Grooving of Difficult-to-cut Materials

Hiroshima Institute of Technology  NARUTAKI Norihiko
Hiroshima University  OCHI Akio

1. Introduction

In grooving or parting of difficult-to-cut materials on a lathe, there exist many problems such as tool breakage or short tool life for example. In this experimental study, in order to improve the grooving efficiency of difficult-to-cut materials, tests with round insert tool were conducted on mainly adhesive β-C titanium alloy in comparison with other materials. Forces, chip shape and others were investigated and results were discussed.

2. Experimental procedure

Summarized experimental conditions are shown in Table 1. β-C titanium alloy is very adhesive and austenitic stainless and high manganese steels are severe work hardening type materials.

Tested tools are commercially available round and straight edge grooving tools. Their tool materials are ISO K20 carbide. Both precise tool geometries are shown in Figure 1.

Table 1 Experimental conditions

<table>
<thead>
<tr>
<th>Work materials</th>
<th>Tested tools</th>
<th>Conditions</th>
<th>Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-C titanium alloy Ti-3Al-8V-6Cr-4Mo-4Zr</td>
<td>1. Round insert K20 Diameter= 4mm For profile turning</td>
<td>V=60<del>80m/min f=0.06</del>0.07mm/rev (mainly)</td>
<td>JISK2241-2000 A1-1 type emulsion fluid PRTR law compliant</td>
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<tr>
<td>S55C, SUS304, 23%Mn low carbon high manganese steel</td>
<td>2. Conventional straight edge tool K20 Width=4mm</td>
<td>Inching feed 2mm+2mm+1mm for life tests</td>
<td>2 directional supplying with two 180w pumps for life tests</td>
</tr>
</tbody>
</table>

3. Test results

3.1 Performance of round insert tool

Round insert tool shows excellent performance in grooving of adhesive titanium alloy. Its tool life is about two times longer than that of straight edge tool for β-C titanium alloy [1-2]. This excellent performance depends on reduced friction and adhesion on tool-chip-groove interface.

3.2 Cutting force

From the viewpoint of cutting force, round insert tool may show larger value when compared to straight edge tool. However, Figure 2 shows the results that round insert tool shows much lower component forces compared to straight edge tool. This is probably realized by the above-mentioned reduction of friction of grooving interfaces and large positive rake angle of tested tool. Figure 3 shows the results on the work materials. In average forces, β-C titanium alloy shows lower value than other materials. However, in case of the vibration of forces, the group of difficult-to-cut materials shows much larger value compared to plain carbon steel. So, this vibration may be the judgment of the difficulty in grooving of each material.

3.3 Chip formation

Although round insert shows good tool life or lower cutting forces, there may be some unsolved problems. One of them is the shape of produced chip. In case of round insert, the chip is exhausted continuously in straight condition especially in grooving of titanium alloy when compared to other tested materials. This continuous chip is often coiled round the work material shown as Figure 4 and may strike the tool. To prevent this phenomenon, only inching feed technique is available at this stage.

4. Concluding remarks

Through the grooving test of some difficult-to-cut Materials, round insert tool shows superior characteristics in some points of view when compared to straight edge tool. This round insert may be a strict solution for the grooving of adhesive alloy. However, some unsolved problems are left and further investigation should be continued on these tools and materials.

References

1) NARUTAKI Norihiko, OCHI Akio, Grooving of difficult-to-cut materials with round insert. Proceedings of JSPE Spring meeting, 2002 413. (In Japanese)