DIDACTIC TESTS BENCH: PROPOSAL OF INTEGRATION OF UNDERGRAD AND GRADUATE STUDIES IN CEFET/RJ

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Abstract*: The work presents the proposal of integration between the applied research and the education of engineering in the CEFET/RJ. The project and the development of a Didactic Tests Bence, related to master's degree inserted in a line of research of the institution is being used as education and research resource for engineering graduation students in the disciplines of Dynamic of the Machines and Applied Instrumentation Engineering. The experiment consists in instrumentation of a transmission system CVT (Continuously Variable Transmission) type, getting data of typical performance, necessary for the project of vehicular systems, like study of the relation of variable transmission in function of the imposed rotation to this system and the resistive load applied to it. This experiment gives sustentation to the technological development of the follow prototypes and the learning of advanced models for the future engineers. On the other hand, it evidences the commitment of the research conducted in the Master's Degree in Technology Course of the CEFET/RJ with an immediate technological application. The related system is capable to reduce the vehicular emissions, to diminish the number of components and subsystems of the vehicle, as well as increasing its global efficiency thus allowing a smaller consumption of energy.*

Keywords*: CVT, Dynamics to propagate, Assays, Education of engineering.*

1. Introduction

The relative knowledge to the dynamics of system CVT - Variable Continuously Transmission, and the respective implications of its functioning have been a frequent obstacle for the engineering students that take part of Project SAE (Society of Automotive Engineering) Mini Baja. Actually this type of transmission has being used since 1999, in these competitions promoted annually by PETROBRAS and SAE, where just a small number of cars employed this system. In 2004, 90% from 77 teams coming from different states of Brazil registered the in the competition, had used transmission CVT as part of its transmission. Amongst the teams of the state of Rio de Janeiro using CVT transmission can be detached: the CEFET/RJ, illustrated in "Fig. 1", PUC RIO and UFF. There seems to be a clear tendency for this choice to be adopted by the majority of teams, as well as can be observed in 2004th edition, there are also serious problems in adjustments to obtains the best performances from these equipments. Regulation parameters demand yet an accurate research.

Figure1. Mini Baja of the Zerovinteum Team of CEFET/RJ

2. Project and Construction of the Tests Bench

The project of the tests bench has as objective to make feasible the project of some automotive systems upon dynamic analyses by experimental means and also numerical computational support. This bench was concept and build up as part of a master degree research and is utilized, in present time, to model dynamic behavior of a CVT set. This is of particular interest for students involved with Mini Baja SAE Project as well students currently coursing regular disciplines of Dynamics, Mechanical Design among others. This interchange between after and under graduation activities has stimulated improvements in real prototype project and also greater interest in research for many students that otherwise would probably keep apart from this scientific world.

The illustrated schematical drawing in Fig. 2, represents the main components of the didactic tests bench.

