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THE INFLUENCE OF AFFECTED LAYER OF EDM ON THE WEAR CHARACTERISTICS OF CEMENTED TUNGSTEN CARBIDE

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This paper describes the wear characteristics of WC-Co cemented carbides machined with Wire-cut or Die-sinking EDM. We prepared the specimens with different grades of grinding to remove the affected layer after the EDM. These specimens were experimented by block-on-cylinder type tribometer. The result indicated that although the hardness of the affected layer was lower than that of the bulk, wear resistance was increased. In order to investigate the cause of the increase in wear resistance of the affected layer, the layer was observed and analyzed by SEM and ESCA. We also discussed the mean free path of Co phase.

Keywords : Cemented Tungsten Carbide, Wear, Affected Layer, EDM

1. INTRODUCTION

Since WC-Co cemented carbide is very hard, it has been widely used as a wear-resistant material. It is used for press-working dies, and its wear governs the operating life of die. The dies are usually formed by EDM. But EDM causes the affected layer that can influence mechanical properties of finished surface of cemented carbide. Little is known about the details of mechanical properties of this layer.

In this paper, the wear characteristics of WC-Co cemented carbide machined with Wire-cut or Die-sinking EDM were examined. We prepared the specimens with different grades of grinding to remove the affected layer after the EDM. And these specimens were experimented by block-on-cylinder type tribometer.

2. EXPERIMENT METHODS

The apparatus was used a block-on-cylinder type tribometer using a lathe, which is schematically shown in Fig.1. The cylinder specimen (S45C in JIS) was gripped by a chuck. The block specimen (WC - 8% Co) was fixed by a holder, which contained a ring-type load cell for measuring a normal load and friction force. It was pressed onto the rotating cylinder specimen. The normal load was applied by a serbo motor controlled to a constant value by personal computer via amplifier and AD/DA converter. The dimension of the block specimen was 15 x 4 x 0.5 mm, as shown in Fig.2. We prepared four grades of surface roughness by EDM (Wire-cut or Die-sinking EDM), followed by six grades of grinding. These parameters of machining are shown in Table 1.

Table 1 EDM conditions of each specimen

Specimen	EDM	Roughness	Working speed
A1	Wire-cut	16 - 18 um	6-7 mm/min
A2	Wire-cut	11 - 13um	6 - 7 mm/min
A3	Wire-cut	3 - 5 um	6 - 7 mm/min
A4	Wire-cut	0.8 - 1.2 um	1.8 - 2.6 mm/min
B1	Die-sinking	14 um	0.11 g/min
B2	Die-sinking	9.8 um	0.02 g/min
B3	Die-sinking	5.5 um	0.0034 g/min
B4	Die-sinking	1.2 um	0.000026 g/min

The test was carried out under dry condition at a normal load of 100N, a sliding velocity of 232 mm/s, and a sliding distance of 800 m. After the test, surface traces of wear scar were obtained with profilometer, and wear scar was also observed and analyzed by SEM and ESCA.

