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# FREE -FORM SURFACE PROCESSING – ISSUES REGARDING IMPROVING QUALITY AND PRODUCTIVITY

BY

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**Abstract.** This paper describes an approach on tool paths optimization in CAM-type software for milling free forms, with the goal to improve efficiency in processing using CNC machine tools. Current methods of processing free-form user involve some important decisions regarding the track to follow on surface profile by modifying and editing tool path. The methodology proposed in this paper, tackles the problem of mechanical processing in 3 axes using ball nose milling cutters of small diameters, which follows a freeform profile. I will consider two cases: the first one considers the ball nose end mill route on a free form with an angle of less than 30 °, the second one with a tool path greater than 30 °. The main objective of this paper is to determine the optimum angle in order to obtain a better surface roughness, a shorter time of processing and also a higher tool-life, all these by considering all other factors that occurs in the manufacturing process. This will be done by indicating and editing the tool path so that the tools will the minimum entries and exits on the surface of the piece. This will lead to a 10% decrease of the working time.

**Key words:** CAM, tool path, free form, optimization

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## 1. Introduction

Milling is the process of removing material volume by the relative movement of the cutting edges on the surface of the part.

This process is controlled by implementing CAD / CAM algorithms in order to achieve tool paths. Current methods in processing complex surfaces involve some important user decisions regarding tracking the surface profile of the piece, by modifying and editing tool path. All these decisions are important in determining the precise interval successions of routes that will execute and finding the best route tool that will process the workpiece surface.

We will adopt new approach routes tool using software CAM on a segment of complex surface where we will edit the tool paths using two boundary instruments in an optimal way and in which the tool will follow the profile of the piece, in order to minimize the inputs and outputs over the entire surface to be processed. This method will make the surface roughness much better a higher tool life expectancy and also less processing time

These complex surfaces are often found in manufacturing of plastic injection molds, aluminum vacuum casting and aeronautics. Even with a complex CAM system, machining strategy, which will define the direction of the tool path, plays a major role in the entire process of production. Choosing and defining the strategy process involves finding the optimal parameters, which often require a series of operations in hard to reach complex surfaces areas, these surfaces are found in the machining of molds.

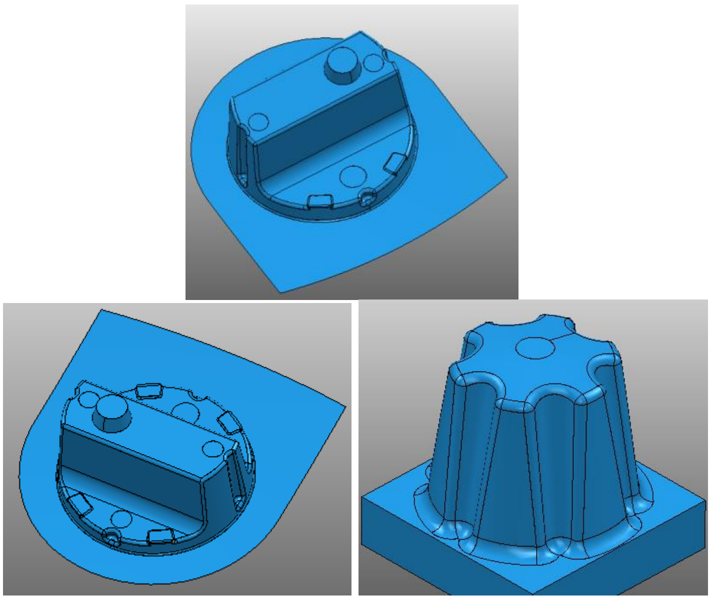

Fig 1. – Free form surfaces

Processing complex surfaces methodology consists in massive roughing, semi-finishing and finishing. Besides this sequence of operations, must be considered tool selection, processing parameters for generating tool path using CAM system algorithm.

Usually complex surfaces are composed of several irregularly shaped surfaces with different inclination angles and often these surfaces are connected mostly with small radii, which increases the difficulty in achieving the NC program.

