Effect of Cobalt to Bronze Ratio on Transverse Rupture Strength of Diamond Segments

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Abstract

Diamond segments were fabricated by cold pressing and sintering under pressure at the temperature up to 750 °C. Based on the results of this investigation, it can be concluded that the segments containing 39wt.% cobalt in the matrix material have the highest bending strength at a fracture probability of 50 % due to the weibull distribution method. According to the weibull statistics, it was also determined that the transverse rupture strength was the best for 39 wt.% cobalt ratio in the matrix material for the fracture probability when the other variables are the same.

Keywords : Diamond Segment, transverse rupture strength

1. Introduction

A circular diamond sawblade consists of a steel core with radial slots, and between each slot, diamond impregnated segments are brazed on the periphery. The segments are composed of a large number of diamond particles randomly distributed in a metal matrix [1-4]. Processing of diamond in metal bonds often results in a reaction between the diamond surface and the surrounding metal matrix. The extent of this reaction depends upon the specific composition of metal powders, their particle size and distribution, the processing temperature and time [5]. In this study, the effect of the composition of the metal matrix material on the transverse rupture strength of diamond sawblades was investigated.

2. Experimental and Results

Typical segment composition for natural stones was selected in this study. The segment material was composed of cobalt, bronze, tungsten carbide (WC), and synthetic diamond. Diamond concentration and WC 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 (Table.1). 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}.

Table 1. The composition and properties of seven different segment materials.

Co (wt.%)	Bronze (90/10) (wt. %)	Microhardness (0,98N)	Wear loss (mg)
19	79	219	13,4
29	69	249	13,0
39	59	273	8,4
49	49	300	5,6
59	39	317	3,2
69	29	349	1,1
79	19	394	0,3

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.

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 with a regime as shown in Fig.1. Transverse rupture strength of the sintered specimen was determined using a three point bending configuration. The fractured surface was examined by scaning electron microscope (SEM).

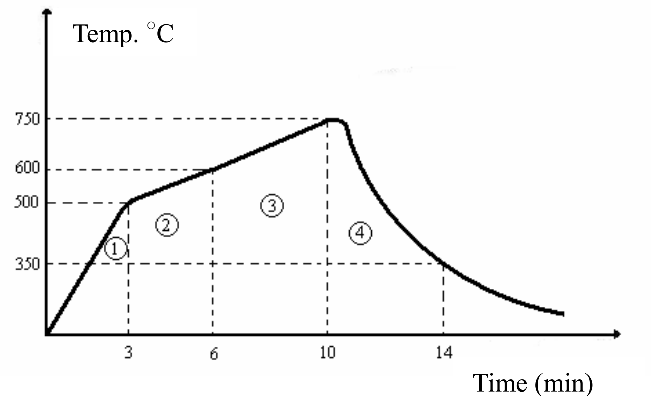
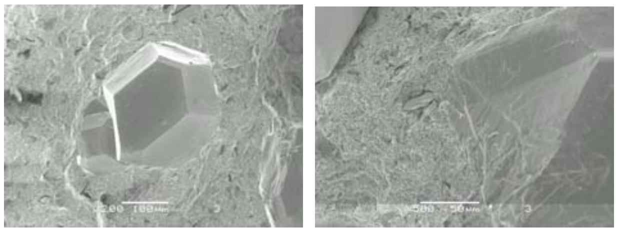


Fig. 1. The sintering process applied to the segment tablets in graphite die.

A SEM micrograph of cubo-octahedral crystal with well-developed faces and sharp edges is shown in Fig. 2a. The rough surface is in superior bond retention. This type of diamond is suited for use in sawing applications in the natural stone industry [5]. SEM micrographs of strong bonds between the diamond surface and the surrounding metal matrix are shown in Fig. 2b. The extent of this bond reaction is dependent upon the specific composition of metal powders, their particle size and distribution, the presence of oxidizing or reducing gases during processing, and the processing temperature and time.

In addition to its intrinsic brittleness, diamond has two important limitations. Diamond begins to oxidize and/or graphitize rapidly at temperatures above 600-700 °C in air or an oxidizing atmosphere. The bond reaction of the diamond surface and surrounding metal matrix influences the efficient tool performance greatly. With this type of cutting/abrasive material produced by PM techniques, the primary important factor is cleanness (cleanness of operation media, cleanness of powders and diamonds used). In addition, sintering during the hot pressing is expected to enable the microstructural formation of the ideal matrix to occur in technological conditions [5].

Tranverse rupture strength of the segments for the seven different compositions was determined by three point bending test apparatus. Seven samples was used for each composition to determine the strength of the segments. The transverse rupture strength is known to show defects leading to crack formation and propagation in hard materials [6]. It is found from the test results that, the segment containing 39 wt.% cobalt has the highest tranverse rupture strength at a fracture probability of 50% and is also less sensitive to crack propagation as compared to the other specimens.



(a) (b)

Fig. 2. (a) SEM micrograph of cubo-octahedral crystal with well-developed faces and sharp edges, (b) strong bonds between the diamond surface and the surrounding metal matrix.

3. Summary

Based on the results of this investigation, it can be concluded that the segments containing 39wt.% cobalt in the matrix material have the highest bending strength at a fracture probability of 50 % due to the weibull distribution method.

4. Acknowledgements

The author would like to gratefully acknowledge the support of the ZES company and E. Alper Gürçay through their help for the production of diamond segments.

5. References

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