A DIGITAL PROTOTYPING EXPERIENCE IN THE ENGINEERING COURSES

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Abstract. *The traditional manufacturing engineering concept of the products is being substituted due to new equipments and technologies available at the market. The digital prototyping has allowed to execute expensive or impossible tests in laboratory. Engineers or planners can handle parts or assemblies virtually and to observe the interference, collisions and contacts. Also, it is possible to observe effects of forces, connections and joints. The main advantages of the digital prototyping are: the easiness in the building of a digital prototype, the time reduction and costs decreasing. The Computational Graphy has incomparable advantages in relationship to the traditional drawing. It provoked the restructuring need in the teaching drawing (contents and methodologies) of several universities. Thus, to the better performance of the engineering students for the industrial reality. CAD and CAE techniques (prototyping) were applied in discipline of the engineering course. Equipments were modeled with the help of CAD software and simulate through the finite elements method. Then, in this work it was approached and this aspect was discussed, aiming at to contribute for the drawing teaching modernization with the graphic computation integration and the using of the new technologies in the formation of best professional.*

Keywords*: Digital prototyping, Modeling/simulation, Teaching methodology*

1. INTRODUCTION

In recent years, the competition intensification allied to the complexity increasing of the manufactured products, has demanded of the companies substantial alterations in the Products Development Process (PDP), to aim to reduce the development total time, together with increase of quality and competitiveness. These alterations involve many aspects of the development process management, as well as the computational work with new techniques and project tools, analysis, simulation and optimization of the manufactured components. Many times, the commercial guarantee of success of a product is associated with the ability of the company in identifying the necessities of the customers and immediately to develop products that take care of satisfactorily to these necessities. Amongst all the involved activities in the PDP, the use of physical model it is essential to improve the communication among the involved ones in the process, as well as to reduce the imperfections possibility and to improve the product quality.

The beginning of the manufacturing process called Fast Prototyping and some important events that they had preceded its appearment and some its possible applications and a more detailed description of the existing technologies, processes could be meet in work of Ahrens *et. al.* (2007).

2. MANUFACTURING FAST PROTOTYPING PROCESS

The manufacturing main mechanical processes normally have principles derived from the Fusing and posterior molding of the material (e.g. several types of metal casting in permanent mold or not, molding for plastic injection, etc.), of the material removal, until it arrives at the desired shape (tilting, milling machine, hurricane, rectify, electro erosion, machining, chemistry, electrochemical, etc.), of the forming that generate the final geometry of the part from the plastic strain of the initial material (e.g. plate forging, forming and stamping, drawing, rolling, powder metallurgy, among others), and of material addition (e.g. welding, brazing, glue, among others -that they can promote the junction of simpler parts to compose a more complex part). This last group also includes manufacturing process of parts in fiber glass, where it occurs the addition of successive layers of glass fibers and resins on a mold. More recently, in the end of the decade of 80, a new process was developed also based in the addition of material, but with the difference of this being in layers plain. A great differential of this in relation to the too much processes of addition is the easiness of its automatization, excusing molds and tools, minimizing considerably the operator intervention during the process. This was reached; therefore the same uses the geometric information of the part to be manufactured directly of CAD *(Computer Aided Design)* system for the process planning that occurs of sufficiently automatized form. The generated information is sent directly to the machine that, a prepared time, executes the work without assistance of an operator.

Due to the fact of the conception of this manufacturing process to have been applied initially in the fast production of parts aiming at a first materialization of idea (prototype), without many requirements in terms then resistance and precision, this same were called of Fast Prototyping. Although some authors to have suggested other names, such technical perhaps more appropriate *Layer Manufacturing, Solid Freeform Fabrication, Desktop Manufacturing, Material Incress Manufacturing,* the original name has prevailed[1,2,3]. This denomination persists currently, exactly after the processes having been improved the point of some to be able to be used for the manufacture of parts for use in final products. It perhaps Fast the Prototyping name is incoherence and it represents not more the important manufacturing process. Although it is not considered most appropriate, this original name was kept; therefore it became popularly most accepted.

Due to importance and to the potentiality, that it derives from the great economy in manufacturing time and the capacity to manufacture complex geometries, the appearance of the LP can be considered a landmark in terms of manufacture technologies. Ahrens *et. al*. (2007).

2.1 Principle of the fast prototyping

The prototype of a product or essential component is part in its development process, therefore it makes possible that the analysis of its shape and of the features are made in a previous step before to the definitive production of tool rack.

Historically, the physical representations of the products (or simply prototypes) come being used since the antiquity, and they evolve of manuals, still sufficiently used, for virtual prototypes in years 80th, with the popularization of three-dimensional CAD systems, and more recently with the fast prototypes.

The LP can be defined as a process of manufacture through the addition of material in form of successive plain layers, that is, based in the beginning of the manufacture for layer, as illustrated in Fig. 1.

The fast prototyping technology: it allows to manufacture components directly (prototypes, models, etc.) physicists in 3 dimensions (3D), with gotten information of the generated geometric model in CAD system, of fast form, automatized and total flexible.

The process initiates e1ectronicaly with the 3D model of the part in “the sliced” CAD being, getting curves of levels 2D that they will define, in each layer, where it exists or not material to be added.