In this paper we will follow the optimal way of 3-axis processing a complex surfaces with a high degree of difficulty for tool paths with a small diameter, in areas with an angle of up to 30º as found in the literature and in many CAM systems algorithms. Generally CAM software fail to control the process when it comes machining areas which have a surface leaning which can reach up to 90º. When small diameter Boll Nose end mill are used, a number of problems occur when surfaces have a regular shape.

To process these complex surfaces we must identify and mark those areas that are classified as having an angle of inclination less than 30º and those who have a higher than 30º inclination. This will be done through the using Boundary command of Shellow type.

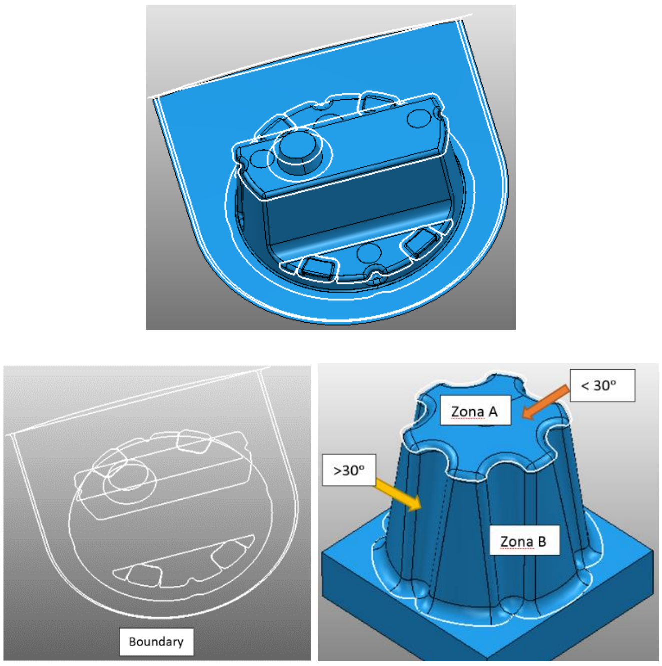

Fig 2. - Boundary command

After finding the two areas, the next step is machining complex surfaces using CAM software, considering algorithm of the software and the specifications given in the literature. As an example will consider a practical application that consists in making a mold for the piece shown in Figure 3.

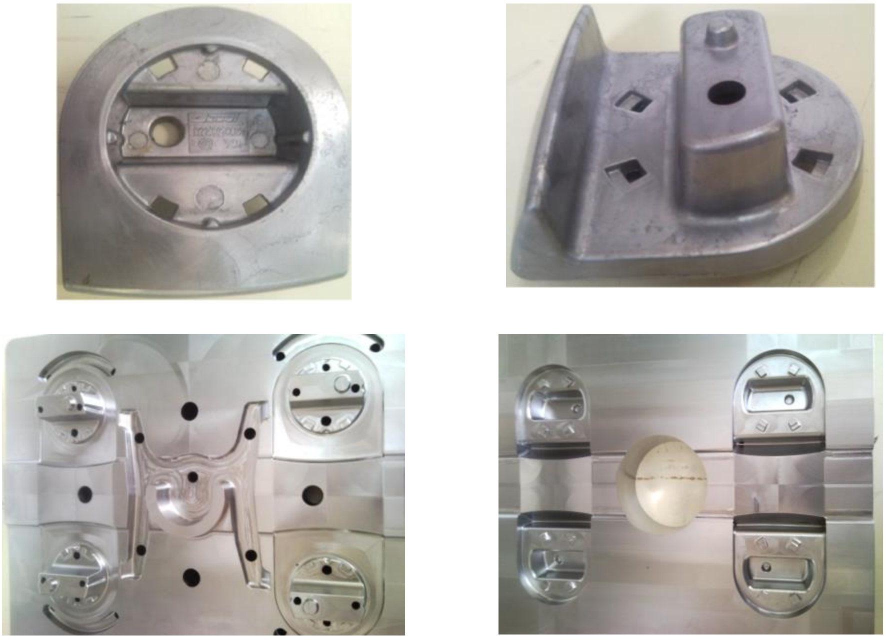

Fig 3. – Demo piece and corresponding mold

Case study 1.

