New PCBN for Heavy Interrupted Cutting of Hardened Steel

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Abstract

PCBN tools are used worldwide for machining of hardened steel parts in automotive industries. But in heavy interrupted cutting of hardened steel, the tool life is not so stable by sudden breakage of the cutting edge, and total cost of cutting by PCBN is not so economical compared to the grinding. To solve this problem, new PCBN has been developed. New PCBN has very fine and homogeneous microstructure to increase the toughness of sintered body that it provides a reliable tool life for heavy interrupted cutting.

Keywords : PCBN. Heavy interrupted cutting, Hardened steel

1. Introduction

Polycrystalline cubic boron nitride (PCBN) has hardness and thermal conductivity second only to diamond and low reactivity with ferrous metals. In 1977 the first PCBN tools were developed in Japan which successfully replaced grinding processes with cutting processes for the finish machining of hardened steel products such as automotive parts and machine parts [1].

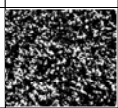
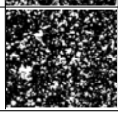
Since then, PCBN cutting tools have been widely applied for the machining of hardened steels and manufacturers in various fields such as automobiles, aircraft and other industries have benefited from the improved productivity. Up to now several kinds of PCBN materials have been developed to machine work pieces which were thought to be difficult to be cut before [2],[3].

The trend is from grinding towards cutting, but still there remain some cases where cutting cannot be applied. Heavy interrupted cutting has been such an application. The problem of cutting for those applications exists in the unreliability of tool life due to sudden breakage. To solve this problem, new PCBN, which has ultra fine and homogeneous microstructure, was developed. This paper reports features and cutting performances of this new grade.

2. Heavy interrupted cutting of hardened steel

Features of PCBN. Table 1 shows the features of PCBN-1 and conventional PCBN-2. PCBN-1 has ultra fine and homogeneous microstructure and uses TiN-based special ceramic binder to increase the toughness of sintered body. Fig. 1 shows the relationship between transverse rupture strength (TRS) and the thickness of the bonding phase which holds cBN particles. The thickness of the bonding phase depends on the cBN content, the particle size of cBN and binder material and mixing method. The bonding phase is weaker compared to cBN particle. Therefore thicker bonding phase increases the defects that cause the decrease in sintered

Table 1. Features of PCBN-1 and PCBN-2

Grade	Microstructure	CBN Content [vol%]	CBN grain Size [μ m]	Binder Materials	Hardness [GPa]	T.R.S [GPa]
PCBN-1		60	1	TiN	33-35	1.2-1.3
PCBN-2		60	1	TiN	32-34	1.1-1.2

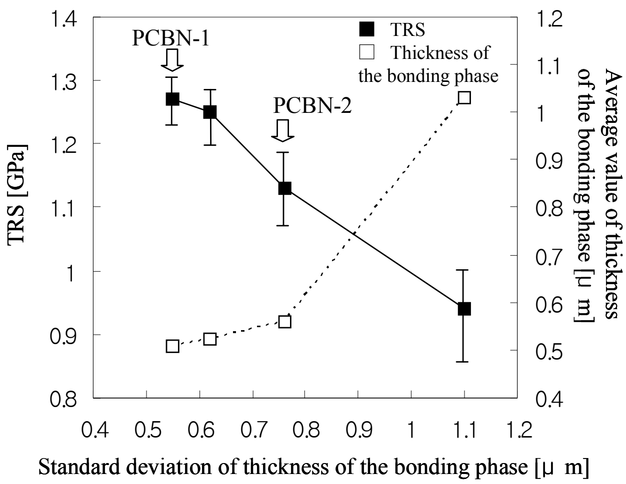


Fig. 1. Relationship between TRS and thickness of the bonding phase.

body's toughness. As both the standard deviation and average value of the thickness of bonding phase are decreasing, the average value of TRS is increasing and the variation of TRS is decreasing as shown in Fig. 1. As a result, PCBN-1 has higher TRS compared to PCBN-2, and the toughness of PCBN-1 is improved considerably. PCBN-1 provides reliable tool life in heavy interrupted cutting, in which the stress applied to cutting edge is very high.

