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Development of Computer Aided Machining (CAM) from Computer Aided Design (CAD)

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Abstract: The machine tools have played a fundamental role in the technological development of the world, until they reach the point of saying that they directly intervene in industrial development.

Computer-aided manufacturing offers important advantages compared to traditional methods. Generally, CAM equipment eliminates human error during processes and the reduction of labor costs. However, the constant precision and optimal use of the equipment represents even greater advantages. CAM equipment is based on a series of numerical codes, stored in computer files, to control manufacturing tasks.

Computer Numerical Control (CNC) is obtained by describing the operations of the machine in terms of the special codes and the geometry of shapes of the components, creating specialized computer files or part programs. The creation of these parts programs are a task that, to a large extent, is carried out today by special computer software that creates the link between CAD and CAM systems.

The characteristics of CAD/CAM systems are used by designers, engineers and manufacturers to adapt them to the specific needs of their situations. Computer Integrated Manufacturing (CIM) takes full advantage of the potential of this technology by combining a wide range of computer-aided activities, which can include inventory control, material cost calculation and total control of each production process. This offers greater flexibility to the manufacturer, allowing the company to respond with greater agility to market demands and the development of new products

Keywords: CAD, CAM, Design

1. Introduction

CAD, or computer-aided design and drafting (CADD), is technology for design and technical documentation, which replaces manual drafting with an automated process. Computer-aided design (CAD) is the use of computer programs to create, modify, analyze and document two- or three-dimensional (2D or 3D) graphical representations of physical objects as an alternative to manual drafts and product prototypes. CAD is widely used in computer animation and media special effects as well as in product and industrial design.

CAD is used throughout the engineering process, from conceptual product design and layout through assembly analysis to manufacturing method definition. CAD enables engineers to interactively test design variants with minimal physical prototypes to achieve:

- lower product development costs
- greater speed
- increased productivity
- quality assurance
- accelerated time-to-market

Some benefits of using CAD are:

- Speed up the design process, enabling better visualization of sub-assemblies, constituent parts and the final product
- Get easier, more robust documentation of the design, including geometries, dimensions and bills of materials
- Easily reuse design data and best practices
- Achieve greater accuracy so that errors are reduced

2. Literature Review

Acronym for computer-aided design/computer-aided manufacturing, computer systems used to design and manufacture products. The term CAD/CAM implies that an engineer can use the system both for designing a product and for controlling manufacturing processes.

Computer-aided design (CAD) involves creating computer models defined by geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of parts, which can be readily altered by changing relevant parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real-world conditions.

Computer-aided manufacturing (CAM) uses geometrical design data to control automated machinery. CAM systems are associated with computer numerical control (CNC) or direct numerical control (DNC) systems. These systems differ from older forms of numerical control (NC) in that geometrical data are encoded mechanically. Since both CAD and CAM use computer-based methods for encoding geometrical data, it is possible for the processes of design and manufacture to be highly integrated. Computer-aided design and manufacturing systems are commonly referred to as CAD/CAM.

2.1 The Origins of CAD/CAM

CAD had its origins in three separate sources, which also serve to highlight the basic operations that CAD systems provide. The first source of CAD resulted from attempts to automate the drafting process. These developments were pioneered by the General Motors Research Laboratories in the early 1960s. One of the important time-saving advantages of computer modeling over traditional drafting methods is that the former can be quickly corrected or manipulated by changing a model's parameters.

The second source of CAD was in the testing of designs by simulation. The use of computer modeling to test products was pioneered by high-tech industries like aerospace and semiconductors. The third source of CAD development resulted from efforts to facilitate the flow from the design process to the manufacturing process using numerical control (NC) technologies, which enjoyed widespread use in many applications by the mid-1960s. It was this source that resulted in the linkage between CAD and CAM. One of the most important trends in CAD/CAM technologies is the ever-tighter integration between the design and manufacturing stages of CAD/CAM-based production processes.

The development of CAD and CAM and particularly the linkage between the two overcame traditional NC shortcomings in expense, ease of use, and speed by enabling the design and manufacture of a part to be undertaken using the same system of encoding geometrical data. This innovation greatly shortened the period between design and manufacture and greatly expanded the scope of production processes for which automated machinery could be economically used. Just as important, CAD/CAM gave the designer much more direct control over the production process, creating the possibility of completely integrated design and manufacturing processes.

The rapid growth in the use of CAD/CAM technologies after the early 1970s was made possible by the development of mass-produced silicon chips and the microprocessor, resulting in more readily affordable computers. As the price of computers continued to decline and their processing power improved, the use of CAD/CAM broadened from large firms using large-scale mass production techniques to firms of all sizes. The scope of operations to which CAD/CAM was applied broadened as well. In addition to parts-shaping by traditional machine tool processes such as stamping, drilling, milling, and grinding, CAD/CAM has come to be used by firms involved in producing consumer electronics, electronic components, molded plastics, and a host of other products. Computers are also used to control several manufacturing processes (such as chemical processing) that are not strictly defined as CAM because the control data are not based on geometrical parameters.

