An investigation of surface texture after turning PM Armco iron

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Abstract

The paper presents the experimental results collected during finish turning of PM Armco iron. The study was conducted for three cutting speeds and two feed rates. For comparison, machining tests were performed using two cutting tool materials: multilayer coated carbide and CBN tools. During the tests two components of the resultant cutting force were measured and turned surfaces were visualized and measured using a profilometer 3D. Moreover, in order to evaluate the results of Armco irons machining some turning tests were performed using a reference workpiece material. The obtained results confirmed the influence of the type of workpiece material on surface quality assessed by the representative 2D and 3D roughness parameters. Also, the use of CBN tools seems to be very efficient in terms of the surface quality of PM Armco iron parts. In particular, the occurrence of plateau areas was observed using 2D and 3D mapping. In the case of machining of sintered materials, it is important to select a set of the representative roughness parameters which accurately determine the geometrical features of machined surfaces.

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Keywords: Turning; Coating; Roughness; Powder Material;

1. Introduction

Powder metallurgy (PM) iron is generally considered as a net or an approximate net shape process. Nevertheless, many sintered parts are machined prior to final assembly. These machining operations include both drilling and final turning. The machinability of PM irons already differs from wrought materials due to the presence of porosity and the frequent heterogeneous microstructure. The porosity microstructure of PM is more difficult to machine in order to obtain the required surface quality [1,2,3]. It is necessary to appoint the influence of tool material and process parameters on the quality of the obtained surface. Therefore, the work focused on identifying changes of the surface geometric structure (SGS) after finish turning the PM Armco iron in relation to a comparable conventional material.

2. Experimental procedure

Experimental studies include turning machining tests of cylindrical samples. Workpieces were powder metallurgy and conventional Armco iron. PM iron was prepared from powder NC 100.24 (99.78% Fe, 0.01% C, rest H2). The Armco iron chemical composition was: 0.03% C, 0.15% Mn, 0.04% Cu, 0.02% Si, 0.01% P and S, rest Fe. In comparison, machining tests were performed using two cutting tool materials: multilayer (TiC/TiCN/Al2O3/TiN – code 4L) coated carbide and CBN tools. Technological parameters, dimensions of samples and stereometry of the tool are given in Table.1.

Table 1. Summary of test conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting speed (3), m/min:</td>
<td>80, 105, 150</td>
</tr>
<tr>
<td>Feed rate (2), mm/rev:</td>
<td>0.04, 0.10</td>
</tr>
<tr>
<td>Depth of cut, mm</td>
<td>0.1</td>
</tr>
<tr>
<td>Dimensions and properties of cylindrical samples:</td>
<td></td>
</tr>
<tr>
<td>diameter:</td>
<td>Ø20 mm</td>
</tr>
<tr>
<td>length:</td>
<td>20 mm</td>
</tr>
<tr>
<td>hardness:</td>
<td>120 HV5</td>
</tr>
<tr>
<td>Tool stereometry:</td>
<td>χ =90°, γ =5°, α =5°, λs = -6°</td>
</tr>
<tr>
<td>ISO codes for indexable inserts:</td>
<td></td>
</tr>
</tbody>
</table>
ISO-P20 carbide with 4L layer  
CBN tool

Fig. 1. Components of cutting forces in turning PM and conventional irons using carbide and CBN tools. Feed rate \( f = 0.04 \, \text{mm/rev} \).

In this study the measurements of 2D and 3D roughness parameters were carried out by means of a TOPO 01P.

3. Results and discussion

Values of tangential \( F_c \) and feed force \( F_f \) components obtained for both workpiece and tool materials and for the lower feed rate (0.04 mm/rev) are shown in Fig. 1.

Machining of PM iron, by using coated carbide tool, requires lower forces than for Armco iron. A similar dependence was observed for higher feed rates (\( f = 0.1 \, \text{mm/rev} \)). The use of CBN cutting edge produced a slight increase of cutting forces.

Fig. 2 shows the arithmetic mean deviation Ra and the total height of profile Rt calculated for tested cutting conditions. As can be seen from Fig. 2a, the lower cutting speeds obtain higher values of the Ra parameter for PM material in relation to Armco iron. This applies to machining with coated carbide tool. Moreover, the surface after turning the conventional material was characterized by constant and high values of total height of profiles for whole range of cutting speed (Fig. 2b). Generally, the increase of cutting speed generates a decrease of the analyzed roughness parameters. On the other hand, machining with CBN tool leads to significant reduction of the roughness parameters. In this case, the reduction of Ra and Rt parameters (extending up to 30%) was achieved. Fig. 3 shows the selected topography of the scanned machined surfaces after turning with CBN tool \( (v_c = 143 \, \text{m/min}, \, f = 0.10 \, \text{mm/rev}) \). The analyzed topography includes visible regular sharp peaks. Similar to the 2D surface profiles were determined 3D roughness parameters amounting respectively \( \text{SRa}=0.474 \, \mu \text{m} \) and \( \text{SRz}=2.726 \, \mu \text{m} \). As shown on the Fig. 2, generally 2D parameters are comparable to the 3D parameters.

Fig. 3. Isometric view of surface of PM iron machined with CBN tools. Cutting speed \( v_c = 143 \, \text{m/min}, \, \text{feed rate} \ f = 0.10 \, \text{mm/rev} \).

4. Concluding remarks

I. During the turning of PM material is generated less cutting forces, which may results from the fact that machining material has a porous structure.
II. Acceptable values of roughness parameters were obtained for higher cutting speed and feed rate \( f = 0.1 \, \text{mm/rev} \).
III. The use of CBN tool material significantly improves the surface quality.

References