Cutting Temperature in Diamond Turning of Tungsten Carbide

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Abstract

The sintered Tungsten Carbide is expected to be applied to dies and moulds for its high hardness and wear resisting characteristics, and the cutting with sintered PCD tool or sintered CBN tool is emerging as one of the key processing methods of the sintered Tungsten Carbide. In order to analyze the wear characteristics of the cutting tools, the cutting temperature is measured in turning of sintered Tungsten Carbide with a single crystal diamond tool by employing the two-colour pyrometer method. The cutting temperature measured reached to 550℃ under the cutting conditions of the cutting speed of 27m/min and the depth of cut of 0.3mm.

1 Introduction

The authors carried out series of turning experiments of sintered Tungsten Carbides with various kinds of sintered poly-crystalline diamond, or PCD tools and sintered CBN tools in order to develop a new method to machine sintered Tungsten Carbides for dies and moulds [1]. The experimental results show that the sintered Tungsten Carbides can be well turned with PCD tools and the CNB tools tested, while the tool wear was found to be critical. The tool wear varies much depending on the grain size of the PCD or CBN grains and also the contents of them. In order to investigate the thermal effect on the tool wear, the cutting temperature is measured in turning of sintered Tungsten Carbide with a single crystal diamond tool by employing the method of two-colour pyrometer in the current research.

2 Experimental method and procedure

A disk of sintered Tungsten Carbide was turned on an engine lathe, and the cutting temperature was measured by applying the two-colour pyrometer method developed by one of the authors [2], which is a kind of infrared radiation pyrometer with use of optical fibers. As shown in Figure 1, a small hole with diameter of 0.5mm was drilled in the tool shank under the single crystal diamond tool bit. The chalcogenite optical fiber is inserted into the hole so that the end of the fiber directly touches the bottom of the single crystal diamond tool bit. The infrared light generated at the rake face of the tool is transmitted through the transparent single crystal diamond and led to the optical fiber. It is further transmitted to the two-colour pyrometer of InSb and MCT detectors via the condenser lens to measure the cutting temperature.

The work is a disk of sintered Tungsten Carbide containing 78% of Tungsten Carbide with mean grain size of 5 μ m and 22% of Cobalt binder. The Vickers hardness of the work is HV840. The major cutting conditions are as follows:

Cutting speed; 15m/min, 20m/min, 27 m/min,

Depth of cut; 0.1mm, 0.3mm, 0.5mm,

The feed rate is kept constant at 0.1mm/rev. The cutting test was carried out under the dry cutting condition.

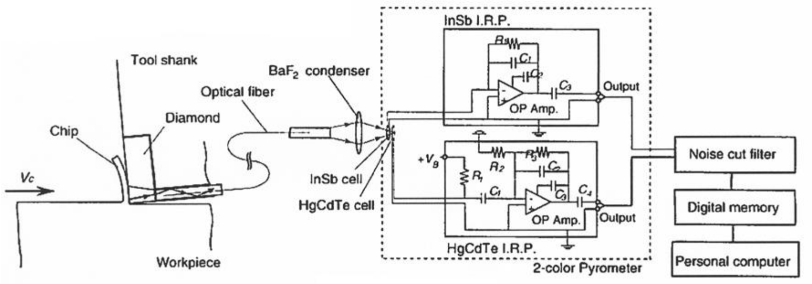


Figure 1: Experimental method to measure cutting temperature at rake face.

3 Experimental results and discussions

3.1 Calibration of pyrometer

The result of calibration of the pyrometer is shown in Figure 2, which shows the output voltages of InSb detector and MCT detector against the surface temperature of the sintered Tungsten Carbide heated to the given temperatures. The output voltages of the detectors show good correlation with the temperature.

