Transactions of the Materials Research Society of Japan 31[4] 917-920 (2006)

Processing Characteristics of Woodceramics during Vibration Cutting 2

K. Ogawa, [1],T. Okabe[2], M. Ogawa[3]
[1]Tokyo Inst. Polytechnic Univ., 2-32-1 Ogawanishi-machi Kodaira,Tokyo187-0035,Japan
[2]Aomori Ind. Res. Center, 4-1 1-6,Daini - Toyamachi , Aomori 030-0113,Japan,
[3]Shibaura Inst. of Tech. ,307Fukasakumachi,Omiya.Saitama 330-8570 ,Japan

Woodceramics is hard but also brittle and thus cannot be easily processed. Therefore establishing a better processing method has been studied. In this study, experiments were conducted, in order to bring out processing characteristics of woodceramics by investigating correlation between cutting resistance and contact pressure during cutting with a lathe. As a result, a good correlation between cutting resistance and contact pressure was found and could confirm the prediction of processing conditions according to the hardness of the woodceramics. In addition, by using vibration cutting, cutting resistance could be halved and the surface roughness of the processed face could also be improved. From this, it was confirmed that vibration cutting is an effective method in the processing of woodceramics.

Key word woodceramics、vibration cutting

1. INTRODUCTION

Woodceramics (abbreviated as WCS) is a generic term for carbon material produced by carbonating wood, which has been saturated with thermosetting phenolic resin, at 300-2000℃under anoxic and depressurized conditions.[1] WCS can be adjusted to various functions by changing the carbonating temperature and is expected to be used as a humidity and ammonia sensor[2)~4)], electromagnetic shield[5),6)] or a heating medium[7),8)]. Because of uneven impregnation of phenolic resin, WCS shows higher cutting resistance at both ends in the cross-sectional direction than through the middle during vibration cutting[9)]. It is assumed that WCS has uneven hardness and its distribution varies widely. Furthermore, this hardness hinders cutting, since it has a higher cutting resistance. In fact, this uneven hardness is one reasons influencing the ability to processing by conventional cutting. In this study, experiments were conducted, in order to clarify one of the processing characteristics during conventional cutting of WCS by investigating the correlation between cutting resistance and contact pressure, after pressure measurements on the pushing pressure on the contact face was conducted. Additionally experiments to confirm the effectiveness of vibration cutting were also conducted.

2. EXPERIMENTAL METHODS

2.1 Material

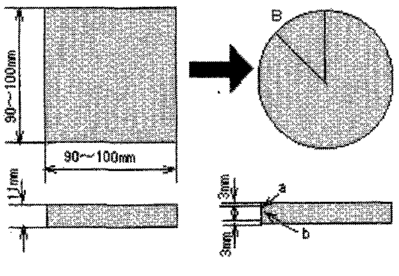


Fig.1 An examination body and the measurement point.

As shown in Figure 1, a circular disk with a 90-100mm diameter and 11mm thickness, which is made from square-shaped WCS (burning temperature was 1200℃), was used for the experiments. Comparison was also made between samples, where a sample was processed by filing for a smooth measuring surface, versus a sample that was not preprocessed (filing). As shown in Figure 1, point of 3mm from the surface with a-part and a center with b-part. For circumferential direction, measurement was conducted by defining the part corresponding to the side of original square as A-part and the part at 45° angle from A-part as B-part, respectively.

2.2 Pushing experiment

A sample piece was attached to a lathe with a clamp and a pushing device was fixed to the tool rest of the lathe. A pushing pressure experiment was conducted using the feed gear of the lathe. The pushing device was made by processing the tip of a ¢ 10mm high-speed steel in a cone form with an apex angle of 90° and used for experiment. Regarding Rockwell hardness, the apex angle is 120°, but for this experiment, it was set at 90° in order to decrease projection indentation since the thickness of the sample was between 10-11mm, comparable to the diameter of pushing equipment. Load was measured for a pushing amount between 0.1-1mm, by 0.1mm intervals per each measuring point. After measurement, comparison was conducted by dividing the measured load by the projection area of the pushing equipment.

$$P_C=W/A$$

(P_C; contact pressure, W; hemeasured load, A; the projection area of the pushing equipment)

The result of the calculation was defined as the contact pressure and compared for each pushing amount.