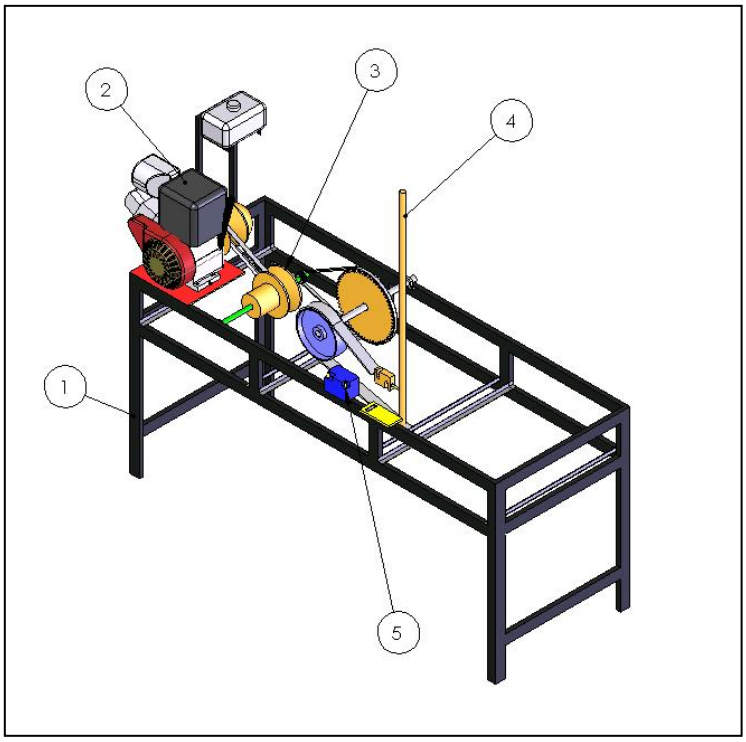

Figure 2. Illustrative drawing of the Didactic Tests Bench

The main components that constitute the bench, in accordance with the "Fig.2", are:

1. Structure
2. 8 HP Engine
3. CVT
4. Fixed reduction and Load imposition system
5. Instrumentation

Some improvments had been introduced during the construction and assembly of the components from the drawing represented in "Fig. 2". The substitution of the handspike of brake, item 4 of the drawing, by screw to the flabby branch of the brace of brake allows to establish and to fix the load to be imposed to the system, during the assays and the instrumentation, item 5. In "Figure 3" after is presented the final situation of the tests bench assembly.

Figure 3. Final configuration of the Tests Bench

2.1. Structure

The structure was constructed in steel profiles, welded in way that allowed the installation of all the components (motor, system of transmission, system of load imposition and instrumentation), as well to stand the efforts generated for the set under operation.

2.2. Engine

The used engine of internal combustion is the "Briggs & Stratton" of 8 HP, that is similar to the engine used in current competitions SAE of Mini Baja. The only difference between them is its nominal rated power, that is 10 HP.

2.3. The CVT

The used CVT is of the type expansive pulley, model COMET 780, as indicated in "4 Fig." and "Fig 5". CVTs worked based balance between dynamical demands(rotation and torque) of output device and dynamical input taken from an engine through a set of expandable pulleys linked by a special rubber belt. The expansions of the pulleys are operated by centrifugal forces acting on internal masses and determine continuously variable transmission relations based on changing contact arches. The movement to open and to close the pulleys, due to the constant length of the rubber belt, provides infinite relations of transmission between the engine and primary axle, inside of the characteristic limits of the CVT. Further technical details can be found in [5].

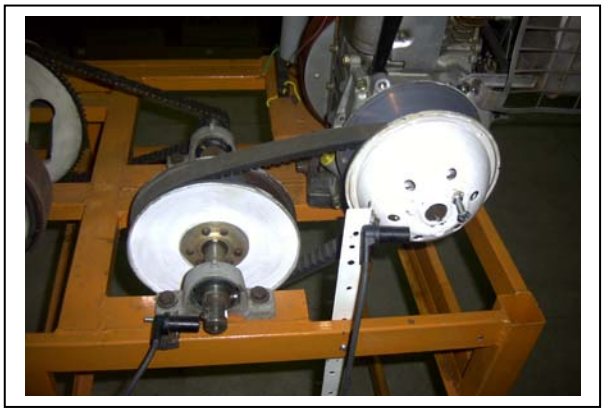

Figure 4. Set CVT mounted in the Tests Bench

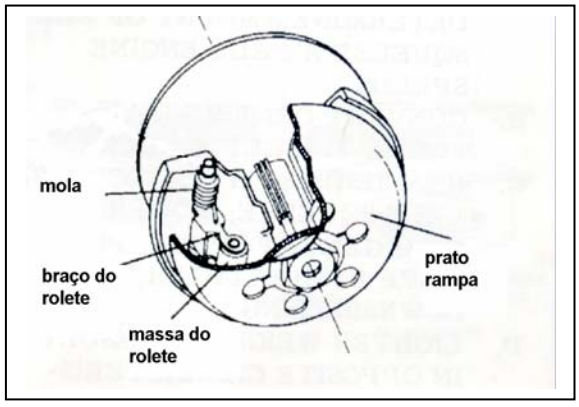

Figure 5. Detail of the motor pulley of the CVT

2.4. Fixed Reduction

It is composed of two teethed wheels (crown and nut) and roller chain and provides a fixed relation 6.33/1 of transmission. It is used to increase the available torque in the transmission system and allow a secure and smooth method to enhance load imposition to the system.

