of the six spherical-prismatic-spherical segments, how is the position and orientation errors of the platform? We developed an algorithm that enable us to analyse the shape of the errors. The analysis has been carried out by considering a initial position and orientation of the platform, obtaining the nominal length of the SPS segments, using the inverse position kinematic problem. Imposing length errors from 0 to 20% to the SPS segments, the new position and orientation of the platform can be obtained using the direct position kinematic equations. Results of the shape of the errors are presented.

Keywords: *Estruturas robóticas, Manipulador paralelo, Plataforma de Stewart, Robôs de alta precisão / Robotic structures, Parallel manipulator, Stewart platform, Robot precision*

COB646 **MODELAGEM DE TRANSPORTADORES VIBRATÓRIOS LINEARES COM EXCITAÇÃO REAL / LINEAR VIBRATORY FEEDERS MODELING WITH REAL EXCITATION**

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Vibratory feeders are excellent for selecting and orienting parts with simple or complex shape. Its efficiency is traduced by the transport velocity of parts on its track, that mainly is function of the track slope, the friction between the parts and the track an the exciter (amplitude, frequency and excitation wave). This work presents the results of the theoretical conveying velocity of an industrial vibratory feeder, using a mathematical model that considers the four movement modes of the parts - backward sliding, forward sliding, flight and at rest - and the real characteristics of the parts, the track and the exciter. The theoretical and experimental mean conveying velocity are compared.

Keywords: *Vibratory Feeders, Automation, Handling, Handling Materials / Transportadores Vibratórios, Automação, Manipulação, Manipulação de Materiais*

COB818 **DETERMINAÇÃO DO NÚMERO DE GRAUS DE LIBERDADE DA ESTRUTURA CARTESIANA TOTALMENTE PARALELA / NUMBER OF DEGREES OF FREEDOM DETERMINATION FOR A FULLY PARALLEL CARTESIAN STRUCTURE**

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In spite of being widely used, serial robotic structures still present problems due to their own constitution. One alternative to using serial structures is the application of so-called parallel structures made of kinematic closed loops. In the study of parallel structures, determination of number of degrees of freedom is of paramount importance since this number determines the amount of independent parameters

needed to define the spacial configuration of the structure. These parameters are used to formulate the equations of the kinematics model. This work presents three methods to obtain the number of degrees of freedom for a Fully Parallel Cartesian Structure. One of the methods allows classification of the type of parallel structure.

Keywords: *Parallel Manipulator, Degrees of Freedom, Robotics, Spacial Structures - Manipulador Paralelo, Graus de Liberdade, Robótica, Estruturas Espaciais.*

COB979 ANÁLISE E DESENVOLVIMENTO EXPERIMENTAL DE UM ACIONAMENTO EM MICROPASSO / ANALISYS AND EXPERIMENTAL DEVELOPMENT OF A MICROSTEPPING DRIVER

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The present paper reports the development of an inexpensive and reliable microstepping driver to be used with 2-phase step motors. Increased resolution on positioning and low vibration level are the main advantages obtained in motor operation. The paper presents a discussion on the subject and first hand experimental results.

Keywords: *Step motors, Drivers, Microstepping*

COB1168 ROBOT RSA2

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This work is being made within the BID-CONICET project called "Modeling, simulation and control of manufacturing flexible cells". It consists of the design and construction of a five degrees of freedom anthropomorphic robot. Among the main features, the manipulator has a trajectory control. The movements of each axes are independent, with CC motors for the first three axes and stepper motors for the last ones. The movement control is obtained from kinematics and dynamic analysis and trajectory generation routines. The control is implemented with a PC and a digital interface based on microcontrollers. The design of this digital interface has been made in order to be able to control some auxiliary devices (e.g., material handling systems), which can interact together with the robot. This interface allows to control a more than five axes robot. The mechanic design has been implemented with Autocad (in 2 and 3 dimensions). The manufacturing as made with CNC machines and using a CAD-CAM software. The high-level control and simulation software, which runs on a PC, implements a Virtual Reality environment.

Keywords: *Robótica - CAD-CAM - Control - Diseño - Desarrollo*

TEMA 95 - Elementos de Máquinas

COB453 CARREGAMENTO DINÂMICO DE MANCAIS RADIAIS COM CAVITAÇÃO DO FILME DE ÓLEO / DYNAMIC LOADING OF JOURNAL BEARINGS WITH OIL FILM CAVITATION

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Hydrodynamic lubrication of journal bearing is governed by the Reynolds equation. The main difficulty in using Reynolds equation resides in the precise determination of the edge or the angular position after which the oil cavitates and starts to flow into a series of streamers. One of the objectives of the present work is to revise and compare some of the numerical algorithms encountered in the open literature to deal with the cavitation phenomena. Emphasis is also placed on selection of the coordinates system used to analyze the problem. Usually the hydrodynamic lubrication problems have been studied based on Reynolds equation referred to a rotating coordinates system where one of the coordinates is coincident with the centerline of the journal bearing. Here, the integration of Reynolds equation is performed with respect to an inertial coordinates system, and this is a novelty. The numerical results were obtained from both static and dynamic loading under conservative and non conservative boundary condition applied to the cavitation front. The Reynolds equation in fixed coordinates system performed well, and the Elrod Algorithm proved to be the most effective method for dynamic loading calculations.

Keywords: *Cavitation in bearings, lubrication, dynamic loading, Reynolds equation in fixed coordinates system. Cavitação, lubrificação, carregamento dinâmico, equação de Reynolds em sistema de coordenadas fixo*

COB477 APLICAÇÃO DE FERRAMENTAS COMPUTACIONAIS NO DESENVOLVIMENTO DE PROGRAMAS DIDÁTICOS PARA PROJETO DE EIXOS/ APLICATION OF COMPUTATIONAL METHODS TO THE DEVELOPMENT OF DIDACTIC PROGRAMS FOR SHAFT DESIGN

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The main purpose of this work is to modernize the project of rotating machinery, by the development of a computational code including the calculation procedures adopted in the design of these components, considering, however, its dynamical behaviour as a fundamental part of a rotating machine.

Keywords: *Funções de Singularidade, Concentração de Tensões, Resistência à Fadiga, Projeto de Eixos, Deflexões, Velocidades Críticas. / Singularity Functions, Stress Concentration, Fatigue Resistance, Shaft Design, Deflection, Critical Speeds*

COB1209 MANCAL RADIAL DE DESLIZAMENTO: DETERMINAÇÃO DE RAMOS DE SOLUÇÕES PERIÓDICAS E PONTOS DE BIFURCAÇÃO COMPLEXOS/RADIAL JOURNAL BEARING: PERIODIC BRANCHING AND HOPF BIFURCATION POINTS DETERMINATION

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In the mechanical engineering moving system's field the radial journal bearing is one of the great interest. It consists of a circular inner cylinder (the rotor) that turns inside a hollow cylinder of slightly larger radius (the stator). The cavity between the cylinders is filled with a lubricant and any load carried by the rotor must be supported by the fluid forces exerted by the lubricant on the rotor. The system can be described by a set of four first order's nonlinear ordinary differential equations which the fluid forces are approximate solution of partial differential equations and shows a great richness of behavior same at the simplest case of cavitation model, autonomous, unforced and balanced-mass rotor system. Rigorous geometrical constraints are impose on the moving of the rotor's center about stator's center to avoid the contact between them. Otherwise, the contact could well result in bearing failure. Starting from the Reynolds approximation for the long bearing the paper uses numerical methods for bifurcation problems to calculate Hopf bifurcation points and numerical methods of continuation to obtain branching of periodic orbits that emanate from stationary solutions. The paper also shows the amplitude and frequency of periodic solutions as a function of rotor's angular velocity for the low, medium and high loads.

Keywords: *Numerical methods; Hopf bifurcation; radial journal bearing; mancal radial hidrodinâmico; bifurcação*

TEMA 96 - Tribologia

COB266 O COMPORTAMENTO VISCO-ELÁSTICO DOS FLUIDOS LUBRIFICANTES NA ZONA DE VEDAÇÃO DE RETENTORES / THE VISCOELASTIC BEHAVIOUR OF LUBRICANT FLUIDS AT SEALING ZONE OF RADIAL LIP SEALS

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The existing models that explain the lubricating and sealing mechanisms of radial lip seals consider behaviour of the fluid at sealing zone. Experimental results showed that the fluid supports very high shear rates ($>10^5 \text{ s}^{-1}$). At these conditions that fluid may deviate from newtonian behaviour and elastic properties might appear in the fluid. The non newtonian behaviour can explain why a lubricant film remains in the sealing zone of radial lip seals without leakage. This work presents a new hypothesis including a mathematical description in order to explain the lubricating and sealing mechanisms of radial lip seals.

Keywords: Radial Lip Seal, Non-Newtonian Fluid, Fluid Film Thickness, Pumping Mechanism Retentor, Fluido Não-Newtoniano, Espessura de Filme, Mecanismo de Bombeamento

COB267 SEALING ZONE CONDITIONS OF RADIAL LIP SEALS CONSIDERING THE VISCOELASTIC PROPERTIES OF LUBRICATING FLUIDS

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The proceedings in the sealing zone between a lip seal and shaft surface are still not thoroughly understood. Due to the small fluid film thickness (micrometer range), the high temperatures (up to 200°C), the shear stress (MPa range) and the shear rate ($> 10^6 \text{ s}^{-1}$) it is difficult to achieve accurate measurements. A recently developed model takes the non-newtonian fluid behavior into account in order to describe the existence of a fluid film in the sealing zone. The radial pressure of the seal is compensated by the viscoelastic properties of the fluid and no deviation from parallel of the surfaces in micro and macro range is mandatory for this model. The measurement of rheological data of lubricating fluids at high shear rates is difficult and reliable data is hardly accessible. Therefore the data of higher viscous polymer melt and solution experiments is taken to model the viscoelastic behavior of lower viscous lubricating fluids. This simulation shows for various working conditions the influence of the fluid properties upon fluid film thickness, torque and pumping action of radial lip seals.

Keywords: Radial Lip Seal, Non-Newtonian Fluid, Pumping Mechanism, Fluid Film Thickness

COB342 NUMERICAL INVESTIGATION OF LAMINAR FLOW IN A FLAT WAVY CHANNEL**Jin Hu and Hans J. Leutheusser***Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, Ontario, Canada*

A numerical approach is described which was developed to analyze experimental findings of flow passing between a sinusoidally wavy and a flat wall. The experimental data were obtained in a two dimensional wind tunnel, specially designed to simulate lubricant flow in a hydrodynamic bearing when the thickness of the fluid film approaches the order of magnitude of the size of the surface roughness. As such, the present investigation provides new insights into the physics of fluid film tribology.

Keywords: *Finite Element Method; Laminar Flow; Lubrication; Roughness; Reynolds Equation.*

TEMA 97 - Otimização de Sistemas e Processos

COB134 INDÚSTRIA ARTESANAL DE RECICLAGEM DE ANODOS DE SACRIFÍCIO DE ZINCO / THE HANDMADE RECYCLED THE SACRIFICE ANODES OF ZINC.

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In the Amazon region the boats that do the fishing in offshore use sacrifice zinc anodes as cathode protection of their metallic hull against the electrochemical corrosion process, that is a common way of corrosion in waters of Equatorial Atlantic. Because of the necessity of the maintenance of these boats the local small industries began to produce sacrifice zinc anodes but it was observed that they didn't have good work against the corrosion mechanism. This paper considers the production process of these anodes showing the most important operational parameters involved. The results show us that the recycle handmade industry doesn't have a quality and quantitative control having as result the production of inert anodes which are not fitted to the desired protection. For this research were collected some types of samples made by these industries. The chemical composition of all anodes was analyzed and finally it was made a comparative study of their micro and macrostructure.

Keywords: *Anodo, Sacrifício, Zinco, Reciclagem, Corrosão*

COB215 UM MODELO QUANTITATIVO PARA RECONHECIMENTO DE PADRÕES EM SISTEMAS DINÂMICOS / A QUANTITATIVE MODEL FOR PATTERN RECOGNITION IN DYNAMIC SYSTEMS

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This paper describes a model to analyze relevant properties of dynamic systems. The variations that the system shows during its use has been considered by the model. It identifies actions to correct and avoid the variations. The actions must be taken in the production process (system control). The model uses a quantitative evaluation (unusual in this kind of analysis). Several modules compose the model. Some of them are described in this paper as well as their results. It allows to understand the contribution of the model to the problem solution.

Keywords: *Dynamic systems, system control, quality evaluation, pattern recognition, quality assurance. Sistemas dinâmicos, controle de sistemas, avaliação da qualidade, reconhecimento de padrões, garantida da qualidade*

COB310 BAYESIAN INFERENCE FOR PLANT DATA RECONCILIATION SYSTEMS

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In the present work, a new method based on the Statistical Bayesian Inference and the Maximum Likelihood Principle is developed to analyse a set of measurements data in the presence of gross errors. It permits a rapid localisation, identification and correction of source of extremals using as criterion of optimization the satisfaction of energy and material equations. The new method allows to overcome the practical limitations of previous works which attempted to deal with the problem. The proposed strategy proceeds in three levels. Statistical criteria are used to check whether the set of measurements contain gross errors. A bayesian inference technique and the maximum likelihood principles are used to quantify and localize the gross errors. A new set of reconciliated plant measurements is calculated for estimation and optimization purposes.

Keywords: *Data adjustment, gross errors, statistical inference, thermofluid systems. Tratamento de dados, erros grosseiros, inferência estatística, sistemas termofluidos.*

COB425 REDES DE PETRI AUTO MODIFICÁVEIS PARA SISTEMAS DE MANUFATURA CONSIDERANDO FALHAS E PROCEDIMENTOS DE MANUTENÇÃO / SELF-MODIFYING PETRI NET FOR MANUFACTURING SYSTEMS CONSIDERING FAILURES AND MAINTENANCE PROCESSES.

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Automated systems has been more and more complex and large scaled with the technological development. Examples of such systems are flexible manufacturing systems, computers/communication networks, etc. They have motivated the study from the point of view of discrete event dynamic systems, in which the state changes only at discrete points in time in response to the occurrence of specific events. The Petri net is a powerful approach for modeling and analyzing these systems which are characterized as being concurrent, asynchronous, distributed, etc. However, unexpected events and conditions are very complex to be included in the ordinary Petri nets representation of automated systems. Therefore, this paper introduces an extension of Petri net called Self-modifying Petri net as a tool for the design, analysis and control of flexible manufacturing systems, which considers failures, maintenance processes and operation mistakes.

Keywords: *Sistemas de manufatura, sistemas dinâmicos a eventos discretos, redes de Petri, redes auto-modificáveis, recuperação de falhas e erros. / Manufacturing systems, discrete event dynamic systems, Petri net, self-modifying net, failure and error recovery.*

COB474 ANALISE DA APLICAÇÃO DE METODOLOGIA DE PROJETO NO DESENVOLVIMENTO DE NOVOS PRODUTOS/ANALYSIS OF PROJECTS METHODOLOGYS APLICATION FOR NEWS PRODUCTS DEVELOPMENT

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The transition from the industrial to the knowledge era, is performing social and economic deep changes for the industrial comportment. These changes in all the internal and external factors out the environment deeply affected the products economics and qualitative sufficiency. During the preliminary project, is more turning the testes of necessity of these aspects. These necessity is involving the Manufacturing Systems, the statment of industrial comportment as well the Social, Economic and Financial aspect. Several metodologies are looking at the functional and optimal outputs, but seldom are looking the mentioned aspects and the relative factors for the products development. Still less are worried of the Reactive or Proactive Statments and of the Designer's Human Resources. With the purpose to establish the metodological bases for the future computational development, this work analise the conditioning factors of the creative process , through one of the holistic views of social-industrial universe.

