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Porous cast-iron bonded diamond grinding wheel

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A new grinding wheel was developed focusing at the anchoring force of abrasive grains against the bridging matrix. Cast iron powder was utilized to form the skeleton matrix. Stronger anchoring effects were achieved by bonding the abrasive grains and the skeleton cast iron matrix through chemical reaction between the abrasive grains and skeleton cast iron matrix. The newly developed grinding wheel exhibits longer life and higher grinding efficiency then conventional ones.

Key words: porous materials, grinding wheel, chemical reaction.

Introduction

Almost all the new advanced materials, including engineering ceramics, and electronic materials are hard and tough to machine. The resulting high machining costs inhibits their use in manufacturing. In machining of functional devices such as semiconductors and magnetic recording media, submicrometer flatness and surface roughness of the order of nanometer are required, and these requirements are becoming severer according to the improvement of the performance of the functional devices. However, to achieve an accuracy of less than submicrometer will be limited by improving the stiffness and the accuracy of grinding machines. We have developed porous cast-iron bonded diamond grinding wheels to machine hard materials using a knowledge of fabrication of porous materials in our group [1-5].

A grinding wheel consists of abrasive grains, bridging material to form skeleton structure and pores (Fig. 1(a)). When a grinding wheel is designed, the three components are considered and decided, such as volume fraction of the three components and species of abrasive grain and skeleton materials [6, 7]. For instance, in order to obtain a smooth surface, a small abrasive grain size and a narrow distribution of grain size is used. Meanwhile, thenremoval rate decreases with decreasing abrasive grain size. Therefore, high grinding efficiency and smooth surface finish are always contradicting to each other.

A new grinding wheel has been developed focusing at the anchoring force of abrasive grains against the bridging matrix. Cast iron powder was utilized to form the skeleton matrix. Stronger anchoring effects were achieved by bonding abrasive grains and the skeleton cast iron matrix through a chemical reaction between the abrasive grains and skeleton cast iron matrix (Fig. 1(b)). The newly developed grinding wheel exhibits longer life and higher grinding efficiency then conventional ones.

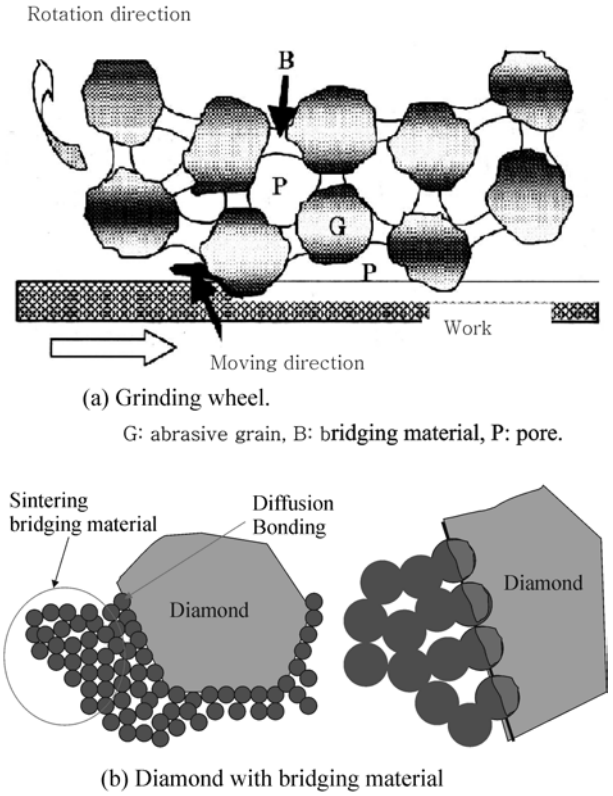

Fig. 1. Schematic illustration of grinding wheel and bonding between cast-iron and diamond.