2.5. Load Imposition System

The system used is brake of brace set type. The load is applied turning clockwise the screw that pulls the brake system. There is a load cell linked to the brace used to measure the applied resistive load to the system, as represented in Fig. 6". "Figure 7" shows the detail of the load application to the system through the manual operation screw.

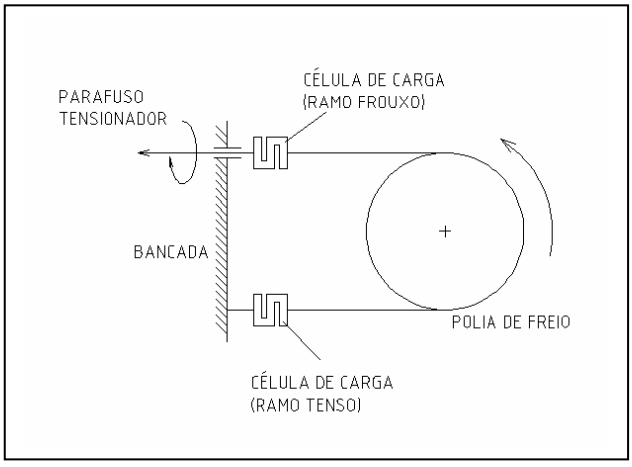

Figure 6. Schematical representation of the Load Imposition System

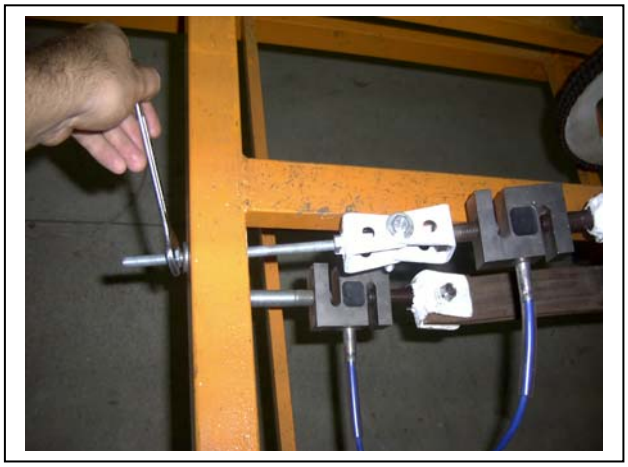

Figure 7. Motion of the Load Imposition System

2.6. Instrumentation

The instrumentation system was installed to measure torque and angular speed. The system is composed basically for:

- 01 Pentium 200 MHz Micro computer
- 01 Converter A/D
- 02 Load Cells “ S ” type of 1000 kgf
- 02 Speed sensors of hall-effect, commercial model

Two load cells "S" type of 1000 kgf capacity, with sensitivity of 2 mV/V, settled had been used to the brake brace, for measurement of force and two sensors Hall-effect, to read of the angular speed in each axle. The four instruments are on to a converter A/D and this to a Pentium 200 MHz micro computer, where the commercial program Aqdados Version 5 is installed, for acquisition of data, as "Fig. 6". The measured force is converted mathematically into torque by means of the equation (2), second Albuquerque,1974. The rotation sensors inform the frequency in Hz of each axle, that are converted into rotations per minute.

$$P_1 = P_2 \cdot e^{f \cdot \theta} \tag{1}$$

$$T = (P_1 - P_2) \cdot \frac{D}{2} \tag{2}$$

where:

P_1 – Force in the flabby branch of the leather strap (N)

P_2 – Force in the tense branch of the leather strap (N)

f – Frictional factor between pulley and the brake brace

θ – Angle of envelopment (rad)

D – Diameter of the pulley of brake (m)

T – Torque applied in the wheel (Nm)

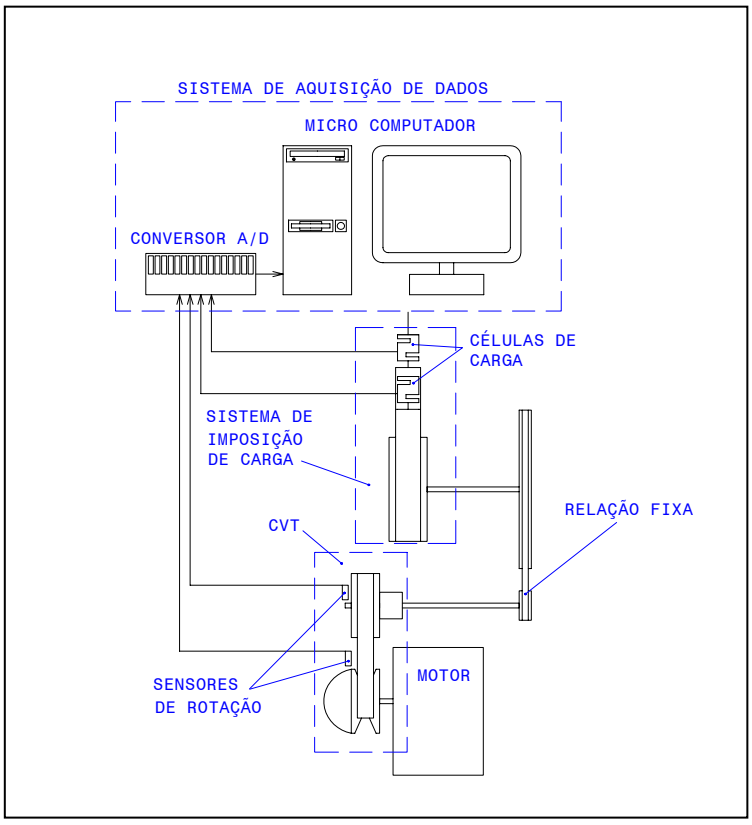

Figure 8. Instrumentation Applied to the Tests Bench

3. Experimental procedure

The procedure adopted for the accomplishment of the experimental assays aimed to study the behavior of the relation of transmission of the CVT function of the angular speed of the engine and the resistive load tax to the system.

The goal is to simulate, by means of experimental procedure, real interest situations of CVT behavior, as for example, slope ascent and drag test during SAE Mini Baja competition.

The procedure consists of applying load gradients to the system, through the device of load imposition for particular speed values of the engine axle. A characteristic curve of CVT set is obtained experimentally as function of engine rotation and resistive torque tax applied to the system. Calculations of resistive torque used equations (1) and (2), second Albuquerque, 1974. However, it is important to point out that, according to Nobrega, 2004, small variations of the factor of attrition between the pulley and the brace of brake *(f)* or the angle of envelopment *(θ)*, can significantly influence the value of the calculated torque.

