

THE MECHANISM OF CBN QUILL IN SURFACE GRINDING

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1. Introduction

Parts with deep-grooves and the grooves need be precisely machined are extensively used, nowadays, the grooves are generally machined by using end mill. But, with constructions of these parts are improved, materials of these parts become high strength and high hardness, machining process become simple and low cost, and machining precision requirements are risen and so on, in more and more situations the grooves need be ground. In this research, deep-grooves are ground precisely by using CBN wheel with shaft (quill), by which, the flanks and bottom of curved shape deep-grooves can be ground. For analyzing the characteristics of CBN quill in grinding process, it is divided into surface grinding and face grinding, then study is individually conducted. In the preceding paper^{1,2)}, the experimental research of CBN quill in surface grinding process is stated, it is said that reason of CBN quill being bad in grinding performance is CBN grits early fall off. In this paper, by theoretically analyzing the characteristics of quill in surface grinding process, the reasons of CBN grit fall off are discussed, and the selections of CBN quill grinding parameters are experimentally researched by selecting grain cutting parameters.

2. Experimental procedures

The equipment of experiment is refitted by a surface grinding machine, its spindle is re-equipped by air and oil-spray high-frequency spindle (the maximum rotational speed $8 \cdot 10^4$ rpm, output 2.8 kw). Figure 1 shows the shape of resinoid bonded CBN quill for trial this experiment. The width of grinding is taken as 5 mm, and the grinding is carried out by using the front end of CBN quill. The CBN quill was dressed by a cup type of GC wheel. Coolant is 5% aqueous emulsion and down-cut grinding are used. The workpiece material is cast iron and its dimensions are L105_H45_T5 mm. The grinding forces are measured by using a parallel plate dynamometer. The wearing values of wheel are got by means of copying the surfaces of CBN quill in carbon pieces.

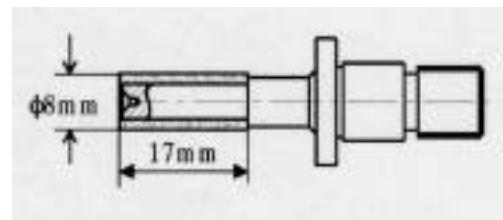


Fig.1 Shape of resinoid CBN quill

3. The characteristics of CBN quill in surface grinding

We can take the surface grinding process as a collective effect of individual grain cutting action, as shown in the Figure 2. The fundamental grinding parameters can be indicated by maximum grain depth of cut g_m , wheel-workpiece contact length l_c and the maximum grain cutting force f_g .

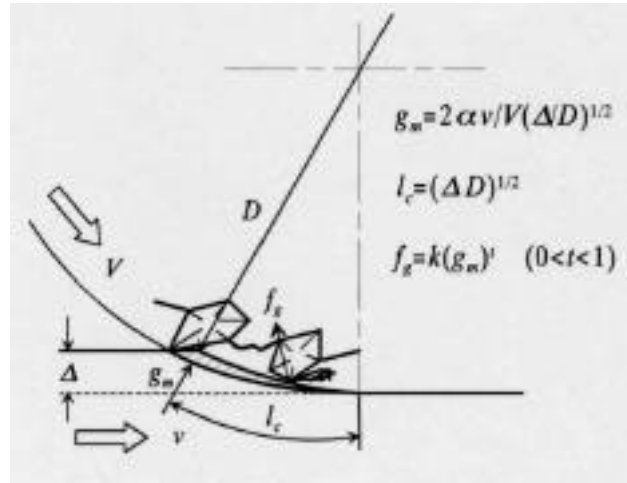
The grain cutting parameters of quill ($\phi 8$ mm) and general diameter wheel (for example $\phi 80$ mm) in

surface grinding are calculated, the specific values of their parameters $\alpha(y) = y(\phi 8) / y(\phi 80)$ are listed in Table 1.

