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Precision Cutting Characteristics of Diamond Cutting Wheel to Woodceramics

K. Ogawa, K Hata[1)], M. Mayuzumi[2)],T. Okabe[3)], M. Ogawa[4)] and M. Otsuka[5)]
Tokyo Inst. Polytechnic Univ , 2-32-1 Ogawanishimati kodaira,Tokyo187-0035,Japan
Fax 81-042-344-5609,e-mail:ogawa@tokyo-pc.ac.jp
[1)]Shiga Polytechic College, , Furukawa－Cho, omihachiman, Shiga 523－8510,Japan
Fax81-0748-31-2255,e-mail:hata@ac.shiga-pc.ac.jp
[2)]Research Institute Tokyo technology adbiser, 3-13-10 kitaku-misigaoka,Tokyo115-8586,Japan
[3)]Aomori Ind. Res. Center, 4-1 1-6,Daini - toyamachi , Aomori 030-0113,Japan,
Fax 81-017-739-9676,e-mail: okabe @ aomori - tech.go.jp
[4)]Shibaura Inst. of Tech. , Shibaura3-9, Tokyo 108-8548 ,Japan
Fax 81-048-687-5055,e-mail:ogawa @ sic.shibaura-it.ac.jp
[5)]Shibaura Inst. of Tech. ,307Fukasaku,Omiya.Saitama 330-8570 ,Japan
Fax 81- 03-5476-2419,e-mail:otuka @sic.shibaura-it.ac.jp

Woodceramics is a versatile carbon material derived from plant-based raw materials. Woodceramics has a variety of functions, including use as a heating medium. As it is hard and brittle it cannot easily be cut. In this study, more efficient cutting and processing conditions for woodceramics are considered by examining cutting resistance and cut surface.

Key words: woodceramics, carbon,cutting

1. INTRODUCTION

Woodceramics (WCS) is a porous carbon material, created by firing wood or sawdust which has been saturated with phenolic resin. Thus, it is viewed as a new environment-friendly material. Features of WCS include a porous structure, lightness, hardness, heat resistance, low cost and good conductivity.[1)2)] Currently many studies are being conducted for the application of WCS. These studies focus on WCS as a heating medium, acoustic material, electromagnetic shielding material, etc.[3)4)] Its excellent characteristics are also being verified for other fields as well.

While WCS is considered to be an excellent material, its hardness and brittleness are disadvantageous when cutting and shorten the lifetime of the cutting equipment. Woodceramics can be cut both before and after firing. But since WCS contracts and can change shape during firing, cutting must be done after firing to get a precise shape. Therefore, effective cutting conditions after firing must be determined for the practical use of WCS. In this study, cutting was done with a diamond cutting wheel used for difficult-to-machine materials.[4)] Changes in machining conditions were conducted and the surface was observed, and surface roughness and machining resistance were measured. As a result of the above studies, better machining conditions could be determined.

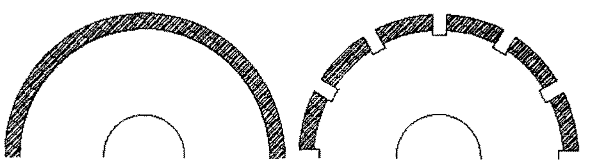
2. EXPERIMENTAL PROCEDURE

A woodceramics test sample was made from MDF and fired at 650C. MDF (Medium Density Fiberboard) is a board (fiberboard) which has been saturated with an adhesive and shaped into a product of medium density. MDF is normally used as the raw material of WCS. When saturated with phenolic resin, differences in the degree of saturation between its surface and interior cause a difference in hardness. In order to conduct experiments under a constant condition, saturation differences were avoided as much as possible by trimming 10 mm from the edges of the Woodceramics board (100 mm x 100 mm x 10 mm). Next, the board was used with a cutting machine (MC-100 Maruoto Corporation) with feed gear. Experiments were conducted for the following items.

2.1 Study of wheel type

Regarding the cutting wheel, both blade and continuous types were studied. For bonding, both electric and metal types were studied. Observation of edge defects and cracks was conducted for cutting at feed rates of 100 mm /

min – 500 mm / min and a wheel edge speed of 452 mm / min. The types of the tool is shown in Fig.1.