2.3 Difference in contact pressure with and without filing.

The sample of WCS with pre-processing filing and the sample without filing were compared. For the filing sample, sand paper of #240 was used.

2.4 Cutting resistance

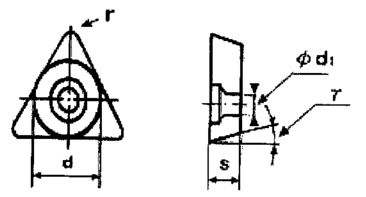
Comparison was performed by turning the outer circumference of the same circular disk as used for the pushing test, made of WCS carbonated at 1200℃ under the conditions described in Table 1 with vibration cutting, against the sample without vibration cutting. By contrasting the cutting resistance with the result of the measurement experiment for the contact pressure, uneven contact pressure made by carbonation of WCS could be confirmed. Then comparison was again done to understand how this unevenness affects cutting resistance as well as how this could influence the cutting surface. Processing was conducted by using STGC (Super Tough Grooving Chip for router). We shows shape of STGC for Figure 2. A supersonic vibratory cutter (vibratory frequency: 26970Hz, vibration width: 19μm) of FUJI Ultrasonic Engineering Co., Ltd. was used for vibration cutting. As for cutting resistance, back and feed components were measured individually and then a comparison was conducted for each component. Figure 3 shows a measurement direction of cut resistance

2.5Cutting resistance in case of low speed processing

Because uneven contact pressure in both the cross-section and circumference directions could be predicted, factors for this unevenness was examined by measuring cutting resistance per single rotation by lowering the cutting speed (feed amount: 0.5mm, cutting depth: 1mm, rotating rate: 12rpm, cutting speed: 17.7m/min) during conventional cutting.

Table1 Cutting conditions

Feed rate (mm)	0.05、0.3、0.5
Cutting depth (mm)	0.5
Rotation rate (rpm)	220、450



Inscribed circle	Thickness	Nose radius	Hole diameter
d (mm)	s (mm)	r (mm)	d1 (mm)
6.35	2.38	0.4	2.8

Fig.2 A diagrammatical view of lip

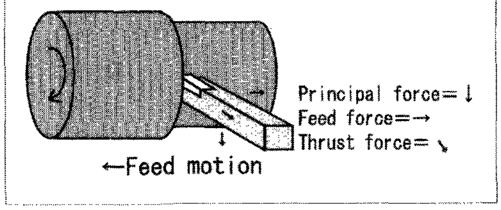


Fig. 3 Measurement of cutting resistance.

3. RESULTS AND DISCUSSION

3.1 Contact pressure by pushing

Figure 4(a) and Figure 4(b) shows that contact pressure for the sample with preprocessing could be greatly decreased at depths between 0.1-0.2mm. This indicates that a layer with extremely high contact pressure had appeared on the surface. Between the end and the center parts (a, b), no major difference in contact pressure could be seen. On the other hand, a 2 to 3 times difference could be observed between A-part and B-part. This confirms that the contact pressure of WCS is strongly influenced by the processing depth from the surface. When measurement was conducted for the sample without preprocessing, a large decrease in contact pressure between 0.1-0.2mm was not observed. From this result, mass density is assumed to decrease along the inward direction (center) and the ratio of space was thus increased. In comparison with the sample without preprocessing, there was no large decrease in contact pressure at the surface. It is assumed that the reason for this is that filing the rough surface results in the filling of the concave space of the surface, allowing for smoother surface for entry. By comparison of both cases, results showed that filing of the surface could greatly influence the results of the pushing experiment.

