RESEARCH ON ROUGHNESS RESULTEO THROUGH MILLING OF THE SURFACES WITH CBN TOOLS

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ABSTRACT

Optimization of machining parameter for finishing complex surfaces is particularly useful in the aircraft industry and the construction of molds. The right choice of technological parameters of the finishing process can save time, substantially improve the quality of machined surface, and increase cutting tool life. The purpose of the paper is to determine, through experimental research, the optimal process parameters in order to obtain a milled surface with the right roughness. This paper proposes an experimental study in which, using different cutting speed, but the same tool and same technological parameter, it is milled the surface of a spherical piece. The experiment that underlies this paper is designed for a 3-axis machining center.

Keywords: milling, cutting tool, toolpath, roughness.

1. Introduction

Milling is a cutting process that removes the excess material of a semi finished in the shape of small elements, named splinters. These splinters are formed at the intermittent interference of the cutting tool, the mill, and the semi finished. These cyclic interference is generated by the rotational movement of the tool, that has the cutting blades positioned at space intervals, and by the relative feed movement that exist between the semi finished and the tool. As a consequence, the milled surface is composed by a series of geometrical elements (small surfaces) individually generated by each blade of the tool. Bellow, in the figure 1, there can be easily remarked the influence of the tool geometry and its repositioning by feed movement towards the geometry of the machined surface.

The roughness of a surface is determined by measurements, after machining. These irregularities can be also determined by mathematic relations, so there appears the issue of optimizing the technological process, having imposed the quality of the surface, with the condition of maximizing the production. The difficulty is due to the relation between the mechanism that generates the surface and of the non controllable elements that influence this process.

The quantification of this milled surface is given by the roughness level of the obtained surface. As a consequence, the deep understanding of the milling phenomena offers a support in optimizing the parameters of the technological process. In a modern milling process, using the numerical commanded machines, there is a number of parameters that influence the quality of the machined surface. These parameters can be seen in the fish diagram shown in figure 2, with the names translated in Romanian [Benardos, Vosnikos, 2003].

For the optimization of the technological parameters there is necessary a study of the influence of each one by changing its value but keeping the others at the reference value. In this way, for steel used in the fabrication of the core of the injection moulds for reflectors, there were determined in the previous experiments the next technological parameters:

- Milling path- from down to up
- the direction of the radial feed- to the left
- the optimal machining allowance-0,05 mm
- feed/tooth- 0,01 mm
- radial step-0,025
In the case of this paperwork, the machining process is having place using a 3-axes machine. The technological parameters of the cutting process, according to diagram, that can influence the quality of the surface are the cutting speed and the cooling fluid. For what next, there will be made an analyze of the influence of the cutting speed.

2. Experimental activity

2.1. Working environment

The experiment took place on the 3 axes CNC machine Mori Seiki Duravertical 5080 placed in the manufacturing centre, equipped with machine tools, of the Petru Maior University (figure 3). The raw material, a stainless steel recommended for the manufacturing of the active parts of the moulds used to obtain projectors, it has the standard number DIN X40Cr14 (STAVAX by commercial name), with the chemical composition: 36-0.42%, Si max. 1%, Mn max. 1%, P max. 0.03%, S max. 0.03%, Cr 12.5-14.5 %. The semifinishing, having the shape of a spherical calotte, was made through roughing operations, with a machining allowance of a 0.3 mm, followed by a heat treatment that raised the hardness to 48HRC, and than semifinishing, keeping a optimum machining allowance of 0.03 mm.

For finishing it was used a toric end mill Pokolm Voha with the diameter of 6 mm, with 2 blades, having the radio to the corner 1,5 mm. The raw material of the tool is CBN, in order to be able to work at high speeds cutting.. The use of toric end mill presents the advantage of a smaller variation of the cutting speed, as opposed to the ball-end tools. The fixation of the tool is made with a usual system, so that the assembly tool - adaptor, to have the maximum run out error under 10 µm. The cooling of the mill is made with compressed air.

In order to achieve high cutting speeds, we used a high-speed spindle system from Pokolm company, capable to delivery up to 60000 rot/min.

The establishment of the CAM process is made using the CATIA V5 R20 environment. The postprocessor used is Fidia 3X that generates a
code in ISO language.

