Design of New Slotted Structured Grinding Wheel

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Abstract — The grinding efficiency of conventional grinding wheel is low, and the phenomenon of grinding burn is serious. Although the ordinary slotted grinding wheel can reduce the grinding temperature, it also reduces the machining accuracy of the workpiece. In view of this problem, a new design scheme of slotted grinding wheel is proposed while only a part of the groove on the grinding wheel is slotted, and the grinding mode of the groove and the non-groove is used to alternate with each other. It is not only beneficial to the entry of grinding fluid to reduce grinding temperature, but also to improve the problem of poor roughness in the machining process of groove grinding wheel.

1. Introduction

Grinding as the last procedure of machining, its machining effect seriously affects the final effect of the workpiece. In the rapid development of industrial technology, with the breakthrough of various key technologies, more and more new materials are put into service. But the specific grinding energy is higher in the grinding process. The high energy of the input is converted into the grinding heat and accumulated in the grinding arc zone, resulting in a sharp rise in the temperature of the grinding zone, and if the heat radiation cannot be dissipated in time, the surface of the workpiece will be damaged by thermal cracks, thermal deformation and other thermal damage, which seriously affects the surface quality of the workpiece. The traditional grinding wheel has some disadvantages, such as low grinding efficiency, large grinding force and serious burn of workpiece. Changing grinding fluid, grinding wheel speed, grinding wheel particle size and other factors can no longer meet the machining needs of new materials. Therefore, the research on the structure of grinding wheel has become a hot spot in the research of grinding wheel grinding performance.

In recent years, scholars at home and abroad have done a lot of research on the structure of grinding wheel. Nakayama had a 60o spiral groove with a width of 2-2.5mm and a distance of 4mm on the surface of the grinding wheel of the ceramic bonding agent by rolled, and studied the effect of the spiral groove on the grinding performance of the grinding wheel of the traditional ceramic bonding agent. The results show that the grinding force and the grinding heat of the grooved grinding wheel are all reduced. This is the first time to introduce a grooved wheel, which is the beginning of the development of structured grinding wheel. Tawakoli [1-3] proposed a kind of cross line structure on the surface of grinding wheel, and tested it on the surface of resin binder and ceramic bond CBN grinding wheel. The width of cross line structure is 0.6 -1.5mm, the depth is 0.03mm, spacing is 0.8 - 1.9mm, and the angle of cross line is 60o. The results show that the surface area of the wheel is significantly reduced (down to 25%), the grinding force is reduced, the grinding heat produced in the grinding area is reduced, and the grinding
temperature is low. However, because the wear of grinding wheel is more serious than that of conventional grinding wheel, the surface roughness of workpiece is increased. Gao Hang, Song Zhenwu [4-6] et al. of Northeastern University in China made grinding wheels with different geometry by using TS tool steel. It is found that the intermittent contact of structured grinding wheel reduces the accumulation of heat, which can reduce the burn of workpiece in the grinding of slotted grinding wheel. However, due to the existence of grooves on the surface of structured grinding wheels, the front of the protruding part of grinding wheels is more impacted, the greater the grooves, the greater the impact, and the faster the wear of grinding wheels, which will have a negative effect on the surface finish of workpiece. Wu Chunli, School of Mechanical Engineering of Shandong University conducted simulation [7] and experimental research on mechanical shock and thermal shock in grinding polycrystalline diamond by slotted structured diamond grinding wheel. The results show that in the process of intermittent grinding, the grinding force also changes periodically because of the periodic change of the contact area between the structured grinding wheel and the workpiece, which promotes the brittle micro-breakage removal of the grains on the machined surface of polycrystalline diamond materials and improves the grinding efficiency. Due to the sudden increase of the grinding force between the front of the grinding wheel surface and the workpiece in contact with the workpiece, the obvious mechanical force impact occurs, which makes the abrasive particles on the front of the grinding wheel mainly broken and worn, improves the self-hardening of the structured diamond grinding wheel, and improves its cooling performance and chip removal conditions. But the relative loss of grinding wheel increases and the service life decreases. It can be seen that the grooved grinding wheel can improve the grinding efficiency and reduce the occurrence of the grinding burn, but it still needs a great improvement in the surface quality of the workpiece. In this paper, a new type of grooved grinding wheel is designed on the basis of the conventional grooved grinding wheel, so that it can not only reduce the grinding temperature, but also make up the problem that the surface quality of the grinding wheel can be reduced in the grinding process.

2. Design of new grinding wheel

2.1 Principle of Improving Grinding Efficiency
When a groove grinding wheel is used for grinding a workpiece, the groove on the surface of the grinding wheel reduces the contact area [8] of the grinding wheel relative to the workpiece, can contain the chip, reduces the chip blockage during the grinding process, can fully enter the grinding liquid and the air, and reduces the grinding temperature, And the heating deformation and the crack of the workpiece are reduced. In addition, the crushing of abrasive particles increases the self-sharpness of grinding wheel and reduces the number of dressing. A lot of manpower and material resources have been saved.