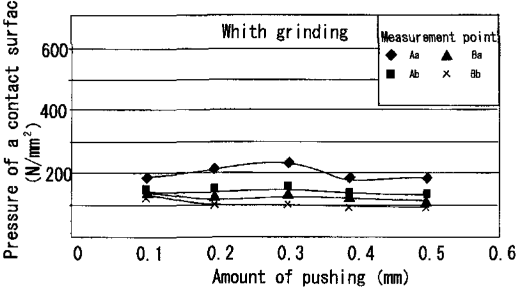


Fig. 4(a) Relationship amount of pushing and pressure. (Whith grinding)

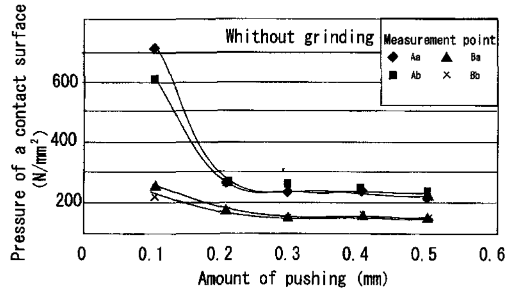


Fig. 4(b) Relationship amount of pushing and pressure. (Whithout grinding)

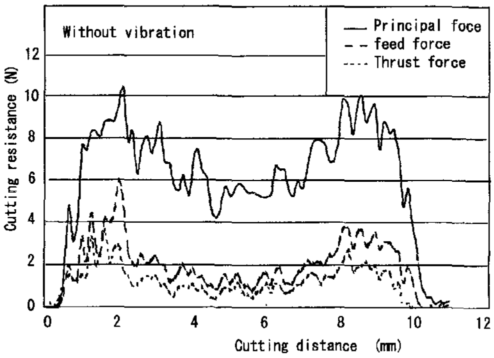


Fig.5 Cutting resistance in the case of conventional cutting
(Rolation rate :4500rpm.Feed rate:0.5mm)

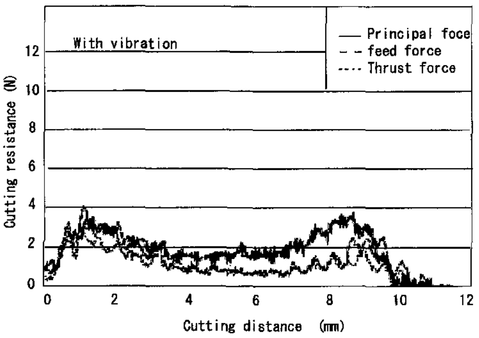


Fig.6 Cutting resistance in the case of vibratory cutting
(Rolation rate :4500rpm,Feed rate:0.5mm)

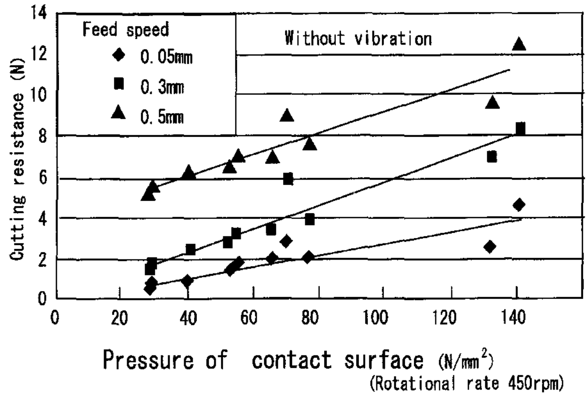


Fig.7(a) Relationship between cutting speed and pressure of a contact surface according to change in feed speed.(whithout vibration)

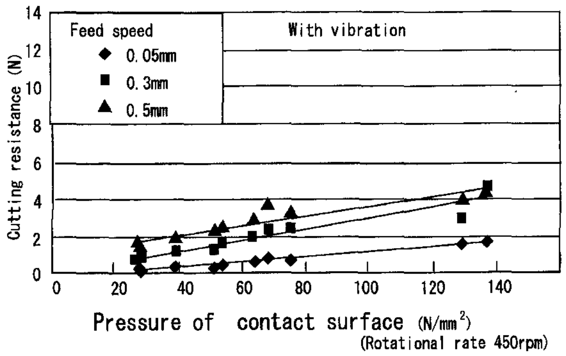


Fig.7(b) Relationship between cutting speed and pressure of a contact surface according to change in feed speed. . (with vibration)