4. Conclusion and Future Works

The preliminary assays had been conducted and the results are under analysis. In Figures 9, 10 and 11 is showed an example of the data aquisited in such assays. In this event the relation of transmission of the CVT appears as function of the load imposed to the system and the engine rotation, obtained second Albuquerque,2003, Nobrega, 2004 and Rosenberg et al, 1983. The dynamic behavior is currently under analyses for a large range of applied loads against several engine rotations and the authors intend to compare these numbers with real engine HP versus rotation curve. This will support the development of other numerical simulations and bond graph models for best understanding of CVT. In teaching context the next step is to organize didactical documentation to adopt these well studied procedures as part of formal disciplines context. In Mini Baja project it is necessary to prepare other experiments customized for real prototype demands and design. The concept of the bench itself must be improved with with lesser uncertainty added to the system of instrumentation of the Tests Bench. An idea is a torque sensor, substituting the indirect attainment of exactly through the load cells. The results can be used in Matlab program type for simulation of special interest. The influence on Mini Baja performance of relative sliding between the belt and range of rotation and torque of CVT is, certainly, of real interest. In literature are some works, as in Chen, 1996, WHERE EXPERIMENTAL TESTS WERE CONDUCTED, HOWEVER, WITHOUT EXPRESSING THE TRANSMISSION RELATION AS FUNCTION OF THE ROTATION OF THE ENGINE AND THE APPLIED RESISTIVE TORQUE.