The processed layers will be sequentially processed generating it physical part through the piling up and tack of the same ones, initiating in the base and going until the top of the same one.

Practical implementations of the manufacture for layers for the current necessities of manufacturing had been overcome possible, due to integration of traditional manufacturing processes, such as the more recent drawing, powder metallurgy, weld and usinagem CNC, diverse the other accessory technologies, such as controls of high precision movement, new materials, DeskJet printing systems, laser technologies, among others.

Truly the interactions are the base of the diverse fast prototyping systems available currently in the market. Ahrens *et. al*. (2007).

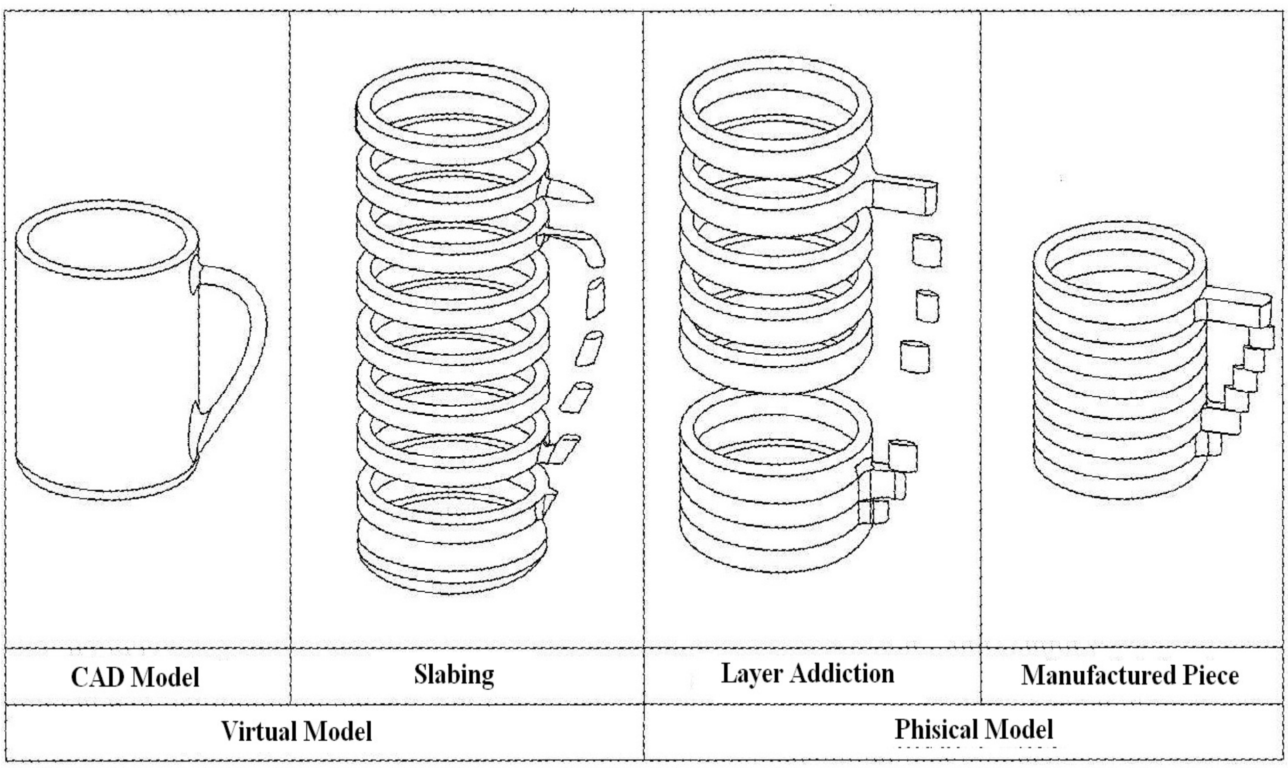

Figure 1. Representation of main steps of the manufacturing for layer process

2.2. Manufacturing engineering project

All manufacturing engineering project of products requires a step where it showed the components shape. The engineer, in this step, need to create a piece geometric model. This geometric model represented by Descriptive Geometry, a science that emerged in the 17th century that it aims to represent at plane (2D) a shape of 3D space. Traditionally, the piece is drawn on a paper sheet with the aid of instruments as: squares, rulers and compasses (Cabral and Assis, 2008).

The development of computer and plotters (printer for technical drawing) in the 50's years, the modern solutions to view the pieces began to appear. A MIT (Massachusets Institute of Technology) pioneer project, called SKETCHPAD marks the beginning of the software development that automates the technical drawing process. These software were called CAD (Computer Aided Drawing) or computer-Aided Design. Firstly, this software was used only as a substitute for drawing table and they produced 2D drawings only, as Fig. 2. Now days, this technology can to generate a 3D model. Thus, 3D view all piece on desired angle, as Fig. 3. Then, it could to do the 3D cuts to simulate or to observe 3D details, as Fig. 4.