3.2 Cutting resistance

Figure 5 shows the cutting resistance for conventional cutting without vibration. As shown in the graph, in comparison with a common metal based material used for cutting, the feed force tended to be smaller than the thrust force. The reason may be due to the breakdown of minute spaces in the WCS, which are derived from its porosity, by the repeated pulverization during cutting. As seen for all 3 forces, vibration was clearly recorded in the total diagram. This is probably due to the difference in distance from the firing surface, because the sample piece was cast as disk. This was confirmed by low-speed cutting in the following experiment. As can be seen by the total diagram, cutting resistance at the both ends was relatively higher and decreased in the direction towards the center. This corresponds to the results described in the distribution diagram of pressure on contact surface obtained from the pushing hardness experiment. Therefore pushing force is said to be related to cutting resistance. Figure 6 showed the wave profile of cutting resistance for vibration cutting under the same conditions as in Figure 5. When both diagrams were compared, it was observed that the main force greatly decreased. Additionally it could be confirmed that the initial rise in cutting resistance at the beginning could be decreased more with vibration than without vibration (Figure 5). More precise observation revealed that for conventional cutting without vibration, a peak resistance was indicated at 2mm from the cutting surface, but for vibration, this peak appeared earlier at 1.5mm – 2mm. It was considered that suppression of face defects at the beginning could be achieved by adding vibration. Figure 7 (a)and Figure 7 (b) compares cutting resistance (the maximum value of main force) and feed amount between 0.05-0.5mm. It was confirmed that irrespective of vibration, the relation between pressure on contact surface and cutting resistance was proportional. It was also confirmed that cutting resistance could be reduced by more than half by vibration cutting for any feed speed. In addition, when I perform comparison with whith vibration(Figure 7 (a)) and whithout vibration(Figure 7 (b)), Whith vibration was able to confirm that cut resistance largely decreased with a half at 1/3, 0.05mm at 0.5mm。 As a result, we were able to confirm that vibration cut was effective for processing of WCS.

3.3 Cutting resistance in the case of low-speed cutting

In the diagram in Figure 9, cutting resistance is shown for low-speed cutting. From this, it was confirmed that cutting resistance is not constant even for the same material. This was indicated by the appearance of both hard and soft parts during conventional cutting due to the fact that a square-shaped sample body was cast as a disk. Accordingly, this confirmed

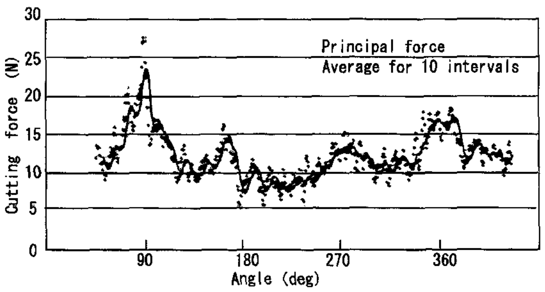


Fig.8 Cutting resistance in case of low-speed cutting
(Rolation rate :220rpm,Feed rate:0.5mm)

the need to consider this kind of occurrence when conducting an experiment on cutting resistance. The wave profile in the diagram on cutting resistance was confirmed to not be the influence of noise.

3.4 Surface roughness

Figure 8 summarizes pressure on contact surface and surface roughness (Ra) for each feed amount. The figures indicate that for cutting with vibration, the surface roughness decreased as pressure on contact surface increased. For feed amounts of both 0.05mm and 0.3mm, no significant difference in surface roughness was observed, but for the feed amount of 0.5mm, surface roughness increased in comparison to the previous 2 conditions. According to this, a feed amount between 0.3-0.4mm is considered to be able to maintain cutting accuracy of the finished surface form. For most areas of the contact face during cutting with vibration, the average roughness Ra decreased with the addition of vibration. For areas where pressure on the contact surface decreased, the Ra value increased for cutting without the addition of vibration when the feed amount was 0.5mm. From results above, for areas where the pressure on the contact surface is higher, vibration cutting is effective when the feed amount is between 0.3mm to 0.4mm. When feed amount is greater than this, an effect from vibration cutting was not obtained. On the other hand, for areas where pressure on contact surface decreased, an effect was obtained when the feed amount was even greater than 0.5mm. Through both observations, it was said that the addition of vibration for a feed amount of 0.3mm leads to a reduction in average roughness Ra in comparison to not including vibration, and thus the deference of surface roughness between the areas with higher and lower pressure on contact surface is smaller. Approximation lines for both 0.0 and 0.3mm feed amounts were similar, but a higher value was shown when the feed amount was 0.5mm. According to these results, vibration cutting is considered effective when the feed amount is between 0.3-0.4mm.