Keywords: *Projeto Mecânico, Economia, Manufatura, Desenvolvimento de produtos ótimos / Mechanical Design, Economy Manufatura, Optimal, Products Development.*

COB489 OTIMIZAÇÃO DO POSICIONAMENTO DE ATUADORES PIEZO-CERÂMICOS EM ESTRUTURAS FLEXÍVEIS USANDO UM ALGORITMO GENÉTICO

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In this work, a method to determine the optimal location of active elements in structures using a genetic algorithm technique involving discrete variables is presented. A finite element formulation is used for modeling the dynamics of the structure for both passive and active elements, and an optimization algorithm minimizes the dissipation energy with an optimal control designed using the LQR theory. The optimal location of active members is treated in terms of (0,1) variables. Numerical results obtained for a simply supported beam with two piezoceramic actuators are presented to illustrate the actuator placement optimization method. The obtained results show that the genetic algorithm can be successfully applied to combinatorial optimization problems such as the actuator placement problem in scope.

Keywords: *Posicionamento de Atuadores, Atuadores Piezocerâmicos, Algoritmos Genéticos.*

COB555 ALGORITMOS GENÉTICOS E SUAS POSSIBILIDADES DE APLICAÇÕES EM ENGENHARIA MECÂNICA/GENETIC ALGORITHMS AND ITS APLICATIONS IN MECHANICAL ENGINEERING

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Genetic algorithm(GA) is a potential tool for the resolution of combinatorial problems with the advantages of simplicity, flexibility and robustness in the solution. There are some drawbacks in this

kind of algorithms, mainly because a GA algorithm is usually tailor-made for most of the application problems. This paper describes some possibilities of application for genetic algorithms in the field of engineering activity as production planning, assembly line balancing, layout design, cell formation, production scheduling and shows a specific application for determination of the maximum profit velocity in a lathe operation

Keywords: *Genetic algorithm, engineering, optimization, combinatorials problems/ Algoritmo genético, engenharia, otimização, problemas combinatoriais.*

COB614 PROPOSAL OF A FRAMEWORK FOR EFFICIENT MANAGEMENT OF THE ENGINEERING CHANGE (EC) PROCESS

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Due to the never ending improvement product development process required by the market, the Engineering Change (EC) process is also a never ending process with huge impact in the product cycle time. Modifications to a project may be necessary not only for product improvements but also for many other reasons, such as error corrections, further product information needed during the manufacturing stages, cost reduction policy adopted by the company, and changes to reflect modifications in the market. Analysing these causes, it is clear that proper management of the EC process requires involvement of many departments within the company, therefore, a well structured approach is needed to achieve it. The adoption of the Simultaneous Engineering approach supported by the Cross - Functional Team philosophy establishes an environment where the EC process may develop successfully. This paper aims at presenting a framework where the main factors impacting the EC process are established and the relationships between and among them are analysed. Moreover, the support given to the EC management process by an organisational structure where all of the departments inside the organisation share the responsibility of updating, using and communicating product data is shown as one of the essential elements for company's success

Keywords: *Engineering Change, Change management, Product Development Process.*

COB615 DESENVOLVIMENTO DE UMA CÉLULA FLEXÍVEL DE MANUFATURA PARA FABRICAÇÃO DE QUADROS DE BICICLETA /DEVELOPMENT OF A FLEXIBLE MANUFACTURING CELL FOR MANUFACTURING BICYCLE FRAMES

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This paper shows preliminary development of a Flexible Manufacturing Cell (FMC) for welding bicycle frames. This work presents the main units of the FMC and required procedures for welding the frame joints. The process is improved by using the ABB IRB 2000 six-degree of freedom

robot, for welding the tubes. This innovation provides a better productivity and repeatability for the whole process.

Keywords: *1-System Optimisation and Process, 2-Automation and Robotic, 3-Welding, 4-Flexible Manufacturing Cell / 1-Otimização de Sistemas e Processos, 2-Automação e Robótica, 3-Soldagem, 4-Célula Flexível de Manufatura*

COB621 REPRESENTAÇÃO DE PROCESSOS ATRAVÉS DE NÍVEIS HIERÁRQUICOS/PROCESS REPRESENTATION BY HIERARCHICAL LEVELS

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The processes planning automation has been considered, but still not achieved, as a necessary condition to integrated design and manufacture activities. The main reason for this drawback is found out in the enormous and not structured body of knowledge related to every process. In this paper we purpose a methodology to structure this knowledge and, therefore, we explain how the information flow can be directed through this structure. This proposal is based on structural dependence, operational dependence and operational flexibility concepts which will be formalized here. These concepts will be helpful in order to determine the hierarchy of designed levels and reduce the planning complexity but without losing the interaction among process variables. This interaction will be possible thanks to the constraints propagation among all levels. For every level it's possible to create an Expert Module which can perform in a nearly-independent way. The constraint propagation among Modules will characterise a multidirectional and opportunistic information flow. This methodology has been implemented successfully. A practical result was an Expert Module used to select machining conditions.

Keywords: *Planejamento de Processos, Sistemas Especialistas, Usinagem / Process Planning, Expert Systems, Machining.*

COB623 SEQUENCIAMENTO DE OPERAÇÕES EM AMBIENTE DE FABRICAÇÃO DESCONTÍNUA

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The job shop scheduling problem consists of determining a sequence of jobs to be processed on each of the available machines such the schedule time is minimized. The parts are processed in accordance with a prespecified technological ordering and the required processing times of the operations pertaining to each job are known. In this paper we study the job shop scheduling problem in two ways, namely, integer programming and graph theory. A computational program based on graph theory was

developed and tested. This program allows us to solve efficiently several examples, despite the non-polynomial nature of the problem studied.

Keywords: *Job Shop, Optimization, Scheduling, Integer Programming, Graph theory*

COB773 OPTIMIZATION OF A NATURAL GAS DISTRIBUTION SYSTEM

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Optimization problems which contain large embedded network structure arise in a wide range of practical applications. Specialized algorithms that capitalize on the graph structure can be developed to solve efficiently these problems. In this paper is described a study of the natural gas distribution system in the São Paulo region. The model developed for optimizing the operation system was structured as a nonlinear programming problem on network with nonlinear side constraints. The network can be represented by a graph whose nodes and arcs correspond to the consumers-points/city-gates and pipes, respectively. The objective is minimizing the pressures in the city-gates satisfying sets of continuity and flow constraints. For solving this problem exploiting the graph structure of the continuity equations it can be used the Lagrangian Relaxation method. An efficient code based on this method has been developed. Results and conclusions about the model developed for optimizing the operation system are reported.

Keywords: *Natural Gas Distribution System, Nonlinear Network with Side Constraints, Lagrangian Relaxation Method, Subgradient Method*

COB801 OTIMIZAÇÃO DE COLUNA EM CONCRETO COM RESTRIÇÕES DINÂMICAS

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We present the Augmented Lagrangian in optimization of dynamic problems. This method solves a sequence of unconstrained optimization. A program in language C is developed and the method is applied to a dynamic problem. The cost of a concrete column is minimized and human comfort related to vibration perception is verified. The mathematical model is viscoelastic.

Keywords: *Análise dinâmica, minimização de custo e conforto.*

COB807 METODOLOGIA PARA DETERMINAÇÃO DE CURVAS E CONSTANTES CARACTERÍSTICAS TÍPICAS EM ACIONAMENTOS ELETROMECÂNICOS ROTATIVOS FRACIONÁRIOS / METHODOLO-

*GY FOR DETERMINING THE TYPICAL CHARACTERISTIC CURVES AND
CONSTANTS IN ELECTROMECHANICAL ROTATIVE FRACTIONARY DRIVES*

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This paper presents the development and realization of a test system that allows the evaluation of the whole variety of fractional power motor-drives with their stages of electro-electronics, coupling different kinds of mechanical loads like friction, inertia, combined forms and of a wide range of values, besides coupling the suitable sensors to measure torque, rotation, position, etc., in order to get information on their static and mainly on the dynamic behavior, for the appropriate design and application of this drives. This test system consists of a test bench with a number of mechanical modules, measurement and control instrumentation and also includes a computer for data acquisition and automatic operation.

Keywords: *Acionamentos eletromecânicos fracionários, instrumentação, testes e medidas automáticas, freio a pó magnetizável, análises de sistemas dinâmicos / Fractional electromechanical drives, instrumentation, automatic test and measurement, magnetizable powder brake, systems dynamics analysis*

COB808 DESENVOLVIMENTO DE UM POSICIONADOR SUBMICROMÉTRICO EMPREGANDO TÉCNICAS DE CONTROLE / DEVELOPMENT OF A SUB-MICROMETRIC POSITIONER APPLYING CONTROL TECHNIQUES

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This paper concerns about the optimization of the static and dynamic behavior of a sub-micrometric positioner through the implementation of positioning control techniques. The objective is to discuss control strategies which enable position and repeatability errors in a sub-micrometric range and transient response as fast as possible without overshoot. It is necessary to keep this behavior stable when changes occur (feed rate, friction, etc.) in the sub-micrometric positioner's operating conditions. The prototype assembly consists of an air bearing slide, with 400 mm of travel, and the motion is provided by a brushless DC linear motor. The position feedback is provided by an opto-electronic scale with 0.1 μm of resolution or by an interferometric LASER with 1.54 nm of resolution, and a DSP-CNC board hosted in a personal computer processes the position feedback through a control algorithm, whose behavior is such that it try to make the actual position of the motor to match the commanded position. The results obtained with the application of the PI-D+feedforward control and the gain scheduling adaptive techniques are presented in this paper. Using the scale, the results show a peak positioning error smaller than 1 μm and an average error less than 0,5 μm when the gain scheduling adaptive techniques is applied. Using the interferometric LASER, the peak positioning error is 0.27 μm and the average error is smaller than 30 nm.

Keywords: *Posicionador Sub-micrométrico, LASER Interferométrico, Escala Opto-eletrônica, Guias aerostáticas, Controle PI-D+feedforward, Escalonamento de Ganhos, Sub-micrometric Positioner, Interferometric LASER, Optoelectronic scale, PI-D+Feedforward Control, Gain Scheduling*

COB838 AIRPLANE CONCEPTUAL DESIGN IMPROVEMENT AIMING PERFORMANCE OPTIMIZATION

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The objective of this work is to describe a method developed to determine an optimized set of aircraft design parameters with respect to a performance criterion. The conceptual design phase is essentially handmade and the quality of the resultant aircraft configuration strongly depends on the experience of the design group. In order to develop an optimization procedure which minimizes a combination of performance parameters, models for estimating the airplane drag and performance have been selected and implemented. The performance criteria adopted in this work are based on the estimated time and fuel spent to fly a typical mission profile. The 2 degrees of freedom performance models of climb, cruise and descent are used to evaluate the mission block fuel and block time. An empirical model calculates the takeoff field length taken as an optimization constraint. To obtain an accurate prediction of the airplane drag, a comprehensive model has been selected and implemented due to its capability of handling changes in geometric and aerodynamic data. For the optimization procedure, the following wing parameters have been selected as decision variables: area, aspect ratio, taper ratio, thickness to chord ratio and sweepback angle. Engine and flap parameters have been also considered as design variables. The main results presented in this paper are sensitivity analyses and comparisons among final optimal configurations obtained using different criteria.

Keywords: *Optimization; Airplane performance; Aerodynamic Drag;*

COB872 SISTEMA COMPUTACIONAL PARA O CÁLCULO DE PARÂMETROS DE DESEMPENHO NA ACELERAÇÃO DE VEÍCULOS COMERCIAIS / COMPUTATIONAL SYSTEM FOR THE CALCULATION OF PERFORMANCE PARAMETERS IN THE ACCELERATION OF COMMERCIAL VEHICLES

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The aim of this paper is to present a computational system for analyses of performance of the commercial vehicle. The accelerating performance of a road commercial vehicle is an item which shows the vehicle quality for both, manufacturer and customer. The work contains a database and an interface design for commercial vehicles. This computational system has been evaluated based on the values of experimental tests.

Keywords: *Sistema computacional, banco de dados, simulação, veículos rodoviários comerciais / Computational system, database, simulation, road commercial vehicles*

COB902 OTIMIZAÇÃO APLICADA À CONFIGURAÇÃO E OPERAÇÃO DE SISTEMAS DE COGERAÇÃO / SYNTHESIS AND OPERATION OPTIMIZATION OF COGENERATION SYSTEMS**Flávio Neves Teixeira, André Ramon Silva Martins & Luiz Augusto Horta Nogueira***Instituto de Engenharia Mecânica, Escola Federal de Engenharia de Itajubá - EFEI**CEP 37.500-000, Itajubá, Minas Gerais, Brasil - E-mail: horta@iem.efei.rmg.br*

A methodology to specify and operate optimally cogeneration plants is presented, aiming to lower the cost for energy production, attending electric power, heating and cooling demands. The general configuration adopted for the cogeneration system includes prime mover, heat recovery steam generator, process boiler, conventional and absorption cooling systems and electricity supply from utility. The equipment capacities and operational policy for the cogeneration plant are determined simultaneously in order to minimise the pay back time. It is presented the modelling of thermal (low and high temperature) and electric loads, taking into account constant demand in 8 periods of time over the year and according the periods used by utilities to price energy. It is developed the modelling of prime movers, using lineal approach to simulate the dependence performance and useful heat availability on the load factor, allowing to consider real commercial equipment. A case study is solved for a shopping center, in order to demonstrate the validity of the proposed method.

Keywords: *Cogeneration, Optimisation of Thermal Systems, Gas Turbines, Alternatives Engines Cogeração, Otimização de Sistemas Térmicos, Turbinas a Gás, Motores Alternativos*

COB922 MONITORAMENTO DE INFORMAÇÃO TECNOLÓGICA SOBRE MATERIAIS PARA PASTILHAS DE FREIO/ MONITORING OF TECHNOLOGICAL INFORMATION ON MATERIALS FOR BRAKE LINING PAD**Leandro Innocentini Lopes de Faria⁽¹⁾, José Angelo Rodrigues Gregolin⁽¹⁾ & Raimundo Nonato Macedo dos Santos⁽²⁾***(1)Departamento de Engenharia de Materiais - Universidade Federal de São Carlos - Rod. Washington Luís, Km 235, C.P. 676.**CEP 13565-905, São Carlos - SP - e-mail: leandro@nit.ufscar.br e gregolin@nit.ufscar.br**(2)CITEC - Instituto de Pesquisas Tecnológicas do Estado de São Paulo - IPT - Av. Almeida Prado, Cidade Universitária, C.P. 7141.**CEP 01064-970, São Paulo - SP - e-mail: raimund@ipt.br*

In this work, it has been developed an information treating procedure to support the decision making in materials selection, that allows the constant knowledge update of available materials, processes and technologies, enhancing the innovation. This procedure involves the subject contextualization by using the International Patent Classification, the recovering of informations available in several electronic databases, its integration in an single database, and the apresentation of table, graphic and text form results, obtained by automatic information treating. The procedure allows the identification of study themes, researches, companies, research institutions and materials, related to a focused product. To illustrate the developed procedure utilization, it has been carried out a study about the product "brake lining pad". It has been identified the main alternatives for the solution of two important problems related to this product: the "elimination of asbestos-containing materials" and the "study of brake system originated noise and vibration".

