Grinding Performance of a Grain-Arranged Diamond Wheel and a GC Wheel against CFRP

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Abstract

During the process of drilling or cutting of CFRP plates, tool wear and detachment of the back surface of the plates occur frequently. To overcome these problems, a grain-arranged diamond wheel has been developed and applied to a grinding test of CFRP. When orientation of the carbon fibres was set parallel to the cutting direction of the diamond grains, detachment of the fibres is widely observed on the finished surface. When the fibre direction was rotated by 30-90 degrees in the horizontal plane, the detachment was effectively reduced. The diamond wheel showed superior finishing capability of CFRP to a conventional GC wheel.

1 Introduction

CFRP is widely used for sports gear and components of cars and aircraft etc. because of its superior specific strength. CFRP components usually require trimming and drilling. Less frequently, they require cutting. Under the process of drilling or cutting, tool wear and detachment of the back surface of CFRP plates occur frequently [1]. In order to overcome these problems as well as enhance the machining efficiency, the grain-arranged diamond wheel of #60-mesh is developed. The wheel is applied to a grinding test of CFRP plates and its performance is compared to a conventional GC wheel of #120-mesh. Effects of carbon-fibre orientation, setting angle of the CFRP plate, and the grinding fluids on the finishing performance are experimentally investigated.

2 Experiment and Conditions

Fig. 1 shows the concept of the grain arrangement. The diamond grains of #60-mesh are set on the steel-disk periphery with 0.7 mm spacing. The arrangement angle of 23.2 degrees is chosen to generate a fine surface [2]. The working surface of the

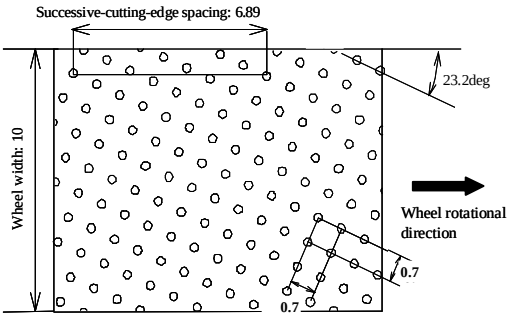

Fig.1 Arrangement pattern of diamond grains

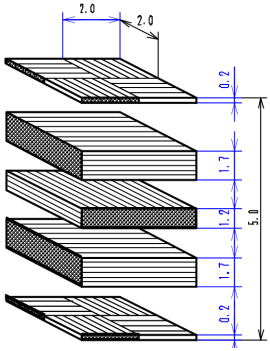

Fig.2 Structure of CFRP

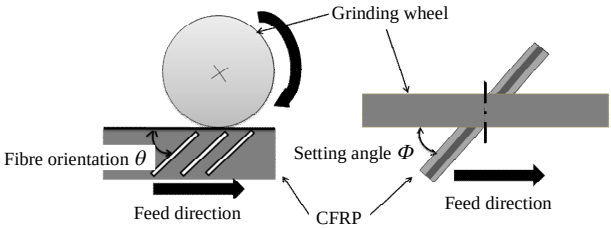

Fig.3 Fibre orientation, θ, and setting angle, Φ, of CFRP plate

developed wheel is precisely trued using a diamond-impregnated dresser under the condition: down-feed is at 0.1 μm; and cross-feed speed is 20 mm/min. Through the truing process, the level of the cutting edges are precisely adjusted and the tip of the cutting edges are finely flattened. The finishing performances of the developed wheel and a conventional grinding wheel, GC120H8V, with fine dressing, are compared.

Fig. 2 shows the structure of the CFRP plate. In the experiment fibre orientation, θ, and work-piece-setting angle, Φ, are arranged as shown in **Fig. 3.** The effects of θ, Φ, and grinding fluids on the maximum roughness of the finished surface, Rz, are investigated. In the grinding experiment a high-precision grinding machine, Kuroda SPG-25, is used under supplying chemical-solution-type coolant, SC95. The machine has hydrostatic oil bearings for horizontal motions, and its minimum feed is 0.1μm.

The lubricants: CRC 5-56; ZnDDP (zinc-dialkyl-dithiophosphate); Bluebe LB10; LB80; and WB1 (emulsion-type lubricant) are also tested using a MQL (minimum quantity lubrication) system, Bluebe FK1-L-LM. The basic grinding conditions are shown in **Table 1**.

