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CONSTRUCȚII DE MAȘINI

## MACHINING COMPLEX SHAPE

BY

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**Abstract.** We present in this paper a detailed analysis of the design process and manufacture of parts of complex shape. The techniques of modeling the surfaces are a concept of integration between product and process. After having explained the concept of the machining surface, we analyze a priori its implementation and its contribution in design and in the trajectories generation using specialized software.

**Keywords:** complex shape; design process; trajectories generation.

### 1. Introduction

Controlling of the three criteria Cost, Quality and Time means the use more efficient and flexible all production means that a company have. Chips forming in high speed machining are a micro-geometric phenomenon affecting several macro-geometrical parameters that has to be monitored on a machining center. Mastering these parameters contributes to:

- make the machining process more reliable,
- to guarantee the geometric quality of the machined surfaces (surface condition and dimensional accuracy),
- to ensure productivity,

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– to reinforce the safety of the operators and the machining cell.

The optimization of cutting conditions is becoming an assisted solution, thanks to the development of CAD/CAM software and CAPP. Their development and use also require that this software could be able to predict machining configurations using only a 3D CAD model, for a desired tool/material pair, therefore to model it as closely as possible to the experimental situations encountered (Baharudin *et al.*, 2004).

## 2. Machining Complex Shapes

Until recently, machining complex shapes, involved a complex machining technology who engaged a lots of technologies, and also a lot of time for machining.

In these days, the machining centers, allows to the companies to concentrate and also to eliminate certain operation, like EDM machining, and others to be speed up, like grinding, until to a certain surface quality.

Finally, thanks to the adiabatic phenomenon when cutting in HSM the heat treatment phase can be done upstream of all the machining operations.

The goal of machining centers is to remove the grinding/polishing phase which is difficult to automate, in the case of complex parts with large/small cavities, because the accessibility of surfaces is very small. The HSM will allow us to obtain the desired quality by tightening the machining passes without having too much machining time, because we can move much faster than traditional machining. This suppression will be done only with a total control of the HSM phenomenon.

In the following work, we will focus more particularly on the machining forging tools. This machining phase is very different depending on the machined part. Indeed, the machining of stamping dies shapes and parts with small cavities (mold or punch tools) can be done in “single scan”, that is to say that the machining direction is the same for the whole part.

Nevertheless, it is not advisable to use this same method, in the framework of the forging tools which have deep cavities, to obtain the productivity and the desired quality.

Before the 3D CAD models, the mold manufacturers only had wired models from a 2D Finite Element analysis of flow material. The machining entities were extracted from this wired model and then called “classical” strategies. These tools were special and therefore the machining process was very flexible based on a 2D CAD model.

Now the context is very different because the manufacturers have a 3D CAD model of the tools. On the one hand, the division into an entity is no longer implicit, because it is necessary to distinguish the functional surfaces of the different connections. On the other hand, the change of process, involves a modification of the strategies. In order to increase the flexibility of the

strategies, the special tools are abandoned and replaced by more generic tools namely the hemispherical tool and the thoric tool. So it is impossible to associate the same machining strategies with the same basic geometric entities.

### 3. Trajectory Generation

To generate a machining sequence, it is necessary in particular to generate machining paths. Several methods of generating trajectories exist. In 3 axes the construction of these paths requires the knowledge of a machining direction, a transverse pitch and longitudinal pitch (Hornig *et al.*, 2008).

Depending on the type of numerical control that is used, the paths can be expressed as straight line segments, circular arcs, B-splines, or Nurbs. In the case of our study, the paths will only be expressed as segments (Fig. 1). Thus the longitudinal pitch characterizes their length and the transverse pitch represents the distance between two consecutive passes (Laverhe *et al.*, 2006).