Using CAD, it is possible to simulate in three dimensions the movement of a part through a production process. This process can simulate feed rates, angles and speeds of machine tools, the position of part-holding clamps, as well as range and other constraints limiting the operations of a machine. The continuing development of the simulation of various manufacturing processes is one of the keys means by which CAD and CAM systems are becoming increasingly integrated. CAD/CAM systems also facilitate communication among those involved in design, manufacturing, and other processes. This is of importance when one firm contract another to either design or produce a component.

3. Experimentation

In our research we seek to observe the process of CAD and CAM of a turbine. The CAD part was taken from model 2 (Dominguez et al., 2017) which is shown in Figure 1, which was designed in the CATIA V5 program of Dassault Systèmes. So in our experimentation process we will focus on the CAM area.

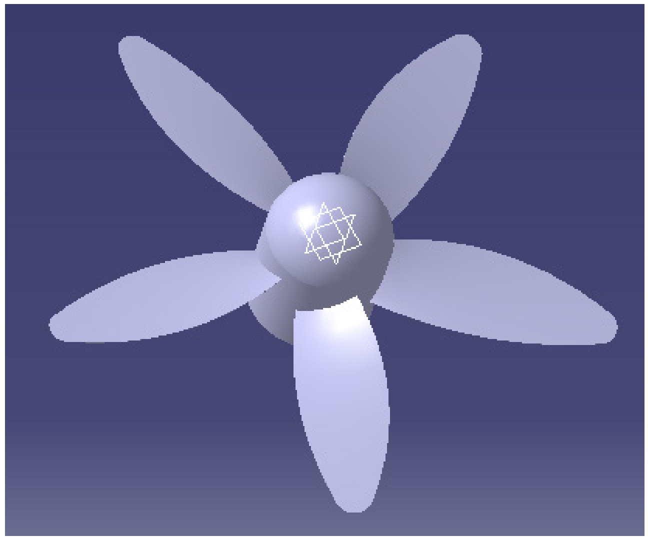

Figure 1. Propeller Model designed in CATIA.

3.1 Methodology

The CATIA Advanced Multi-axis and Pocket Machining option is the all in one reference milling option that enables machining of the most complex parts, using 2.5-axis to 5-axis and advanced aerospace multi-axis processes. NC programmers benefit from full associativity with CATIA design parts and powerful machining automation capabilities to drastically reduce NC programming and machining time.

3.2 Advanced Machining in CATIA V5

In our research, this is the advanced machining module of CATIA V5, which allows us to generate the machining in the interface of the program and with this we can perform the simulation and even obtain our NC program (Figure 2).

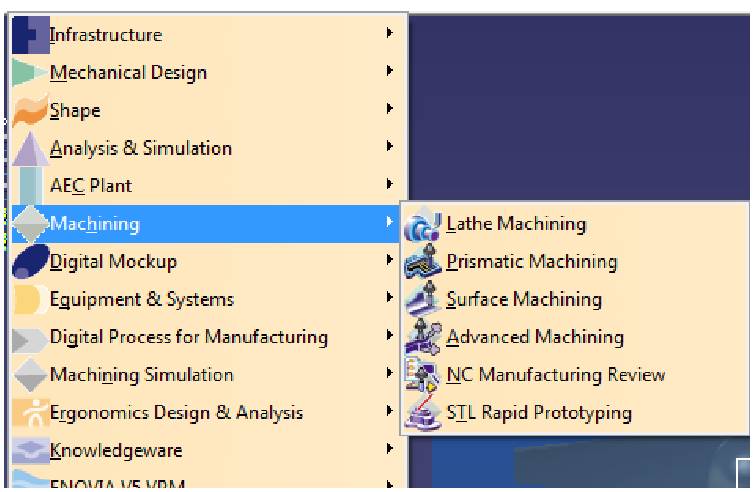

Figure 2. Advanced Machining Module

In the configuration of our machining parameters in CATIA, we will make the configuration of our operation. We will configure the type of machine we will use, in this case a 3-axis machine (X, Y, Z). Our point of origin will also be

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configured, from which our program will be configured to obtain the machining coordinates. Finally, we will define our piece to machine, as well as the work material and dimensions (Figure 3).

