Cutting Performance in Threading Turning and Grooving Turning of Ti-6Al-4V Alloy with a High-Pressure Coolant Supply

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INTRODUCTION

Titanium alloys have high specific strength (strength/density) and corrosion resistance. Due to dimensional accuracy, titanium alloys are machined using a metal removal process. Titanium alloys have low thermal conductivity and show high chemical reactivity with many cutting tool materials [1]. Therefore, in cutting titanium alloys, as the cutting temperature is higher, and strong adhesion at the interface between the cutting tool and the chip occurs, the tool wear becomes large. The machinability of titanium and its alloys is poor due to the inherent properties of the materials [2]. In cutting Ti-6Al-4V alloy, complex wear mechanisms such as adhesion and diffusion are caused at higher cutting speeds [3]. Therefore, in cutting Ti-6Al-4V alloy, a slower cutting speed is necessary than that in cutting carbon steel.

To improve productivity, a high-speed cutting method is desired. In high-speed cutting, because the cutting temperature increases greatly, the tool materials are required to have both excellent wear resistance and heat resistance. For cooling and reducing tool wear, a wet cutting method is effective.

Due to the increase of the cutting fluid flow rate by injecting fluid at high pressure into the cutting edge, the cutting temperature decreases and the flank wear decreases [4]. High-pressure coolant cutting, which supplies coolant to the cutting part at high pressure, is effective for lowering the cutting temperature and reducing the tool wear [5, 6]. Furthermore, by supplying high-pressure coolant, the chip breakage performance is also improved [7]. For this reason, high-pressure coolant cutting is used for cutting of difficult-to-cut materials such as titanium alloy [8-13] and Inconel [4].

However, in the threading turning and the grooving turning of Ti-6Al-4V alloy with a high-pressure coolant supply the effects of the coolant pressure on the cutting performance have not been reported.

In this study, in threading turning and grooving turning of Ti-6Al-4V alloy with a high-pressure coolant supply, in order to identify an effective PCD tool for the high-speed cutting of Ti-6Al-4V, the effects of the diamond content and the diamond particle size on the tool wear were experimentally investigated. As the Ti-6Al-4V alloy was threading turned and grooving turned with a high-pressure coolant supplied, the chip configurations and the tool wear were experimentally investigated.

Conclusions

In this study, Ti-6Al-4V alloy was threading turned and grooving turned with a pressurized coolant supplied, and the chip configurations and the tool wear were experimentally investigated.

The following results were obtained:

A. Cutting Performance in Threading Turning Titanium Alloy with a Pressurized Coolant Supply

(1) The main tool failure of un-coated ISO K10 cemented carbide was flank wear with a pressurized coolant supply.
(2) Comparing the conventional coolant supply method and the pressurized coolant supply method, the flank wear width of the pressurized coolant supply method was smaller than that of the conventional coolant supply method.
(3) Comparing the coolant pressures in the case of the pressurized coolant supply method, the flank wear width decreased with the increasing of coolant pressure, and the flank wear width “VB” became significantly smaller.

B. Cutting Performance in Grooving Turning Titanium Alloy with a Pressurized Coolant Supply

(1) The high-pressure coolant supply method was effective for improving the chip breakage performance.
(2) In the case of the conventional coolant supply cutting, the fracture of the cutting part was becoming bigger at a cutting distance of 106.2 m. However, with the high-pressure coolant supply cutting, although wear is observed slightly on both sides of the flank face, no major fracture are seen.

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