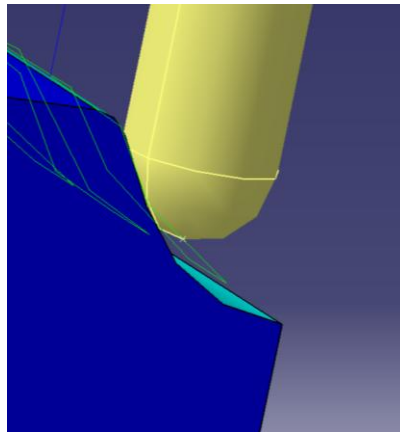


Fig. 1 – Trajectory generation.

In order to generate these machining paths, it is necessary to be able to move from the contact position of the tool on the surface to the position of the controlled point. In the case of 3-axis milling, the calculation is made from a machining surface corresponding to the offset surface.

Once these parameters are set, the programmer will be able to generate all the machining sequences by varying the parameters still free. For example, it will be able to vary the machining curve, the tool diameter or even change the type of machining strategy to obtain all CAD feature for the machined part.

In this article we will use a function of the CAM software, Rework area, to analyze and to find all the areas that couldn't be machined by the current tool because its diameter is bigger than certain areas.

In Fig. 2, we present the simulation of two machining operations for roughing and finishing. In order to reduce the machining time, we have to use the biggest tool diameter that is possible. The problem is that all the small areas won't be machined (Fig. 3).

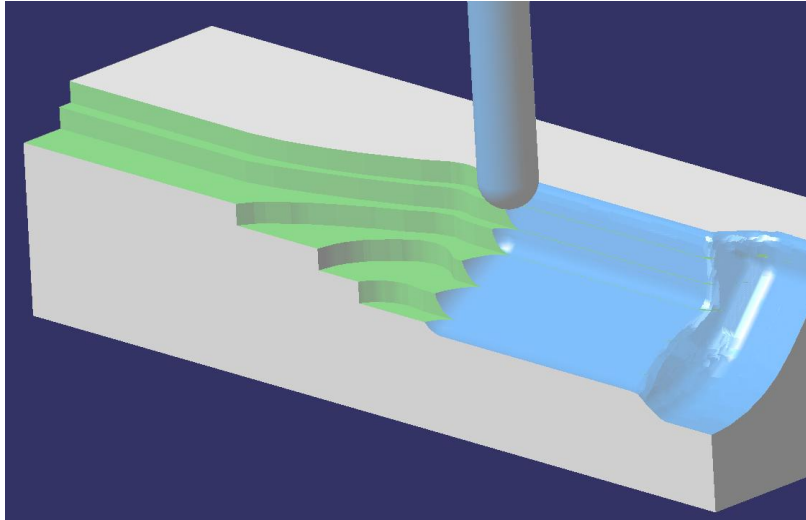


Fig. 2 – Machining operation.

After the machining analyze using the Rework area, is done, the rest of material to be machined, is visible in Fig. 3.

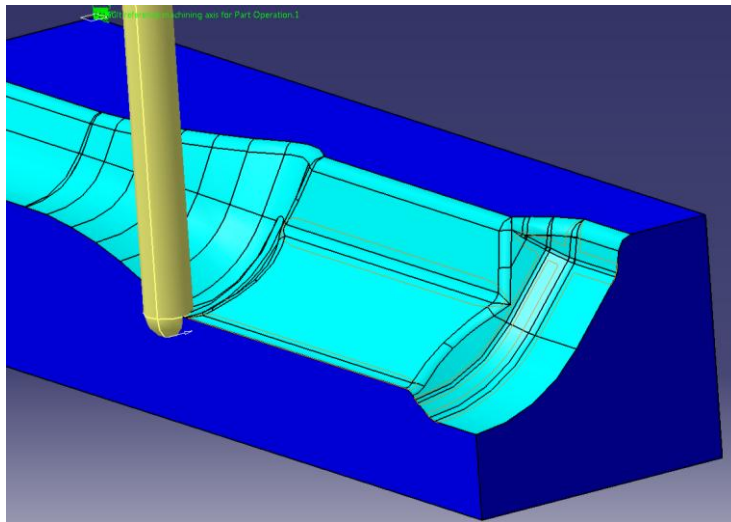


Fig. 3 – The rest of material to be machined.

