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THE PROCESS OF GENERATING COMPLEX SHAPES

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Abstract. We present in this paper a detailed analysis of the digital manufacturing process of parts of complex shape. The techniques of manufacturing process of 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

In different sectors such as automotive, extractive industry or steel industry, competitiveness leads to the development of products with an increasingly innovative design and increasing quality demands. These products with complex shapes are obtained according to the nature of the materials by molding, injection, stamping or forging, which requires the production of associated tools. The expertise and the machining time required to obtain these tools make them products with very high added value.

On the other hand, the process of making the molds and matrices has largely been modified through the use of new techniques such as high-speed

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machining and the digital model, that is to say the complete modeling of the product and its process in a CAD/CAM system. The use of high-speed machining makes it possible to avoid polishing operations, therefore the final shape of the part is directly associated with the shape machined by the movement of the tool (Zhiwei *et al*., 2013).

2. The Process of Generating Complex Shapes

The process of making the complex-shaped parts must ensure the conformity between the part and the functional specifications expressing the designer's initial idea (Fig. 1). The process is decoupled into identification of customer need activity, design activity and a manufacturing activity.

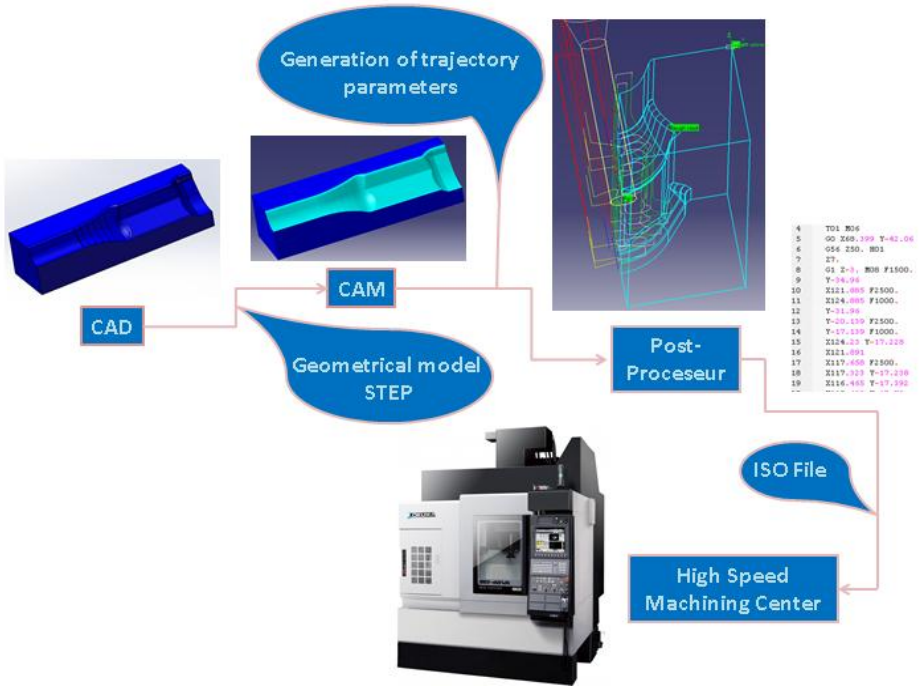

Fig. 1 – The simplified digital manufacturing process.

In the first activity, to create a CAD model, there are organised interviews with targeted focus groups to identify their points of views and their needs. These results are synthesized and presented to design engineers that will create a part model.

In the second activity the geometrical model is built from designer possibility to assemble the functional specifications, customer needs and designer’s philosophies.

This is the reference digital 3D model. This 3D model has to follow the accuracy of the customer needs and designer solutions of "how to do it?/how to make it possible!". Than the tool paths for machining the 3D part (whether it's a mould or a die or rather a part) are calculated by the CAM software.

Finally, the workpiece is machined according to the previously calculated trajectories and also to the real possibilities to do it.

In this moment, customer needs, designer's ideas and manufacturing possibilities are put together in a final product that is inspected to be sure that there are no differences between these milestones (Fig. 1).

In high speed milling HSM, the main requirement of companies is to be able to quickly predict the machining time with values close to reality for the machining of a piece of complex shape, and to determine the optimal parameters which tend to reduce the time and subsequently the manufacturing cost (Msaddek *et al*., 2012).

The diameter of the cutting tool and the machining strategy has a pronounced influence on the machining time of the manufactured parts. The optimization of these two parameters is confronted with various constraints, such as the reduction of the length of the trajectory, by using a bigger tool diameter, and the decrease of the number of discontinuities which are generated by the impossibility of the tool to machine areas that are smaller and induce instability of speed displacement over the axes.

In this context, the optimization of the trajectory is linked between the diameter of the tool and the minimal dimension that can be machined. Indeed, on the one hand it is necessary to adapt the geometry of the trajectory to the kinematic and dynamic behavior of the HSM machine and on the other hand it is necessary to find the diameter of the tool which makes it possible to reach the good compromise between a minimal trajectory and a maximum feed rate to obtain the shortest time (Othmani *et al*., 2011).

The detailed analysis of these phenomena has given rise to a lot of scientific papers designed to improve the trajectory of the tool in the context of high speed machining.

This paper is based on possibility to add an arc to the crossing of discontinuities and also to add before and after the arc of the crossing of discontinuities 2 linear zones where the feed rate speed is reduce and then is accelerated again. The radius of this arc is determined for a discontinuity between two linear interpolations. As regards the modeling of the feed rate, it is developed either by an analytical model which is based on the law of acceleration, or by a modeling of the servomotors control of the axes.

The manufacture of a complex piece on a CNC machine can be simplified by the digital manufacturing process shown in the Fig. 1.

Complex parts require an important preparation phase for CAD design and trajectory generation in CAM. More generally, the manufacture of a more

or less complex part requires its numerical definition to generate the program for controlling the axes of the machine tool (Cherif, 2000).

The generation of the CAM model consists of calculating the path of the tool center driven on the surfaces of a CAD model. The CAM model is described as a Numerical Control File (NCF) that includes the coordinates of the points in the path that the tools will have to follow.

The post-processor then performs a translation of the generated NCF points file into an ISO file interpretable by the NC controller. The NC controller interprets the trajectory and generates the speed and position instructions from the acceleration-deceleration profiles. Then, at every moment, the information needed to control the axes of the machine is calculated from a double integration operation.

3. Conclusions

It should be noted that in the context of high-speed machining, the machining time depends mainly on the slowdowns of the machine during the paths taken. The main objective sought by the injection mold manufacturing industries is the determination of the actual machining time, which remains a very delicate task for estimating a price offer.

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PROCESUL DE GENERARE A SUPRAFEȚELOR COMPLEXE

(Rezumat)

Lucrarea de față prezintă o analiză detaliată a procesului de realizare digitală a unor piese cu formă complexă. Tehnica de realizare a proceselor de prelucrare integrează atât procesele ce stau la bază, cât și produsul implicat în acest proces.