Keywords: *Seleção de Materiais; Pastilha de Freio; Informação Tecnológica; Bases de Dados Eletrônicas; Classificação Internacional de Patentes. / Materials Selection; Brake Lining Pad; Technological Information; Electronic Data Bases; International Patent Classification.*

COB937 IMPLEMENTAÇÃO DE REQUISITOS QS-9000 EM UM AMBIENTE INTEGRADO DE ENGENHARIA / QS-9000 REQUIREMENTS IMPLEMENTATION IN AN INTEGRATED MANUFACTURING ENVIRONMENT

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The economic globalization and growing competitiveness bring great challenges to the Mercosul economy. As an answer to these challenges, the companies implement new technologies and philosophies to become world class manufacturing companies. QS-9000 certification has as goals the guarantee of continuous improvement, defect preventions and reduction of variation and waste, establishing a new relationship between Original Equipment Manufacturer (OEM) and suppliers. The Model Integrated Factory (FIM) is an implementation environment in which occurs the assesment of methodologies and proposal solutions. Working with Business Processes-BP representation, the Integrated Engeneering Group actually works with the BP Product Development. The objective of this article is to show how this BP was adequated at the QS-9000 requirements, a must at the automotive sector nowadays.

Keywords: *QS-9000, product development, reference model, desenvolvimento de produtos*

COB941 SELEÇÃO DE SISTEMAS COMPUTACIONAIS COM BASE EM MODELOS DE PROCESSO / SELECTION OF SYSTEMS BASED ON BUSINESS PROCESS

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The proposal of this work is to present a procedure to help enterprises in the selection process of information systems really adequate to supply their needs for information. The selection procedure presented is included within an integration methodology, enabling the selection process to start from the knowledge of the enterprise's current situation and allowing its information needs to be extracted from a reference model, to be defined from the modeling of the enterprise. The systematics is subdivided in eight phases wich include the training of the personal to be involved in the selection process, definition of the main requirements (functional, technical and commercial) to be satisfied by the systems available in the market, besides the method used to formalize such requirements, in search for the final choice among the analyzed systems.

Keywords: *System Selection, Integration, CAD, CAPP, Seleção de Sistemas, Integração, CAD, CAPP*

COB943 GERENCIAMENTO DE DADOS DE PRODUTO EM AMBIENTE DE ENGENHARIA SIMULTÂNEA / PRODUCT DATA MANAGEMENT AT CONCURENT ENGENIEERING ENVIRENEMENT

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The economic globalization and growing competitiveness bring great challenges to the Mercosul economy. As an answer to these challenges, the companies implement new technologies and philosophies to become world class manufacturing companies. QS-9000 certification has as goals the guarantee of continuous improvement, defect preventions and reduction of variation and waste, establishing a new relationship between Original Equipment Manufacturer (OEM) and suppliers. The Model Integrated Factory (FIM) is an implementation environment in which occurs the assesment of metodologies and proposal solutions. Working with Business Processes-BP representation, the Integrated Engineering Group actually works with the BP Product Development. The objective of this article is to show how this BP was adequated at the QS-9000 requirements, a must at the automotive sector nowadays.

Keywords: *PDM, Implementation Methodology, Customization, Workflow.*

COB944 DEFINIÇÃO DE REQUISITOS PARA A IMPLANTAÇÃO DE SISTEMAS PDM EM AMBIENTES DE ENGENHARIA SIMULTÂNEA / REQUIREMENTS DEFINITION FOR PDM SYSTEMS IMPLANTATION IN CONCURRENT ENGINEERING ENVIRONMENTS

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Concurrent Engineering is a technology used in the new product's process development, however, there are problems derived from the use of this tool, for example, the large amount of information generated. Besides that, it is necessary that this data is always available to people who need it. The PDM (Product Data Management) Systems has been implemented to make the data available, however, in the past, its potential wasn't fully realized. The objectives of this project are to define essential requirements to successfully implement the PDM Systems in different kinds of enterprises, based on the Concurrent Engineering. Thus, the characteristics and potentialities of PDM are being analyzed, such as project revision management, product structure management, programming and workflow. And, the requirements to the system's implementation are discussed, like the identification of enterprise characteristics, the format of the documents that will be managed, the users and their access level, and the data workflow.

Keywords: *PDM; product development; data management; Concurrent Engineering / PDM, desenvolvimento de produtos, gerenciamento de dados, Engenharia Simultânea*

COB945 **MODELO DE REFERÊNCIA PARA O BUSINESS PROCESS DE DESENVOLVIMENTO DE NOVOS PRODUTOS / REFERENCE MODEL FOR THE NEW PRODUCT DEVELOPMENT BUSINESS PROCESS**

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Product development is one of the most important activity concerning to the enterprise competitiveness in a changing global market, where the product life cycle is always shorter. Simultaneous Engineering has been adopted by many world class enterprises. The real results of its application are beyond to the expected ones due the limited vision of the conventional Simultaneous Engineering. This vision must be enhanced through an holistic view of the business. The business mapping using a business process (BP) reference model allows us getting this holistic view. After an introduction to BP mapping is presented a BP reference model "Product Development". Its first level is then discussed. The strategies, activities, information, resources (methods, techniques, software,...) and organization (structure, knowledge, teams) are presented and after that the new role of the engineering area is discussed.

Keywords: *New Products Development, Reference Model, Simultaneous Engineering, Desenvolvimento de Novos Produtos, Modelo de Referência, Engenharia Simultânea.*

COB1198 **CONCEPÇÃO ÓTIMA DE SISTEMAS MECÂNICOS: DECOMPOSIÇÃO E COORDENAÇÃO / OPTIMAL DESIGN OF MECHANICAL SYSTEMS: DECOMPOSITION AND COORDINATION**

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Optimal design of mechanical engineering systems has known a great development during the last years. In fact, design problems become larger due to the important number of design variables and constraints, so researches are turned to processes of decomposition in the area of mechanical design. The results of these researches permit to define two types of decomposition: hierarchical and non-hierarchical.

Non-hierarchical decomposition based optimization, especially when compared to the hierarchical one, has the advantage that no restriction is imposed on how the decomposed subsystems should interact with one another. However, the difficulty inherent in non-hierarchical decomposition is how to coordinate together subproblems in order to achieve a global optimum.

In this paper, a general method of decomposition and a process of coordination is presented. The principal interest of this method is to decompose all problems of optimal design and to solve the subsystems by iterating on linking variables until the optimum is achieved. To illustrate the application of this interesting method an exemple is treated.

Keywords: *Optimization, design, decomposition, coordination, iterative.*

COB1268 DESARROLLO DE UN HIERRO NODULAR BAINÍTICO PARA FABRICAR PIEZAS DE EQUIPOS DE LA CONSTRUCCIÓN./ BAINITIC DUCTILE IRON FOR CONSTRUCTION MACHINES PARTS

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The aim of this work is the development of a fabrication technology for 1.0% copper alloyed bainitic ductile iron. The alloy is intended for using it in automotive, construction, agriculture and other related industries, where low alloyed carbon steel spare parts are imported at very high prices in hard currency. The principal task to be carried out was the selection of an optimum heat treating technology; that means; austenization and austempering parameters. Metallurgical quality of the alloy after the heat treatment was assessed by means of different tests including mechanical properties, optical and SEM microscopy and X rays diffraction and microanalysis. Strain hardening of the alloy was evaluated through a compression test. Austenization at 880 o C during two hours and austempering at 380 o C also during two hours were the selected parameters for heat treating of several spur gears and pneumatic hammers handles that are now being evaluated.

Keywords: *hierro nodular bainítico, fabricación, tratamiento térmico / bainitic ductile iron, fabrication, heat treatment*

COB1462 UM MÉTODO DE ANÁLISE TERMEOCONÔMICA PARA OTIMIZAÇÃO DE UM SISTEMA DE COGERAÇÃO / A THERMOECONOMIC ANALYSIS METHOD FOR A COGENERATION SYSTEM OPTIMIZATION

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This article presents an exergoeconomic analysis of a cogeneration plant, applied as a rational technique to produce electric power and saturated steam. The aim of this new methodology is the minimum manufacturing exergy cost, based on the Second Law of Thermodynamics. The decision variables selected for the optimization are the pressure and the temperature of the steam leaving the boiler, because they affect significantly the energy and the economic performance of the cogeneration system. The equations for calculating the capital costs of the components are formulated as a function of these decision variables. An application of the method using real data of a multinational chemical industry located in São Paulo State is presented. The cogeneration system is intended to be integrated in a process plant whose energy demands are 6000 kW of electricity and 5.834 kg/s of saturated steam at 1.5, 0.6 and 0.25 Mpa. The conditions which establish the minimum cost are presented as final conclusions.

Keywords: *Termoeconomia, Segunda Lei da Termodinâmica, Exergia, Cogeração, Otimização, Thermoeconomic, Second Law of Thermodynamics, Exergy, Cogeneration, Optimization.*

TEMA 101 - Ensino de Engenharia Mecânica

COB226 MÉTODO KELLER EN MECÁNICA BÁSICA Y DE TECNOLOGÍA DE MECÁNICA INDUSTRIAL

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The traditional system in college education, specifically in Mechanical Engineering, is not appropriate to deal with the ever increasing amount of knowledge. In this regard, and as an alternative, the Keller Methods can be considered as an innovation to the education system, based on independent learning; due to the fact that until now changes in higher education have been applied to a course in Basic Mechanics in an Industrial Mechanics Associate Degree Program at the Universidad Tecnológica de Panamá, Centro Regional de Veraguas. This paper discusses about its implementation, and after two years of application, a comparative study on the academic performance of the students that were under the Keller Method and those under the traditional method is made; taking as a reference those courses with requirements for registration.

Keywords: *Higher education, Independent learning, Academic Methodology, Methods of learning, Academic performance*

COB303 ANÁLISE DE REDES DE TUBULAÇÃO: DESENVOLVIMENTO DE INSTALAÇÃO EXPERIMENTAL E MODELAGEM MATEMÁTICA / ANALYSIS OF PIPELINE NETWORKS: DEVELOPMENT OF EXPERIMENT AND MATHEMATICAL MODELING

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An experiment on Fluid Mechanics for educational purposes regarding pipeline flows and pump association is designed. Also, a mathematical model for steady-state, isothermal flow of an incompressible fluid is developed. The model is especially suitable for extensive pipeline networks. The solution method for the system comprised of non-linear algebraic equations is based on the quasi-linearization technique. Simulation results are discussed.

Keywords: *fluid mechanics, pipeline networks, educational experiment, pipeline modeling, quasi-linearization / mecânica dos fluidos, redes de tubulação, experimento didático, modelagem de redes de tubos, quasi-linearização*

COB407 SISTEMAS ESPECIALISTAS - ESPECIFICAÇÃO DE CORRENTES DE ROLOS / EXPERT SYSTEMS - SELECTION OF ROLLER CHAINS

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Our intention was to help the mechanical engineering designer in the specification of machine components and diminish the time expended on machine design, we succeeded in elaborating an expert computational system for the evaluation and selection of Roller Chains. The algorithm was based on recommendations and specifications found in the IBAF chain manufacturer catalog.

Keywords: *Palavras chaves: Correntes de Rolos, Sistemas Especialistas, Elementos de Máquinas, Projeto de Máquinas/Roller Chains, Expert Systems, Machine Elements, Machine Design.*

COB408 O ENSINO DA CIÊNCIA E ENGENHARIA DE MATERIAIS NOS CURSOS DE GRADUAÇÃO EM ENGENHARIA MECÂNICA / THE TEACHING OF MATERIALS SCIENCE AND ENGINEERING IN THE MECHANICAL ENGINEERING COURSES

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Engineering for Mechanical Engineering courses. Some trends of the Materials Engineering area are pointed out, focusing aspects like basic programs, compatibility between theoretical and practical approaches, as well as integration of laboratory experiences and lectures. Some experiences of the authors in teaching Materials Science and Engineering are briefly discussed.

Keywords: *Materials Science Teaching, Mechanical Engineering Curricula - Ensino de Ciência dos Materiais, Currículo de Engenharia Mecânica*

COB424 AMBIENTE INTEGRADO PARA TREINAMENTO EM CONTROLE DE SISTEMAS DINÂMICOS A EVENTOS DISCRETOS / INTEGRATED ENVIRONMENT FOR TRAINING ON CONTROL OF DISCRETE EVENT DYNAMIC SYSTEMS

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In academic environment, generally, dynamic systems are approached from the point of view of continuous variable dynamic systems (CVDS). Only in very special cases, the other class of dynamic systems, i.e., discrete event dynamic systems (DEDS) are considered. However, most of the large-scaled and complex man-made systems requires control systems based on the concept of DEDS. One of the problem is the lack of an effective tool for assimilation of fundamental concepts involved in DEDS. Without a practical experience it is very difficult to understand the idea of "events", "conditions", "control object", "control realization device", etc. The existing didactic simulators and systems with programmable controllers are very limited to this goal because of their particularities. These

tools do not consider a methodology for design of whole control systems neither a general technique to describe the control strategies. Therefore, we introduce an Integrated Environment for teaching and training of control systems for DEDS. The case of a manufacturing cell is used to exemplify the task of validation of control strategies developed in a systematic approach based on Production Flow Schema/Mark Flow Graph (PFS/MFG) technique.

Keywords: *Discrete event dynamic systems, control system design, computer aided training system, PFS/MFG Methodology / Sistemas dinâmicos a eventos discretos, projeto de sistemas de controle, ferramentas para treinamento auxiliado por computador, metodologia MFG/PFS.*

COB446 USO DA SIMULAÇÃO NO ENSINO DE ENGENHARIA / USE OF SIMULATION FOR ENGINEERING TEACHING

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The economic globalization brings a dramatic increase in the competition among companies. It emerges then the necessity to search higher competitive levels with the remodelling of the productive systems (with the substitution of obsolete equipment and acquisition of more labour qualification). These two factors are deeply correlated since new equipment is more complex, and handles a larger number of variables, demanding then, more qualified labour. This required qualification of labour demands news methods of teaching and training to extend the escape of traditional methods, and simulation arises as a powerful tool for this goal. It allows the knowledge transmission in a richer and more interactive manner than expositive methods, with reduced cost when compared with real systems. It also prevents people and equipment from being exposed to some risks that normally are present at learning stage. This works aims at standing out the possibilities of improvement of the teaching process in engineering within academic and industrial environment using of simulation resources. Also comments on some cases where the simulation is used with success to teaching and training are made and, finally, a prognostic with the trends in development of simulators systems is presented.