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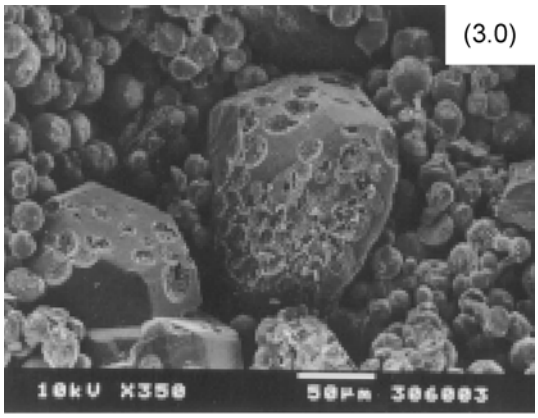
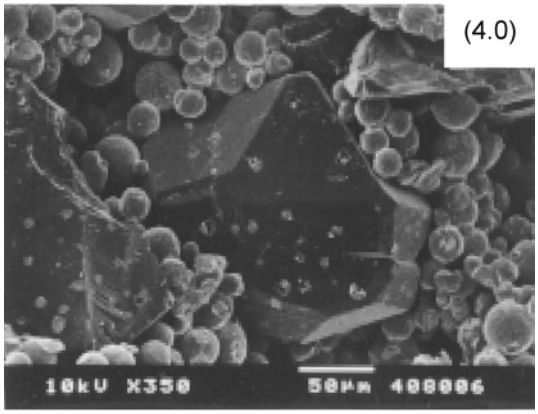


(a) 3.0 mass% carbon concentration



(b) 4.0 mass% carbon concentration

Fig. 2. SEM micrographs of cross section of grinding wheel.

Results and Discussion

Figure 2 shows micrographs of cross section of porous grinding wheels by scanning electron microscope. More dimples are observed on the diamond surfaces for the cast iron of 3.0 mass% carbon concentration as seen in Fig. 2(a) than ones on the diamond surfaces for the cast iron of 4.0 mass% carbon concentration as seen in Fig. 2(b). The reason why the cast iron of Fig. 2(a) has more dimples is due to the stronger chemical reaction between the diamond and cast-iron with lower carbon content. The size of dimples is bigger as the carbon concentration of the cast-iron decreases, and suggests that the bonding strength can be controlled by carbon content in cast-iron.

As mentioned previously, achieving finer surface finishes often compromises the rate of material removed, thus the removal efficiency was measured. Polycrystalline silica, a material that is expected to be used as a substrate for hard disk, was polished to evaluate the removal rate. Figure 3 shows removal rate as a function of grinding pressure. As the grinding pressure increases, the removal rate increases slightly. The porous grinding wheel shows the highest removal rate of investigated grinding wheels, i.e., resin and vitrified

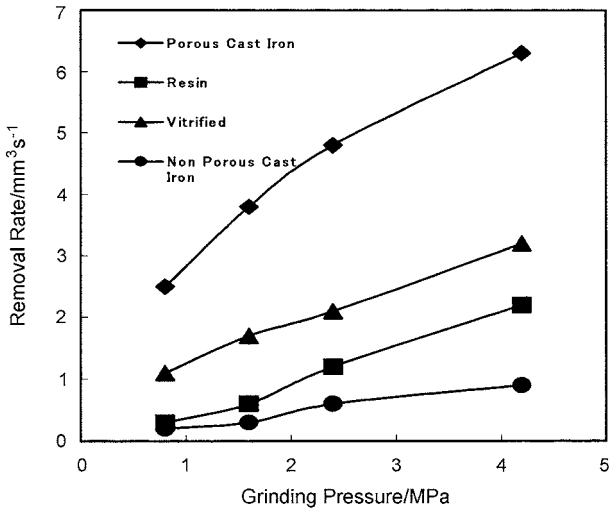


Fig. 3. Removal rate as a function of grinding pressure using grinding wheels of various types.

bonding and non-porous cast-iron-bonded grinding wheels. Since the diamond grains on porous grinding wheel have a high protrusion height and high bonding strength between the diamond grains and the skeleton matrix, it is considered that the penetrating depth of diamonds on the porous grinding wheel is higher than on conventional grinding wheels. It is concluded that the porous grinding wheel has a high grinding efficiency and is expected for defect free grinding due to the low grinding pressure acting on the grinding plane.

Conclusions

The new grinding wheel is proposed to achieve a high removal rate and smooth surface grinding simultaneously.

(1) Stronger anchoring effects were achieved by bonding abrasive grains and the skeleton cast iron matrix through a chemical reaction between the abrasive grains and the skeleton cast iron matrix

(2) The bonding strength can be controlled by the carbon content in the cast-iron.

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