4. CONCLUSION

The correlation between "pressure on contact surface" and "cutting resistance", could be confirmed from this pushing experiment. The results were applicable for all 3 forces such as principal, thrust and feed forces. It was also confirmed that reprocessing by filing could change the pressure on contact surface. It was also observed that cutting resistance could be halved by vibration cutting. Using vibration cutting led to improvement in surface roughness as well as reduction of face defects. According to these results, it is can be concluded that the vibration cutting is effective for the processing of WCS.

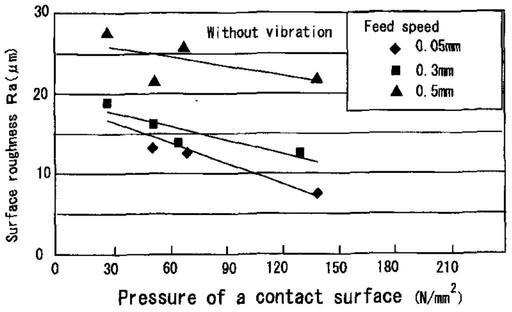


Fig. 9 (a) Relationship between surface roughness and pressure of a contact surface according to change in feed speed.. (without vibration)

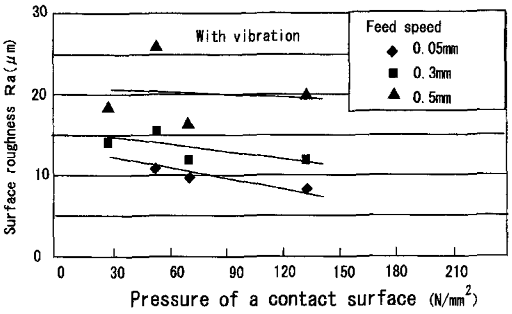


Fig. 9 (b) Relationship between surface roughness and pressure of a contact surface according to change in feed speed.. (with vibration)

REFERENCES

[1]T. Okabe, K. Saito: Trans. Mat. Res. Soc. Japan, 18, 681-684 (1995)

[2] K. Shibata, T. Okabe and K. Saito : Trans. Mat. Res. Soc. Japan, 20, 123-125 (1996)

[3]K. Kakishita and T. Suda: Trans. Mat. Res. Soc. Japan, 26 ,875-877(2001)

[4]K. Kakishita and T. Suda : Trans. Mat. Res. Soc. Japan, 29, 2427-2430 (2004)

[5] K. Yamamoto, T. Matsuura, M. Mondo, S. Tsukawaki, M. Miki and J. Takada: Trans. Mat. Res. Soc. Japan, 26, 863-866 (2001)

[6] M. Miki, T. Kikuchi, M. Nakamura, K. Hatakeyama and J.Takada: Trans. Mat. Res. Soc. Japan, 26,867-870 (2001)

[7] T. Okabe, T. Hirose, R. Ozao, M. Otsuka, M. Mayuzumi, J. Tuzi, H. Chiba and S. Shibata: Trans. Mat. Res. Soc. Japan, 29,2431-2434 (2004)

[8] T. Hirose, T. Okabe, K. Odagiri, K. Toki, H. Yasuta, M. Shinmachi and S. Shibata : Trans. Mat. Res. Soc. Japan, 25, 713-716(2000)

[9]: K. Ogawa, M.Sato,K.Hata, M. Mayuzumi,T. Okabe, M. Ogawa and M. Otsuka :Trans. Mat. Res. Soc. Japan., 30 1183-1186 (2005)

(Received July 12, 2006;Accepted September 15, 2006)