Keywords: *Simulação, Ensino e Treinamento, Sistemas Especialistas, Realidade Virtual. Simulation, Teaching and Training, Expert Systems, Virtual Reality*

COB462 METODOLOGIA PARA ANÁLISE DA DINÂMICA NÃO-LINEAR DE SISTEMAS DE MÚLTIPLOS CORPOS - APLICAÇÃO A SATÉLITES / METHODOLOGY FOR ANALYSING THE DYNAMICS OF NONLINEAR MULTIBODY SYSTEMS - APPLICATIONS TO SATELLITES

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This work gives a practical contribution to the Dynamics of Nonlinear Multibody Systems. A methodology based on Dynamics' principles and axioms formulated by Newton-Euler-Jourdain and

computer animation techniques are presented with application to Satellite Dynamics. The main goal of combining animation techniques and dynamical simulation is to become easier understanding nonlinear motions and trajectories. Numerical results are presented in this paper in two different ways: graphically, illustrating the trajectories describes by the center of each satellite's face and by computer animations. Such animation are able to illustrate the creation of the mentioned trajectories. For qualitative experimental verifications of the nonlinear dynamics of satellites with internal rotors, a prototype is designed. It is mounted on a special support which allows three consecutive rotations (Kardan's angles). By means of this support it is possible to simulate physically the satellite's attitude in a point of its stable orbit. This methodology based on dynamical modelling, numerical simulations techniques and prototype designing results in a very efficient tool for engineering education.

Keywords: *Methodology/metodologia, multibody dynamics/dinâmica de múltiplos corpos, nonlinear systems/sistemas não lineares, satellite/satélite, computer animation/animação gráfica.*

COB470 O ENSINO DE METODOLOGIAS DE PROJETOS PARA ALUNOS DE GRADUAÇÃO / TEACHING DESIGN METHODOLOGY TO UNDERGRADUATED STUDENTS

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This paper describes the work done to improve the formation of Unicamp's Mechanical Engineer. The development over three years has proved that a mechanical design course can provide to students a global vision of courses administrated during their formation. It was made a evaluation of requirements of a mechanical design discipline to undergraduate students.

Keywords: *Engineering Teach, Engineer Formation, Design Methodology / Ensino de Engenharia, Educação do Engenheiro, Metodologias de Projeto*

COB653 IMPLEMENTAÇÃO DE UMA SERVOVÁLVULA E UM TÚNEL DE VENTO PARA ANÁLISE DE CONTROLE EM LABORATÓRIO/ IMPLEMENTATION OF A SERVO-VALVE AND A WIND TUNNEL TO LABORATORY CONTROL ANALYSIS

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This paper analyzes and discusses the implementation of a servo-valve and a wind tunnel process in experiments with conventional control like PI, PID and self tuning controllers in order to study practical aspects of control theory. A comparative study of the applicability of each controller was carried out analyzing their dynamics and non-linear characteristics.

Keywords: *Laboratory education, conventional control, digital control, estimation parameters, self-tuning control, process equipment. / Ensino em laboratório, controle convencional, controle digital, estimação de parâmetros, controle auto-ajustável, equipamento de laboratório.*

COB845 A UTILIZAÇÃO DA REALIDADE VIRTUAL NA ENGENHARIA MECÂNICA / THE UTILIZATION OF VIRTUAL REALITY IN MECHANICAL ENGINEERING

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The virtual reality is an advanced interface technique, in which the user can immerse, navigate and interact in a synthetic tridimensional computer generated environment. Through virtual reality software, it is able to shape mechanical apparatus, vehicles and devices, simulating the real behavior of the equipment. This diminishes costs and development cycles and allows training sessions with the virtual product. The virtual reality aids the CAD development system; the designer can interact, manipulate and validate his workpiece with the facilities provided by these tools. Following the idea of modelling and simulation, the new trend of simulators points at interactive and intelligent systems, in which will be widely used the virtual reality technique, allowing the user not only to interact with the system's components during his "virtual function", but to immerse in the model giving more realism to the system and allowing a richer exploration of it. The virtual reality can also be applied on undergraduate courses helping in lectures on utilization of last generation machine tools, which are expensive and large and are not usually available at the universities.

Keywords: *Virtual Reality, Simulation, Modelling, Virtual Manufacturing and Virtual Reality Software/Realidade Virtual, Simulação, Modelamento, Manufatura Virtual e Softwares de Realidade Virtual*

COB867 RESISTÊNCIA DOS MATERIAIS, O NASCIMENTO DE UMA DISCIPLINA / STRENGTH OF MATERIALS, THE BIRTH OF A DISCIPLINE

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In this paper the bases of the Strength of Materials are discussed. To this aim, the epistemological foundations of this science are analyzed, especially in Da Vinci's and Galilei's works, when an understanding of the discipline's constitution is attempted. Its birth is associated with an intensified relationship between theory and practice, sustained by laboratory-made idealizations of structural elements. These idealizations, by its turn, would be engaged with the very frame of the engineer's profession. Engineering is understood as a body of ideas, compromised with paradigms which orient the actions of its practitioners.

Keywords: *Strength of Materials; History of engineering; Epistemology / Resistência dos Materiais; História da engenharia; Epistemologia.*

COB869 OBSERVAÇÃO E INTERPRETAÇÃO EM METALOGRAFIA / OBSERVATION AND INTERPRETATION IN METALLOGRAPHY

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In this work the argument that observation and interpretation in the technical area could be uncoupled, conceptually and in fact, is contested. The inter-relationships between these two actions are discussed, in order to question the researcher's supposed neutrality in face of his work. Some metallographic and optical illusion images are analyzed in order to exemplify the impossibility of this disengagement. The theoretical reference adopted includes the metallography specialist as belonging to a professional group aligned with steering paradigms of theoretical and practical procedures.

Keywords: *Metallography; Professional behaviour; Paradigms; Observation-interpretation / Metalografia; Comportamento profissional; Paradigmas; Observação-interpretação.*

COB870 SOBRE A FORMAÇÃO DE PROFESSORES DE ENGENHARIA / ABOUT THE FORMATION OF ENGINEERING TEACHERS

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The purpose of this paper is to discuss the formation process of engineering teachers, pointing out some solutions for a problem that is becoming serious in this field. In the essay we assume that the present situation of engineering teaching in Brazil is demanding a look towards quality enhancement. The understanding that the possession of technical knowledge of a profession is a sufficient premise to transform a legally graduated individual in a teacher is criticized. A formation process of engineering teachers for the technical field which tries to conciliate needed technical-professional qualifications with didactic-pedagogical ones is proposed.

Keywords: *Engineering teaching; Formation of teacher; Didactic. / Ensino de engenharia; Formação de professores; Didática;*

COB942 CAPACITAÇÃO DE PESSOAL PARA O PROCESSO DE DESENVOLVIMENTO DE PRODUTOS/ PERSONNEL QUALIFICATION FOR PRODUCT DEVELOPMENT PROCESS

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Nowadays the formation of people for working with product development must be one of the main concerns of the enterprises. This is necessary to get the benefits of the application of Concurrent Engineering techniques and new computer tools and surpass the challenges of a changing global market, where product cycle is always shorter. This article presents a new profile for the professional working in product development and a new education method that has been introduced at Model Integrated Factory (FIM). This new education method emphasizes the use of active didactics techniques in order to get the formation of people for working with product development.

Keywords: *Education Methods, Product Development, Teamwork, Concurrent Engineering / Métodos Educacionais, Desenvolvimento de Produtos, Trabalho em Equipe, Engenharia Simultânea*

COB968 A SISTEMÁTICA DE AVALIAÇÃO NO ENSINO DE PROJETO DE MÁQUINAS / EVALUATION PROCEDURES IN MACHINE DESIGN TEACHING**Nicola Getschko**

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This paper discuss some important aspects related to Machine Design disciplines evaluations. Former evaluation methods and statements are compared with some new hypothesis and concepts. In order to make a case study, a brief description of the disciplines PMC 201 - Introduction to Machine Design and PMC 205 - Construction Machine Elements I of the Mechanical Eng. Dept of the Polytechnic School - University of Sao Paulo , is presented. The evaluation systems analysis is made by means of a statistical approach, based on four year data. The results confirm the main suggested hypothesis.

Keywords: *machine design, evaluation, mechanical engineering, education, statistics / projeto de máquinas, avaliação, engenharia mecânica, educação, estatística.*

COB1005 LEVANTAMENTO DA CURVA DE PRESSÃO DE VAPOR DA ÁGUA – EXPERIMENTO DIDÁTICO / VAPOR-PRESSURE CURVE DETERMINATION**Vicente de P. Nicolau, William A. Lehmkuhl & José A. Bellini da Cunha Neto**

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This paper describes a quite simple experimental set-up which can be used on undergraduate studies in thermodynamics. It deals with vapor-liquid phase equilibrium. The substance used is water, placed in a hermetic container. This system can be heated to 100°C and cooled to 20°C. Acquiring temperature and pressure values during the cooling process, the vapor-pressure curve can be plotted and compared with published data in the area.

Keywords: *Pressão de vapor, curva de saturação, equipamento didático, termodinâmica, saturation curve.*

COB1176 SIDAM - UM SISTEMA INTELIGENTE PARA DIAGNÓSTICO DE AVARIAS EM MOTORES**António José Ferreira da Silva & Fernando José Ferreira**

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SIDAM is an Integrated Computer System which includes an Expert System for diagnosis of malfunction engines. SIDAM is under development at Instituto Superior de Engenharia do Porto in

cooperation with Salvador Caetano (Portuguese Toyota). The project aim is two fold. It may be used in an industrial environment for diagnosis of malfunction engines and can also be use for didactic purposes in a mechanical engineering laboratory. The system contains a Knowledge Base with information about periodical maintenance and an historical database with the previous cases solved by the system. The data base of solved previous cases is used to collect statistics that guide future diagnosis. It is also possible to simulate the more typical set of electrical and mechanical malfunctions that affect the engines. It is known that any system in this domain has to deal with many different kinds of knowledge and information sources and use different types of inference processes. Artificial Intelligence techniques like Production Rules, Frames, probabilistic and mathematical models are among different knowledge representation formalisms which have been used to encode the domain knowledge. At the moment, project SIDAM is in the testing stage of development.

Keywords: *Technology Education, Interactive video, Engine Repair System, Expert System.*

COB1383 O ENSINO DA ENGENHARIA MECÂNICA FACE AOS PROCESSOS DE GLOBALIZAÇÃO / THE TECHING OF MECHANICAL ENGINEERING FACE THE GLOBALIZATION PROCESS

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The globalization process induces the necessity of a review in the process and methodology used in every area of human activities. It is urgent a review analysis of all the concepts and methodology in the technology domain with emphasis in the area of specialized human resources; in this area the methodology used in the preparation of engineers deserves a special attention. This paper points to some aspects of fundamental importance such as: the necessity of a multidisciplinary approach in the engineering schools, the necessity of the development of the ability to model engineering problems, the necessity of a scientific versus a technological information oriented approach, etc.

Keywords: *Globalization, modelling process, transfer of technology.*

COB1422 MEDIÇÃO DE EMISSIVIDADE E DE TEMPERATURA SEM CONTATO - EXPERIMENTO DIDÁTICO / EMISSIVITY AND NON-CONTACT TEMPERATURE MEASUREMENT

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This paper describes a quite simple experimental set-up which can be used on undergraduate or graduate studies on thermal radiation heat transfer. It deals with non-contact temperature and emissivity measurements at low temperature (ambient to 400 °C) in the infrared range.

Keywords: *Emissividade, temperatura sem contato, equipamento didático, radiação térmica/ emissivity, thermal radiation.*

TEMA 111 - Bioengenharia

COB49 TURBULENCE AND HEMOLYSIS. THE ROLE OF THE SMALLEST EDDIES

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Last decades have witnessed efforts on the development of methods capable of predicting red blood cell (RBC) damage in artificial organs. However, all of them have had limited success to predict hemolysis. The primary cause of this problem is that such models do not take into consideration structures of turbulent flow. It has been observed a correlation between the size of the smallest eddies occurring in the turbulent flow and its hemolytic potential. The aim of the present paper is to describe a new methodology to evaluate mechanical red blood cell damage in turbulent flow. The correlation between the size of the smallest eddies occurring in the flow and its hemolytic potential were checked by using data from the literature of different well-documented situations involving turbulent blood flow. Hemolytic and non-hemolytic conditions were successfully identified by employing the new methodology.

Keywords: *Turbulent Flow, Red Blood Cell Damage, Kolmogorov Microscales*

COB60 FLOW VISUALIZATION OF HEART VALVES PROSTHESES IN A STEADY FLOW MODEL

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Although prosthetic heart valves have been used successfully for many years, an ideal prostheses has not been developed yet. Since the major part of heart valve prostheses related complications are due to flow disturbances, valve hydrodynamic characterization is an useful aid in designing new prostheses. In the present report, flow visualization in steady state flow model has been employed to study flow disturbances occurring downstream two types of bioprosthesis (porcine and bovine pericardium) tested in the mitral position. Flow visualization is an important tool for prosthetic valves evaluation using simple and low cost facilities.

Keywords: *Flow visualization; dye injection; cardiac bioprosthesis; heart valves testing; steady flow; visualização de escoamento; injeção de corante líquido; biopróteses cardíacas; teste de válvulas cardíacas; escoamento não-pulsátil.*

COB123 DUREZA DAS RESINAS ODONTOLÓGICAS E QUANTIDADE DE RADICAIS DETERMINADAS POR ESR / HARDNESS OF DENTAL COMPOSITES AND AMOUNT OF RADICALS DETERMINED BY ESR**Walter Sano & Cristina Barkevui Mekitarianian de Mello***Departamento de Física Aplicada, Instituto de Física - USP - 05315-970 São Paulo, SP Brasil E-mail: sano@if.usp.br*

Light-curing composite resins even being today one of the most used in restorative dental works its photo-polymerization process had not been completely explained. The type containing Bis-GMA and inorganic charge of zircon and silica was studied after its activation by a conventional visible light unit. Electron Spin Resonance (ESR) spectra were obtained along one month, commencing immediately after the activation and then recording periodically, so obtaining the decay over time of the relative number of the free radicals. A post-curing evidence was observed in agreement with Watts et al., 1987 who have been reported the evolution of the hardness number over time of similar materials. Analyzing the decay of the ESR intensity after the light activation, it is concluded that the resin cure process is due to the remaining radicals. Firstly half of them is converted in 1.2 days, in agreement with the results of the hardness number which starts from 45% and in one day attains 90% of the maximum value. Latterly they decay more slowly, with half-life of 12.6 days, also in agreement with the hardness number which reaches 96% in one week and tends to 100% in one month.

