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Effect of Filler Metal in High Vacuum Brazing of Diamond Tools

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Abstract

The purpose of this study was to examine the interfacial reaction between diamond grits and Ni-based, Ag-based, brazing filler metal, respectively. The morphology of the interface between diamond grits and Ni-based, filler metal exhibited a very good condition after this heat treatment. Cr-carbide and Ni-rich compounds were detected by XRD analysis in the vicinity of the interface between diamond grits and Ni-based, filler metal after vacuum induction brazing. Chromium carbide is considered to play an important role in the high bonding strength achieved between diamonds grits and the brazing alloy..

Keywords : diamond tool, brazing, chemical reaction, filler metal

1. Introduction

If one compares the tool life of diamond core-bit with a sintered metal bond, for example in the machining of natural stone, with that of electroplated tolls, the tool life advantage in favour of sintered tolls is some three to four times that of electroplated tools. But these tolls suffer not only from the disadvantage that the amount of diamond used is very high, but also their cutting speed is limited because of the small chup spaces. All the same. With brazed diamond tools a tool life can be obtained of about 50-70 % that of sintered tools. As with electroplated tools, here too tha amount of diamond grit used is low. However the bond forces when brazing are considerably greater, as the diamond grit is held in the tool body not just mechanically buty also chemically. This chemical bond also provides for improved heat dissipation and also for the presence of large chip spaces. Because of this, a reduced supply of collant has less of negative effect. The success of brazing the diamond grits onto the steel-core depends on the adhesion strength between the diamond grits and the brazing alloy, which is usually enhanced by the incorporation of active elements, such as Ti, Cr, V, and Zr, into the brazing alloy.[1, 2] These active elements can easily develop interfacial compounds with the diamond grits during the brazing operation, which can alleviate the interfacial stress caused by the different crystallographic lattices and thermal expansion coefficients between the diamond grits and the braze matrix. Various alloy systems, such as Ni–B–Cr alloys, Cu–Sn–Ti, and Cu–Ag–Ti alloys are commonly used as the brazing alloys of diamonds[3]. This aspect of interfacial behaviors has not been sufficiently studied for the Ni-based filler metal for the development of better quality tools. The current study is to examine for optimum condition of vacuum brazing process and for the interfacial behaviors between the diamond grits and the Ni-based filler alloys.

2. Experiments and Results

Synthetic diamond grits (MBG 660, General Electrics Co.,) with particle size of 200 ㎛ was used. Ni-based, Ag-based filler metal was used as the brazing filler metal as shown in table 1.

Table 1. Chemical composition of filler metal and its braz-ing temperature.

Filler	Chemical composition									MELTING RANGE(℃)	BRAZING TEMP.(℃)
Ni-base	Ni	Cr	Si	Fe	B	Co	C	Ti	Others	971-999	1010-1177
	Bal.	6~8	4~5	2.5~3.5	2.8~3.5	0.1	0.06	0.05	0.5		
Ag-base	Ag	Cu	Sn	Zn	Cd	Pb	P	C	-		
	60	30	10	0.001	0.001	0.002	0.002	0.005	-	601-713	713-843
	72	28	-	0.001	0.001	0.002	0.002	0.005	-	779	779-899
	Ag	Cu	Ti	Others	-	-	-	-	-		
	Bal.	25~26	3~5	0.5	-	-	-	-	-	780-830	850-950

The brazing machine is fitted with a special graphite heater that enables working temperatures of up to about 1200 ℃ at a final vacuum of < $2x10^{-5}$ torr.

When using Ni-based filler metal is used at temperatures of about 950/1050 ℃, with a corresponding dwell time and cooling rate these steel-cores can be hardened in parallel with the brazing process. If Ag-based filler metal at a brazing temperaute of about 850-950 ℃ it must be expected that there will be some hardness loss of steel-core.

To bond diamond grits to the tool body filler metal referred to above, silver braze and nickel braze were used. These braze were available as a paste already mixed with a binder liquid.

Fig. 1 shows the SEM micrographs of the surface and longitudinal section of the diamond grits in for the vacuum-brazed specimen. Samples of fig 1. (a) and (d) are vacuum brazed at 950 ℃ for 10 min. It was found that voids are observed near the interface because Ni-based filler metal dose not melt. In the case of (b) and (e) of fig. 2, samples are vacuum brazed at 1000 ℃ for 10min. Microstructure observation of SEM exhibited sound surface morphology and contact angle between Ni-based filler metal and diamond grits. The diamond grits of samples vacuum brazed at 1050 ℃ for 10 min was reacted completely with Ni-based filler metal as shown in (c) and (f) of Fig. 1. The formation of reaction products can be observed adjacent to the diamond grit region. Microstructure observation of SEM showed that optimum brazing temperature obtained was brazing temperature of 1000 ℃ for 10min according to various temperature conditions.