Table 1. The specific values in surface grinding

y	$V(\text{m/s})$	$n(\text{rpm})$	g_m	l_c	f_g
$\alpha(y)$	1	10	3.17	0.31	3.17^t

As shown in Table 1, for CBN quill, the maximum grain depth of cut g_m is 3.17 times as large as one in general diameter wheel grinding, and the wheel-workpiece contact length l_c is decreased to be less than one third. That is, the cut layer shape of grain is changed to being short and thick, the maximum cutting force acted on grain f_g is 3.17^t ($0 < t < 1$) times as large as one in general grinding. The peak value of cutting force pulse is increased, the acting time is shortened and the cutting force is changed as one with impact. This is the essential reason why the fall off and break of the grits of CBN quill are brought out easily. On the other hand, the grain grinding frequencies of CBN quill are ten times as large as one in general grinding in the same time. CBN grits are high frequently used for grinding, high frequently impacted by cutting force and cutting heat, which can result in the bond around CBN grits is fatigued and injured. It makes the bondability between CBN grits and bond be weakened, and becomes the reason why fall off of CBN grits of quill is brought out. It is thus clear that cutting environment of CBN grits in CBN quill surface grinding is seriously worsened as compared with general grinding. So, which result in the questions of CBN quill being excessively worn, machining precision being low, machining process being unstable and so on. The ways by which the grinding performance of CBN quill can be risen, on the one hand are to select the essential factors of CBN quill (for example, bond type, grain density) which can make the retentivity of CBN grits be risen, and on the other hand are to select the grinding parameters which can make the maximum grain depth of cut g_m be decreased and the wheel-workpiece contact length l_c be increased.



α : Length between successive cutting grain

Fig.2 Model of a grain in cutting

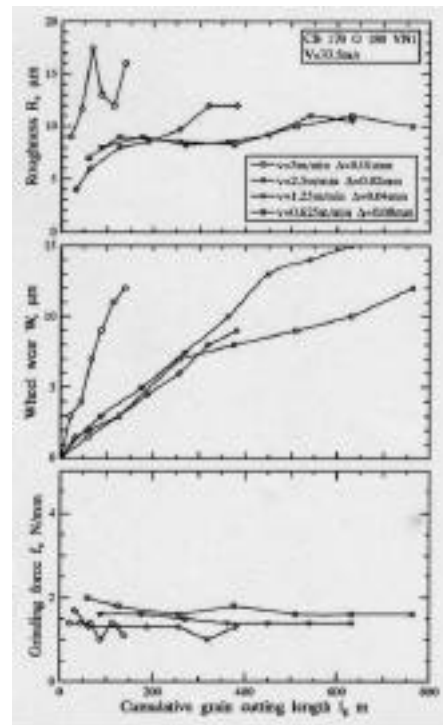


Fig.3 Experiment results in the differential g_m

4. Grinding experiments

The effect of various factors on grinding process is analyzed by comparing the changes of ground surface roughness R_z , wheel worn value W_r and normal grinding force in unit grinding width f_n with cumulative grain cutting length l_g ($l_g = l_c$).

4.1 The Effect of g_m in same grinding efficiency

When the volume of wheel removal in unit grinding width and unit grinding time ($Z = v \Delta$) is constant, but grinding feed speed v and depth of grinding Δ are changed, experiment results are shown in Figure 3.

It can be seen that grinding force tends to be decreased but wheel worn is steeply increased and ground surface roughness is increased and unstable when table is speedily fed and depth of grinding is small. It is shown the characteristics of grain fall off type of wheel worn. As grinding feed speed is decreased and depth of grinding is increased, grinding force value is increased but wheel worn is slowed down, ground surface roughness value tends to be stable and grinding of wheel is in a condition approaching to normal one. That is to say, when the maximum grain depth of cut g_m is decreased wheel worn is slowed down. But at same time the wheel-workpiece contact length l_c is increased, the number of grits which join the cutting is increased, it result in the grinding force of wheel is increased. From these experiment results, it can be known that using small grinding feed speed and large depth of grinding can make the cutting force acted on grains be decreased, so that fall off of CBN grits of wheel be decreased in CBN quill grinding.