3. Experimental results

Fig. 4 shows the effects of grinding fluids and θ on Rz for the diamond wheel. When SC95 is supplied the developed wheel shows best performance in surface finishing because the fluid has superior grinding-chip cleaning capability when it is introduced by a conventional coolant-supply system. When θ is set at zero degrees, the diamond grains cannot cut carbon fibres and detachment of the fibres is widely observed as shown in **Fig. 5 (θ=0°)**. In this case, Rz increases up to the fibre diameter, 7μm. When θ is set at 90 degrees, Rz is the smallest but the finished surface is mostly covered by a thin resin layer.

Fig. 6 shows the effect of down-feed, *t*, on Rz when θ=0°. Rz gradually increases with increased *t*. The diamond wheel shows superior finishing capability to the conventional GC wheel.

Fig. 7 shows the effect of Φ on Rz. When Φ is sifted from

Table1 Basic grinding conditions

Work-piece	Two directional CFRP
Grinding wheel	Grain-arranged diamond wheel, GC120H8V
Fibre orientation θ	0, 90 degrees
Setting angle Φ	0 degrees
Grinding fluid	SC95 (Type A-3)
Down-feed	5 μm
Wheel speed	1160-1260 m/s
Table speed	0.5 m/min

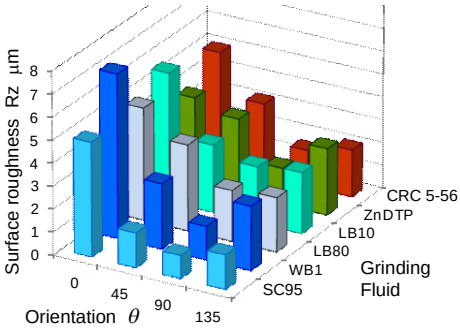

Fig. 4 Effect of grinding fluid and θ on Rz

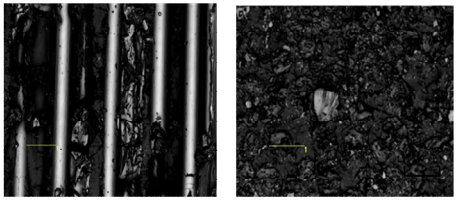

Fig. 5 View of the finished surface

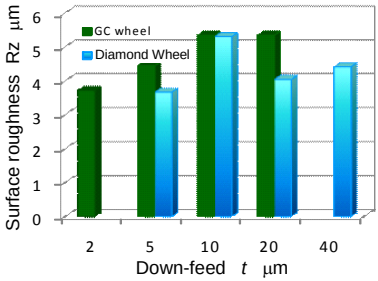

Fig. 6 Effect of down-feed, *t*, on Rz

30 degrees to 90 degrees detachment of the fibres is effectively reduced, and Rz is diminished to less than about 1.5 μm for the diamond wheel even when θ=0°. Through the experiments following results are also obtained: (1) Decreased wheel-peripheral speed results in better surface finishing; (2) Just after dressing, GC wheel has a capability of cutting the fibres even when θ=0°. This ability, however, quickly disappears with increased grinding passes.

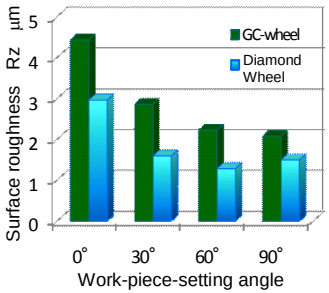

Fig. 7 Effect of Φ on Rz when θ=0°

4. Conclusions

The grain arranged diamond wheel developed showed superior finishing capability of CFRP to the conventional GC wheel. The diamond grains, however, hardly cut carbon fibres and detachment of the fibres from the finished surface occurred frequently when θ=0°, because each cutting edge had a large wear-flat area due to very fine truing. When work-piece-setting angle, Φ, was shifted from 30 degrees to 90 degrees, detachment of the fibres was effectively reduced. In order to enhance the finishing capability of the diamond wheel, smaller grains with sharp cutting edges have to be arranged.

Acknowledgement:

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References:

[1] S.Hanasaki, J.Fujiwara, and M.Nomura: Tool Wear Mechanism in Cutting CFRP, *Journal of the Japan Society of Mechanical Engineers*, Ser.C, Vol.60, No.569 (1994) pp.297-302 (In Japanese).

[2] S.Okuyama, A.Yui and T.Kitajima: Grinding Performance of a Grain-Arranged Diamond Wheel against Aluminium Alloys and Ti6Al4V, *Advanced Materials Research*, Vols. 126-128 (2010) pp.107-112.