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CAD/CAM SOFTWARE ANALYSIS: COMPARISON, PERFORMANCE AND APPLICATION IN A MANUFACTURING PROCESS

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Abstract. *This paper aims to analyze programs aided by computer used to design three – dimensional models (3D) and manufacturing process, namely, respectively, Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM). It is intended to make a market overview of the programs and its characteristics. After the second half of the last century, companies developed their services linearly until the product reaches the final customer without interaction among both parts during the manufacturing process. Currently international competition and shorter delivery times make the customer participates in the decision of manufacturing process. CAD and CAM software assist this process because effectively they permit you to plan the design and manufacturing process of the part, avoiding errors and waste of material, allowing the conclusion part in a shorter time. A few years ago, the decision to invest in a CAM system for machine programming took into account only the technical resources linked to production. Now it is necessary to verify the capacity of CAM integration with the other sectors of the company, such as the Sales and Engineering that use CAD programs; this joint work is important because parts that have already been designed in 3D do not need to be redesigned and the system itself must be able to plan and prepare the part to be machined automatically. The integration of the program with the commercial sector allows the company to generation of budgets more accurate and avoiding lost deals by overbilling, as avoiding inventory, controlling the input and output of materials. Another significant advantage is the possibility of visualizing the finished product in digital format and to simulate its manufacturing virtually being possible to make any correction if necessary. Using simulation and analysis systems for product validation is a way to avoid errors and problems in the part in later steps*.

Keywords: *CAD, CAM, design, manufacturing, simulation.*

1. INTRODUCTION

In recent decades, the growing demand for industrial production has brought strategic issues of competitiveness, healthy and sustainability. The process of globalization has brought strong dynamics of competitiveness in several sectors. In the industrial sector, an induction to major transformations is encouraged, which have forced the companies to seek more innovations and researches to improve high aggregate quality, reduction of production costs, elevated productiveness, society satisfaction and sustainability (Slack,2002). The need of more implements to new technologies has generated the industrial development on several sectors of products. The CAD/CAM systems has been turned a suitable tendency to higher production and enhance of accuracy required in certain areas. The industries, mainly the automotive, aeronautical, ceramic, aesthetics restorations and prosthetic, have developed many products through of the application of the CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing) systems. In many cases, the product design processes are developed through three-dimensional geometric models, which enable the observation of all characteristics and avoid the possible errors during the manufacture process of several products (Xiao *et al*, 2015, Faust *et al*, 2017). However, there are the problems of expertise and maintaining of the healthy skills for utilization of the automated manufacturing procedures.

The Computer-Aided Design and Manufacturing is a technology that encompasses graphic design, manipulation of databases for design and manufacturing, numerical control of machine tools, robotics and computer vision. The combination of these tools allows the transfer of design information to product manufacturing planning without the need to retype product geometry data. In machining operations, an important feature of CAD'/CAM is its ability to generate the toolpath for various operations such as turning (Culler and Burd, 2017). The several possibilities, sectors of utilization and low cost to operation, the CAD/CAM software have represented the best choice to technical education

institutions and universities. According to the implementation of the National University of Singapore, CAD/CAM programs is presented for engineering courses to the developing of specific projects and new software packages, as such as the building of interfaces to existing packages. This direct experience has been considered necessary to synchronize with the local industries. Therefore, CAD/CAM programs have indicated the reliability and precision of the projects, for example with the rapid prototyping technology (Nee and Hang, 1989).

Similarly, CAD/CAM techniques have advanced for several manufacturing industries to develop profile cutting, form sculpting, routing and molding. The migration between CAD programs, such as SolidEdge, SolidWorks, Inventor, Cobalt, AutoCad and others have occurred to provide the cost reduction with licenses and adapt the interface of the software with the manufacture process. Equally, the CAM systems have been chosen by license cost and interaction with the manufacturing processes. Therefore, the managing of projects and manufactures developed through the CAD/CAM systems can provide upper production reliability, higher productivity, decreasing of waste, loss of materials, and lower cost in the industrial process.