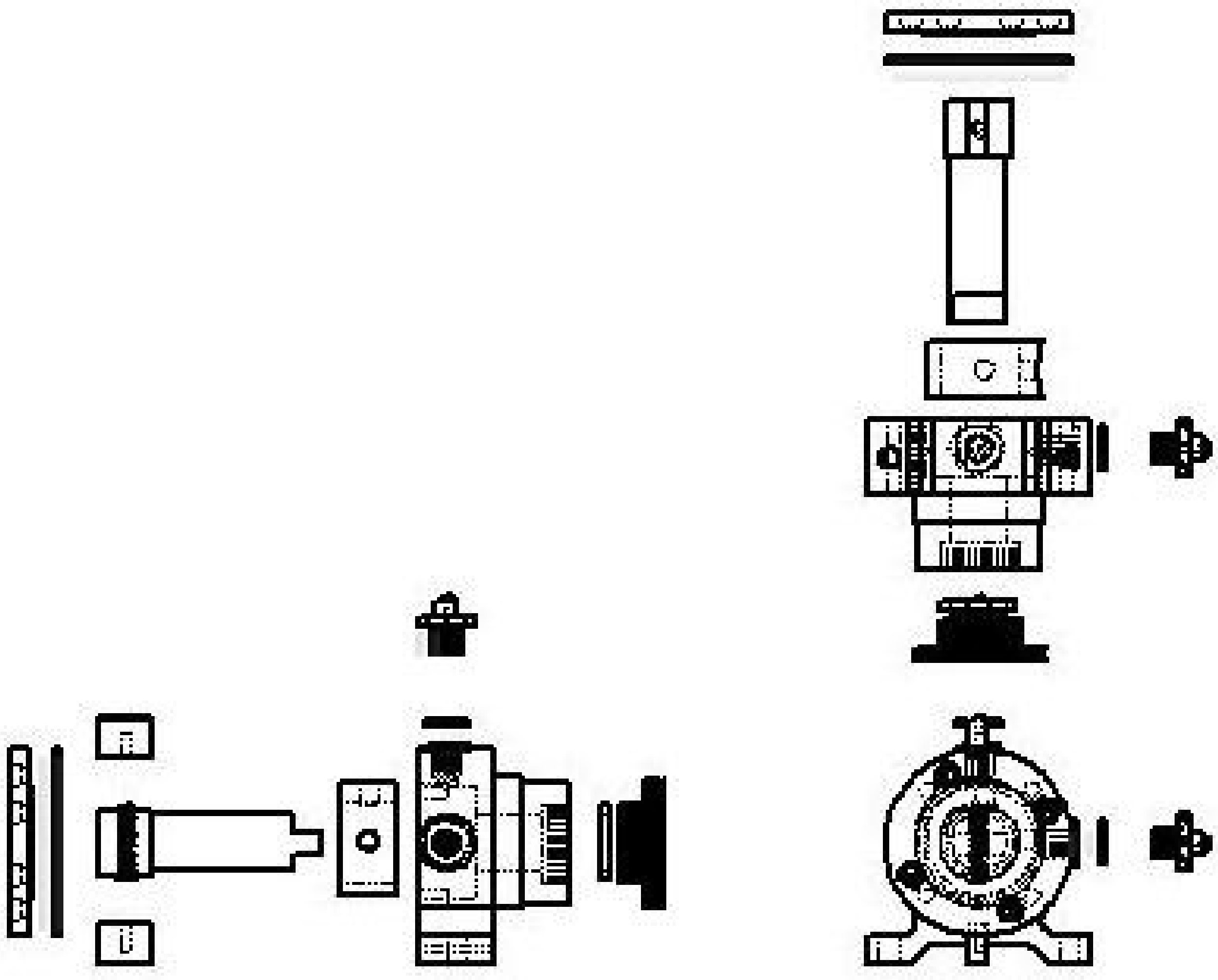

Figure 2. 2D piece set

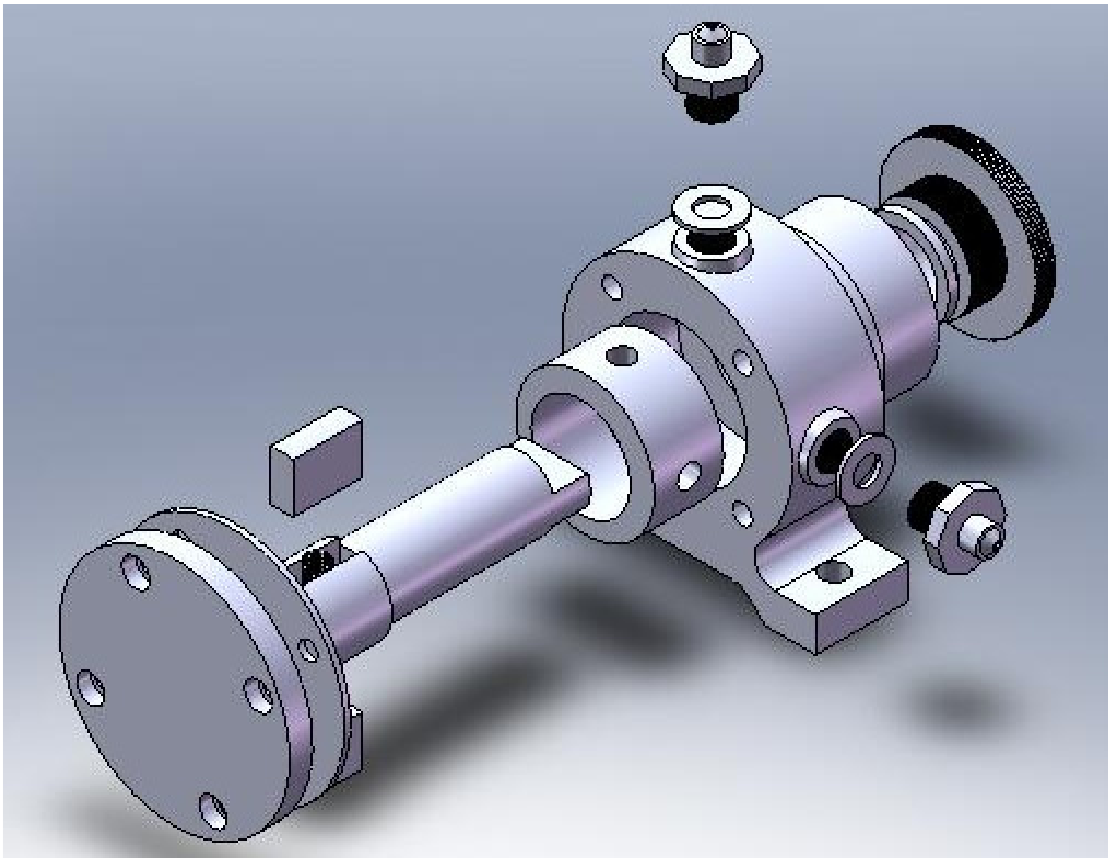

Figure 3. 3D piece set

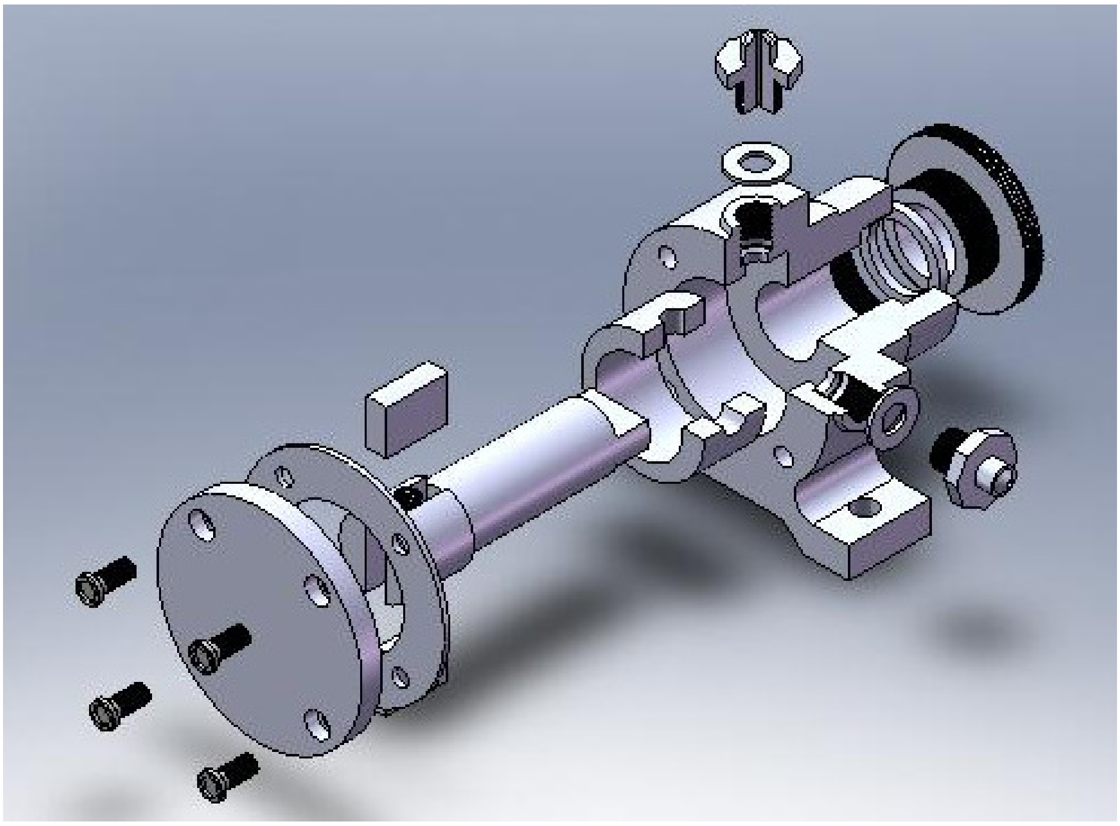

Figura 4. 3D cut in piece set

The CAD system can to store and to restore the data project quickly and it allows the quick sharing of project information among members of this. The Combining of this advantage and the observing easy of the piece with instant communication via the Internet allows a large gain in time and quality of final product (Cabral, and Assis, 2008).

The obtaining of 3D piece allowed optimizing the design. Then, from this opportunity comes a new software style, called CAE Computer Aided Engineering

3. CAD MODELLING AND CAE SIMULATION

The major advantage of the CAE software is to analyze digitally the mechanical tests results. The 3D models are constructed using the CAD technology, as Fig. 4 and then exported to the CAE software. This simulates physical phenomena, as Fig. 5, 6, 7 and 8. Several tests can be made such as stresses (Fig. 8), strains (Fig. 9), etc… The process simulation using software is very important because it avoids the conventional procedure which employs the trial and error technique. Thus time and money are saved in the product manufacturing (Ashley, 1994).