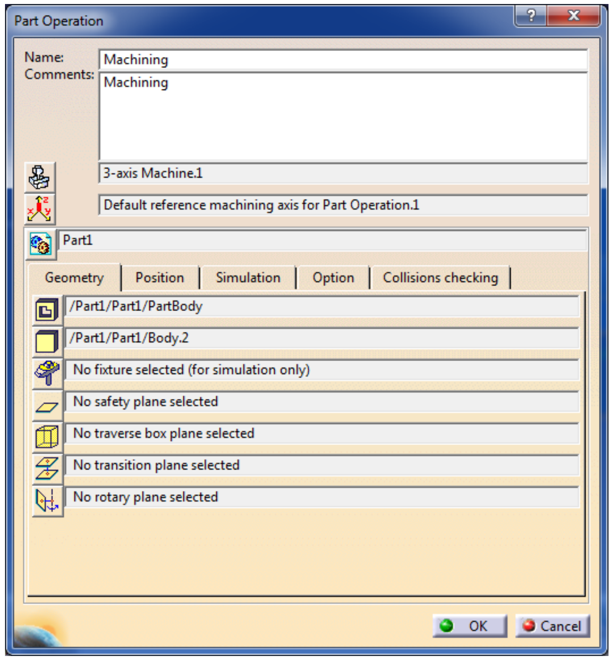

Figure 3. Operation settings

After making our initial configuration of machining parameters, we proceed to add the machining operations, the first would be Roughing with which we will configure the machining of roughing in our machine, with this operation we will define the lowest part of the machining, security plan, bottom plan, as well as the configuration of our tool to use (Figure 4).

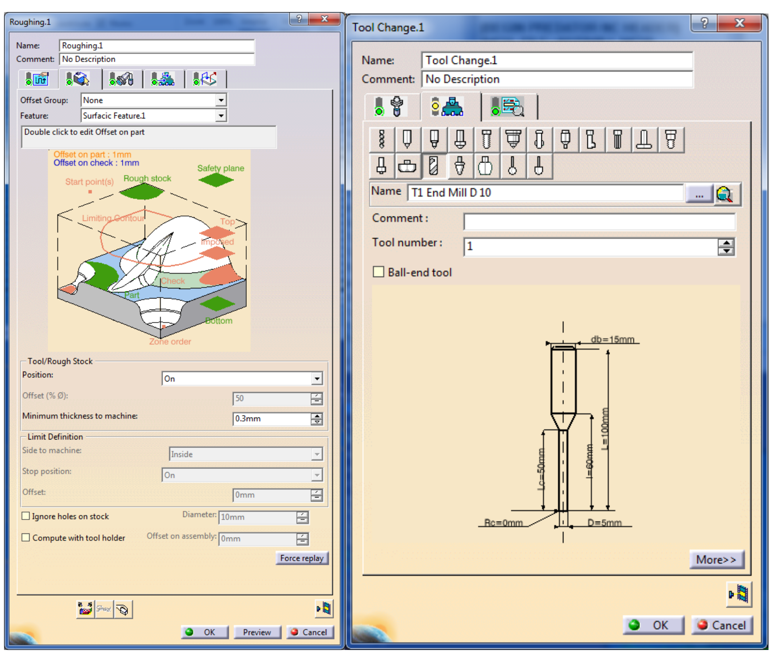

Figure 4. Roughing settings

Once we perform the configuration of the Roughing operation, we will proceed to add our second operation that is Sweeping, with which we will give the finish or refinement to our machining. In the configuration we will define parameters like safety plane, lower face, as well as the configuration of our machining tool (Figure 5).