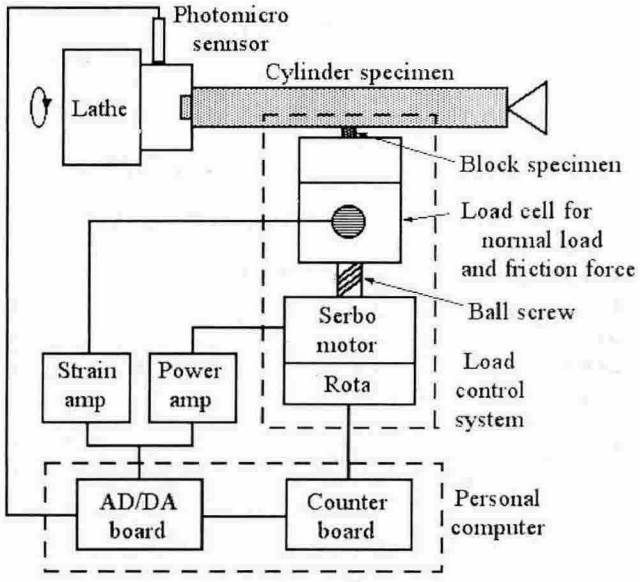

Fig.1 Sliding wear test system

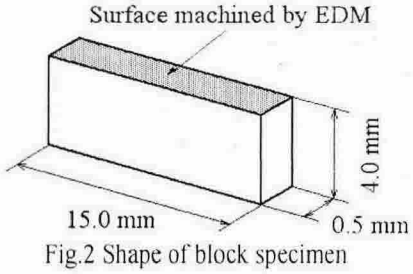

Fig.2 Shape of block specimen

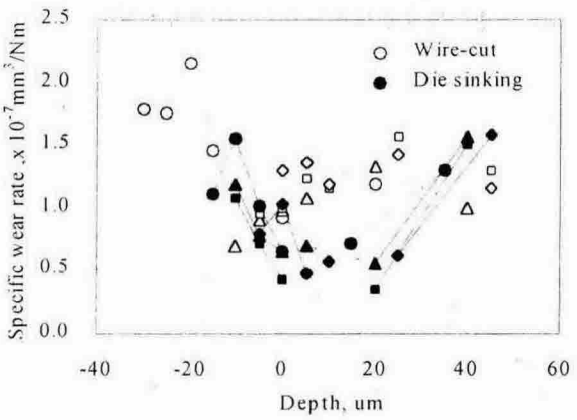

Fig.3 Wear characteristics of WC-Co with EDMs

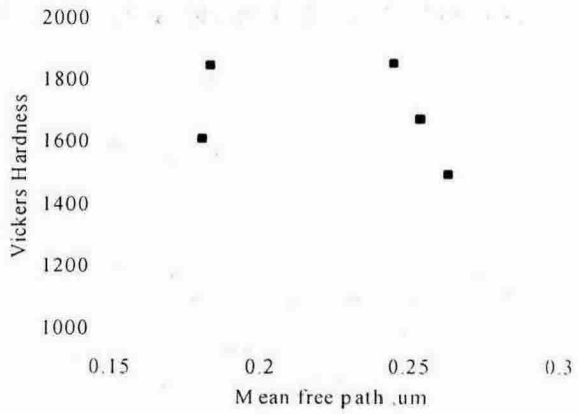

Fig.5 Relationship between Mean free path and HV

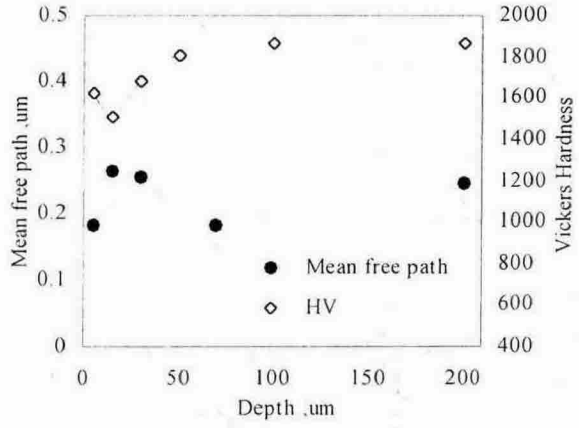

Fig.4 Mean free path and HV against depth

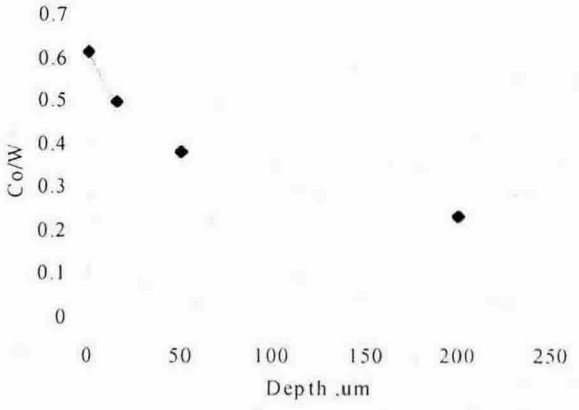

Fig.6 Ratio of Co to W against depth

3. RESULTS AND DISCUSSION

3.1 Wear result

The specific wear rate of WC-Co cemented carbide against displacement of grinding depth is shown in Fig.3. The reference depth is based on valley of surface roughness, and negative depth means the asperity height. If the specific wear rate at depth of 35 - 45 um represents the property of bulk, the specific wear rate decreases by a factor of two or three at depth of 0 - 20 um for Die-sinking EDM. The specimen by Wire-cut EDM showed the almost constant specific wear rate.

3.2 Properties of the affected layer

As shown in Fig.4, the hardness was decreased in the affected layer. This result was contradictory to decreasing specific wear rate.

In order to investigate the cause of decreasing specific wear rate in the affected layer, we observed this layer with SEM and counted the number of WC particles and measured these size. Then, the mean free path of Co phase was calculated by the equation of Fullman[1], as shown in Fig.4. This result indicated that mean free path increased in the affected layer. Generally, a mean free path is in inverse proportion to a hardness. In fact we obtained a result like that, as shown in Fig.5.

3.3 Analysis with ESCA

The ratio of Co to W analyzed by ESCA is shown in Fig.6. The ratio is increased to the surface. We think that this increase is caused by a high temperature of EDM machining. The WC-Co cemented carbide was melted and WC particles tended to sink in Co phase due to its higher density than Co. then the ratio of Co increased in the surface layer. This result indicates a possibility that the specific wear rate relates to the properties of Co phase. For example, the specific wear rate decreases because a holding strength of Co phase was increased in the layer.

4. CONCLUSION

1. The specific wear rate of the specimen with Die-sinking EDM decreased in the affected layer.
2. The mean free path of Co phase increased and the hardness decreased in the layer
3. The ratio of Co/W was increased compared with these properties of the bulk.

REFERENCE

[1] R.L. Fullman, Measurement of Particle Size in Opaque Bodies, J. Metals, (Mar., 1953), 447