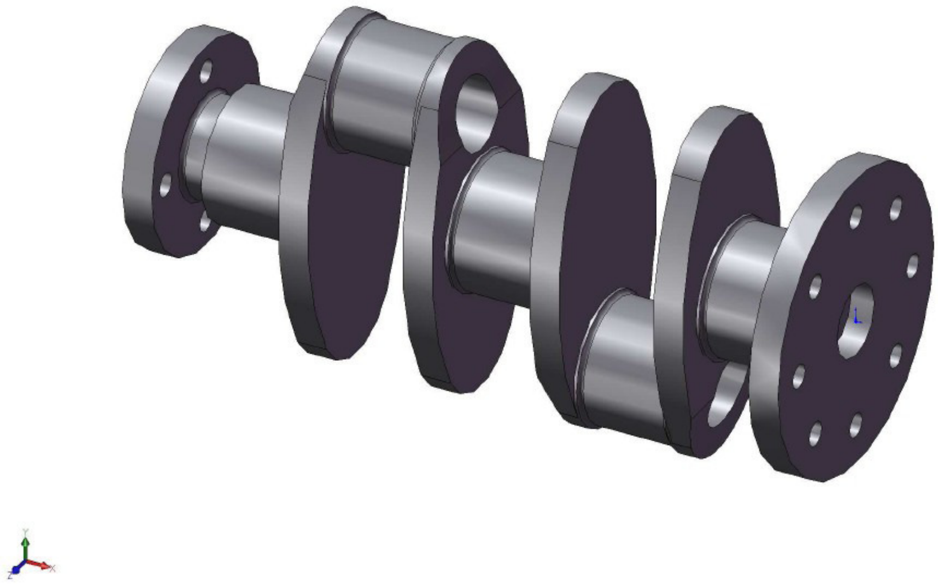

Figure 5. 3D crankshaft

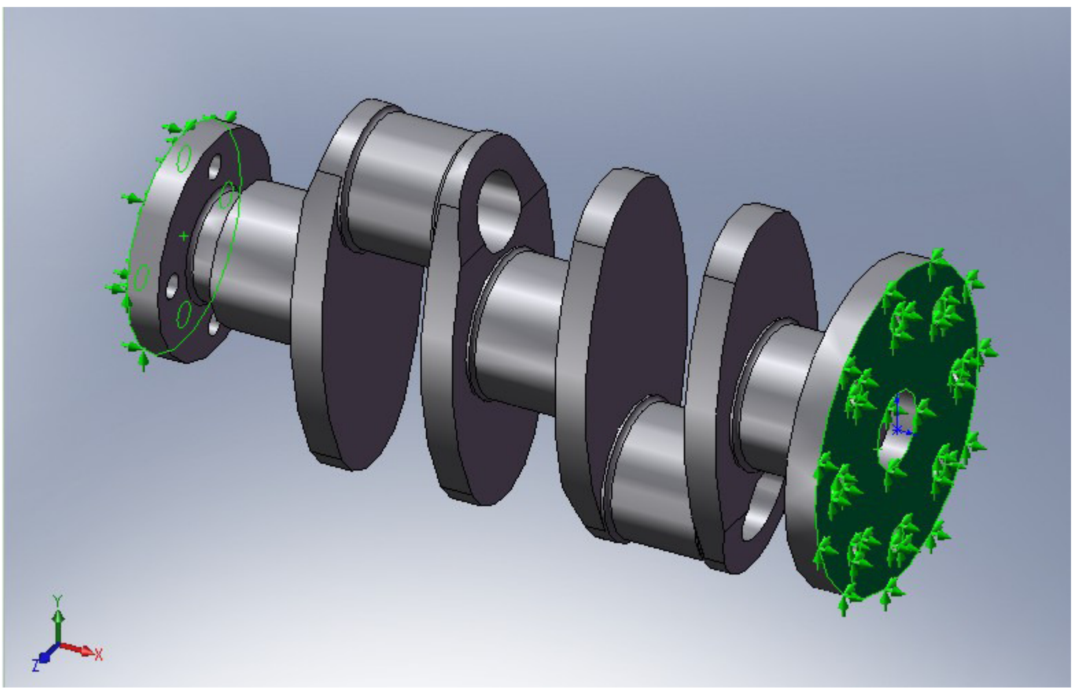

Figure 6. 3D crankshaft CAE simulation CAE (constrained points)