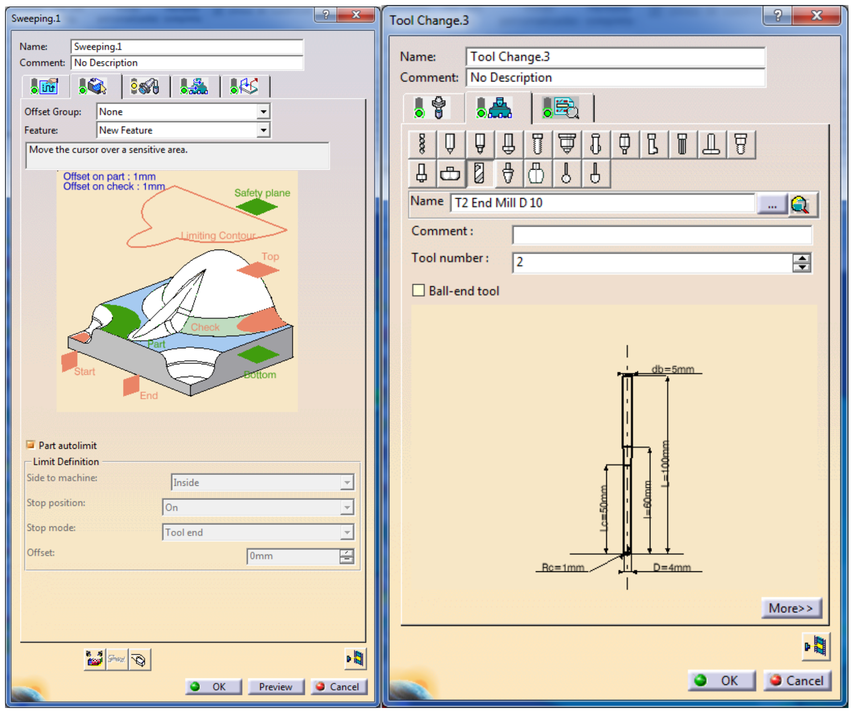

Figure 5. Sweeping settings

Once we have our operations configured correctly and we keep them, the program will generate the view of the trajectories of our tools, with which we can observe in a visual way the trajectories of the tools (Figure 6).

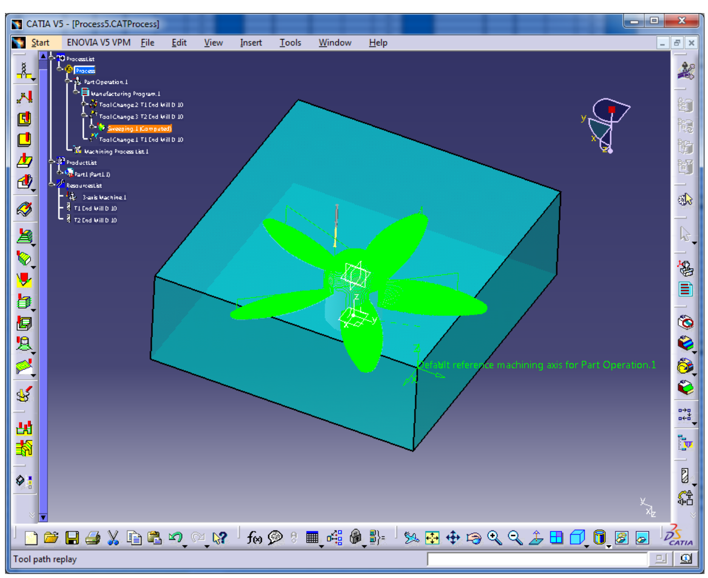

Figure 6. Trajectories of tools

4. Results

In the results of our work we can see the simulation of our machining in CATIA V5, which will show us in a graphic way the whole machining process of our piece. We will observe in video mode the behavior of our first tool when performing the Roughing operation, which we have previously configured, and we will observe how our material is cut to perform the machining.

After this we can observe the simulation of our second Sweeping operation, which gives the refinement to our machining, to generate a better finish in our piece. The results of this simulation can be seen in Figure 7.

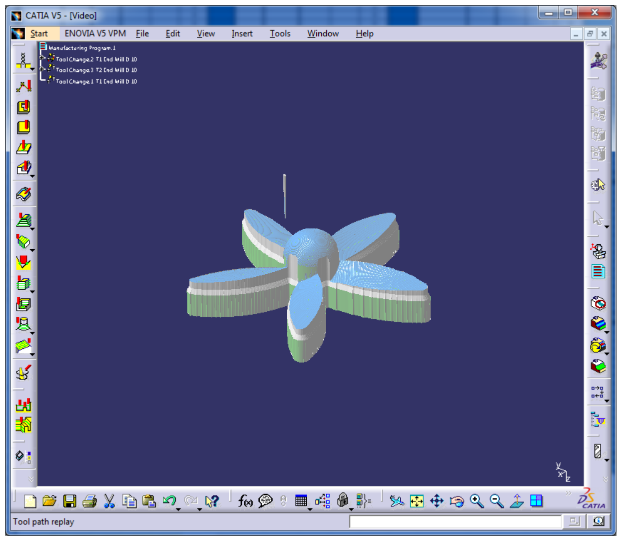

Figure 7. Simulation of machining advanced.

The CATIA V5 interface in addition to generating an advanced machining process, allows us to generate our NC program, which can be used in a physical machine and perform the machining that we have already programmed and simulated.

5. Conclusions

Nowadays CAD and CAM operations have had a great importance in the industry and with advances in technology these are perfected more than ever, supporting to a large extent modern industry to be able to make more advanced designs and improve manufacturing processes.

Our objective in our work was to show part of the CAD / CAM processes, which are a very important part in the current industry and not only that, but also a pillar in the training of engineering students, since the knowledge in this area prepares them to face the challenges of the current industry and prepares them for globalization.

Finally, we can mention that this type of projects helps us to develop the knowledge previously acquired and advance the challenges of the industry.

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