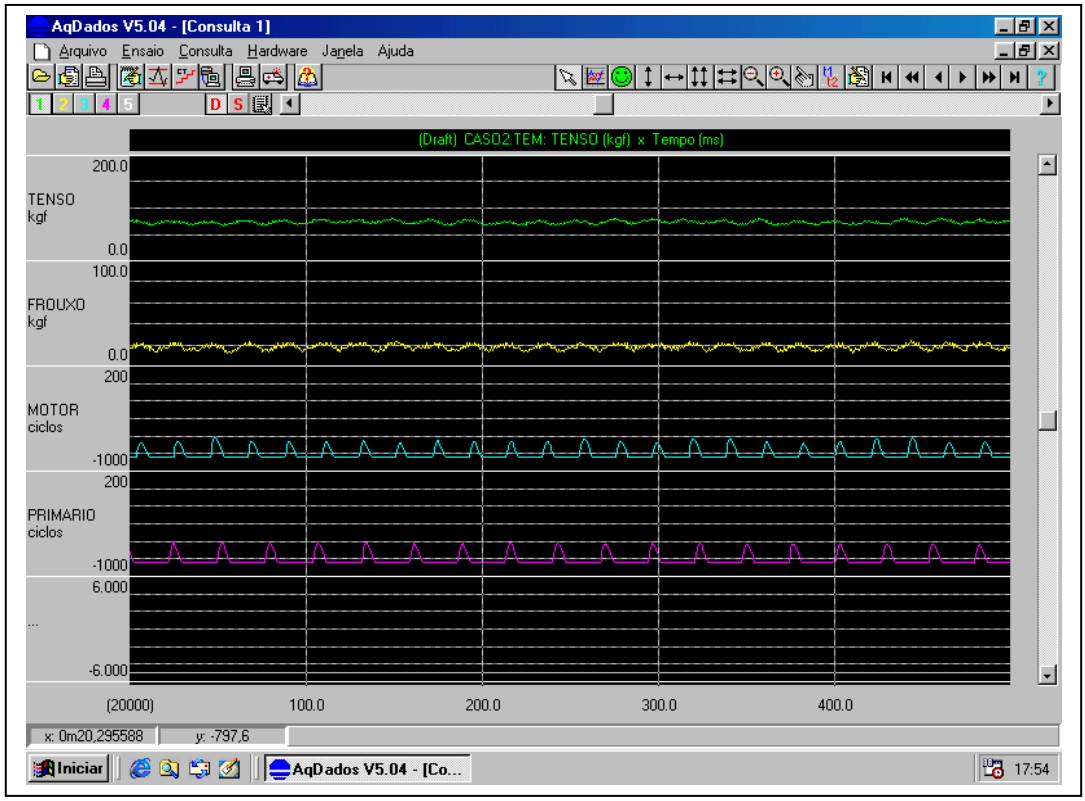

Figure 9. Screen of the program of acquisition of data

instante	tempo (s)			torque (N.m)	relação de transmissão	rotação do motor (rpm)	carga		frequência Motor (Hz)	frequência primário(Hz)
							ramo tenso (N)	ramo frouxo (N)		
1	0	a	1	5,00	0,44	2160	61	13	36	16
2	1	a	2	4,94	0,49	2100	61	13	35	17
3	2	a	3	5,40	0,47	2160	60	8	36	17
4	3	a	4	5,53	0,46	2100	62	8	35	16
5	4	a	5	5,55	0,47	2160	62	8	36	17
6	5	a	6	5,63	0,47	2160	64	10	36	17
7	6	a	7	5,15	0,49	2100	64	14	35	17
8	7	a	8	5,63	0,46	2100	63	9	35	16
9	8	a	9	5,64	0,46	2100	64	10	35	16
10	9	a	10	5,72	0,44	2160	65	10	36	16
	média			5,42	0,46	2130				
	desv. padrão			0,29	0,02	31,62				

Figure 10. Extracted spread sheet of data of the program of acquisition of data

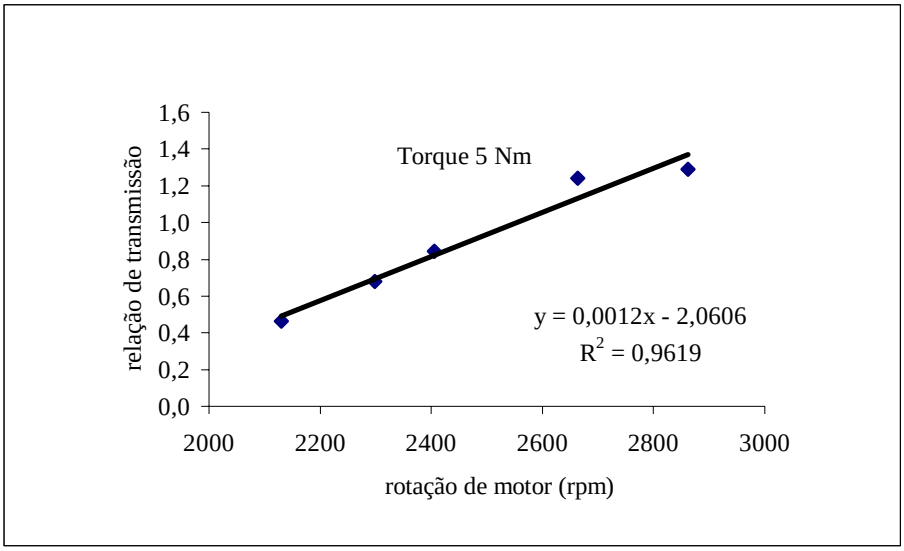

Figure 11. Graphical relation of transmission versus rpm

6. Bibliography

Albuquerque, A. A., “Caracterização das Respostas Dinâmicas de uma CVT com Polias Expansivas”. 2003. Dissertação (Engenharia Mecânica) - Universidade Estadual de Campinas. São Paulo. Brasil.

Albuquerque, O. A. l. p., “Dinâmica das Máquinas”, McGRAW-HILL.1974.

Chen, T.F., Lee, D.W., Sung, C.K., “An Experimental Study on Transmission Efficiency of a Rubber V-Belt CVT”. Mechanism and Machine Theory.1996.

Forti, A. W., “Estudo Teórico Experimental de Parâmetros de Projeto de uma Transmissão Continuamente Variável Tipo Esfera-Cone.”, 2003. Tese de Doutorado (Engenharia Mecânica) - Universidade Estadual de Campinas, São Paulo, Brasil.

Nobrega, M.J.R., “Modelagem, Simulação e Análise Experimental de um Sistema de Transmissão com CVT”. 2004. Dissertação (Mestrado em Tecnologia) – Centro Federal de Educação Tecnológica –Celso Suckow da Fonseca. Rio de Janeiro. Brasil.

Rosenberg, R.C. & Karnopp, D.C., “Introduction to Physical Dynamics”, McGraw Hill,1983.

6. Responsibility notice

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