Continuous type Blade type

Fig. 1 Types of cutting wheel.

2.2 Grain size of wheel and observation of cut surface

Grain sizes of cutting wheels used here were #120, #230 and #320. Observation for edge defects and cracks was conducted for cutting at feed rates of 100mm/min, 200mm/min and 300mm/min and a wheel edge speed of 452mm/min.

2.3 Feed rates and surface roughness

Cutting was conducted under the same conditions as above. Next, surface observation was performed. Measurements for surface roughness (maximum roughness (Ry), average roughness of 10 points (Rz) and the mathematical average of roughness (Ra)) using roughness measuring equipment were taken. The shape of the sawdust samples was also observed using SEM.

2.4 Cutting resistance during cutoff

As shown in figure 2, cutting resistance was next measured by constructing a device, where the test sample mounted onto a carriage with a dynamometer could move under the cutting wheel at a fixed speed. Figure 3 shows a magnified picture of the machining section. Test samples were set so as to pass the height of 10mm from the edge of cutting wheel. Feed rate of the cutting wheel was set at 100-2000 mm/min and measurements in the horizontal and vertical directions were taken by setting the sampling frequency of resistance at 100Hz in both the horizontal and vertical directions. Signals from the sampling were amplified, A-D converted and entered into a computer. Comparison of the cutting conditions was done by calculating the resistance in the tangent direction of the wheel. After measurement, a comparison was also taken of the resistance in the tangent direction of the measuring device.

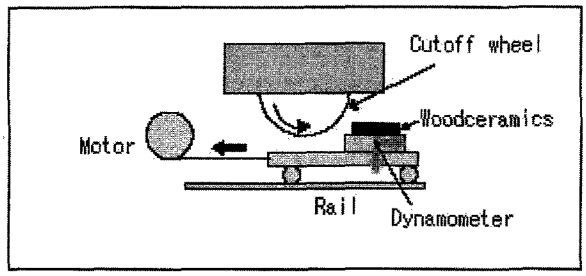


Fig. 2 Diagram of cutting resistance detection.

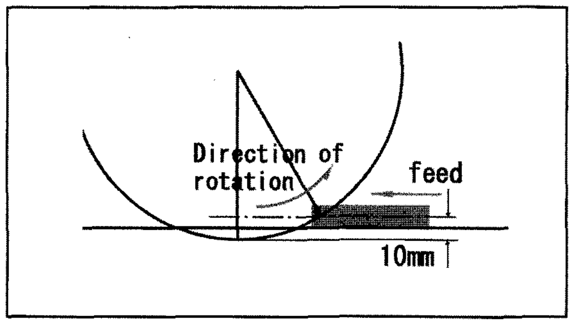


Fig. 3 Magnified view of the machining part.

3. RESULTS

3.1 Type of cutting wheel

Defects are caused in the case of a blade type cutting wheel when each blade hits the Woodceramics. It was confirmed that many defects and cracks along the edge were generated on impact. Therefore it was concluded that a blade type is not suitable for cutting Woodceramics. Also, it was confirmed that the type of bonding did not influence the cut surface.

Table 1 Relation between the cutting wheel and feed rate.

Bonding	Shape of wheel	Grain size	Feeding rate mm/min	
			100	500
Electric	Blade type	40	△	×
	Continuous	50	O	O
	Continuous	120	O	O
Metal	Blade type	40	△	×
	Continuous	120	O	O

△ Generation of a edge defect × Generation of a crack

3.2 Grain size of wheel and observation of cut surface

Cutting by 4 grades of cutting wheels from #50 to #800 was conducted. The results shown in Table 2 were obtained from observation of the cut surface and demonstrate that high-speed cutting with a fine grain of #800 is difficult.

Table 2 Relation between feed rate and grain size.

	Feeding rate		
	100mm/m	200mm/m	300mm/m
#50	O	O	O
#120	O	O	O
#300	O	O	O
#800	O	△	×

△ Generation of a edge defect ×Generation of a crack

3.3 Feed rates and surface roughness

Figure 4 shows the relation between grain size of the wheel and surface roughness in relation to the feed rate. At the slowest cutting rate of 100mm/min, no improvement in surface roughness was observed for grain sizes from #50 to #300 but a smoother surface was observed for #800.