The programs for numerical control of the machines are generated by system and can be modified by responsible programmer of optimization of the manufacture operations of products and material, which demand of high precision. The CAD / CAM systems allow the coding and classification of parts in groups of similar formats using alphanumeric codes. The introduction of these two systems can improve the major impact to manufacture with appropriated results. In the industries, the standardization of the product developed and the reduction of hours spent on project representation of the increase and the gain on productivity, further on cost reductions. The economy of materials by use of these software systems is very elevated, when compared to manual programming. One other attractive is the capacity of programming by individuals less the experience of the expert programmer. Therefore, the speed and agility that software brings is unmatched by human capabilities (Schaeffer *et al*., 2012).

In example, the field of dentistry, many researches have demonstrated that the CAD/CAM is the way of producing and placing the restorations with the chair-side CAD/CAM is better than restorations made by conventional laboratory (Baroudi and Ibraheem, 2015). Similar results were achieved to Griffit *et al*.2012, which investigated open platforms to improve global production of modular systems and fundamental building manufacturing systems for global applications. According to the authors, the system was efficient primarily for the construction of buildings using moldable composite materials for housing developments in urban and rural regions in developing countries. According to several researchers and industrial managers, the CAD/CAM tools can mean the elevation of the productivity, quality and efficiency to the projects that need precise characteristics less the material loss in large amounts.

This study had the objective to investigate the performance and application in manufacturing process of CAD/CAM systems during the management of the production of specimens with high precision with lower loss of materials.

2. METHODOLOGY

Simulation process can be developed through the modeled product of a specific operation in order to determine the availability of the process, improving or increasing its performance. Simulation process can also model different processes and their interactions helping process planners and designers in defining the layout of machines and resources. Some specific manufacturing processes can be modeled with Finite Element Analysis (FEA). The simulation of a multi-process and equipment manufacturing system helps factory engineers to organize machines and identify critical points in the process.

CAD/CAM Costs

A survey of the operational costs of leading CAD / CAM software suppliers has been carried out, enabling several companies acquire the appropriate software for interest purposes, however a cost benefit assessment is required for the associated price. The Figure 1 shows the prices from CAD software licenses ranging from $1.200,00 to $5.600,00. Some of the companies shown in Figure 1 provide special free licenses to students or with the reduced prices; the main goal is promoting the learning and disseminates the respective programs. It is important to note that student versions only provide basic versions of the programs and are not useful for professional use. The Figure 2 indicates the manufacturing software prices, the prices range from $3.000,00 to $6.700,00. CAM software do not have student license.

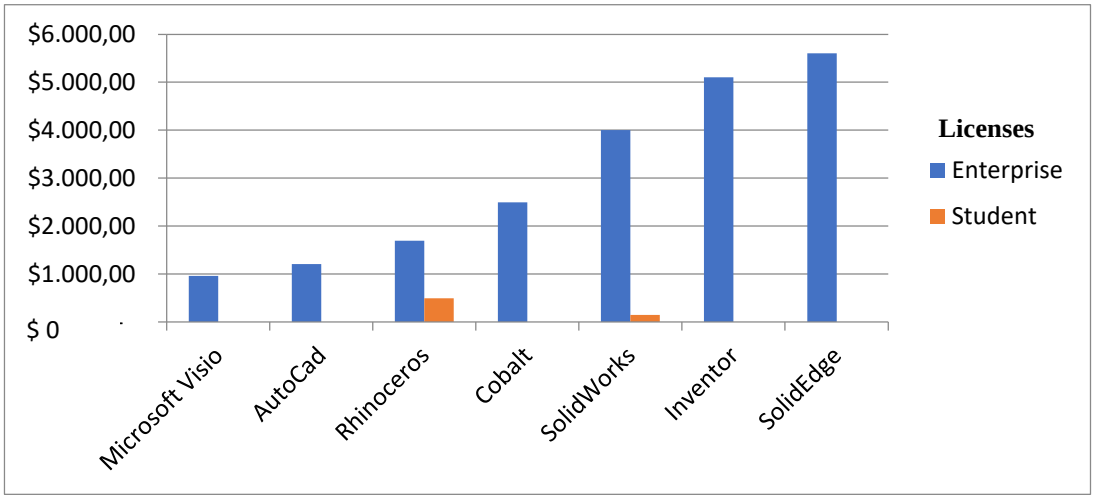

Figure 1 – CAD software costs chart.