To this analyze we can assign another operation only to those rework areas that aren't machined (Fig. 4). This option reduce the machining time considerably, because we can use for the roughing operation and also for the finishing operation the biggest tool diameter that we want to assign, and after that to use tools with smaller diameters (Fig. 5).

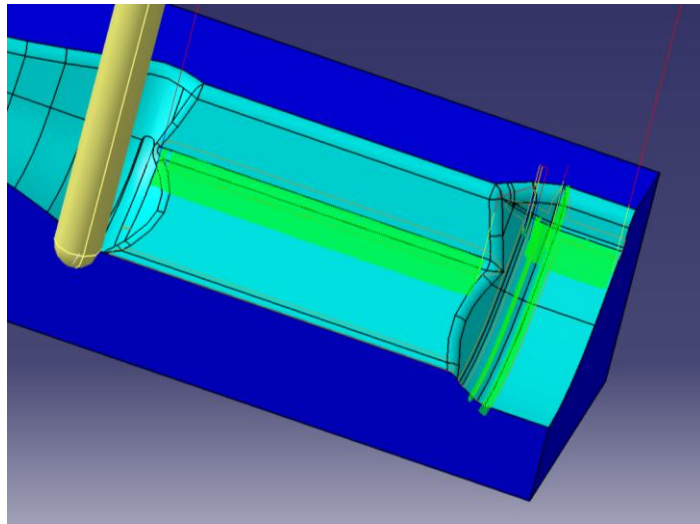


Fig. 4 – The rest of material to be machined.

Like we can see in the Fig. 5, there will be machined only the rest of material.

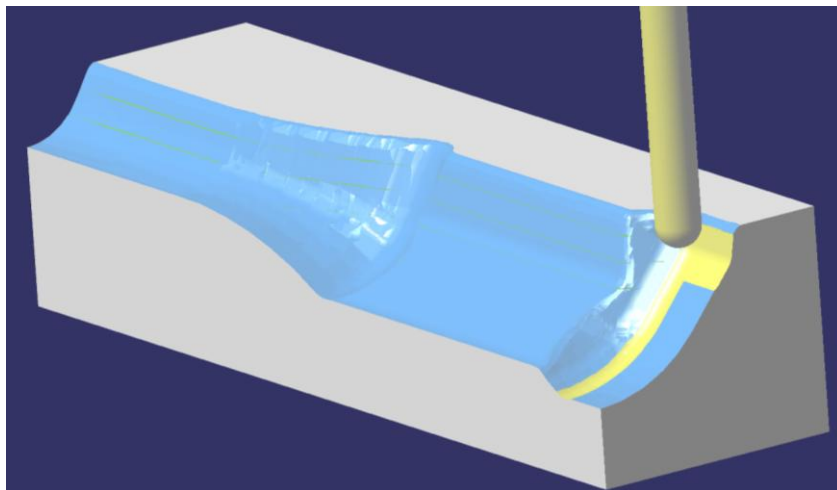


Fig. 5 – The rest of material to be machined.

The quality of surface is the same like in the case of machining the all part surface.

### 3. Conclusions

The competition between companies causes a rapid development of technologies to be deployed for two reasons. First of all is to determine an accurate machining time close to those obtained in the reality for machining a complex shape, and on the other hand to determine the optimal parameters that allow to the programmer to reduce the fabrication costs.

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### PRELUCRAREA SUPRAFEȚELOR COMPLEXE

(Rezumat)

Lucrarea de față prezintă o analiză detaliată a procesului de proiectare și fabricarea unor piese de formă complexă. Tehnicile de modelare a suprafețelor sunt un concept de integrare între produs și proces. După ce am explicat conceptul suprafeței de prelucrare, analizăm a priori implementarea și contribuția sa la proiectarea și generarea traiectoriilor folosind un software specializat.