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Fabricated of Metal-bonded Grinding Wheel with Cubic Boron Nitride Abrasive Grains by Centrifugal Casting

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Al/cubic boron nitride (cBN) metal-bonded grinding wheel for drilling of carbon fiber reinforced plastic (CFRP) was fabricated by the centrifugal mixed-powder method (CMPM), which is application of centrifugal casting. Drilling performance of fabricated grinding wheel is tested using the gyro-driving grinding wheel system.

Keywords: *Centrifugal casting, composite, cBN, carbon fiber reinforced plastic (CFRP), drilling*

1. Introduction

Nowadays, carbon fiber reinforced plastic (CFRP) is increasingly used as a structural material in the aerospace industry due to its superior properties such as low weight, high strength, good toughness and so on. Drilling of CFRP is the most common post process of structural parts of aircraft fields. However, CFRP is known as a difficult to machining material, fiber pullout, delamination, burrs and splintering have become problems in machining CFRP by common drills.

Recently, gyro-driving grinding wheel system has been developed as a new CFRP drilling system [1,2]. This system provides holes with high precision on CFRP without delamination and burr formation. In the gyro-driving grinding wheel system, a grinding wheel was used, instead of drill bits for drilling.

In our previous study, Al-bonded grinding wheel with diamond abrasive grains was fabricated by CMPM [3]. In this study, cBN grinding wheel for drilling CFRP has been fabricated by the CMPM, since cBN is known as a diamond competing superhard material. Drilling performance of fabricated metal-bonded grinding wheel is also tested using the gyro-driving grinding wheel system.

2. Experimental procedure

Pure Al particles of 99.9% purity having 75 to 150 μm diameter and abrasive grains (cBN abrasive grains or diamond abrasive grains) having 125 to 150 μm diameter were mixed. The volume fraction of the abrasive grains in the mixed-powder was 25 vol.%. After that, the mixed-powder was put into a mold which was made by lost-wax method and the prepared mold was set in a compact vacuum centrifugal casting machine, show in Fig.1. After setting the mold, pure Al ingot of 99.9% purity was melted at 1300 ºC by heating coil under vacuum condition. After melting, the motor was rotated to apply centrifugal force and molten Al was poured into the mold by its centrifugal force. After air cooling, the metal-bonded grinding wheel with 20 mm in outer diameter was obtained. The casting conditions are show in Table 1.

The microstructural observations of the fabricated samples were carried out with scanning electron microscope (SEM). CFRP drilling test was conducted at peripheral wheel speed of 7000 rpm, spindle speed of 2800 rpm and feed rate of 5 mm/min.

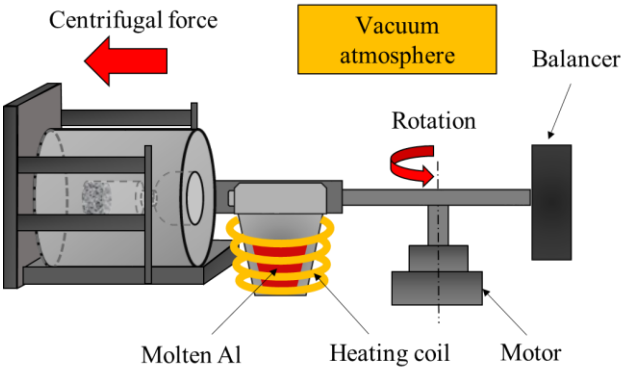

Fig. 1 Schematic illustration of centrifugal mixed-powder method.

Table 1 Casting conditions

Samples	Al/cBN	Al/diamond
Amount of Al particles [g]	2.73	
Amount of abrasive grains [g]	1.19	1.17
Amount of Al ingot [g]	30	
Casting temperature [ºC]	1350	
Gravity multiples [G]	85	

3. Results and Discussion

Al/cBN and Al/diamond samples were successfully fabricated by CMPM. Figure 2 shows SEM images of abrasive grains in (a)Al/cBN and (b)Al/diamond samples. As seen in Fig. 2, it was observed that cBN abrasive grains were embedded in Al matrix without space between Al matrix and cBN abrasive grains. On the other hand, the space between Al matrix and diamond abrasive grains were observed. Therefore, better bonding force between the abrasive grains and the Al matrix is expected for the Al-cBN sample.

Figure 3 shows photos of the 30th hole on CFRP plate drilled by (a)Al/cBN and Al/diamond griding weels. As seen in Fig 3 (a), some burrs were observed for the hole drilled by the Al/cBN grinding wheel. On the other hand, as seen in Fig. 3 (b), there was no burr for the hole made by Al/diamond grinding wheel. From the results, Al/diamond grinding wheel was able to more high quality drilling than Al/cBN grinding wheel.

Figure 4 shows surface roughness of the machined CFRP as a function of number of machined holes. As seen in Fig. 4, it was found that the surface roughness values obtained by CFRP drilling test with Al/cBN and Al/diamond samples were lower than the requirement for certification.

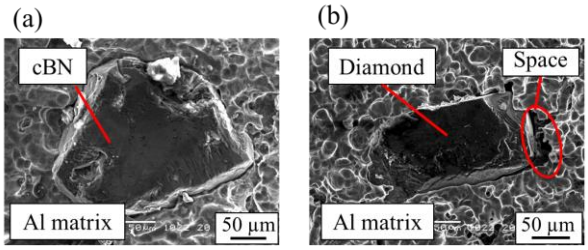

Fig. 2 SEM images of abrasive grains in (a)Al/cBN and (b)Al/diamond samples.

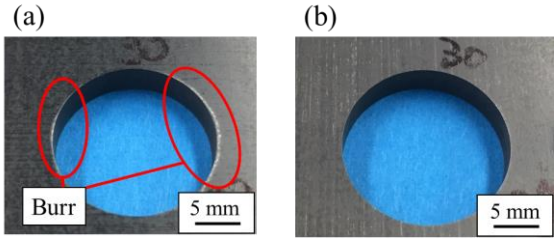

Fig. 3 Photos of the CFRP plate after making 30 holes with (a)Al/cBN and (b)Al/diamond samples.

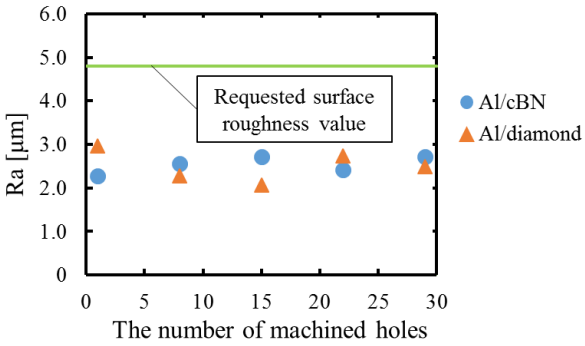

Fig. 4 Surface roughness of the machined CFRP

4. Conclusions

Al/cBN and Al/diamond grinding wheels have been successfully fabricated by CMPM. From obtained results, it was found that the surface roughness values obtained by CFRP drilling test with Al/cBN and Al/diamond grinding wheels were lower than the requirement for certification. It is also found that Al/diamond grinding wheel was able to more high quality drilling than Al/cBN grinding wheel.

References

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