2.2 Shortcomings to be Overcome in New Grinding Wheels
Grinding temperature is the key monitoring object in grinding. Slotting on the surface of grinding wheel is helpful for grinding fluid to enter [9] and reduce temperature to reduce grinding burn. But the distributed groove makes the continuous grinding to be intermittent grinding, and the vibration generated during the grinding can improve the roughness of the surface of the workpiece.

The new grinding wheel designed in this paper is to overcome the shortcomings of improving its roughness and obtain a slotted grinding wheel with relatively superior performance. The particle size of grinding wheel has a great influence on the roughness of workpiece. Too large particle size can improve the grinding efficiency but increase the surface roughness of grinding wheel. The fine particle size can reduce the surface roughness of workpiece. However, the particle size of grinding wheel should not be too small in grinding, otherwise it is not conducive to chip excretion. The design adopts silicon carbide grinding wheel with particle size of 80. The size of the groove can also affect the surface quality of the workpiece, and the proper groove parameters can be selected during the grinding process, so that the contact area of the grinding wheel and the workpiece can be kept dynamically and constant. Because of the grooves on the surface of the structured grinding wheel, the front of the protruding part of the grinding wheel is more impacted during grinding. The larger the groove, the greater the impact, and the faster the
wear of the grinding wheel, which will have a negative effect on the surface finish of the workpiece. The groove is too small, the chip is not easy to discharge, the grinding fluid is not easy to enter, and the grinding effect is not obvious.

We synthesize the slotting scheme of grooving grinding wheel in the past, and finally determine the new slotting scheme as shown in the figure. The grinding wheel adopts incomplete grooving mode. On the one hand, the grinding fluid and air can enter the groove to reduce the grinding temperature, on the other hand, the non-slotted part can be used for continuous grinding to repair the surface accuracy of the workpiece. Finally, it is determined that the new grooving scheme is the way of cross grinding between grooves and non-grooves. The three-dimensional model is shown in figure 1.

![Fig.1. 3-dimensional diagram of a new groove grinding wheel](image1)

Figure 1 is a three-dimensional figure of a new type of grinding wheel, which adopts a wave shaped and diamond shaped groove. Compared with the commonly used spiral groove, it reduces the pattern reproduction and increases the surface finish of the workpiece.

It can be clearly seen from the figure that the new type of grinding wheel adopts the mode of cross distribution of wavy groove and rhombus groove, which makes the workpiece surface more smooth. The enlarged drawing of the groove is shown in Fig. 2 and Fig. 3.

![Fig. 2. Partial drawing of wave groove](image2)

![Fig. 3. Partial view of diamond groove](image3)
2.3 Matters Needing Attention in the Process of Grinding Wheel Slotting

Dynamic balance problem: Grinding wheel balance is a very important and indispensable step in grinding experiments. If the balance is not mobilized or the grinding wheel is not satisfied with the dynamic balance before the experiment, it will bring great danger to the experiment. Since the slot is an intermittent slot, the groove shall be in a symmetrical position in the slot, and the opposite groove shall be on the same straight line. As shown in the figure, the grooving distribution of the new slotted grinding wheel is shown, which is designed to meet the requirements of dynamic balance.

Resonance problem: The resonance problem is also a big problem to be noticed in the grinding of the grinding wheel. The resonance can affect the machining effect of the workpiece, and damage the main shaft of the machine tool when it is serious. It should be noted that the spacing of adjacent grooves cannot be equal in the slotting, so as to avoid the resonance caused by periodic impact. From the figure, we can see that the spacing between the grooves is different. The layout of its groove position is shown in Figure 4. In the picture, the light color part is the groove area, and the grinding wheel is divided into four groove areas, which are two corresponding two pieces of 60 fan-shaped. In order to adjust the dynamic balance conveniently, the same groove is designed on the relative position.

3. Use effect

According to this scheme, slotting can improve the self-sharpness of grinding wheel. The gap slot increases the cutting edge of the grinding wheel and reduces the dressing times of the grinding wheel, thus improving the grinding production efficiency and reducing the cost. Because the groove is beneficial to the entry of air and grinding fluid, it can effectively reduce the occurrence of grinding burn. Compared with other slotted grinding wheels, the surface quality of the workpiece will be better.

4. Summary

According to the new slotting scheme, it makes up for the shortcomings of the former slotting wheel in roughness. Intermittent grooving can improve the surface quality of workpiece and the grinding efficiency of difficult-to-machined materials. It provides a certain guarantee for the processing of difficult workpieces and new materials.

Acknowledgment

This project is supported by the 13th five year plan of science and technology research program of Jilin Provincial Department of education No.JJKH20191189KJ

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