Matrix Composition Effect on the Wear Behavior of Diamond Segments

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Abstract

Diamond tools were fabricated by cold pressing and sintering under pressure at the temperature up to 750 °C. Investigation of the microhardness behaviour of the segments was showed that increasing the cobalt ratio causes the increase of the hardness of the matrix material. This caused to decrease of the wear rate of the matrix. Because the matrix wears more slowly than the diamonds, the space between the cutting edges and the matrix is constantly reduced. The swarf cannot be carried away properly, and the segment will continuously lose its ability to cut with higher cobalt contents.

Keywords : Diamond sawblade, diamond segment, wear

1. Introduction

With the increasing use of granites and marbles around the world, there is a great demand on optimizing the wear behavior of the diamond sawblade and process parameters so as to reduce the overall production cost and enhance the production efficiency [1]. The matrix must be capable of dispersing and supporting the diamond, distributing impact and load as the diamond attacks the work piece, providing controlled wear while allowing crystal protrusion, and holding the diamond sufficiently tightly to prevent premature pullout. The matrix may also need to carry away much of the heat generated by abrasion, particularly if no coolant is provided (dry rather than wet cutting) [2-5]. Generally speaking, three major factors determine sawblade performance: (1) the diamond type and size; (2) the diamond concentration; and (3) the hardness of the metal bond formulation. As the interface between diamond grits and metal matrix withstands the moment to which the diamond grits are subjected, a strong interfacial cohesion arising from an interfacial reaction is the basic requirement for enhancing tool life [6]. In this study, we have investigated the effect of the composition of metal matrix material on the wear properties of diamond sawblades.

2. Experimental and Results

The segment material was composed of cobalt, bronze, tungsten carbide (WC), and synthetic diamond. Diamond concentration and WC (2 wt.%) contents were not changed in order to investigate the effect of cobalt to bronze ratio in matrix composition on the bending strength of diamond segments. For that reason seven different matrix compositions were prepared by changing the ratio of cobalt to bronze in the matrix. Synthetic diamond grits of 60/70 mesh (SDA -70) was used in this study. Cobalt powder with an average particle size of 1.8 μm and bronze powder with Cu-10% Sn alloy with a median particle size of 100 μm were selected as the starting materials. The concentration of diamond grits in these composite blocks was maintained at 20vol.%, where 100 vol.% concentration of diamond grits was designated as 4.4 carat cm^{-3}. Segment dimensions were 40x2.8x6 mm, in length, thickness and wide, respectively. After the determination of the quantity of segment materials, these powders were mixed by using V-type powder mixing machine with paraffin. Powder mixture was pressed at room temperature with a pressure up to 4 MPa. The pressure was very low in order to prevent the break up of diamonds. 22 segments were produced for each of the seven different compositions. Then, the segment tablets were placed into a graphite die and the sintering was applied at 750°C. The fractured surface was examined by scaning electron microscope (SEM).

The hardness of the matrix was determined by taking the average of 8 measurements using a microhardness test device under a load of 0,98 N. Wear test was carried out by using planning machine with directional scratching the segments on the marble.

Microhardness values of each composition were measured for eight times and the average of these values was taken as the hardness of the matrix materials. Fig. 1 shows the microhardness test results according to the cobalt ratio change. It is seen from the figure that the hardness value of the matrix material was increased with increasing of the cobalt ratio. The hardness of the matrix material is very important due to the sawing mechanism. The correct exposure of the diamond grits during service is vital to cutting efficiency, which is partially determined by the density, hardness and the transverse rupture strength of the matrix. A metal matrix that is too hard or wear-resistant will not be removed rapidly enough to keep fresh diamond cutting edges exposed, which will result in the phenomenon of glazing. On the other hand, a matrix, which is so soft as to be eroded easily during machining, can cause premature loss of diamond grits. Consequently, the matrix phase must be specially formulated to wear at almost the same rate as the diamond grits so that when the diamond cutting edges become worn, new diamond grits will protrude to facilitate efficient cutting constantly [3].