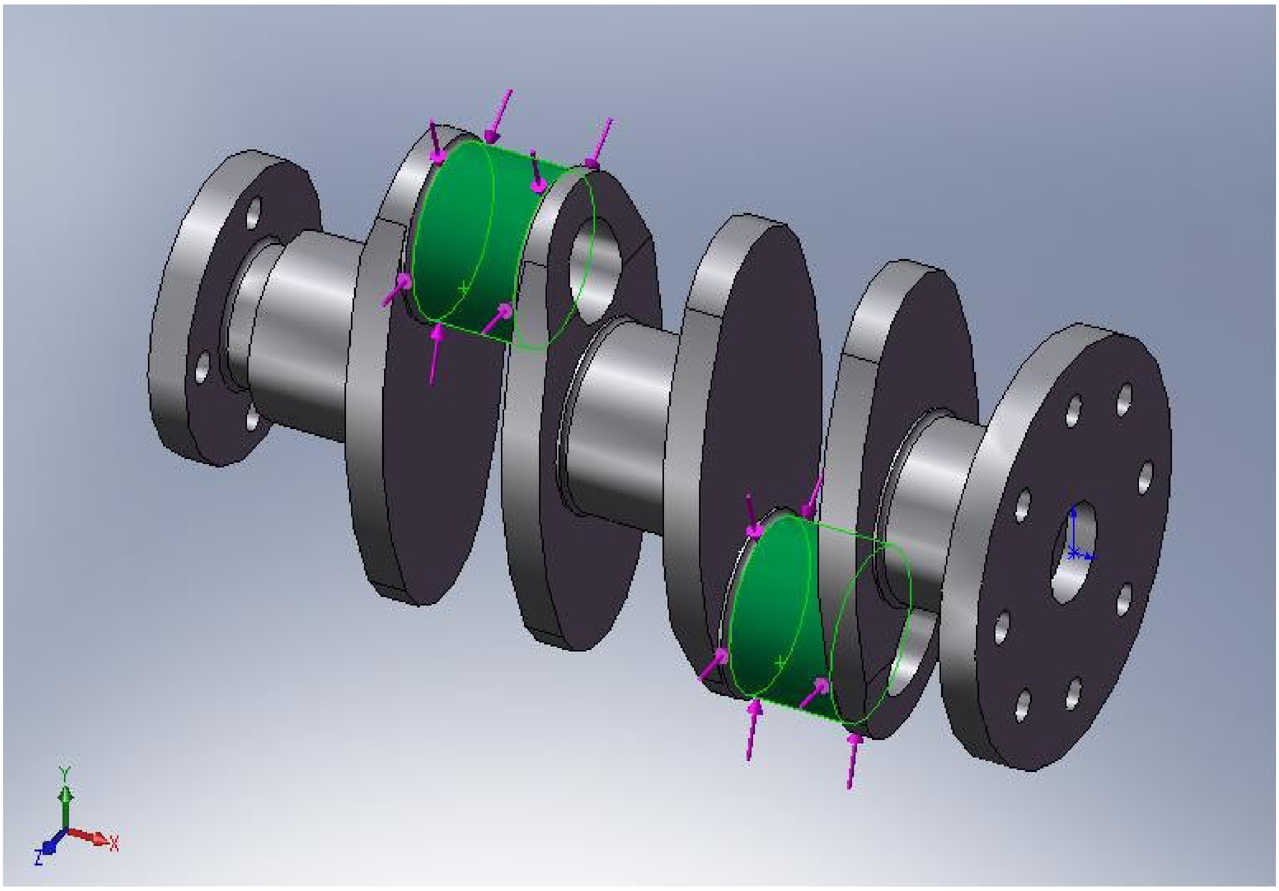

Figure 7. 3D crankshaft CAE simulation (loading application points)

