Effect of Filler Metal Powder on Microstructure and Polishing Characteristics of the Brazing Diamond

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Abstract

The present study has shown that the effect of boron and phosphorus in Ni-Cr-Si-X alloy to interfacial reactions and bonding strength of diamond-steel substrate, and the influence of various construction parameters on the formation of the topography of the tool. And these factors are required to making a good brazed tool.

The microstructures and phase change of the brazed region were analyzed into SEM, EDS. According to the electron probe microanalysis, while brazing, the chromium present in the brazing alloy segregated preferentially to the surface of the diamond to form a chromium rich reaction product, which was readily wetted by the alloy.

Keywords : Diamond, Active brazing, Ni-Cr-Si alloy, Diamond tool

1. Introduction

The need for improved abrasive tools to cope with ever-increasing demand for higher productivity has led to numerous developments in the field of abrasive tool manufacturing. These activities have been mainly directed towards improvement of the adhesion of abrasive particles to the bonding matrix, along with increase of its strength and wear resistance.

The good compatibility of nickel-chrome alloy has already been utilized in the fabrication of abrasive tools with tungsten carbide particles by liquid-phase bonding, and quite a number of patents [1-5] have been obtained. The other constituents of these alloys are Fe and B. Sometimes Si and Mo are also present.

An abrasive article, for instance a metal-bonded diamond wheel, has been patented [6] where the bonding matrix consists of Cu, W, Fe, Ni, Cr, Sn, C, B and Si in different amounts.

The use of Ni-Cr alloy containing Si or Si and Ti in brazing graphite to stainless steel has also been reported [7]. The brazing was carried out at 1126 to 1176 ℃ in a vacuum furnace.

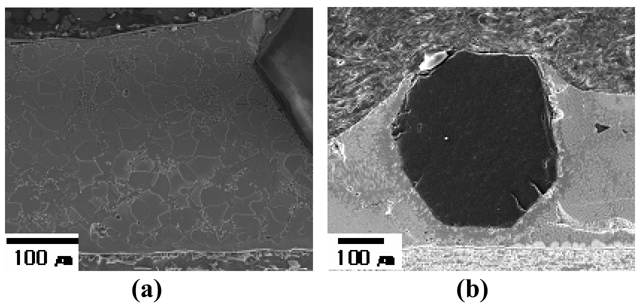
The basic objectives of the present work were to study the wetting behaviour of Ni-Cr-Si active metal brazing alloy on a steel substrate towards diamond grit when vacuum brazing was carried out in vacuum of 2×10^{-5} Torr and to investigate the effectiveness of the bond developed in retaining the grit on the tool surface during grinding.

2. Experimental and Results

Two different brazing alloys in powder form were compared in this study. They are Ni-Cr-Si-B and Ni-Cr-Si-P. The solidus temperatures of the –B alloy and –P alloy are 980 ℃ and 850 ℃ respectively. Synthetic diamond grits with particle sizes ranging from 300 to 450 ㎛ were first mixed with the brazing powder and then applied onto a steel substrate (SM45C) having a thickness of 500 ㎛. Brazing operation was carried out in Vacuum furnace. In vacuum brazing, the system was maintained at a vacuum below 2×10^{-5} Torr at the brazing temperature. The thermal profile included heating the samples at a rate of 10 ℃/min. to 750 ℃, held for 10 min., again heating at a rate 10 ℃/min. to 1050 ℃ for the –B brazing alloy, or 900 ℃ for the –P brazing alloy, and held for 7 min. All specimens were furnace-cooled after brazing completed.

The brazement thus obtained was sliced and polished to obtain the cross-sectional micrograph shown in Fig. 1. The impression that can be gained from this picture is that the Ni-Cr-Si-X alloy wetted and bonded the diamond crystals quite effectively.

It is interesting to note from the X-ray images of nickel, chromium and silicon shown in Fig. 2 that the chromium present in the alloy segregated during brazing towards the diamond surface, most probably to form a chromium



(a) (b)

Fig. 1. Wetting and bonding of diamond grit with (a) Ni-Cr-Si-B, (b) Ni-Cr-Si-P brazing alloy.