The PowerMill CAM software algorithm, used on pieces with an intersection of surfaces that can reach even up to 90º, will split the tool path in two types. This is done in two ways, the first way is the route formed in the upper area “A zone” where the slope is less than 30º, the second way, in the “B zone”, the route formed on a slope greater than 30 º (Fig. 4) where the tool follows the piece profile.

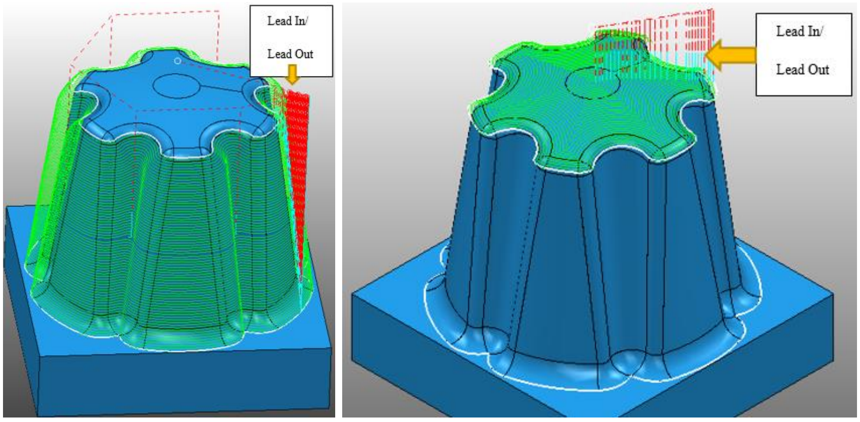

Fig.4 - Free form machining using 2 zones

Using this strategy (Fig. 4) makes the production time to be bigger and the part surface will suffer because of the input and output (lead-in and lead-out) of the tool on the surface to be processed and also because of the advance movements of the tool to reach another level in Z axis. Following this strategy, the piece area will have a greater roughness due to movements on Z axis. To achieve better roughness is necessary to reduce the advance steps between routes, which will automatically lead to increased production time because of the multitude of newly created paths.

Case study 2.

To achieve a better surface roughness, the user can impose certain parameters in CAM software that improves the surface of the part. Besides delimitation presented in case 1, user can apply the Pattern command. This command is derived from Boundery function or after a tool path. With Pattern command we can indicate the shape of the tool path and the advance direction of the machining tool. With Pattern command we can easily create a program to follow the shape of the surface, and to consider the advance direction of the tool and to follow the profile set by this command.