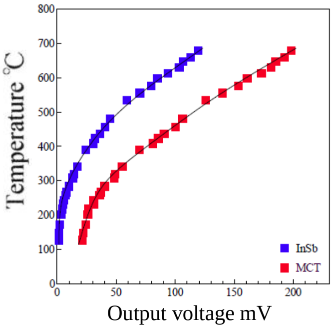


Figure 2: Result of calibration; temperature vs. output voltages of sensors.

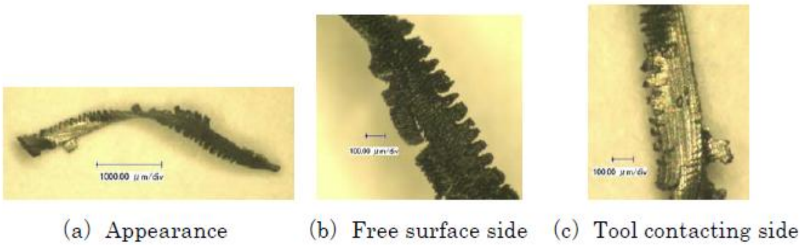


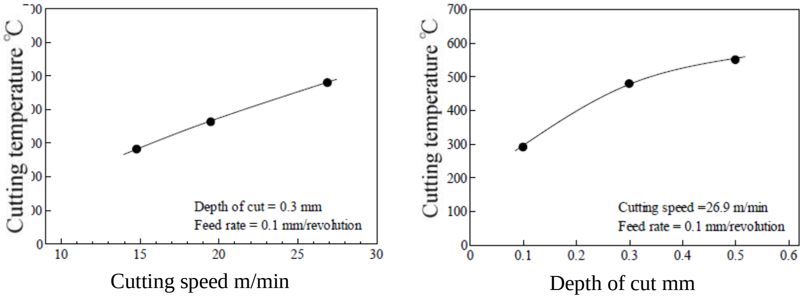
Figure 3: Example of chip of Tungsten Carbide formed by diamond turning.

3.2 Chips

Continuous chips were formed in turning of sintered Tungsten Carbide with the single crystal diamond tool, while Tungsten Carbide is generally regarded as a brittle material. Figure 3 shows examples of photographs of the chip formed. Detailed examination of the chips shows that the sintered Tungsten Carbide grains were cut and broken into small pieces by the tool.

3.3 Cutting temperature

The cutting temperature measured is summarized and shown in Figure 4. Figure 4 (a) shows that the cutting temperature rises with an increase in the cutting speed, and Figure 4 (b) shows that the cutting temperature also rises with an increase in the depth of cut. The cutting temperature reaches to 550℃ at the cutting speed of 27m/min and the depth of cut of 0.5mm. The Cobalt binder of the sintered Tungsten Carbide generally starts oxidization at a temperature of 350 ℃, and it implies that the oxidization and deoxidization of Cobalt accelerates the wear of the diamond tool. It is also expected that graphitization of the diamonod tool takes place at this temperature.



(a) Effect of cutting speed. (b) Effect of depth of cut.

Figure 4: Cutting temperature measured in diamond turning of Tungsten Carbide.

4 Conclusion

Single crystal diamond turning of sintered Tungsten Carbide was carried out and the cutting temperature was measured with use of two-colour pyrometer method. The major conclusions are as follows:

1. Continuous chips are formed by single crystal diamonod turning of sintered Tungsten Carbide.
2. The cutting temperature is increased with increases in the cutting speed and the depth of cut.
3. The highest cutting temperature measured is 550℃ which was obtained at the cutting speed of 27m/min, the depth of cut of 0.5mm and the feed rate of 0.1mm/rev.

References:

[1] S. Tsurimoto, T. Moriwaki: Machining of Carbides for Dies and Moulds, Proc. of the 12th euspen Int. Conf. (2012)

[2] T. Ueda, et. al. : Development of Infrared Radiation Pyrometer with Optical Fibers – Two-Colour Pyrometer with Non-Contact Fiber Coupler, Annals of the CIRP, 36, 1 (2008) 69-72.