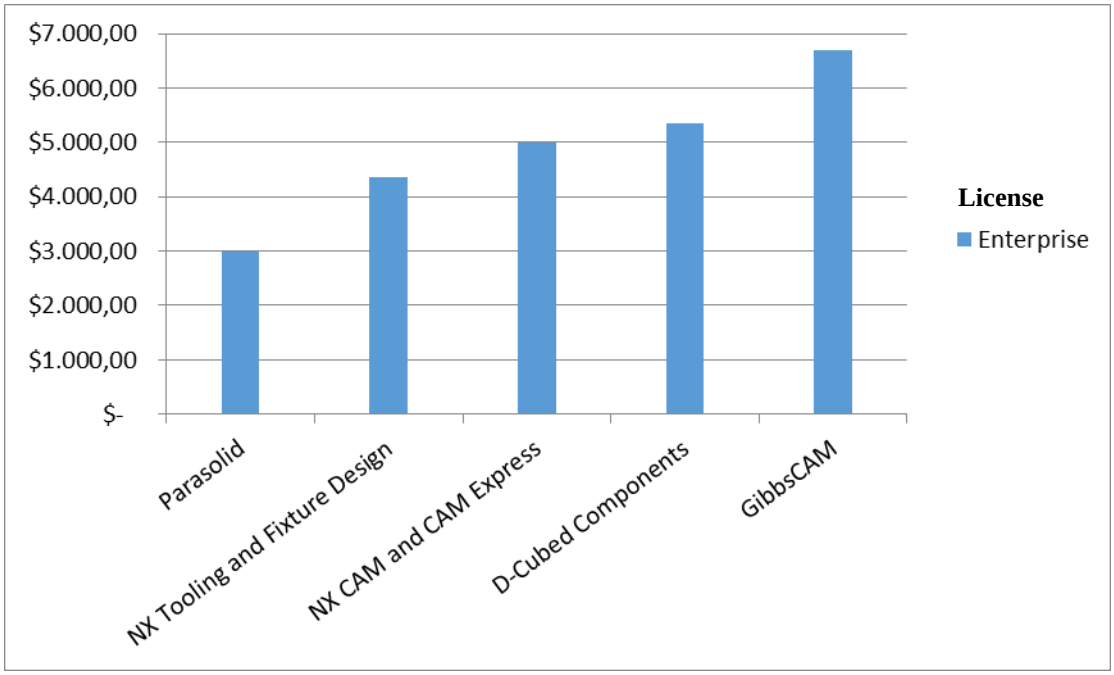

Figure 2 –CAM software costs chart.

2.1 CAM Aplication

One kind of application was performed using the CAM software as shown in Figure 3. The part used in the example encompasses several types of machining operations. The concepts of economic conditions of machining were applied with the purpose of the adjusting parameters and improving of the manufacture optimization. CAM mechanics are one of the most popular systems to generate irregular surfaces, which are widely used in automatic equipment, such as textile machines, internal combustion engines, and other kind of automatic devices. The development of adequate CAD/CAM systems permit a manufacture with high precision of products fabricated for the cam profile CNC grinding machines. Consequently, obtaining of an optimal grinding speed with a constant surface roughness. Generally, projects are manufactured through algorithms and procedures to better effectiveness of the developed CAD/CAM system (Lim *et al.*, 2011).

Figure 3 - Part that will be simulated in CAM software.

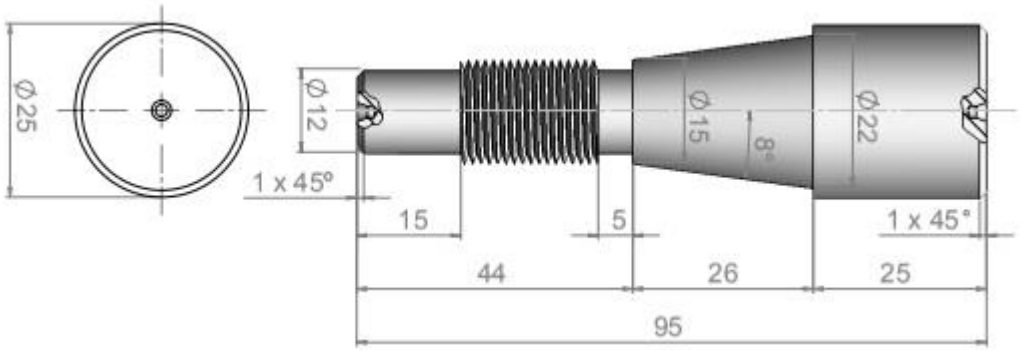

Figure 4 – Part dimensions that will be simulated in CAM software.