Keywords: *dureza, resina odontológica, resina composta, radical livre, ressonância de spin eletrônico / hardness, dental composite, free radical, ESR*

COB175 DINÂMICA DA INTERAÇÃO ENTRE O SISTEMA IMUNOLÓGICO E O VÍRUS HIV DYNAMICS OF THE INTERACTION BETWEEN IMMUNE SYSTEM AND HIV**Tiago Rodrigo Alves de Souza***Departamento de Engenharia Mecânica, Universidade de Brasília. 70.910.900, Brasília, DF - E-Mail: tiagor@guarany.cpd.unb.br***Marcelo Amorim Savi***Departamento de Engenharia Mecânica e de Materiais, Instituto Militar de Engenharia 22.290.270, Rio de Janeiro, RJ - E-Mail: d4savi@epq.ime.eb.br*

The immune system is a complex network of organs containing cells that provides the means to make rapid, highly specific, and in general very protective responses against different pathogens. The acquired immunodeficiency syndrome (AIDS) occurs as a consequence of HIV action on organisms. The virus enters the bloodstream and destroys certain white blood cells, called T lymphocytes, that play a key role in the functioning of the immune system. AIDS impairs the immune system and leaves the victim susceptible to various opportunistic infections. This contribution evaluates the dynamical interaction between immune system and HIV described by the model proposed by Holton & May (1993). Initially, a discussion about immune system, HIV and AIDS is done. Then, the mathematical model is presented. Some numerical simulations are considered.

Keywords: *Non-linear Dynamics, HIV/AIDS Dynamics, Biomechanics. / Dinâmica Não-Linear, Dinâmica HIV/AIDS, Biomecânica.*

COB177 MODELOS CONSTITUTIVOS VISCOELÁSTICOS PARA O PULMÃO: CASO UNIDIMENSIONAL *VISCOELASTIC CONSTITUTIVE MODELS FOR THE LUNG: ONE DIMENSIONAL CASE*

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The simulation of vital phenomena may contribute either to define best conditions for living beings or to determine pathological treatments. These simulations need models which are capable to describe the behavior of biological systems. The simulation of respiratory system may contribute to evaluate some physiologic details of this system. Usually, constitutive models used to describe mechanical behavior of the lung is a combination of models to describe the biological tissue behavior associated with models to describe the surface tension stress effect in the alveolar walls. This work presents an overview of constitutive models for soft tissues and suggests viscoelastic models to describe the complete response of the lung. Polynomial and exponential models are considered to describe the elastic behavior of biological tissue. Some viscoelastic models are presented and discussed. One-dimensional results illustrate with qualitative coherence the stress-strain curves prescribed by these models.

Keywords: *Constitutive Equations, Mechanics of Lungs, Biomechanics. Equações Constitutivas, Mecânica do Pulmão, Biomecânica.*

COB199 MODELADO DE LA COLUMNA VERTEBRAL PARA PATOLOGIA LUMBAR

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This essay is part of an integral spinal analysis (lumbar area) applying the finite element methodology. The software used in Patología lumbar, is NISA DISPLAY III. The objective is understand the spinal behavior and be able to redesign the pedicle screw fit which fail when certain weight condition is apply.

Keywords: *Elemento finito, Modelado, Análisis, Columna vertebral, Análisis Plano.*

COB783 ANUMERICAL MODEL FOR LASER -INDUCED SHOCK-WAVES

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A direct computer simulation technique is developed to analyse quantitatively the influence of the fluid flow and heat transfer in the transient development of a laser induced shock-waves in air. The fluid dynamics of the shock waves propagation generated by the laser emission have been mathematically modeled for 1D spherical geometry case. The TVD (Total Variation Diminishing) method for the numerical simulation is used to solve the complex problem and a versatile numerical code has been developed. The novelty of this work is to treat the shock waves propagation by a numerical procedure instead of using the conventional point source explosion theory. Comparison of the simulated results indicates the good accuracy of the numerical procedure against those predicted by the point-source explosion theory. In this work is presented a numerical simulation study involved in photomechanical processes associated with laser ablation and fragmentation induced by excimer laser radiation. The shock wave evaluation during photofragmentation of hard tissue as kidney stone is modeled under the view point of surrounding air fluid flow and heat transfer.

Keywords: *Shock waves, TVD scheme, laser-induced shock, biological tissue.*

COB784 A MODEL OF THE EQUATION OF STATE FOR DYNAMICS SHOCK WAVE SINBIOLOGICAL TISSUE TYPE

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The aim of the present study is to define a equation of state for a condensed material of biological tissue type and formulate by numerical means the shock wave propagation in this medium. Theoretical studies are conducted into the basic ideas discussed by Zel'dovich and Raizer on shock waves in solids in order to derive the equation of state for biological material. The knowledge about the shock wave properties of tissue in the domain of medical science has been accumulated and investigated recently. This has been conducted because the rules of such phenomenon related with ablation and cavitation bubbles in the damage mechanism of biological tissue are not well understood.

Keywords: *Shock waves, equations of state, numerical scheme, biological tissue.*

COB853 AVALIAÇÃO DA TRANSFERÊNCIA DE OXIGÊNIO EM OXIGENADORES DE SANGUE UTILIZANDO ÁGUA NO LUGAR DO SANGUE / OXYGEN TRANSFER EVALUATION OF BLOOD OXYGENATORS WITH WATER

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In vitro assays with bovine blood are a current practice in blood oxygenators (artificial lung) development. The aim of this work is to show that it is possible to use water in those tests instead of blood and obtain a correlation that can be used to predict blood-gas oxygen mass transfer rate. Water tests have the advantage to avoid logistic problems regarding blood supply. Four commercial blood oxygenators were firstly tested with water at the following condition: flow = 6 l/min., temperature = 37°C, and inlet

pO₂ equal to 30 mmHg. Oxygen 21 % was vented in a 1:1 blood-gas flow relationship. Each oxygenator was secondly tested with bovine fresh blood at a flow of 6 l/min., and 100 % oxygen at 1:1 blood-gas flow relationship. Blood parameters were set according to the AAMI conditions. Oxygen mass transfer effectiveness coefficients (Ef) were calculated. Statistical analysis shows linear correlation with $r^2=0,927$ and $Ef_{\text{blood}} = 1,95 * Ef_{\text{water}} - 1,02$.

Keywords: *Blood oxygenation, membrane oxygenation, cardiopulmonary bypass/ Oxigenadores de sangue, oxigenadores de membrana, circulação extra-corpórea.*

COB1103 DISTRIBUIÇÃO DE PRESSÃO NA VOLUTA DE UMA BOMBA CENTRÍFUGA UTILIZADA EM BYPASS CARDIOPULMONAR COM OXIGENADOR DE MEMBRANA/VOLUTE PRESSURE DISTRIBUTIONS OF A CENTRIFUGAL PUMP WHEN USED IN CARDIOPULMONARY BYPASS WITH EXTRACORPOREAL MEMBRANE OXYGENATION

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Vanless centrifugal blood pump such as Bio-pump has been designed to be used as a ventricular assist device (VAD). Due to the positive results, specially the reported low blood damage, its use has been extend to cardiopulmonary bypass (CPB). Under an engineering point of view, CPB requires a higher operational pressure level due to the use of a membrane oxygenator and arterial filters in the blood circuit. Despite of the successful results in VAD or CPB applications some deficiencies were reported. The long term use in VAD, without pump replacement, is not recommended due to possibility of seal leakage between casing and pump base. Also, for CPB applications has been reported blood damage levels comparable to the ones when roller pumps are employed. In both cases one may associate these phenomena to a non-uniform pressure distribution along the pump volute. This work addresses to the measurements of the pressure distribution along the pump volute with an in vitro analog circuit of CPB. The working fluid was water and the measured pressure drop, flow rate and rotational speed were converted to the values correspondent to the measurements done with a blood analogue fluid by using of the similarity principle.

Keywords: *Centrifugal Pump; Blood Pump; Vanless Pump; Volute; Pressure Measurements*

COB1131 A THERMOREGULATORY MODEL OF THE HUMAN BODY: EXPOSURE TO HOT ENVIRONMENT

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A transient mathematical model for the human heat transfer system has been developed. It is based on a single cylinder, representing the body, with concentric annular layers: core, muscle, fat and skin. It includes metabolic heat generation, conduction of heat in tissue, convection of heat by flowing blood, heat transfer by radiation, convection and evaporation at the surface and loss of heat through the

respiratory tract. The control system has two inputs: the mean temperatures from skin and core. Output variables are: the skin blood flow (vasomotor response) and the sweat rate (sudomotor response). The model can be used to simulate body's response to a rise in ambient temperature beyond initial value or to a sudden exposure to solar radiation. The results were compared to data in the literature and showed good agreement. The model with some modifications can be used in thermal comfort applications.

Keywords: *Temperature regulation, thermoregulation, mathematical model, thermal comfort / Regulação da temperatura, termorregulação, modelos matemáticos, conforto térmico.*

COB1264 DETERMINAÇÃO EXPERIMENTAL DO MÓDULO DE ELASTICIDADE DA TÍBIA HUMANA ATRAVÉS DO DMTA

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In this study of the mechanical properties of bones, focused on human tibiae, it was obtained the axial dynamic Young's modulus. A large number of specimens from several locations and at different orientations were harvested from one fresh human tibia. The axial dynamic Young modulus was obtained directly from the Dynamic Mechanical Thermal Analysis (DMTA). Such tests are commonly used in polymers, and were performed isothermally at 36,5°C using three frequencies: 0,1 Hz, 1,0 Hz and 10,0 Hz.

Keywords: *Bioengenharia, Ossos, Tibia Humana, Ensaio Dinâmico, DMTA, Módulo de Elasticidade.*

COB1265 ANÁLISE DINÂMICA EM TÍBIA HUMANA: SIMULAÇÕES E TESTES EXPERIMENTAIS

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A study on the theoretical and experimental determination of the mode shapes and natural frequencies of dry treated and wet fresh human tibiae is presented. Dynamic simulations are performed using the Finite Element Method. The experimental modal tests are performed using the hammer impact setup, well known in mechanical engineering applications. The four first frequencies and corresponding mode shapes were obtained. The results are compared and the differences are discussed.

Keywords: *Bioengenharia, Ossos, Elementos Finitos, Análise Modal.*

COB1269 MECHANICS OF FACIAL AGING

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This paper presents a model for face aging, that uses a warping technique to emulate the aging changes. The implemented process considers the age features of selected parts of a face such as the face outline and the shape of the lips. These age features were obtained by measuring the facial regions of women that have been photographed throughout their lives. We propose a new method to define the aging parameters based on mechanics analysis and than graphically represents the age effects.

Keywords: *Facial aging, mechanics of aging, warping, biomechanic / envelhecimento facial, biomecânica, mecânica do envelhecimento.*

COB1323 A 4-DIMENSIONAL MODEL OF THE HUMAN HEART

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The development of a four-dimensional solid modeling system is described. The applied technique provides three-dimensional visualization and animation of the human heart during its activated phase (the cardiac cycle). The modeling procedure is based on medical data-images generated by a magnetic resonance (MR) scanner. The visualization of the moving heart is based on a new approach for modeling dynamic free form objects which is particularly suitable for animation. The animation procedure is done by a volumetric morphing technique described as topological merging.

Keywords: *Heart Modelling, 4-Dimensional Modelling, Animation, Visualization, Dynamic Modelling.*

COB1334 ENVELHECIMENTO FACIAL POR GRAVIDADE / THE ACTION OF GRAVITY ON FACIAL AGING

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From the photos of the American astronaut Shannon Lucid, it could be observed that she looked much younger without the gravitational field acting on the muscles of her face. Facial aging is a biological phenomenon but the facial movement of the skin during aging is also due to mechanics. The present research is a first step in identifying the mechanical forces responsible for facial deformation owing to time. With the use of a Nonlinear Finite Elements formulation in a facial mask with the mechanical properties of the skin, it was possible to discuss the effects of gravity in the mechanics of facial aging. A strong correlation between the effects of gravity and the behavior of the aging parameters of our recent work was found.

Keywords: *Envelhecimento, Biomembranas, Elemento Finito. / Aging, Biomembranes, Finite Elements.*

**COB1397 IMPLANTES METÁLICOS RECOBERTOS COM HIDROXIAPATITA
/ COATINGS OF THE HYDROXYAPATITE ON THE IMPLANTS METALS**

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Materials in current use as implants can be classified as bioinert, biotolerable, and bioactive depending on the nature of their interaction with the living tissues. Among the several materials employed in implantology metals deserve special attention because of their high mechanical strength. However, metals are biotolerable materials being not able to bind to bone. On the other hand, bioactive materials can form strong chemical bond with bone but fail under high mechanical loads. Hydroxyapatite is the main component of the bone mineral. It has been extensively studied as a bone graft material and its excellent bioactivity and osteoconductivity have been clearly established. However, hydroxyapatite grafting is only advisable in situations of low or only compressive loads because of its weakness. Numerous efforts have been made to combine the strength of metals and the biological properties of hydroxyapatite via coating procedures. Methods such as ion sputtering, plasma spray, sol-gel, electrolysis, and biomimetic procedures have been used.

In this work the authors present the above mentioned coating techniques and comment on their advantages and disadvantages. They also revise briefly the existing reports on hydroxyapatite coating on metals by the different methods.

Keywords: *Hydroxyapatite, Coating, Bioceramics, Calcium phosphate, Recobrimento, Hidroxiapatita, Biocerâmicas, Fosfato de cálcio*

**COB1415 DESENVOLVIMENTO DE UM TORQUÍMETRO DE PRECISÃO PARA
O ESTUDO DO DESEMPENHO DE IMPLANTES OSSEOINTEGRADOS
/ VELOPMENT OF A TORQUE GAUGE OF HIGH PRECISION TO THE
STUDY OF THE PERFORMANCE ON IMPANTS OSSEOINTEGRATION**

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**** , João Roberto Gonçalves *** & Darcey Zanetta Barbosa ******

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This work show the development about a torque gauge of high precision to improvement of odontological research on osseointegration of dental implant. The results are exame from practical analysis on obtained with the developed tool instrument.

Keywords: *Torque gauge of high precision, odontological research, osseointegration of dental implant.*

COB1416 DESENVOLVIMENTO DE UMA METODOLOGIA PARA A AVALIAÇÃO DO DESGASTE ABRASIVO DE RESINAS COMPOSTAS / DEVELOPMENT OF A METODOLOGY TO AVALIATION OF THE ABRASIVE WEAR OF COMPOSITE RESIN

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This work intends to show a new method where there is a test stand watched by a computer. It can evaluate the wearing (in a quantity form) of the composite resin used in dentistic restoration

Keywords: *Desgaste de resinas dentárias, tribologia de resinas compostas, mecanismo de remoção de material*

COB1470 ESTAÇÃO PARA AVALIAÇÃO IN VITRO DE OXIGENADORES E PERMUTADORES DE CALOR / STATION OF "IN VITRO" TESTS FOR OXYGENATORS AND HEAT EXCHANGERS.

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Divisão de Pesquisas e Publicações - Departamentos de P&D em Mecânica e Eletrônica da Braile Biomédica.