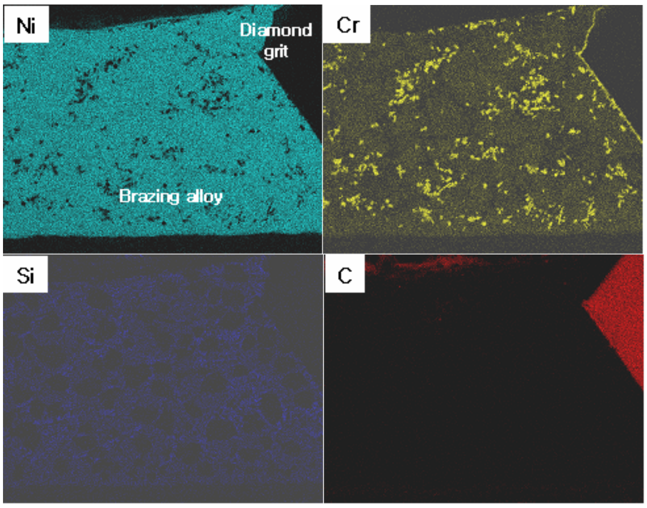


Fig. 2. SEI image and its corresponding dot mappings of Ni, Cr, Si and C for a vacuum brazed structure using Ni-Cr-Si-B as the brazing alloy.

carbide. Evidence of titanium segration to the interface formed with diamond by Cu-Ti and Cu-Sn-Ti alloys which wetted diamond was also found [8, 9].

Fig. 3(a) and (b) shows the surface of an abrasive disk prepared with synthetic diamond grits of sizes ranging from 100 to 125 ㎛. The grit particles can be seen to lie on the disk surface in a single layer. The Ni-Cr-Si-B and Ni-Cr-Si-P brazing alloy was very effective in bonding the diamond particles to the steel disk. Wetting was very uniform on all the grit.

A simulated grinding test was conducted to obtain information about the expected behaviour of the abrasive tool with particular reference to its ability to resist premature grit dislodgement and bond rupture. Fig. 3 reveals that after 4 min. of grinding there was no sign of grit disodgement from the disk surface.

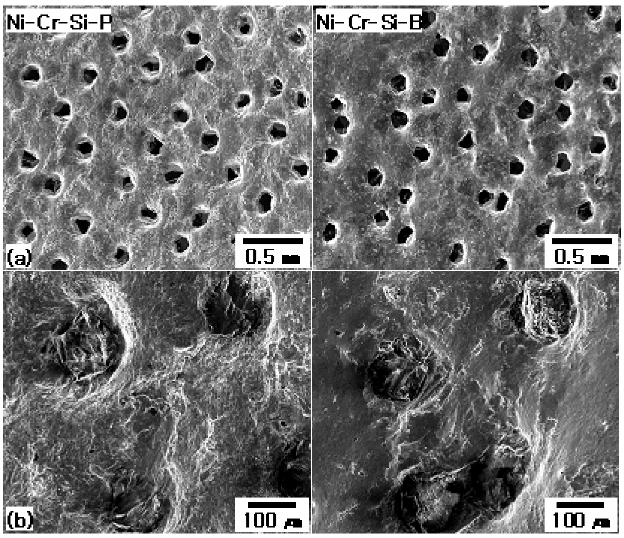


Fig. 3. Surface topography of the diamond grit disk fabricated with Ni-Cr-Si-X brazing alloy (a) before grinding and (b) after grinding.

3. Summary

A Ni-Cr-Si-X alloy on a steel substrate could braze uncoated diamond grit when brazing was carried out by heating at 1050 ℃ for the –B brazing alloy, or 900 ℃ for the –P brazing alloy, and held for 7 min in a vacuum furnace. During brazing, the chromium in the brazing alloy segrated preferentially towards the surface of the diamond to form a chromium rich reaction product at the interface which was readily wetted by the alloy. A grinding test has shown that the grit particles were not released from the matrix during grinding.

4. References

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