When the feed rate was between 200-300 mm/min, the above tendency decreased and the difference in surface roughness between grain sizes of #50 and #300 increased. Regarding grain size of cutting wheel, there was only a slight difference in surface roughness for feed rates between 100 and 200mm/min. But for a fine grain of #800, the difference of Ra and Ry became 1.5 times greater for feed rates between 100 and 200mm/min. This confirmed that cutting should be done at an extremely slow rate of less than 100mm/min. When the cut surface and efficacy of cutting are considered, grain size of #300 gives optimal results.

Scanning electron microscopic observation revealed that the sawdust could be divided into 2 major types. Figure 5 shows the SEM pictures of the sawdust originated from cutting wheels with grain sizes of #50 and #800, respectively. In the picture of #50, larger pieces of sawdust, including porous pieces shown at the left side, can be seen. This showed many defects in cutting and/or that a blade type of wheel was used. On the other hand, when a fine grain such as #800 was used, few porous pieces were observed in the sawdust, as shown in the following picture. When cutting with #50, only small cracks are generated when cutting the WCS fiber. Yet with the fine grained #800, it is thought that the cutting action is done simultaneously with cutting the WCS fiber. This difference is considered to be a major cause for the difference in surface roughness.

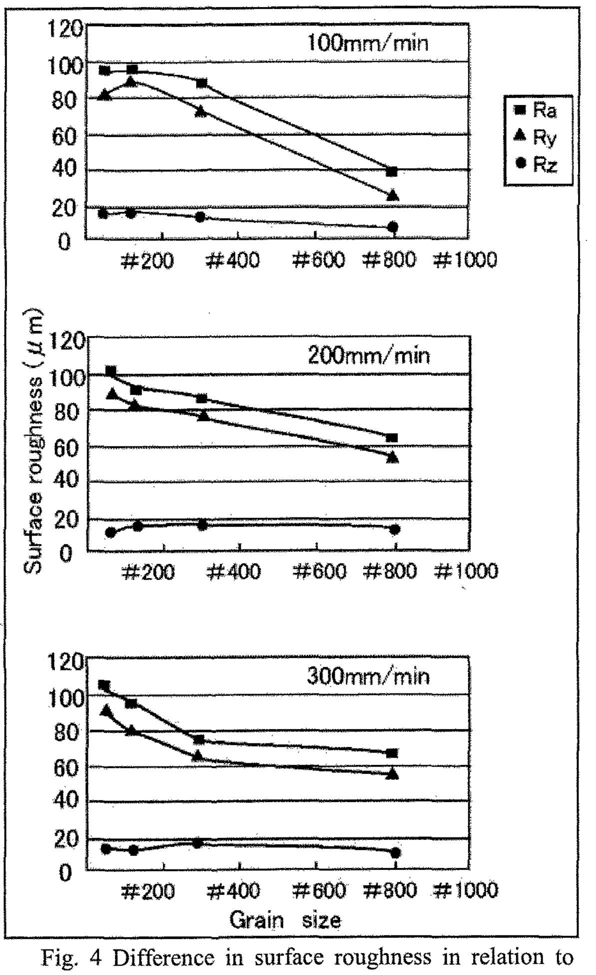


Fig. 4 Difference in surface roughness in relation to feed rate and grain size of the equipment.

3.4 Cutting resistance during cutoff

As a result of measuring cutting resistance, the wave pattern shown in Figure 6 could be seen. Generally, after the test sample comes in contact with the wheel, cutting resistance gradually increased as the contact area increased, and became constant when the contact area between the wheel and the test sample reached maximum. On the other hand, a systematic graph of the generation of cracks in relation to increased resistance as the area of the sample in contact with wheel gradually increased, could not be obtained. Figure 7 compares the values at the time when resistance becomes constant for each cutting condition. From the results, it can be ascertained that resistance increases as grain size of the equipment increases. Also, the blade type (40b) was far from standard. The symbol ▲ in diagram shows the feed rate, at the time when the first defect was generated, when cutting was conducted by increasing the rate. It was observed that defects were generated by a wheel irrelevant to grain size at a position between 10-15N.