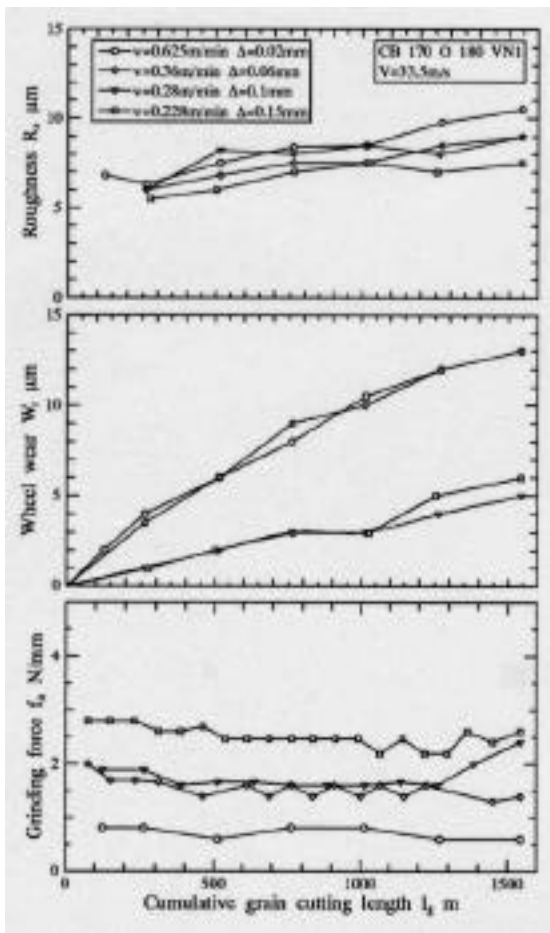


Fig.4 Experiment results in the differential l_c

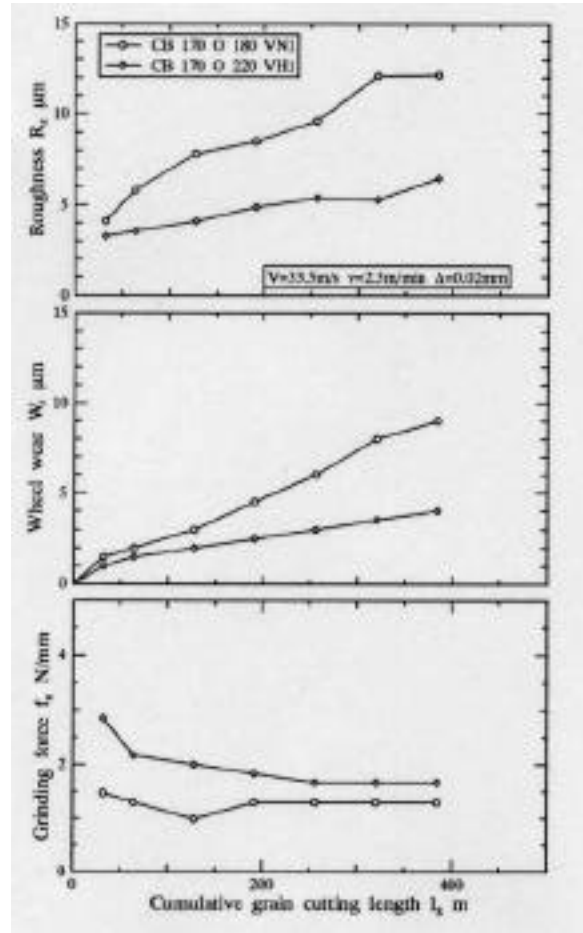


Fig.5 The effects of wheel grain density

4.2 The effect of l_c when g_m is fixed

Taking $v=0.625$ m/min, $\Delta=0.02$ mm as comparison, when the maximum grain depth of cut g_m is fixed, and wheel-workpiece contact length l_c is changed with grinding feed speed v and depth of grinding Δ being changed. Experiment results are shown in Figure 4.

As wheel-workpiece contact length l_c is increased, grinding force is increased in turn, but wheel worn and ground surface roughness are decreased correspondingly. Particularly, in creep feed grinding ($v \leq 0.28$ m/min), wheel worn is steeply decreased and ground surface roughness is improved also. From the characteristics of experiment curves, it can be considered that grinding process of CBN quill in creep feed grinding is in normal grinding conditions. That is to say, wheel-workpiece contact length l_c increment can make the number of grain cutting edges which join the cutting at same time increment and the impact of cutting force on grains be decreased, they are beneficial to the grinding process being smoothly carried out.

4.3 The effect of α

It can be known from Figure 2, that another parameters which affects on maximum grain depth of cut g_m is the length between successive cutting grain of wheel α . When grain density of wheel is increased, α is decreased, g_m is also decreased in the meantime but wheel-workpiece contact length l_c is fixed. The experiments rising grain density of CBN quill in the same grinding parameters are carried out, which results are shown in Figure 5. It can be seen that grinding force is increased but wheel worn and ground surface roughness are all decreased, the grinding process is stable and grinding of CBN quill is in a condition approaching to normal one as grain density of wheel being risen. It is result brought by rising grain density of CBN quill, decreasing maximum grain depth of cut g_m and increasing grain cutting edges which join the cutting at the same time.

5. Conclusions

In this paper, by theoretically analyzing the characteristics of CBN quill in surface grinding process, the essential reason which affects on grinding performance of CBN quill is fully understood. It is the maximum grain depth of cut g_m is increased and the wheel-workpiece contact length l_c is decreased, then the grain cutting force is increased, which results in CBN grain early fall off easily. Using the grinding parameters which can make the maximum grain depth of cut g_m be decreased and the wheel-workpiece contact length l_c be increased, that is, grinding feed speed is small and depth of grinding is large, can make better grinding performance of CBN quill, obtain good grinding results in surface grinding. Using the high grain density of wheel can also obtain the same results.

References

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- 2) Q. Yan, K. Tanaka, K. Syoji and T. Honoki: Grinding of Deep-Groove Flank with CBN Quill-Effects of bond and grain size-, Proceedings of Tohoku Meeting of JSPE, (1998)57.