INFLUENCE OF RADIAL LATHE TOOLS DESIGN ON ACCURACY OF MAKING TURNED PARTS

Keywords
Turned parts, moulding cutter, exactitude, durability and wear.

Abstract
The article describes problems related to machining of complex shapes on turned parts. The results of studies of the machining of elements with mould cutters with soldered and replaceable plates were also presented. It was revealed that smaller shape errors are obtained after application of bit tools.

Introduction
In the conditions of competition on the market of half-products with complex shapes, it is vital to increase, not only the effectiveness of production and decrease the costs of work, but, above all, improve flexibility on every production stage. The notion of flexibility in production is understood as the ability to respond fast to variable demand of the market [1]. Providing production flexibility enables the following:

• Introduce a short production series.
• Shortening the time of production preparation and the element manufacturing.
• Treatment of the parts of various profile complexity degrees, thanks to the application of numerical machines.
In mass production, flexibility plays a less important role due to its character (millions of elements are manufactured every year). The situation is quite different in small firms that have a few numerically controlled machines, manufacturing several or a few dozen parts of a given type. In such plants flexibility is very important. During one working shift a given machine frequently makes a few types of parts of various complexity degrees, often with the same tool, or with the same group of tools.

Manufacturing turning parts of complex shapes causes many difficulties. Parts like a shafts with necks and little phases are manufactured on conventional machines or on Cam-controlled automatic lathes (Fig. 1).

Fig. 1. Typical elements of simple shapes

Manufacturing of these elements does not require a large cost of labour. It is different in the case of manufacturing the parts of the shape shown in Fig. 2.
Elements of these kinds are manufactured mainly in tool room departments, in small batches of items. Such a small number of manufactured items (these are mainly elements of moulds) constitutes an additional problem, namely, the increased frequency of machine refitting. It often happens that setting the machine takes longer than manufacturing all the parts. To decrease the occurrence of these kinds of problems, we aim at grouping elements of similar shapes in one machine socket, if it is possible.

Another problem is created by dynamic phenomena taking place in the system of Machine-Handle-Object-Tool. A less significant role is played here by the handle that transfers the driving torque onto the object; because, in this case, only length deviation can occur, which is caused by incorrect mounting. Another problem is caused by the machine, or, more exactly, its accuracy, because this is what manufacturing of the element depends upon. However, the most serious difficulty in the accomplishment of the machining process is the interaction between the machined object and the tool.

Machining of not very complicated parts with typical soldered tools is not very troublesome. Things are different with the element presented in Fig. 2. These complex shapes make it difficult to manufacture it quickly and faultlessly with traditional mould cutters with soldered plates.

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1 This statement results from experience of the author who works in a tool room as the person responsible for programming and keeping in motion the numerically controlled machines.
1. Characterization of the conducted studies

1.1. The objective of the studies

The main objective of the conducted studies was indicating differences between soldered and bit tools, resulting from the machining of complex shapes. The additional purpose was to indicate that, after the application of bit tools, there are fewer errors in the shape of machined elements.

1.2. Description of the experiment

The studies involved machining the parts made of ŁH15 steel, hardness ca. 15 HRC of the shape presented in Fig. 2. The programme controlling the machine was generated by means of a CAM program, taking radial compensation into account. The studies were divided into two stages. In the first stage, working the sample was performed with the use of a cutter with a soldered plate P20 (ISO 7) (Fig. 3); whereas, in the second stage, it was by means of a bit tool with a radial plate of GC 4025 carbide type (acc. to Sandvik) (Fig. 4).

Fig. 5 shows a scheme of mounting the worked samples on the machine.
Fig. 2. A 2D drawing of the worked part during the experiment

Fig. 3. A graph of a wrongly ground cutter

Fig. 4. A graph of a well made cutter

Fig. 5. Scheme of machining: a) virtual, b) actual

Table 1 contains the values of technological and geometrical parameters.