#50

#800

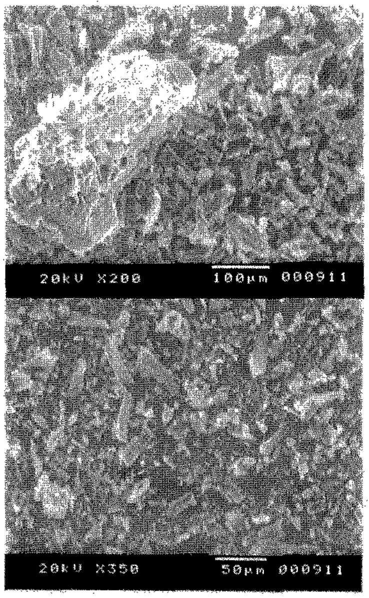


Fig.5 Comparison of sawdusts originated form different wheels.

Figure 8 shows the maximum cutting resistance for each cutting procedure. At maximum resistance, differences due to the equipment were not observed when comparing the average values between #50-#300. When a crack was generated,● is marked at the location of the lowest rate. Cracks were generated near 60N for the continuous type. From above results, it can be said that cracks in the WCS are not related to the grain size of the equipment and are influenced by cutting resistance, in other words, the force with which the equipment pushes the WCS.

4. CONCLUSIONS

The following could be confirmed by this experiment.

1) Blade type equipment is not suitable for cutting.
2) As a whole, wheel with a grain size of #300 demonstrates excellent cutting performance.
3) For grain size of #800, precision cutting is possible when the feed rate was set to less than 100mm/min.
4) There is a correlation between the distribution of the particle size of the sawdust and the roughness of the cut surface.
5) When a continuous type is used, cutting resistance increases as grain size of equipment increases.
6) Defects and cracks are not related to grain size of equipment, but depend on cutting resistance.

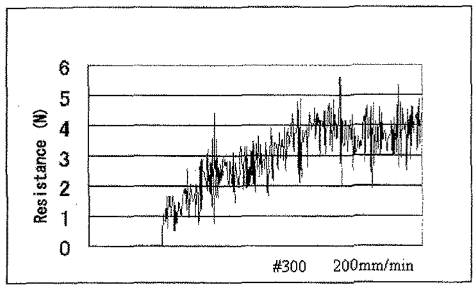


Fig. 6 Cutting resistance using a #300 cutting wheel at a feed rate of 200mm/min.

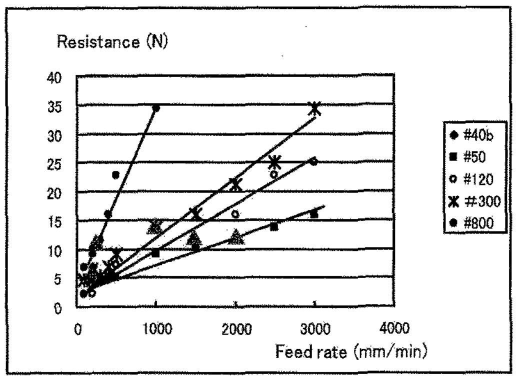


Fig. 7 Relation between cutting resistance and defects (cutting resistance is average value)

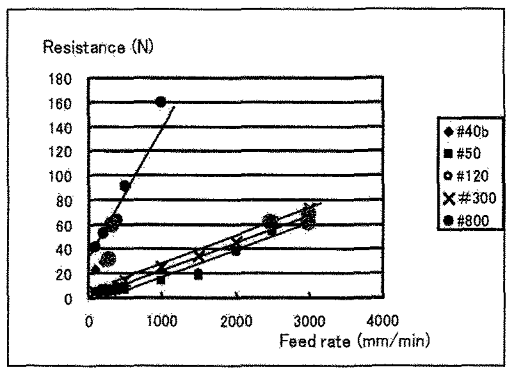


Fig. 8 Relation between cutting resistance and cracks (Cutting resistance at maximum value)

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