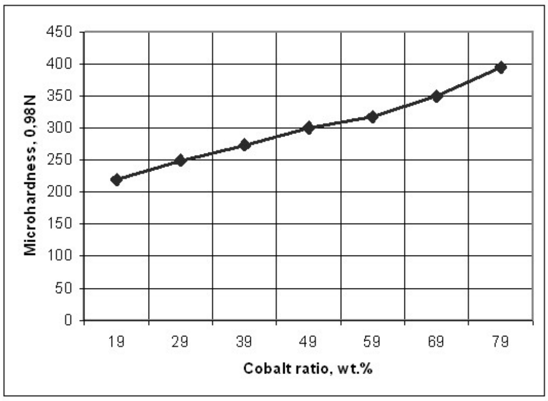

Fig. 1 Average microhardness value change of the se gment matrix material according to the cobalt ratio

Results of the wear tests applied using pin on disk machine was given in Fig. 2. It is seen from figure that the wear resistance of the segments increases with the increa-sing of the cobalt ratio in accordance with the hardness increase of the matrix.

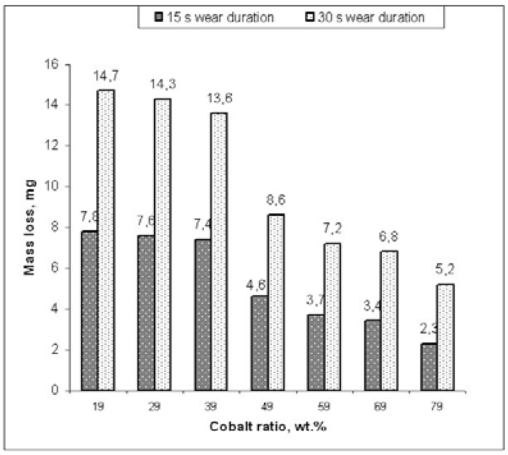

Fig. 2 (a) Mass loss according to the cobalt ratio in wear test using a planning machine, (b) wear behavi our of the segments according to the cobalt ratio an d wear test duration of 15s and 30 s.

It is obtained from examinations of the worn surfaces of the matrix that If the matrix wears too fast, the diamond capacity is not completelty used before the grain is pulled-out. If the matrix wears more slowly than the diamonds, the space between the cutting edges and the matrix is constantly reduced. The swarf cannot be carried away properly, and the segment will continuously lose its ability to cut. A characteristic feature of matrix wear is a crater in front of the single grains. Behind the grain, there is less erosion of the matrix; a bond tail is formed, so that the diamond is sustained against the process forces to remain in the bond. It was obtained from the investigation of the worn surfaces that the characteristic matrix wear was seen for the 49 wt.% cobalt containing matrix. Similarly, in the previous work [7], the bending strength was the highest for the 39 wt.% cobalt containing matrix and the bending fracture probability of the segments was the best for the 39 wt.% and 49 wt.% cobalt containing matrix. That results support that the characteristic wear behaviour was seen in this study for the 49 wt.% cobalt containing matrix.

3. Summary

It was obtained from this study that if we increase the cobalt ratio, the hardness of the matrix increases and the wear rate of the segments decreases. The characteristic matrix wear was seen for the 49 wt.% cobalt containing matrix.

4. References

1. Xipeng Xu: Tribology letters, Vol. 7, p. 245, (2001).
2. M.P. d'Evelyn: Industrial Diamond, in Handbook of ceramics, glasses and Diamonds, ed. Charles Harper, McGraw-Hill, (2001).
3. J. Konstanty: Industrial Diamond Review, Vol.60, no.584, p. 55, 58, 61, (2000).
4. D.N. Wright and H. Wapler: CIRP Ann. Vol. 35, no.1, pp.239-244, (1986).
5. D. Kolarov and M. Gancheva: 8th International Metallurgy and Materials Congress I, Istanbul- Turkey, , pp. 615-620, 6-9 June (1995)
6. Y.Z. Hsieh and S.T. Lin: Materials Chemistry & Physics, Vol. 72, p. 121, (2001).
7. R. Unal: Materials Science Forum, accepted (2006).