In spite of the great number of extracorporeal procedures performed in Brazil, a few places can evaluate the basic function parameters of gas exchangers (oxygenators) and heat exchangers. This paper describes the project, construction and utilization of a station of "in vitro" tests to be able to evaluate the oxygen transfer, heat transfer and pressure drop. It is composed by on line blood gas monitor, peristaltic pumps with control and indication of blood flow, gas blender, manometers, thermometers, magnetic water pump, water reservoir with temperature control, supports of test devices, flow meters and supports for Nitrogen, Carbon dioxide and oxygen cylinders. The project includes electric circuits from water temperature and flow meter management and hydraulic circuit for water circulation. The test circuits and the quantitative results of evaluations are presented in the blood membrane oxygenators and heat exchangers with different materials and designs. This station tests was able to quantify some of the main performance parameters of gas and heat exchangers with easible and safely.

Keywords: *Extracorporeal circulation, oxygenators, gas exchangers and heat exchangers. Circulação extracorpórea, oxigenadores, trocadores de gases e trocadores de calor*

COB1474 AN AUGMENTED ENDURANCE TEST WITH ELECTROMECHANICAL PULSATILE TOTAL ARTIFICIAL HEART (TAH)

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College of Medicine. This TAH successfully underwent a hydrodynamic study, hemolysis study and two acute implantations. Before initiating a preclinical study, the reliability of the device needs to be documented based on the durability of each component including the electrical parts through a long-term endurance study,

This TAH was submitted to a four-month running test with the most severe driving condition where a maximum dP/dt was chosen more than 15,000 mm Hg/sec that is almost six times higher than that of a normal driving condition. The pump was submerged into a water bath that was maintained at 37°C. The TAH was driven in a LMA variable rate mode at 8 L/min outflow, 15 mm Hg preload, 100 mm Hg left afterload and 25 mm Hg right afterload. The outflow, pressures, temperature inside the TAH and electrical current were monitored.

Several stress concentrating portions were detected. The connection between the roller nut and support plate lies in one of the most stress concentrating portions, and a more reliable fixing procedure was required. A redesign was made in this portion to offer a durable connection. No malfunction of the actuator and controller was detected throughout the testing duration. The required electrical power was 14.7 ± 1.6 watts and the total efficiency was 12.6 ± 1.4 %. The temperature in the TAH was 45.9 ± 0.90 °C on the motor, and 37.8 ± 0.30 °C on the centerpiece.

Keywords: *total artificial heart, durability, augmented endurance study, stress concentrating portion*

COB1475 AVALIAÇÃO “IN VITRO” DO ÍNDICE HEMOLÍTICO EM VENTRÍCULO ARTIFICIAL PULSÁTIL / IN VITRO EVALUATION OF THE HEMOLYSIS INDEX IN A PULSATILE VENTRICULAR ASSIST DEVICE

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High biocompatibility and low hemolysis are important characteristics for allowing long term use of blood pumps. We present an improved system for testing the hemolysis produced by an implantable pulsatile ventricular assist device (VAD) presently under development at our laboratory. The system has two flexible blood chambers immersed in fluid filled reservoirs. The chambers are connected to VADs driven by a pneumatic actuator. The results obtained with fresh heparinized bovine blood in four experiments showed that this system has a low degree of contribution on total hemolysis produced and provides a reliable method to determine hemolytic performance of VADs.

Keywords: *Ventricular assist device, hemolysis index, thrombogenicity, in vitro test. Dispositivo de assistência ventricular, índice de hemólise, trombogenicidade, teste in vitro.*

COB1476 MÉTODO DE OBTENÇÃO DE UMA PRÓTESE EM SILICONE PARA TORACOSTOMIA / METHOD FOR PROSTHESIS PRODUCTION IN SILICONE FOR THORACOSTOMY

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This paper presents the design and construction of a thoracostomy silicone prosthesis. Its main utilization is in Clagett's and modified Eloesser thoracostomies and for the treatment of chronic and post-pneumectomy empyemas. The prosthesis designed consists of a silicone tube corrugated and with one internal and one external flange to avoid migration. It can be placed through 30 to 40 mm incision and resection of a segment of solely one rib, minimizing surgical trauma and resulting in an esthetically improved aspect, while maintaining adequate and continuous draining of the pleural space. Hitherto, the prosthesis was utilized in 20 patients subjected to thoracostomy with a follow up period of 11 to 312 days. The results obtained suggest that its utilization presents many advantages in comparison to the traditional method utilized.

Keywords: *Chronic empyema, thoracostomy, thoracostomy prosthesis. / Empiema crônico, toracostomia, prótese de toracostomia.*

COB1477 PRÓTESE VENTRICULAR IMPLANTÁVEL- PROJETO MECÂNICO */ IMPLANTABLE VENTRICULAR PROSTHESIS-MECHANIC DESIGN*

Marina J. S. Maizato, Milton S. Oshiro, Sérgio A. Hayashida, Maria L. Lopes, Eucydes F. Marques, Gina H. Hamamoto, *Cecília A. C. Zavaglia & Adolfo A. Leirner

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This paper describes the design of an implantable artificial ventricular assist device to support the heart as a bridge to heart transplantation, in patients with profound cardiac failure. The artificial ventricle presented has a free floating membrane, dividing two titanium carcass. The driving unit is pneumatic. Two silicone cannulae are used to connect the device to the patient's heart (left ventricle apex to aorta). Each cannula is equipped with one bovine pericardium valve. A computer program (Microstation) was utilized to provide volumetric calculus, bidimensional and tridimensional visualization to optimize the design. The results show perspectives for clinical utilization.

Keywords: *Artificial Ventricle, Mechanic Assist Circulation, Ventricular Assist Device, Artificial Organs, Artificial Implants, Temporary Assist Device. / Ventrículo Artificial, Assistência Circulatória Mecânica, Dispositivo de Assistência Ventricular, Órgão Artificial, Dispositivo de Assistência Temporária.*

COB1479 APRESENTAÇÃO DE UM DISPOSITIVO PARA AVALIAÇÃO "IN VIVO" DE ADESIVOS ODONTOLÓGICOS EM ENSAIOS DE TRAÇÃO. /PRESENTATION OF A DEVICE TO EVALUATE DENTAL ADHESIVES "IN VIVO" BY TENSION TESTS.

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The purpose of this study is to present a device designed to quantify the force required to remove orthodontic brackets directly in the oral environment. Elastic deformation caused by tension are transformed in electrical resistance variations by strain gauges placed in load cells. Electrical signs generated during the movement are amplified by an amplifying bridge and the variations registered in an oscillograph. A previous calibration with definite weights allowed the identification of the force required for removing the brackets bonded on dental enamel. The device was used to verify the "in vivo" performance of two bonding systems. One of them, the Orthodontic Concise (3 M - Brazil) based in composite resin, is widely used in Orthodontics being available since several years. The other, Fuji Ortho LC (GC Corporation) an hybrid composite and glass ionomer adhesive, recently available. The results were mutually compared and analysed.

Keywords: *Extensômetros, Adesão Ortodôntica, Força de Adesão / Strain gauges, Orthodontic bonding, Bond strength*

COB1481 ÍNDICES DE HEMÓLISE E VISUALIZAÇÃO DO FLUXO NA "SPIRAL PUMP"(SP), UMA BOMBA CENTRÍFUGA DE SANGUE POR FUSO CÔNICO/INDEX OF HEMOLYSIS AND FLOW VIZUALIZATION ON THE "SPIRAL PUMP"(SP), A CENTRIFUGAL BLOOD PUMP USING A CONICAL SPINDLE

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The Spiral Pump (SP) is a blood pump that utilizes the two well known centrifugal and axial pumping principles, simultaneously. The hydrodynamic performance of this pump was studied at several test conditions, using a closed circuit loop with plastic tubes and reservoir, filled with 500 ml of 37% glycerin-water solution. The results show that the SP has good pumping performance. The flow behavior was studied in the most important areas of the pump using a stroboscopic planar helium-neon laser light. Amberlite plastic particles (80 mesh) were used in suspension in the solution and were illuminated by the laser light during the pumping process. Several in vitro hemolysis tests were performed using bovine blood, simulating two pump conditions: as left ventricular assist device and as cardiopulmonary bypass.

Keywords: *Centrifugal Pump, Blood Pump, Extracorporeal Circulation, Ventricular Assist Device, Hemolysis / Bomba Centrífuga, Bomba de Sangue, Circulação Extracorpórea, Bomba de Assistência Ventricular, Hemólise*

TEMA 112 - Produção

COB34 PORQUE REDESENHAR PROCESSOS FUTUROS / BECAUSE TO REDESIGN FUTURE PROCESSES

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The present paper described some aspects on the increasing user's of process redesign in many organization, which can lead to dramatical improvements of performance.

Keywords: *Redesign Process, Re-engineering, Redesenho de Processos, Reengenharia.*

COB149 UM MÉTODO PARA IDENTIFICAÇÃO DE AGRUPAMENTOS EM MANUFATURA CELULAR / AN IDENTIFICATION METHOD FOR GROUPING MANUFACTURING CELLS

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This paper presents the Simplified Method for Clusters Identification (the MIDAS method) used for grouping parts and machines in cellular manufacturing. The proposed method identifies and eliminates the exceptional elements of the incidence matrix as a way to obtain a perfect diagonal structure. The application of MIDAS method demonstrates that the method is useful and more simplified than the traditional grouping algorithms. The results permit the analyst deals with several solution alternatives and chooses the most effective one.

Keywords: *CellularManufacturing-ClusterAnalysis-CellFormation-ClusterAlgorithm*

COB394 A INFLUÊNCIA DO MODELO DO SISTEMA DE PRODUÇÃO NA SIMULAÇÃO DE ROTAS PARA AGVS / THE MANUFACTURING SYSTEM MODEL INFLUENCE IN AGVS ROUTES SIMULATION

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Material handling system design plays an important rule in many manufacturing systems. Many times this design is a complex task, as it's integrated to the whole system. The design engineer should feel the impact on facilities layout, logistics policy and production policy. In this paper we discuss the

influence of the manufacturing system model in Automated Guided Vehicles simulations. We present an Arena implemented example of a flow path layout, where models of different scopes and levels were used in order to feel the influence of the manufacturing system in the material handling system model performance. We compare a complex just-in-time model, where most of the production features were modeled, with a simple model, where the production system is modeled just as vehicles jobs.

Keywords: *Automated Guided Vehicles; Facility Layout; Material Handling Systems; Material Flow; Simulation Models. AGVS, Layout, Movimentação de Materiais, Fluxo de Materiais, Modelos de Simulação*

COB842 ESPECIFICAÇÃO E DIMENSIONAMENTO DE SISTEMAS DE MANIPULAÇÃO E TRANSPORTE DE MATERIAIS UTILIZANDO SIMULAÇÃO E SISTEMA ESPECIALISTA / USE OF SIMULATION AND EXPERT SYSTEM FOR MATERIAL HANDLING SYSTEMS SPECIFICATION

Orides Morandin Junior , José Luiz Miranda Junior, Edilson Reis R. Kato, Arthur J. V. Porto
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This paper proposes the use of simulation and expert systems for material handling systems specification. A comercial simulator is used for modeling a system and give data about its features. Then, an expert system is proposed for aid to make decision using data obtained from simulation and some other systems features

Keywords: *Expert Systems, Simulation, Manufacturing Systems, Sistemas Especialistas, Simulação, Sistemas de Manufatura*

COB865 ESTUDO DA APLICABILIDADE DOS MÉTODOS DE SEGMENTAÇÃO DE IMAGENS AO CONTROLE DE QUALIDADE NA INDÚSTRIA TÊXTIL/INVESTIGATION OF THE SEGMENTATION TECHNIQUES TO QUALITY CONTROL ON TEXTILE INDUSTRY

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In industrial manufacturing, product inspection is an important step in the production process. Automated visual inspection has been an active field of research during the last few years. However, very little has been increased in the production lines of textile. This paper investigates the use of segmentation techniques to automatically detect defects on textile industry and presents some examples of the defects which can be usually found. It also compares the efficiency, in quality control, of methods such as thresholding and edge detection.

Keywords: *Computação visual, inspeção têxtil automática, segmentação/ Computer vision, automatized visual inspection, textile inspection, segmentation, thresholding.*

COB951 FLEXIBILIDADE DE MARKETING PARA UMA FLUIDEZ ENTRE MANUFATURA E MERCADO/FLEXIBILITY OF MARKETING FOR FLOWING BETWEEN MANUFACTURING AND MARKET

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This article presents initially the evolutive and cumulative process of the market trends along time. These market tendencies are the reasonable price, quality and variety of products, as well as customized product. Then it is analysed the influence of these requirements on the enterprise as a whole, and specifically on the marketing and manufacturing functions. Thus, the need for development the flexibility of the marketing function risen due these market trend. In the last part it is developed the concept of flexibility of the marketing-mix, with the aim of linking the requirements of the customer by a more variety and customized product with the approaches of the manufacturing functions for answer the market challenges.

Keywords: *Flexibility, marketing, manufacturing, market, customization, customer Flexibilidade, marketing, manufatura, mercado, personalizado, cliente*

COB1006 GERENCIAMENTO DE FERRAMENTAS E SEUS REFLEXOS SOBRE A IMPLANTAÇÃO DE UM SISTEMA DA QUALIDADE BASEADO NAS NORMAS ISO 9000 / TOOL MANAGEMENT AND ITS IMPLICATIONS IN A QUALITY SYSTEM BASED ON ISO 9000 NORMS

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The industrial competitiveness increase has the obliged the companies to review their manufacturing procedures in a way of making possible the costs reduction, productivity and quality enhance. It is verified that the organization and cut tools adequated controls allow many production inconveniencies reduction in the metal mechanic sector companies that employ machined manufacturing process. The tools management techniques can be this way used as an important information administration and the manufacturing process maximization manner. The association of the tool management phylosophy with the ISO 9000 Norms requirements has allowed that more efficient and trustable controls could be specially adapted to the process control items links.

Keywords: *Gerenciamento de ferramentas/Tool Management, Produtividade/Produtivity, ISO 9000/ISO 9000, Controle de documentos/ Document control, Controle de processos/ Process control*

COB1047 VALIDAÇÃO DE NOVOS MODELOS DE GERENCIAMENTO DE CHÃO DE FÁBRICA ATRAVÉS DE FERRAMENTAS DE SIMULAÇÃO / VALIDATION OF NEW SHOP FLOOR MANAGEMENT MODELS BY SIMULATION TOOLS

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Manufacturing companies face nowadays the problem of exponential growth of complexity in their market relations associated with the customer changing expectations. Nevertheless, if this situation imposes new threats, it also brings new opportunities, by the introduction of new manufacturing organization models. However, the risks involved in introducing these models are very high, due to the radical changes involved. New simulation tools open the opportunity to test new solutions with low risk and low investment. This paper describes the SOMA, an organic and autonomous manufacturing system with some innovating characteristics, based on distributed and autonomy concepts. Following, it is discussed the modeling approach, supported by dynamic simulation tools. The results allow to foresee and evaluate the system potential for small batch production, with good flexibility and reliability.