The first economic studies on the machining were made by Taylor in the USA and by Schlesinger in Germany at the beginning of the 20th century (Ferraresi,2006). The machining parameters are chosen according to the capacity and limitation of the process, such as geometry, roughing operation, workpiece finishing operation and machine / tool system conditions. The concepts of machining time, speed and machining interval are fundamental in the economics of the manufacturing process.

Machining Time:

In order to determine the conditions of lower machining cost, it is necessary to know each machining time involved in the manufacture of a particular part.

Cutting Time t_c:

The actual removal of the material in a certain part occurs, where it is calculated from the speed and advance path in the time:

$$t_c = \frac{l_a}{v_a} = \frac{l_a}{a.n} = \frac{l_a \,.\, \pi \,.d}{1000 \,.a\,.v}\ [min] \qquad \text{Eq.1}$$

Where:

v is the cutting speed (m/min).

v_a is the forward speed (mm/min).

l_a: machining feed path (mm).

Where l_a: machining feed path (mm).

$$l_a = l + \frac{p}{tg\ X}\ [mm] \qquad \text{Eq.2}$$

p: cutting depth (mm).
l: machining length (mm).

Then,
Where n (revolutions per minute):

$$n = \frac{1000\ .\ v}{\pi\ .\ d}\ [rpm] \qquad \text{Eq.3}$$

Where d is the part or tool diameter (mm).

Part handling time:
It is the time used with the sharpening and changing of the tool that is being used in the process.

There are two types used:

Tool change time t_{ft}: is the time spent by the operator to remove the tool from the holder for sharpening or replacing it.

Tool sharpening time t_{fa}: is the time that was spent for the sharpening process, being null when the tool is replaced with a new one.

The number of replacements or sharpening of the n_t tool for the machining of a batch of Y parts will be:

$$n_t = \frac{Y\ .\ t_c}{T} = \frac{cutting\ \ time\ for\ lot}{tool\ \ life} \qquad \text{Eq.4}$$

Therefore, the total time spent with the edging will be:

$$n_t\ .t_f\ =\ n_t\left(t_{ft}\ +\ t_{fa}\right) = \frac{Y\ .\ t_c}{T}\left(t_{ft}\ +\ t_{fa}\right) \qquad \text{Eq.5}$$

3. RESULTS AND DISCUSSION

Engineering design must remain closely integrated with the manufacturing process, "ideally, this integration should lead to" Concurrent Engineering" the product life cycle, where design, manufacturing, maintenance, eventual disposal or dismantling, and reuse issues. Product can be considered simultaneously during their project (Shah,1995)".

In order for this integration project to be carried out effectively, the industry has adopted design and manufacturing software known as CAD and CAM. CAD software performs product and component modeling, drawing detailing and better project management. CAM develops a faster production process and components with greater dimensional accuracy and specification of the quantity of raw material, minimizing waste and energy consumption.

This study concluded that the CAD/CAM systems improve high performance in the manufacturing process and elevated efficiency on production of materials aggregating high quality to the project. Therefore, the research with CAD/CAM tools about the parameters more appropriated in the production of specific materials can flexibilize and elevate the productive cycle. The CAD software execute the molding of products and components by detailing of the design, as such as, the managing of the projects. The CAM platform developed the production process faster and with high resolution, which enable the reduction of the costs with energy and material loss. In the final research that will be presented in poster, the final research results be evidenced.

4. CONCLUSION

This research concluded that the CAD and CAM softwares permitted the plannig of the design and manufacture process, which avoided errors and waste materials at shorter time. Therefore, it was possible the observation of the integration between the programs, commercial sector and generation of budgets more accurate.

However, CAD\CAM systems permit to avoid the control of the input and output of materials, such as, visualizing the finished product in digital format and simulation its, through the virtual manufacture, which can make any correction necessary to final production .

This investigation used the simulation and analysis systems for product validation, and according to results demonstrated to be a efficient way to avoid errors and problems in the application to industrial manufacture processes.

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE

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