Observation for Machinability of Hardening Particle Dispersed Iron Based Sintered Alloy

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Abstract

Machinability and machining mechanism were examined in the case where resin impregnation treatment was conducted to the Mo-Co hardening particle dispersed iron-based sintered alloy. As a result, the force required for machining decreased significantly compared with the case where resin impregnation treatment was not conducted. This effect is considered to be attributable to the embrittlement of cutting chips produced by the minimization of the cut material deformation.

Keywords : hardening particle dispersed iron based sintered alloy, machinability, free-cutting content

1. Introduction

Many studies have been carried out since long ago on free-cutting contents in sintered alloy because sintered alloy has poor machinability in comparison with wrought steel. T hese studies confirmed that lead, manganese sulfide, calcium fluoride and resin impregnation were the components that could improve machinability. In special, resin impregnation is attracting attention as a component that can significantly improve free-cutting property without decreasing mechanical characteristics of the material.

On the other hand, the iron based sintered alloy dispersed with hardening particles has been widely used for valve seat as a sealing material to keep air occlusion in engine combustion chambers. In general, the machinability of the iron based sintered alloy dispersed with hardening particles tends to be worse than that of the iron based sintered alloy without hardening particles. Nevertheless, the number of reports is limited on the effect of free-cutting contents added to the hardening particle dispersed iron based sintered alloy as base material.

In the current study, the machinability and its mecha nism are examined for the case where free-cutting cont ent is added to the hardening particle dispersed iron ba sed sintered alloy as base material.

2. Experiment Method

Test samples A, B, C and D were produced for evaluation purpose by using atomized particle (Mo-Co alloy) as hardening particle and Fe-Co-Ni-C as base matrix. No hardening particle was added to Sample A and Sample B, while hardening particles equivalent to 35% were added to Sample C and Sample D. Besides, Sample B was produced by impregnating resin into Sample A, while Sample D was produced by impregnating resin into Sample C. The resin used for the impregnation treatment was PMS-50E (LOCTITE). Figure 1 shows the measurement results on composition, density and hardness of the material.

Table 1. Composition and mechanical characteristics of ha rdening particle dispersed iron based sintered alloy

	A	B	C	D
Hardening particle	0%	←	35%	←
Matrix	100%	←	65%	←
Free-cutting content	—	Resin impreg nation	—	Resin impr egnation
Density (g/cm^3)	6.99	7.08	7.22	7.31
Hardness (Hv10)	102	121	206	232

Evaluation was conducted on the machinability of th ese test samples by using LS-type high-speed lathe（OK UMA Engineering Co., Ltd LS450×800）. Evaluation c onditions are as below:

Average peripheral speed : 80m/min
Feed : 0.08mm/rev.
Cutting depth : 0.3mm
Coolant : Exists
Cutting tool : TUNGALOY SNUA431 AH110

Also, to determine the mechanism of machinability change depending on the resin impregnation treatment, deformation of cut material and the size of cutting chips were examined.

3. Results

Figure 1 shows the evaluation result of the machinability. Comparing Sample C (D) which includes hardening particles with Sample A (B) which does not, Sample C (D) which incl udes hardening particles shows higher cutting force.

On the other hand, comparing Sample B (D) which has resin impregnation treatment with Sample A (C) which does not, Sample B (D) which has resin impregnation treatment shows lower cutting force.