Keywords: *manufatura autônoma, chão de fábrica, simulação, modelagem / autonomous manufacturing, shop floor, simulation, modeling.*

COB1048 MÉTODO DE AVALIAÇÃO DE MÃO-DE-OBRA PARA A SOLDAGEM BASEADO EM ANÁLISE COMPUTACIONAL/ A METHOD TO EVALUATE WORKMANSHIP IN WELDING BASED ON COMPUTATIONAL ANALYSIS

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This work describes a methodology based on a data acquisition system used as a tool for the performance analysis of welders based on the evaluation of the voltage and current behaviour acquired during experimental welding. The signals filtered by the use of Fast Fourier Transform and standard deviations analysis of the signal processed grant a quick evaluation about the skill of welders. To evaluate the methodology a series of tests performed by an automatic machine and a welder was compared. The results shows the superiority of the automatic welding, as expected. As a consequence of this study, the methodology described can be an effective method for the approval of welders in a procedure qualification requirement or as an alternative procedure for welders training system to be used in shop floors.

Keywords: *Welding, Data Acquisition, Fast Fourier Transform, FFT, Transformadas Rápidas de Fourier, Soldagem*

COB1055 TEORIA Y METODOS DE DISEÑO COMO ESTRATEGIAS DE DESARROLLO DE NUEVOS PRODUCTOS EN LA EMPRESA METALMECANICA CHILENA.

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As an activity, design is closely related to field market, everyday becoming more competitive and global worldwide. This statement is a reality overflowing enterprises and has meant that design is

becoming a strategical element for its unfolding, in such a way that design today acquires a gravitating role in the survival and competitive support of these enterprises. In the framework of a free market economy developed in Chile, the national metalmechanic sector does not escape from these premises and it requires support so to correctly back up an increasing effort to power design in order to add value to its products, improving its presence in the present markets as well as in the potential markets, such as Nafta and Mercosul. In that perspective, the project takes forward to promote development strategies of new products from a reality diagnose of design in this enterprise and from the analysis compared to the theories and methodologies of usual designs or developing designs in the industrialized countries. Knowledge of these theories (systematic, integrating, axiomatic) and the methodologies springing from them, will enable the elaboration of a solution fan of interest which will promote the model generation, appropriated to product development experimental type, adequated to the reality of the enterprise in question and strategically in terms of their markets. The limits of these models and asking proposals will be determined by series of factors alienated to design among which are presumably found : human factor, organization maturity, available manufacture means, and input reliability.

Keywords: *Design, Competitive, Manufacturing.*

TEMA 113 - Outros Temas

COB1 AUDITORIA AMBIENTAL PELA SÉRIE DE NORMAS ISO 14000

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The ISO 14000 series are designed for integrating more than 15 environmental standards from 43 countries. This series describes the basic elements of an effective environmental management system, by considering the main aspects concerning environmental issues. Up to now, the ISO 14000 standards are voluntary. This work is mainly about Environmental Auditing, described by ISO 14010, ISO 14011 and ISO 14012 standards. Nevertheless, it is the ISO 14001, describing the basic requirements of an environmental management system, the standard that organizations will implement and the standard to which they will seek third-party registration. It is also intended here, to present an overview of the ISO 14000 series and discuss how an organization could get the benefits of adopting the standards. The benefits could be reached either by using the standards as a guide to measure the environmental impact of the organization's activities in order to assess its environmental performance or as a mean to identify improvement opportunities. The most important consequence of ISO 14000 implementation is their significant contribution to improve sustainable development.

Keywords: *Meio Ambiente, ISO 14000, Normalização Ambiental.*

COB27 CARACTERIZAÇÃO DE ESTANHO(Sn) NA SOLIDIFICAÇÃO UNIDIRECIONAL / CHARACTERIZATION OF TIN (Sn) ON UNIDIRECTIONAL SOLIDIFICATION

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The present work deals with the characterization of unidirectional solidification of electrolytic tin (99,98% purity) (Mei et al., 1980), to verify the solute distribution across the whole ingot (Burton et al., 1991), (Tiller et al., 1953). An unidirectional solidification device comprising a versatile and efficient water-cooled electrical resistance furnace was assembled (Garcia et al., 1983). Macrographic examination over both longitudinal and cross sections were performed. Microhardness testing, optical micrography, SEM/EDS examination and also chemical analysis were performed as well (Petzow et al., 1978). The obtained results showed an efficient unidirectional solidification and so far as the solute distribution, across the top, middle and base regions, is concerned no change was detected, with the exception for iron with higher concentration at the base region.

Keywords: *Unidirectional, purity, ingot, solute, tin / unidirecional, pureza, lingote, soluto, estanho.*

COB126 MODELING OF INSIDE-OUTSIDE FLOW IN FABRIC FILTERS**Antonio C. Caputo & Pacifico M. Pelagagge***Department of Energetics, Faculty of Engineering**University of L'Aquila, 67040 Monteluco di Roio (AQ), Italy. E-mail: caputo@ing.univaq.it*

Direction of the gas flow from inside the bag towards the outside is representative of shaker type and some reverse-air fabric filter cleaning methods. In this paper, after a short description of the general characteristics of fabric filters, the literature methods to evaluate pressure drop are briefly reviewed. In order to give a contribution toward a more detailed characterization of fabric filters performances, an one-dimensional time-dependent mathematical model has been developed suitable for a fairly precise estimation of pressure, velocity and cake fields inside the filter. The iterative use of this mathematical tool allows for an economic optimization of fabric filters design. Having this in mind, an application example is presented with the aim of highlighting the capabilities of the proposed methodological approach.

Keywords: *Fabric filter, mathematical model, computer simulation***COB137 POLYFUNCTIONAL PLANTS FOR INDUSTRIAL WASTE DISPOSAL
I - PROCESS AND EQUIPMENT DESIGN****Antonio C. Caputo & Pacifico M. Pelagagge***Department of Energetics, Faculty of Engineering**University of L'Aquila, 67040 Monteluco di Roio (AQ), Italy. E-mail: caputo@ing.univaq.it*

The structure of a Polyfunctional Plant for liquid and solid industrial waste treatment is discussed highlighting the high level of process integration obtainable and the consequent benefits. The plant comprises an incineration section, a section for chemical-physical-biological treatments and a stabilization-solidification section. Each section is briefly described and an overview of the sizing procedure for main equipments is presented in order to define a methodological approach for plant preliminary design to be used in economic feasibility evaluation studies.

Keywords: *Waste treatment, polyfunctional plant design, industrial waste***COB233 PROJETO TTS - ESTÁGIO ATUAL E PERSPECTIVAS FUTURAS /
TTS PROJECT - STATE-OF-ART AND FUTURE PERSPECTIVES****João Pedro Caminha Escosteguy & Sidney Lage Nogueira***Instituto de Aeronáutica e Espaço, Centro Técnico Aeroespacial - CTIAIE**CEP 12228-904 - São José dos Campos, SP, Brasil - E-Mail, tts@iconet.com.br*

This paper describes the development of the "TTS Project" (Transonic and Supersonic Tunnels), an effort from the Brazilian Air Ministry, through the Centro Técnico Aeroespacial (CTA), to equip Brazil with the installations required for the aerodynamic testing at high velocities. The progress obtained up to this point includes the definition of basic specifications, the concept design of an industrial transonic tunnel with a novel technical solution, and the design, fabrication and initial operation of a Pilot Facility. The transonic regime is the most difficult one to be simulated by theoretical / computational methods. The use of test facilities (wind tunnels) is of foremost importance in the project of vehicles that

cruise at such velocities, as is the case of high-performance transport aircrafts and satellite launching rockets (in the initial phase of the flight). At the moment, Brazil lacks the capability of testing at that regime. Along with explanations concerning the technical aspects of the project, the present paper covers strategic, financial and management challenges that had to be dealt with. Remarks concerning the joint use of computers and wind tunnels, and even the future prospects of the latter, are made.

Keywords: *Experimental aerodynamic, wind tunnels, testing*

COB396 **CARACTERÍSTICAS FÍSICAS DO CaO e CaO.MgO FORMADO EM PROCESSO DE DECOMPOSIÇÃO TÉRMICA DO CALCÁRIO / PHYSICAL CHARACTERISTICS OF CaO AND CaO.MgO FORMED IN A LIMESTONE THERMICAL DECOMPOSITION**

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With the aim to minimize SO₂ emission in fluidized bed combustion, it has been used the solid alkaline injection at high temperature, usually the limestone, during the fossil fuel burn. The efficiency of the SO₂ removal process, depends basically, on the characteristics of the reactant solid developed in the calcination step. This work was developed in a fixed bed experimental system and analyzed the influence of the limestone type, the calcination temperature and time on specific area, porosity and pore size distribution. Two types of limestone were used, Calcitic and Dolomite, like sorbent. The calcination took place at 850°C and 950°C and reacting times of 60 and 180 minutes, according to a experimental design. The results show limestone type and the calcination temperature like the most relevant factors in the calcinated solid physical structure changes.

Keywords: *Aços bifásicos, envelhecimento, pré-deformação / Dual-phase steel, ageing, pre strain*

COB560 **ALTERAÇÕES NO LIMITE DE ESCOAMENTO, FORMA DE ENCRUAMENTO E DUCTILIDADE EM AÇOS BIFÁSICOS ENVELHECIDOS / CHANGES IN THE YIELD STRENGTH, HARDENING COEFFICIENT AND DUCTILITY IN AGED DUAL PHASE STEELS**

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In the present paper, dual-phase microstructures in two kind of low carbon were produced: API-5L-B and API-5L-X52 (microalloyed). The study evaluated the susceptibility to ageing in two kind of steels after deformation 10% upper yield strength. Results indicated that the ageing treatment were responsible in the mechanical properties variations, more specifically in the yield strength. The microalloyed dual-phase steels showed better performance compared to the low carbon dual-phase steels with no alloying elements moreover upper values in the yield strength, its ductility was also bigger.

Keywords: *Aços bifásicos, envelhecimento, pré-deformação / Dual-phase steel, ageing, pre strain*

COB574 ESTUDO DA DISTRIBUIÇÃO DE IMPUREZAS EM SILÍCIO PURIFICADO VIA FUSÃO POR FEIXE DE ELÉTRONS / STUDY OF IMPURITIES DISTRIBUTION IN SILICON PURIFIED BY ELECTRON BEAM MELTING

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Silicon is commonly used to convert solar energy into electrical energy. To make this source of energy economically viable we should decrease the cost of silicon and solar cells devices. The reduction of silicon cost can be done by the use of polycrystalline material. In this work, metallurgical grade silicon (Si-GM) was purified by electron beam melting process. The advantage of this method is the vacuum (near 10^{-3} Pa) inside the chamber and the no reaction between molten silicon and copper crucible. The samples were prepared using variable beam power and variable time and it was conduct that the process can reduce the concentration of Fe, Al, P, Cr, Ni, Cu, O and C. For the resistivity sample analyzed, measurements show that the concentration of impurities was higher in the centre of the sample than the edge.

Keywords: *Purificação de silício; fusão por feixe de elétrons; silício policristalino / Silicon purification; electron beam melting; polycrystalline silicon*

COB582 DESENVOLVIMENTO DE PROCESSO ELETROMAGNÉTICO PARA A PRODUÇÃO DE LIGAS REOFUNDIDAS / DEVELOPMENT OF AN ELETROMAGNETIC PROCESS FOR THE PRODUCTION OF SEMISOLID ALLOYS.

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The work deals with the design and assembly of an equipment for the production of rheocast metallic slurries, based on the principle of modifying the solid growing mechanisms during freezing of the alloy from liquid, by means of electromagnetic stirring. The essential parts of the equipment are: a stator engine, control system, crucible and cooling system to allow control of the material freezing rate. It was designed in a such way to produce a magnetic field with a horizontal and tangential force, related to the crucible longitudinal axis, to promote the necessary shear conditions within the liquid required to the structural modifications to produce rheocast slurry. Rheocast ingots were obtained for Al-4,5wt% Cu alloy, submitted to different operational conditions, in order to explore the equipment performance and potential. Results showed the feasibility of producing rheocast material by controlled electromagnetic stirring of liquid alloy in such a type of reactor. Refined macrostructures, with typical rheocast globular microstructures and additionally, with reduced presence of entrapped liquid in the primary phase, were produced. Therefore, rheocast material, presenting superior quality when compared to those obtained by mechanical stirring, could be obtained by using a reactor of quite simple conception.

Keywords: *Solidificação; Reofundição; Agitação eletromagnética; Eletromagnetic stirring, Rheocasting, Semisolids.*

COB607 CORROÇÃO POR ÁGUA ÁCIDA DE AÇOS DOS VASOS DE CRAQUEAMENTO CATALÍTICO DE REFINARIAS DE PETRÓLEO, POR POTENCIOMETRIA / THE SOUR WATER CORROSION OF THE PETROLEUM REFINERIES CATALYTIC CRACKING VESSELS BY POTENTIOMETRY

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The mechanical properties detriment caused by hydrogen damages in catalytic cracking vessel wall steels are determinant factors to this petroleum refineries equipment's life time. This hydrogen is generated, with iron sulphate, by steel corrosion in sour water produced inside this vessels. The iron sulphate generate a polyssulphate film which give to steels surface some resistance to hydrogen diffusion and consequent damages. Therefore, the steels surface film stability is a important factor to major or minor time life of this equipment. In this work the cyclic polarisation was used to analyse two steel used in vessels building in terms of the stability of the films generated by corrosion reaction. With the obtained results was possible to evaluate what of the two steels could be used preferentially in this vessels building.

Keywords: *danos por hidrogênio / hydrogen damages, seleção de aços / steel selection, estabilidade de películas / layer stability, polarização cíclica / cyclic polarisation.*

COB725 FIRE EXPLOSION SAFETY MEANS FOR ROCKET ENGINES WITH LIQUID AND CRYOGENIC PROPELLANTS

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Review and analysis of principal means for fire explosion proof of launchers with liquid propellant engines are presented. Several methods for safety warranty are proposed. Prevention of origin of explosive mixtures and elimination of sources of fire initiation are obligatory conditions for any safety design. The governing logic of monitoring and control for a safety vent system is analyzed. Comparative analysis for two alternatives of a launcher with liquid cryogenic propellant has been done. It is shown that the use of liquid hydrogen adds a lot of complexity to the explosion-proof system. The results of modelling of possible scenarios of concentration variation in depends of rate of leakage and time delay of the control system are presented.

Keywords: *Launcher, explosion, hazard, liquid propulsion, safety.*

COB873 METODOLOGIA DE DESENVOLVIMENTO DE UM CAMPO MARÍTIMO DE PETRÓLEO / METHODOLOGY FOR OFFSHORE OIL-FIELD DEVELOPMENT

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Economical, technological and human aspects are some of the very important parameters in a engineering design. A development of an oilfield involves minimization of capital and operational cost investments and maximization of oil recovery from the reservoir. The present paper introduces a methodology for development of offshore oilfield based on hierarquical procedure of analysis and design spiral method. A systematic method for developing an oilfield is described in order to evaluate attractivity of developing a oilfield.

Keywords: *Metodologia de desenvolvimento, análise hierárquico, espiral de projeto, projeto multi-disciplinar, campo marítimo de petróleo / Methodology for project development, hierarchical analysis, design spiral, multidisciplinary project, offshore oilfield development..*

COB931 CARACTERIZAÇÃO DE CRISTAIS DE HALOGENETOS ALCALINOS (KCl), DOPADOS COM AS IMPUREZAS CN- E Sn²⁺/ CHARACTERIZATION OF ALKALI HALIDE CRYSTALS (KCl), DOPED WITH CN- AND Sn²⁺ IMPURITIES.