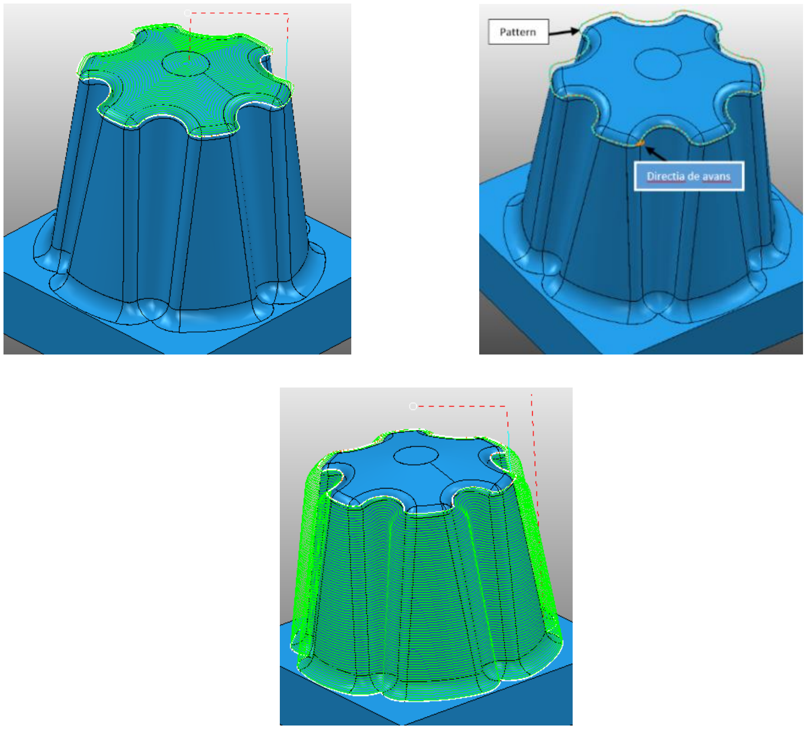


Fig.4 - Helix machining between the two zones

To reduce processing time is necessary to use the above commands ‘Boundery / Pattern'. Using these functions/commands we will achieve a surface with a better roughness and a shorter time. In Fig. 4 is used 'Boundery / Pattern' command which accurately indicates the direction of tool paths, and also helix drilling method in order to reduce production time.

## 2. Conclusions

In the first phase of mold machining using PowerMill software, free form complex surfaces were processed using the solution proposed by the CAM system, resulting in a series of problems to surface finishing, which resulted in a search for a new solution in addressing complex surfaces, solution described in case Study 2.

In Case Study 2 is demonstrated the efficiency in processing complex surfaces by controlling the tool paths, through safety machining and improving in the work surface. The following conclusions were made:

- Removal of material is progressive, resulting in lower cutting forces and good roughness of work surface.

- Advantages of the helix type machining significantly reduces vibrations and shocks during processing due to lower loadings at entry and exit (lead-in and lead-out) of the tool on the surface to be processed, increasing tool life by 15%.
- Method used in Case Study 2 was tested by practical experiment, resulting a surface with a better roughness and a 10% lower processing time.

This result was achieved by moving the tool along the work surface obtaining permanent contact between the tool and the workpiece surface.

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ASPECTE PRIVIND IMBUNATATIREA PRODUCTIVITATII SI CALITATII DE SUPRAFATA LA PRELUCRAREA FREE-FORM

(Rezumat)

Această lucrare tratează optimizarea traseelor sculelor aschietoare în cadrul programelor de tip CAM, pentru cazul prelucrării suprafetelor complexe pe masini-unelte cu comanda numerica. Metodele actuale de prelucrare a suprafetelor complexe implica unele decizii importante a utilizatorului in ceea ce priveste urmarirea profilului de suprafata a piesei, prin modificarea si editarea traseului de scula. In vederea realizării

dezideratului se propune o metodologie care abordeaza problema prelucrarilor mecanice in 3 axe cu o freza cilindro-frontale tip ”ball nose” de diametru mic, ce urmareste profilul unei suprafete complexe. Sunt considerate două cazuri, în ambele cazuri utilizându-se o freză cilindro-frontală de tip ”ball nose”: un traseu al sculei cu o deschidere unghiulară mai mică de 30° și al-2-lea caz in care traseul sculei așchietoare este mai mare de 30°. Obiectivul principal este de a determina care este unghiul optim pentru a realiza o suprafață cu o rugozitate mai bună, un timp mai scurt in procesul de așchiere si totodată o durabilitate a sculei așchietoare mai mare, tinand cont si de ceilalti factori care apar in procesul de prelucrare. Acest lucru se va face prin indicarea si editarea traseului de scula cu ajutorul celor doua instrumente ‘boundary si patterns’ puse la dispozitie de sofurile CAM de specialitate, in asa fel incat scula sa nu aiba mai multe intrari si iesiri de pe suprafata piesei, ceea poate duce la scăderea timpului de lucru cu până la 10%.