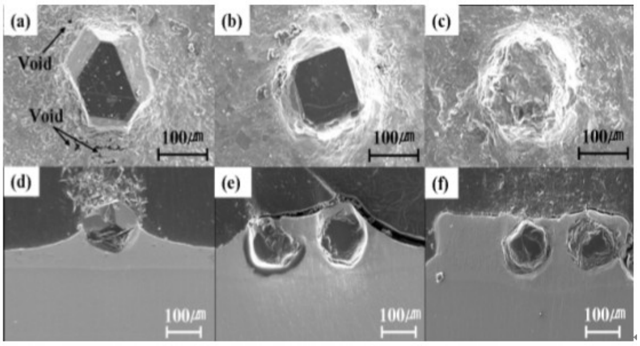

Fig. 1 Surface morphologies of Ni-based filler metal embedded diamond grits exposed at (a,d) 950℃, (b,e) 1000℃, (c,f) 1050℃ for 10min.

Fig. 2 shows mappings of SI, C, Ni, Cr and Ti in the vicinity of the interface between diamond grit and Ni-based filler metal after exposure at 1000 ℃ for 10 min. Pattern of the Cr carbide layer was found to be widely distributed on the surface of diamond grit. The thickness of the Cr carbide layer approved to beabout 5~10 ㎛. The image map of high Ni and Cr concentrations indicated that Ni and Cr-based intermetallic phases may be formed in the interface, respectively.[7] The mappings of the other elements such as Si, Ti, and C, were also analyzed, but their amount was detected to be very small. Si-rich line band with the thickness of several micrometers was found in the filler metal side of Cr-rich zone. Also, chromium carbide particles with the size of about 30 ㎛ was found to be randomly distributed within Ni-based filler metal. It may be considered that Cr and Si element must be migrated to the interface between the diamond grit and the Ni-based filler metal.[4] Consequently, a strong interfacial bond could thus be achieved by migrating elements such as Cr and Si to the interface, leading to the formation of intermetallic compounds.

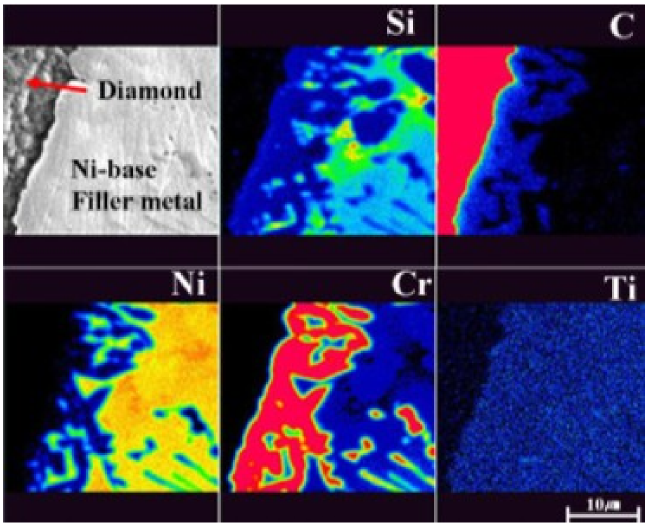

Fig. 2 SEM image and its corresponding dot mappings for the interface of diamond grit/Ni-based brazing filler metal exposed at 1000℃ for 10 min.

3. Summary

The interfacial reaction and optimum vacuum brazing condition in a diamond grit/ Ni-based and Ag-based filler metal system were examined respectively. The optimum brazing condition of diamond grit/Ni-based, filler metal was shown to be brazing at 1000 ℃ for 10 min. CrC, Cr_3C_2, Cr_7C_3, $Cr_{23}C_6$ and Ni_9 Si_4 B_2, Ni_3B were detected by XRD analysis in the vicinity of the interface between diamond grit and Ni-based, filler metal after vacuum induction brazing. A graphite layer degrading the bonding strength of the diamond grit was not formed at the interface between diamond grit and Ni-based, filler metal.

4. References

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