On a part of a spherical calotte there may be defined an infinity of cutting speed value for a tool. In order to keep the manufacturing conditions during an experiment there will be considered only 10 different value (190, 300, 400, 500, 600, 700, 800, 1000 m/min). The 10 finishing strategies are defined according to figure 4.

The active surface of the core was divided in 10 sections, marked with a black line (figure 4).

2.2 The CAM process design

For the CAM process design was used the medium offered by Dassault Systems Company, CATIA V5. There are 3 necessary steps:

A. Establishing the work circumstances

- The machine tools type – Center of milling manufacturing in 3 axis MoriSeiki 5080 Duravertical;
- The coordinate system attached to the piece;
- On demand equipment to write NC code - Fanuc;
- For an accurate simulation is necessary to define both the mark’s geometry and those of the semi-manufactured
- Defining the global safety plan of the manufacturing operation;

- Also can be defined elements that fixes the mark;

B. Choosing the manufacturing phases (roughing, semi-finishing, finishing) in the right order. The manufacturing simulation is necessary after every execution phase and at the end of the all process. Establishing the manufactory technology has grouped in five sections the introduction of some elements as follows:

- Establishing the trajectories
  - Route type
  - Axial step, radial step, or both
  - Calculation tolerance
  - Other different parameters

- Usefull geometrics
  - Part geometrics
  - Stock geometrics
  - Geometrics filters

- Manufacturing addition
  - Tool usage
    - Tool geometrics
    - Tool holder geometry

- Technological elements
  - Speeding power
  - Work advancement
  - Engagement advancement
  - Clearance advancement

- Establishing engagement and clearance mode from manufacture

C. Post-processing and NC code generation.

The roughening is a working phase that must eliminate as much material as possible in the least amount of time; therefore, for these phases is recommended to use the maximum cutting depth value and maximum feed rate. The finishing phase has the purpose to generate the final surface, which in mould’s core for injected reflectors is highly sensitive in terms of surface quality and form deviation. As result, we build a CAM process to determine the optimal manufacturing addition and the right axial step suited for this kind of situations. The active surface of the core was divided in 10 sections, marked with a black line (figure 4).

3. Result analysis

The quality study was made by using two methods: a quantitative one, by measuring the roughness and an evaluative one by examine the topography of the surface enlarged by the microscope.

The quality study was made by measuring with a roughness tester made by Taylor-Hobson, England. The measurements for each surface were made in two directions, according to figure 5, and the data is summarized in tab.1.
Table 1. The evaluation of the milled surface

<table>
<thead>
<tr>
<th>Cutting speed</th>
<th>Ra1</th>
<th>Ra2</th>
<th>Manufacturing time</th>
</tr>
</thead>
<tbody>
<tr>
<td>190</td>
<td>0.219</td>
<td>0.336</td>
<td>22 min</td>
</tr>
<tr>
<td>300</td>
<td>0.253</td>
<td>0.215</td>
<td>13 min</td>
</tr>
<tr>
<td>400</td>
<td>0.226</td>
<td>0.247</td>
<td>11 min</td>
</tr>
<tr>
<td>500</td>
<td>0.328</td>
<td>0.259</td>
<td>9 min</td>
</tr>
<tr>
<td>600</td>
<td>0.320</td>
<td>0.258</td>
<td>8 min</td>
</tr>
<tr>
<td>700</td>
<td>0.224</td>
<td>0.249</td>
<td>7 min</td>
</tr>
<tr>
<td>800</td>
<td>0.261</td>
<td>0.162</td>
<td>6.7 min</td>
</tr>
<tr>
<td>1000</td>
<td>0.236</td>
<td>0.225</td>
<td>6.2 min</td>
</tr>
</tbody>
</table>

The second appreciation method used is evaluation of the surfaces topography photographed to the microscope like figure 6.

Fig.6. Surface topography photographed

4. Conclusions

The experimental study demonstrates that:

- Cutting speed has very little influence on surface quality
- The main reason for increasing the cutting speed is not improved surface quality, but better productivity
- However, this must be done balancing tool wear

Further studies must determine the fine balance between productivity (increasing the cutting speed) and tool wear (surface quality).

Reference

[1]. Chetan, P., Boloş, V., Consideration regarding technical conditions imposed to the execution of headlamps used in automotive industry, MTeM Cluj Napoca of the 9th International Conference “Modern Technologies in Manufacturing”, ISBN 973-7937-07-04

