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Feasibility study of high-speed ultrasonic vibration cutting titanium alloy

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Abstract

For a series of unique properties, titanium alloy has been widely applied in aviation and aerospace fields. However, the poor machinability makes high-speed machining titanium alloy hardly perform as expected even with advanced tool materials due to the high cutting temperature. Intermittent cutting could be an effective method to decrease the cutting temperature and improve the cutting performance. As typical intermittent cutting methods, traditional ultrasonic vibration cutting (UVC) and elliptical ultrasonic vibration cutting (EUVC) have achieved significant advancements. However, the critical cutting speed confines them to the field of low speed machining. This paper proposed a new type of ultrasonic vibration cutting, i.e. high-speed ultrasonic vibration cutting (HUVC), in which the vibration is always along with the feed direction. The separation of the tool and workpiece can be realized under some certain conditions although the cutting speed exceeds far away from the critical speed of the traditional UVC and EUVC methods. As a consequence, it realized high speed cutting on a macro level and intermittent cutting in the micro, and improved the machinability of titanium alloy. Firstly, a theoretical model of HUVC process was established and both of the separation criteria and the duty cycle of HUVC were fully analyzed. Then the feasibility of HUVC method for cutting Ti-6Al-4V was verified experimentally compared with conventional cutting (CC) and traditional ultrasonic vibration cutting (UVC). The results demonstrated that tool life in HUVC were extended by 300% in an optimal situation due to the significantly tool wear reduction. Besides, the cutting efficiency increased by 90% compared with CC method obviously. Furthermore, significant cutting force reduction about 50% and better surface roughness improvement in a successive cutting process were also achieved.

Key words: High-speed machining; Intermittent cutting; Ultrasonic vibration cutting; Titanium alloy;

1. Introduction