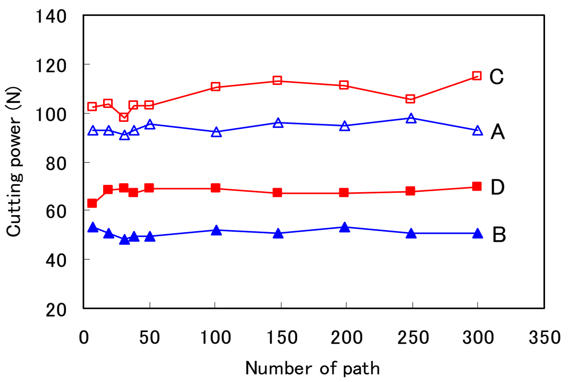
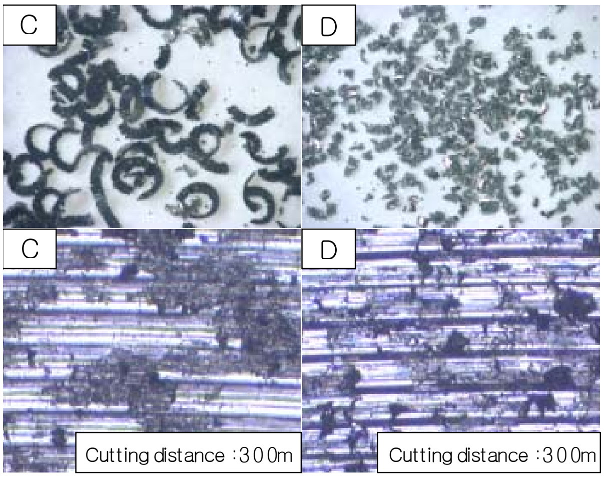


Fig. 1. Machinability of hardening particle dispersed iron based sintered alloy including free-cutting content.

Next, the cause of the better machinability observed on the resin impregnated samples (Sample B, Sample D) versus the samples without resin impregnation is examined. Picture 1 shows the magnified surface pictures of the cutting chip and the cut material of Sample C and Sample D.



Picture 1. Surfaces of cutting chip and cut material of evaluation samples.

Comparing the cutting chips, the chip from Sample D is smaller than the chip from Sample C. Besides, because the number of pores on the cut surface of Sample D is larger than that of Sample C, it is evident that the base material of Sample D underwent no significant deformation. Besides, comparing the surface of cut materials, the pores on the cut surface of Sample C are clogged due to plastic flow, whereas the pores on the cut surface of Sample D are not. This observation shows evidence that no plastic flow took place on the surface of Sample D. Also, when comparing the three component forces, a significant decrease of tangential force is observed（Figure 2）. Based on these results, it is assumed that the breakage limit in the shear deformation range goes down because the pores are stuffed with resin impregnation.[1] As a consequence, the cutting chips are more brittle, resulting in decrease of cutting force. Giving consideration to the fact that the similar effect was reported by Oishi and Yasuda concerning the Fe-Cu-C system, this effect is also observed in hardening particle dispersed iron based sintered alloy. [2]

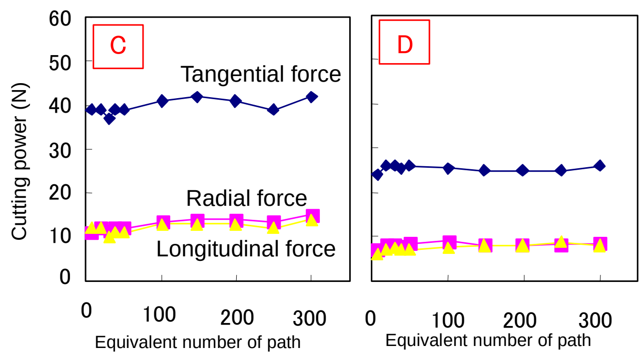


Fig. 2. Fluctuation comparison of the three component forces

4. Summary

The current study leads to the following conclusions:

I. Resin impregnation treatment renders excellent machinability in hardening particle dispersed iron based sintered alloy.

II. Embrittlement of the cutting chips is considered to be a cause of improvement in machinability.

More detailed study on this subject is planned in future.

5. References

1. Kinji OISHI (Kanagawa Industrial Technology Cente r) and Ryo YASUDA (LOCTITE Japan), “Effect of resin impregnation on machinability of sintered meta l” (1995) issued in advance of Autumn Convention of The Japan Society for Precision Engineering
2. Toshio OGASAWARA, Keizo OTANI, Kunio MAKI and Akiyoshi ISHIBASHI, Bulletin from The Japan Society of Mechanical Engineers (Edition C) Vol. 6 3, No. 612 "Machinability of sintered alloy impregn ated with acrylic resin for valve seat”(1997-8)