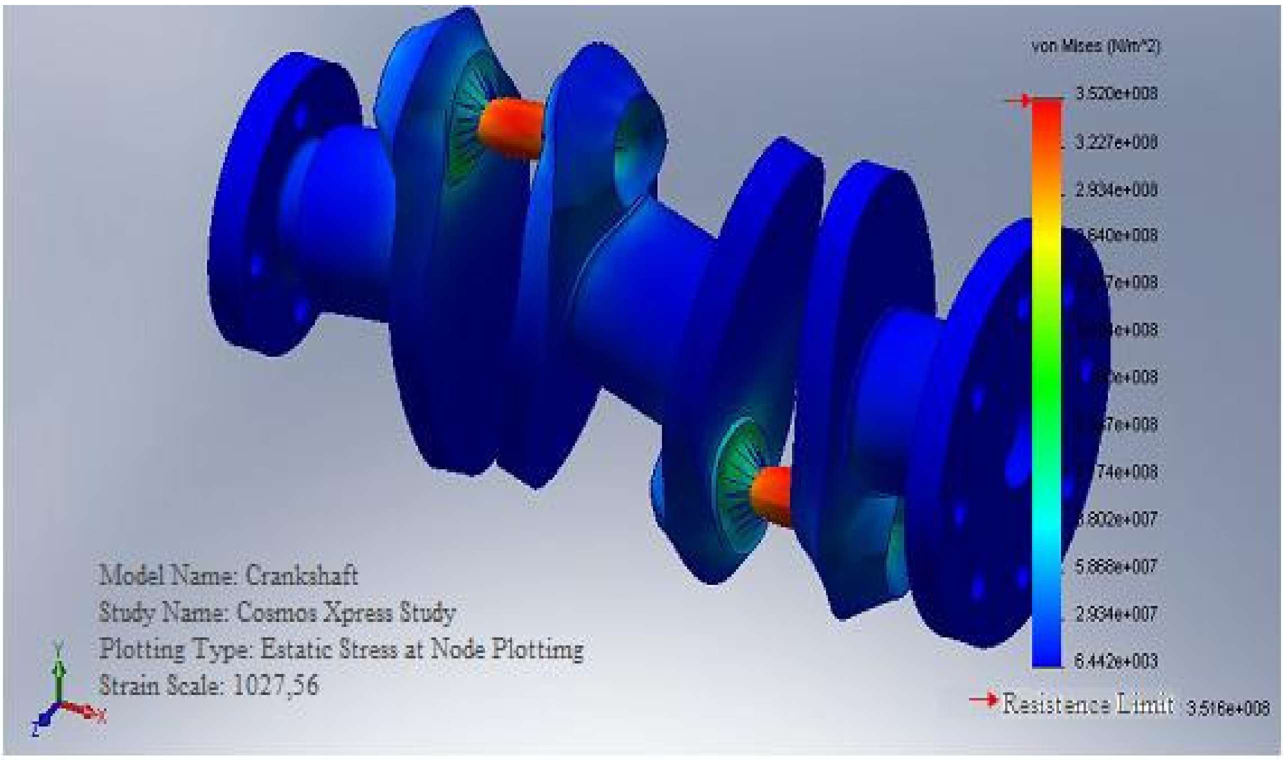

Figure 8. 3D crankshaft CAE simulation (stresses)

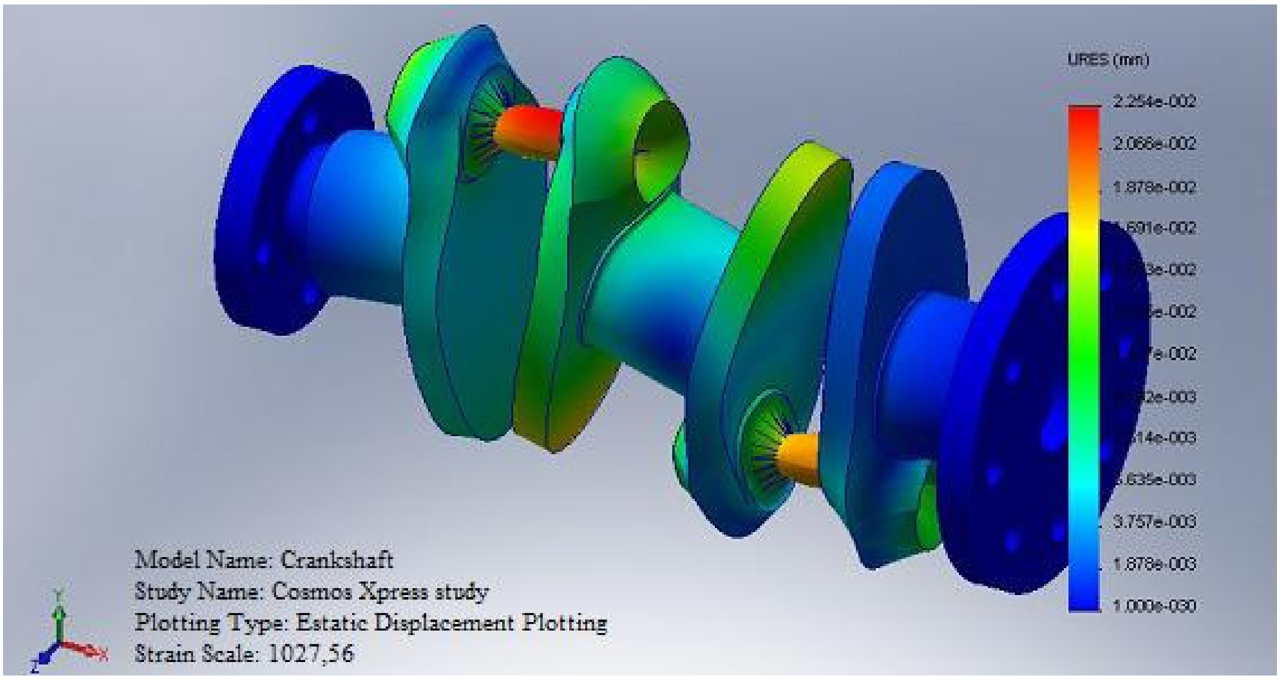

Figure 9. 3D crankshaft CAE simulation (strains)

During a particular step of the project is necessary to predict the project actual behavior. Traditionally a physical prototype is built craftsmen. The physical prototype construction requires a very expensive machinery and hand tools. It added also the loss time with revisions and corrections of the project. These are reasons tend increase the physical prototype manufacturing cost. These are reasons take the physical prototype don´t reproduce always all the features of the final product. A digital prototype is a virtual model of a particular piece or parts set built by software known as CAD. Then, the digital prototyping concept appears.

The digital prototyping allows the execution of tests that are expensive or impractical in the laboratory. Engineers and designers can handle virtually parts or assemblies have been observing collisions and contact. It is also possible to observe effects of loading, connections and joints. The ease in obtaining a prototype digital, the reducing time and the lower costs are key benefits of digital prototyping.

The increasing complexity and products diversity, companies are being pressed to develop new methods for the manufacturing process. Then, the reverse engineering concept had appeared. The reverse engineering had recreated digitally an existing project. The digital acquisition Techniques are designed to obtain data to recreate the product digitally. The contact techniques, as tip, and non contact techniques, as white light and laser are among the digital acquisition techniques. These triangulate acquired points.