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Alkali halide crystals doped with ions of electronic configuration ns² in its ground state have been extensively studied. These crystals are considered ideal hosts for color centers because their properties are strongly affected by the presence of these impurities. Thermally Stimulated Depolarization Current (TSDC) measurements in these crystals allow to understand the relaxation processes. In this work we present TSDC results of a KCl sample, 1.30 mm thick, multiply doped with 1% KCN- e 0.5% SnCl₂. Our results show a wide band about 248 K, which indicates a dipolar relaxation in the sample. The relaxation parameters, Ea, t e Tm are obtained by the Prakash simulation method.

Keywords: *Halogenetos alcalinos, relaxação dipolar, absorção óptica, dipolos elétricos/Alkali Halide, Dipolar Relaxation, Optical Absorption, Electrical Dipole.*

COB932 CARACTERIZAÇÃO ÓPTICA E ESTRUTURAL DE FILMES DE KCl:TI OBTIDOS POR EVAPORAÇÃO RESISTIVA

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The study of defects in alkali halide thin films has shown new results about their optical and structural properties. In this work we present optical absorption results and structural characterization of KCl:TI+ films at 300K. The films were prepared by resistive evaporation and they are 0.5mm thickness. The absorption spectra show absorption bands at 250 and 197nm, like in crystals. If the impurity concentration increases in the film then the intensity of the optical absorption and its half width increases too. These films have 10+20 atoms/cm³ of TI+ concentration and show a large absorption band; this feature suggest probable application for band pass filter.

Keywords: *Alkali halides, KCl, thallium (TI), thin films, resistive evaporation.*

COB1017 A TEMPERATURA NOS FENÔMENOS FOTOINDUZIDOS EM Al y Ga 1-y As / TEMPERATURE EFFECT ON PHOTOINDUCED PHENOMENA IN Al y Ga 1-y As

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We present light induced electrical properties of Al y Ga 1-y As at low temperature. Heat transmission in the sample holder is discussed, in order to achieve temperature control with 0.1 degree of precision. Results of resistance as function of temperature with monochromatic light excitation in the range 0.5-1.5 μm and photoconductivity spectra measured in the range 80-200 K are reported. Temperature dependent resistance shows strong electron freezeout which can be associated to the presence of two distinct deep levels whose behavior is related to energy of exciting light. Photoconductivity spectra show bandgap transition since the measurement temperature is properly selected. The decay of photoconductivity is also measured in the range 50-90 K and its modeling reveals the charge states of existing defects. Persistent photoconductivity in indirect bandgap samples below 60 K, has much lower magnitude than in direct bandgap samples.

Keywords: *Arseneto de Gálio e Alumínio, focondutividade, criostato, dispositivos eletrônicos / aluminum gallium arsenide, photoconductivity, cryostat, electronic devices*

COB1042 ESTABILIDADE TÉRMICA DAS LIGAS AMORFAS $\text{Fe}_{(85-X)}\text{B}_{15}\text{Ge}_X$ PROCESSADAS POR "MELT-SPINNING" / THERMAL STABILITY OF THE AMORPHOUS $\text{Fe}_{(85-X)}\text{B}_{15}\text{Ge}_X$ ALLOYS PRODUCED BY "MELT-SPINNING"

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Amorphous alloys $\text{Fe}_{(85-X)}\text{B}_{15}\text{Ge}_X$ ($x = 0-10$) in the shape of ribbons were obtained by using the process of ultra-rapid "melt-spinning" solidification. The ideal processing parameters were determined and the alloys were produced in a compositions range, according to a theoretical diagram of amorphization compositions. The amorphous state was verified by X-ray diffraction, Mössbauer spectroscopy and ductility tests. Differential scanning calorimetry (DSC) was used to determine the thermal stability of the alloys and observe the evolution of the crystallization peaks. Continuous amorphous ribbons were obtained reaching, in some cases, as much as 20m of length, presenting dimensional homogeneity and good superficial finish. The DSC thermograms showed the crystallization peaks which are characteristic of amorphous alloys, whose thermal stability rises with the Ge content.

Keywords: *Amorphous alloys, "Melt-spinning", Magnetic anisotropy, Amorphization and Crystallization, Ligas amorfas, "Melt-Spinning", Anisotropia magnética, Amorfização e Cristalização.*

COB1053 ANÁLISE DE ELASTO-PLASTICIDADE CÍCLICA EM COMPONENTES MECÂNICOS/CYCLIC ELASTO-PLASTIC ANALYSIS OF MECHANICAL COMPONENTS

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In this work we present a theory and propose a return mapping algorithm for the analysis of cyclic elastoplastic behavior in components. Here, we make use of the elastoplastic equations proposed by Lemaitre (1992). His theory is well-founded in the framework of thermodynamics of irreversible process. The model takes into account a non-linear isotropic and kinematic hardening rule. The algorithm proposed for the integration of the set of evolution equations is based in the work presented by Simo & Taylor (1986) and generalized by Benallal et al (1988) and uses the Newton-Raphson method to solve the set of local non-linear equations, as well as the set of global non-linear equations. The finite element method is employed in the discretisation of the body domain. The finite element obtained makes use of the quadratic, nine nodes Lagrangean interpolation functions. A two-dimensional example is solved, where we assume a plane stress state.

Keywords: *cyclic plasticity, plasticity*

COB1056 MEDIÇÃO E ANÁLISE DOS ESFORÇOS DE CONTATO RODA/TRILHO NA ESTRADA DE FERRO CARAJÁS / AN INSTRUMENTED WHELLESET INVESTIGATION OF THE EFFECTS OF DYNAMIC PERFORMANCE ON GONDOLA CAR AT CARAJÁS RAILROAD

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This paper presents a instrumented wheelset development for lateral, vertical and position measurement at Estrada de Ferro Carajás(EFC). It may identify better track, rolling stock iteration parameter.

Keywords: *Rodeiro instrumentado, manutenção ferroviária, contato roda trilho, instrumented wheelset, railroad maintenance, wheel rail contact.*

COB1058 UN METODO ALTERNATIVO PARA LA ELABORACION DE MOLDES EN UN PROCESO DE FUNDICION DE PRECISION / AN ALTERNATIVE METHOD FOR MAKING SHELLS OF INVESTMENT CASTING

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Investment casting is the process whereby pieces with high dimensional accuracy and very good surface quality are made using ceramic shell molds and lost patterns. In this work evaluations were made in order to replace ethyl-silicate or colloidal silica with sodium-silicate as binder for mold manufacturing. By using sodium-silicate the following advantages are obtained: their utilization is usual in casting, it produces minimal gaseous emission during the pouring of the molten metal, the mechanical strength and permeability values reach or exceed those obtained with other binders, it is water-soluble, it has a low cost and molding time is markedly shorter than that of traditional binders. In order to study the feasibility of their use as a binder, several tests of the variables involved in the process were made. To this aim, green and calcined strength, drying, permeability, molding time, permeability variation with temperature, slurries lifetime, shell thermal properties and cooling of the pieces in the molds, were evaluated.

Keywords: *Fundición, Silicato de sodio, Microfusión, Investment Casting, Ceramic Shell, Sodium Silicate.*

COB1059 MEDIDAS DE TAMANHOS DE GRÃOS AUSTENÍTICOS ORIGINAIS EM AÇOS TEMPERADOS / PRIOR AUSTENITIC GRAIN SIZE MEASUREMENT IN QUENCHED STEEL

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Special surface chemical treatments were performed on samples of hardened martensitic steel to show the original austenitic grains prior to quenching and tempering. Although the samples had a wide carbon content variation a high quality image of the austenitic grains was achieved, allowing computerized measurements. Considering all the formulas used, the compound with picric acid (6g), ether (100ml), water (100ml), hydrochloric acid (2ml) and neutral detergent (25ml) presented the best performance.

Keywords: *Tamanhos de Grãos/Grains Size, Contornos de Grãos/Grain Boundary, Impacto/Impact, Ataques Metalográficos/Metallographic Etching, Têmpera/Quenching.*

COB1076 MATERIAIS COM EFEITO DE MEMÓRIA DE FORMA, CARACTERÍSTICAS PRINCIPAIS E POSSÍVEIS APLICAÇÕES / MATERIALS WITH SHAPE MEMORY EFFECT, MAIN CHARACTERISTICS AND POSSIBLE APPLICATIONS

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Shape Memory Effect is the term used to describe the ability of certain materials to recover its original shape upon plastic deformation. Conventional materials when plastically deformed beyond the elastic limit present plastic deformation. This work will present the main characteristics

of these kind of materials such as the reversibility of martensitic transformation, one way and two way shape memory and pseudoelasticity. Also it will be shown how these peculiar properties can be or are used in practical applications in areas such as naval, aerospace, automobile, nuclear, medicine, etc. Beside that this group, which is working with the development of shape memory alloy since 1994, intend to interact with the engineering community aiming mainly the possibility of exploring practical applications.

Keywords: *Efeito de Memória de Forma (shape memory effect), transformação martensítica (martensitic transformation), pseudo-elasticidade (pseudo-elasticity), atuadores (actuators).*

COB1081 DETERMINAÇÃO DE PROPRIEDADES DO PÓ DE NIÓBIO METÁLICO / DETERMINATION OF PROPERTIES OF NIOBIUM POWDER

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This work presents the results of the determination of properties of niobium powder classified in four fractions of particle size. The properties studied are: particle size, morphology, particle size distribution, crystal structure (X-ray diffraction), specific surface, apparent density and compactability. The niobium powder studied presents high purity. The lattice parameter determined is 3.3067 Å. The morphology of the particles is typically irregular, as well as presents average particle size between 10.27 - 26.84 µm, specific surface between 0.463 - 0.630 m²/g, apparent density between 2.46 - 3.14 g/cm³ and fractional porosity in the range of 63.36 - 71.29%. The obtained results show that there is a close relationship among the investigated properties of the niobium powder and its particle size.

Keywords: *Niobium powder / pó de nióbio, properties / propriedades, compacting / compactação.*

COB1275 STUDY AND DESIGN OF A BATCH INCINERATOR FOR TOXIC WASTES

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The first chapter describes ways to avoid the recombination of dioxins and production of NO_x, CO. A computerized procedure to design the incinerator is described. The second part of the paper deals with the design and operation of a fully automatic incinerator. Simple oxygen and thermocouple probes drive a servo-control system to bring emission parameters into line with legislation with no reference to waste composition. The pilot plant was tested to validate the computerized procedure. For temperature and gas composition measures inside the flame, a water cooled probe was designed. Gas flow rate was measured with calibrated diaphragms. All data were acquired via computer. The incinerator has two combustion chambers. In the first one the waste is destroyed in a pyrolysis like process with low oxygen supply at low temperature and turbulence. The flue gases enter in the afterburner where they burn at high temperature and turbulence with excess oxygen. A fluiddynamic analysis of

afterburner was performed with a finite volume software. The software calculated data were compared with the data collected in the experimental campaign and the computerized procedure results.

Keywords: *Incinerator, Dioxin, Toxic, Waste, Fluidynamic.*

COB1376 RECURSOS DISPONÍVEIS NA INTERNET PARA ENGENHEIROS MECÂNICOS / ON LINE MECHANICAL ENGINEERING RESOURCES AVAILABLE AT INTERNET

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The large amount of information available in the Internet, turns it into a powerful source of engineering data. The Engineer's problem is no longer knowing where to find the information: it is now available in the Internet! The issue has become, how to find a particular information in this media. The present work describes several Mechanical Engineering sources which are available in the Internet Network. The main objective is to provide an initial list of sites, enabling the starting of a particular search, also providing a global overview of resources availability. The chief information sources and document retrieval in Mechanical Engineering, both in Brazil and abroad is classified according to the technological and scientific data structure.

Keywords: *Internet, WWW, Web, Mechanical Engineering Sites / Engenharia Mecânica, Base de dados.*

COB1389 DIAMOND LIKE CARBON COATINGS: AN EXAMPLE OF APPLICATION TO THE CHEMICAL INDUSTRY

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A novel equipment was designed and constructed for the controlled deposition of hard, amorphous, diamond-like thin films (a-C films); the starting material, CH₄ gas, is ionised before impinging on the surface to be coated; the optimum energy of the ion beam is about 30-40keV. The films obtained are transparent, amorphous, insulating, hard (hardness >9 Mohs scale), chemically resistant against concentrated acids and bases, they have a high optical refractive index (1.8-2.2); high resistivity (10¹⁰ - 10¹¹ Ωcm) and show good adherence on many substrates and good wear resistance; besides they were characterised using Raman spectroscopy. The tubes to be coated were stainless steel, 350mm long, 30mm diameter and were coated with a 7000 Å thick hard a-C film. These tubes are part of a fluidized bed reactor used in the INDUPA vinyl chloride monomer plant and they are in contact with hydrogen chloride at about 200°C and with alumina spheres that are constantly impinging on them; under these conditions uncoated tubes have an average life of about 8 months while a-C

coated tubes nearly duplicate this life-time. The main product (a-C) and the reactants are not contaminating products.

Keywords: *diamond like films; protective coatings.*

COB1390 O SISTEMA NACIONAL DE QUALIFICAÇÃO E CERTIFICAÇÃO DE PESSOAL EM ENSAIOS NÃO DESTRUTIVOS / NATIONAL STAFF QUALIFICATION AND CERTIFICATION SYSTEM IN NON DESTRUCTIVE TESTINGS

João Antônio Conte

Executive Director. ABENDE – Associação Brasileira de Ensaios Não Destrutivos (Brazilian Association of Non-Destructive Testings).

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Although equipment, techniques and rules applied in the performance of NDA are extremely important items, they become merely academic if the staff involved in the development and evaluation is not taken into consideration, since the reliability is fully based on the professional performing the inspection. Thus, the issue Staff Qualification and Certification in NDA is extremely important and it is actually vital, whether you consider the need to assess the inspector's knowledge and ability or whether you consider the national and international requirements, such as Rule ISO 9712 and the European Rule EN 473. Staff Qualification and Certification in NDA has been extensively studied by the Association for 16 years, and it has established the National Staff Qualification and Certification System in NDA. The National System is being evaluated by INMETRO itself, based on the requirements established by Rule DINQP 069 and ABENDE shall be accredited as an Accredited Certification Entity – Organismo de Certificação Credenciado OCC. This study tries to objectively approach the National Staff Qualification and Certification System in Non-Destructive Testings.

Keywords: *Qualificação, Certificação, Ensaios Não Destrutivos / Qualification, Certification, Non-Destructive Testings.*

COB1494 POLYFUNCTIONAL PLANTS FOR INDUSTRIAL WASTE DISPOSAL II - ECONOMICS AND MODEL EVALUATION

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Some criteria for estimating capital investment and annual operating costs of polyfunctional plants for industrial waste treatment are presented. The process and equipment design methods presented in part I of this paper, together with the economic approach here proposed allow for complete technical-economic analyses. The overall mathematical model appears as an useful tool in economic feasibility studies. Accuracy of the developed computer mathematical model has been demonstrated referring to actual cost data from literature.

Keywords: *Cost estimation, Economic analysis, Industrial waste*

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