Experimental procedure. Experimental cutting was performed in order to verify the performance of the newly developed PCBN-1 mentioned above. Fig. 2 shows the test conditions. The work material is carburized steel with HRC58-62 hardness. And also it has four U-shaped grooves at the end face for heavy interrupted cutting. This tooling system reconstructs the same failure mode as customers, which is chipping of the end cutting edge. The chipping size was measured. The tool was deemed to break and the cutting test was stopped when the chipping size reached to 0.1mm. The number of impacts until breakage was calculated.

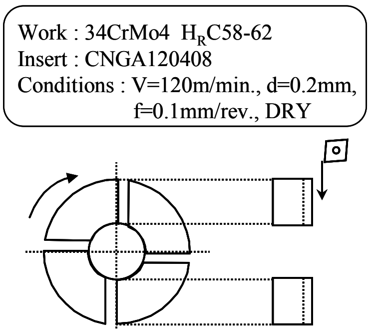


Fig. 2. Test conditions.

Results and discussion. Fig. 3 shows the number of impacts until breakage. Tool life of PCBN-1 was 1.7 times longer than that of PCBN-2. As shown in Fig. 4, compared to the end cutting edge of PCBN-2, in which chipping occurs, the end cutting edge of PCBN-1 is worn smoothly. As PCBN-1 has ultra fine and homogeneous microstructure, probability of micro cracks occurring at the end cutting edge of PCBN-1 is lower than in the case of PCBN-2, whose variation of binder phase thickness is large.

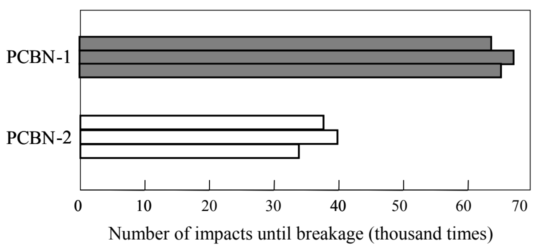


Fig. 3. Tool life determined by breakage.

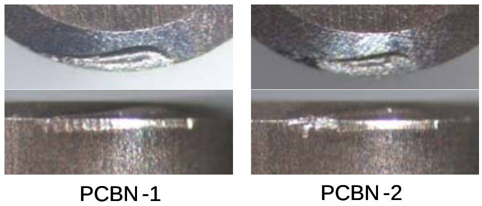


Fig. 4. Photos of the cutting edge after 30 thousand times impacts.

3. Conclusions

Fig. 5 shows the distribution of hardened steel parts about surface roughness and stress at cutting edge. As shown in Fig. 5, the newly developed PCBN-1, which has ultra fine and homogeneous microstructure, have enabled the introduction of hard turning under heavy interrupted cutting conditions instead of the presently prevailing grinding process.

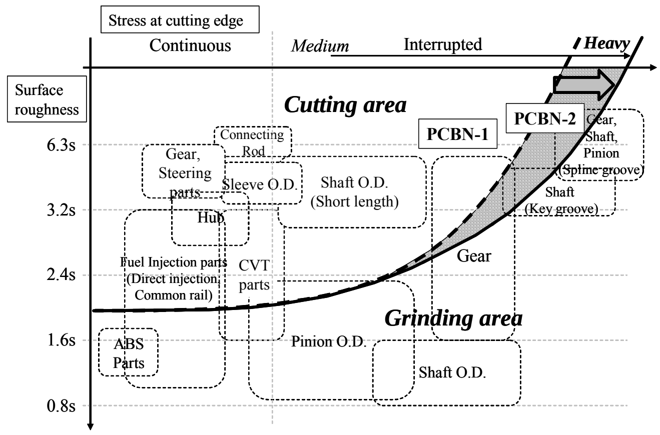


Fig. 5. Distribution of hardened steel parts.

4. References

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