4. RESULTS AND DISCUSSIONS ON THE TEACHING OF THE DIGITAL PROTOTYPING GRADUATION IN MECHANICAL ENGINEERING OF EEIMVR/UFF

In This work execution we teachers of technical drawing and digital prototyping of Fluminense Federal University of Volta Redonda and also referee of Engineering Education Symposium of COBEM 2009 together with the third author our engineering student and research beginner had presented as results examples the proceeding imagens of applications of software to show the potential of these, because is absolutely impossible to show all methodological or pedagogical process. Thus, they show the 2D and 3D drawing of a mechanical set to show as it could be to executed a work in certain project. Also it is showing the loading evolution on a crankshaft that also would be impossible if other method or another technique would be applied. Thus, we believed that they are good examples of digital prototyping applications.

The advantages of a 2D drawing in the industrial environment already is of public domain and the change for 3D drawing in the several project kind is the reality in modern world. Thus, it is common sense the need to teach drawing and digital prototyping in engineering courses. Most details about this work could be obtained with authors. On the other hand, Project is a very complex human task and spacial conception based on traditional descriptive geometry has proved to be valuable to increase mental habilities, but with advent of high technology is normal the evolution for new modeling tools as for example the software for 3D modeling in spite of the demand additional efforts from project initially.

The prototyping of digital technology transforms the way in how a product is generated, i.e., there is a big time gain and quality when this is compared to traditional procedures. Although recognized its importance, its use in academia is slow. The lack of infrastructure makes these new methodologies and technologies cannot substitute the teaching of the previous practice of project development. It results in poorly prepared students for the current reality (Forti, 2005).

There is time that the member's teachers of the graphic expression core of EEIMVR/UFF noted the need to work with software that it aids the creation and development of parts/equipment. Then, they provide not only a theoretical but also they give the student the ability to think and to create solutions, and execute them. In the hand, some teachers of EEIMVR/UFF, argue that the software is only tools, and that a designer must not only be a CAD operator, "but someone who think really, it create solutions and it make a difference in the market. The other hand the students are looking for businesses and industries are requiring more than a theoretical knowledge, and creative skill or methodology, but an experience in at least two or three different software in the kind of prototyping.

The reasons for less favorable to teachers can offer classes in software "that are just tools" lost the power, if it analyzed the question that in grade curriculum have design practical disciplines and it had demonstrated its importance for the complementation of the future professional engineer. It is through these disciplines that students learn to master tools and techniques needed to express their ideas, concepts and projects. A general rule in the using of CAD modeling and CAE simulation software: the student is encouraged to think as a professional dedicated to the machining practice, since many projects of parts in 3D require that their designers quite understand of machining for that the piece is been constructed in 3D as faithful to reality, Thus, it forces the student can develop the ability to think and create solutions.

The inability to teach the students the latest generation software, i.e., technologically advanced, it is due to there is a lack of academic adaptability of the technological developments and needs of industries. The acquisition of a new generation of software for academic using is very expensive for the university and this only occurs, when, through the commitment of teachers who submit research projects for promotion institutions as the of FAPERJ, CNPq, etc..

The fact is that the industry is very selective in recruitment of its practitioners, because it needs to be competitive. Thus, the students who do not acquire a good education to the reality within the classroom, they will tried doing through so-called "complementary courses" outside the academic environment, where the features of the software are presented, without the deep commitment to develop the ability to express in graphical form, i.e., the future engineers must will designers and they will only drawiners.

The low use of students in some disciplines, for example, machine design is due in part to the distance between the reality of the market and topics proposed by the university. There was a significant improvement in the performance of students who studied machine design after a discipline involving CAD/CAE was introduced in grade curriculum between basic design and machines design.

Now days, the Federal Government tries to reduce the rates of the use of public universities students and it improve the use of newly undergraduate professionals and a greater contribution to the preparation of investment professionals dedicated to new technologies, and a greater investment in facilities and software will cause many students now leave public universities due to the large technological gap between university and industries. These students can go to the private universities, where this technological step had been minimized hardly.

5. CONCLUSIONS AND COMMENTS

The CAD modeling is the step of the virtual prototyping where the designer interacts more with the project and it is now considered an essential tool for work in industries where it work with the product design, vehicles assembler, for example, due to the advantages for the project modification without time loss time. Thus, when the CAD modeling step is completed, it started the step CAE simulation for a more complete analysis by the engineer's team, i.e. check whether the project is appropriately sized in terms of effort, for example. When the steps are completed CAD and CAE, then, it will begin the CAM step in which the virtual model is transformed into real object. This last step, CAM has not yet been the subject of studies in this university.

The digital prototyping is a no return path, since it allows the costs involved in a particular product project, from its conception to its implementation, are drastically reduced. The university must have the sensitivity to understand the enormous difference existing between the professional undergraduate in its facilities and the professional that the industry really needs. Thus, the universities could to provide the necessary curriculum changes. It must remember that knowledge is dynamic; the university also needs to be.

The implementation of the CAD modeling and CAE simulation discipline in the graduate course in mechanical engineering, although optional, has a significant improvement in the machines design course in terms of receptivity by the students, because there is not the need to design using the drawing traditional tools, which is tiring, as the class has become more dynamic, including even new themes.

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