2 The graphs are drawn on a HAUSER contour projector of 10 and 20 - ply magnification.
Table 1. Values of technological and geometrical parameters

<table>
<thead>
<tr>
<th>Carbide type</th>
<th>Parameters of machining</th>
<th>Parameters of machining</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>roughing</td>
<td>finishing</td>
</tr>
<tr>
<td></td>
<td>feed [mm/rot]</td>
<td>machining velocity [m/min]</td>
</tr>
<tr>
<td>P20</td>
<td>0.2</td>
<td>85</td>
</tr>
<tr>
<td>GC 4025</td>
<td>0.3</td>
<td>100</td>
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The samples were machined on a numerically controlled turning lathe, WEILER 160 CNC. The lathe is controlled in two axes: X and Z with a SIEMENS Sinumerik 810T controller. The range of rotation velocity varied from 100 to 4000 rot/min, with infinitely variable adjustment and linear velocity range of feed from 0 to 7.5 m/min. The range of working shift for particular axes X and Z is, respectively, 250 and 380 mm. The programmable unit for this machine tool is 0.001 mm. Additionally, the controller has got the G96 function (constant machining velocity) [5].

2. Study results

As a result of machining the part presented in Fig. 6 was obtained.

Fig. 6. Result of machining

Fig. 7. Graph of a part that is wrongly made with a cutter with soldered plate
Fig. 8 shows a graph with an element wrongly made with the use of a cutter with soldered plate. In addition, during the test, two new cutters ground off into the appropriate radius (tearing off the plate, Fig. 8). The reason for the damage was the structure of the cutter. Grinding off the binder connecting the plate with the handle weakened the structure. Joining the plate with the body turned out to be too weak to meet the set technological requirements.

Much better effects are achieved with the application of cutters with replaceable radial plates. The graph presented in Fig. 9 confirms that thesis.

Fig. 9 shows a graph with an element correctly made with the use of a cutter with replaceable plates.
Table 2. Results of measurements of sample diameter $\Phi$ 15.7 mm, $\Phi$ 26.8 mm

<table>
<thead>
<tr>
<th>No. sample</th>
<th>$\Phi$ 15.7</th>
<th>$\Phi$ 26.8</th>
<th>$\Phi$ 15.7</th>
<th>$\Phi$ 26.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.29</td>
<td>-0.4</td>
<td>-0.02</td>
<td>-0.03</td>
</tr>
<tr>
<td>2</td>
<td>-0.28</td>
<td>-0.35</td>
<td>-0.04</td>
<td>-0.05</td>
</tr>
<tr>
<td>3</td>
<td>-0.22</td>
<td>-0.32</td>
<td>-0.03</td>
<td>-0.03</td>
</tr>
<tr>
<td>4</td>
<td>-0.32</td>
<td>-0.41</td>
<td>-0.03</td>
<td>-0.04</td>
</tr>
<tr>
<td>5</td>
<td>-0.20</td>
<td>-0.29</td>
<td>-0.02</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

The cause of the incorrect profile should be seen in inexact making of the radial part of the tool. This caused the incompatibility of the desired profile on the machined element with that designer by the constructor. That resulted in disqualification during the final product inspection. Such faults cannot be found in a bit tool. After working with it, the shape was represented with high accuracy.

Conclusions

The conducted studies reveal that in the case of working the complex-shaped elements mould cutters with soldered plates do not always meet the technological requirements. In the case of complex shapes, it is advisable to use cutters guaranteeing the correct representation of the profile. However, their high price is an obstacle to using these tools.

Using soldered tools increases the risk of catastrophic wear. Such wear may be caused by the cutter’s structure.

It was revealed that using assembled tools influences the increase of machining accuracy and effectiveness.

References

5. Documentation technical - mobile machine engine WEILER 160 CNC.
6. The catalog tools of company SAVDVIK Coromant.

Reviewer:
Edward CHLEBUS

Wpływ konstrukcji noży tokarskich promieniowych na dokładność wykonania części toczonych

Słowa kluczowe
Części tokarskie, nóż profilowy, dokładność, zużycie i trwałość.

Streszczenie
W artykule opisano problemy związane z obróbką części tokarskich o skomplikowanych kształtach. Przedstawiono wyniki badań obróbki elementów profilowanymi nożami z lutowaną płytką, jak również z płytką wymienną. Wykazano, że mniejsze błędy kształtu uzyskuje się po zastosowaniu noży oprawkowych.