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INNOVATIONS IN ON-SITE ELECTRIC SPARK DRESSING OF METAL-BONDED DIAMOND GRINDING WHEELS

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Abstract:
The metal-bonded diamond grinding wheels wear out obviously in grinding process of hard and brittle materials such as SiC ceramics, and the shape accuracy will be destroyed, which will affect the grinding surface accuracy and surface quality. In this paper, a swing arm type electric spark dressing device is designed based on the characteristics of metal-bonded grinding wheel, which can realize high dressing precision. Then the electric sparking experiment was carried out using the dressing device. The experimental results show that higher dressing efficiency and low arc precision can be obtained with large electrical parameters, while higher arc precision and lower efficiency could be obtained with small electrical parameters. Therefore, the experiment can guide the selection of different parameter combinations in different dressing stages to improve the dressing efficiency and precision.

Keywords: electric spark dressing, diamond grinding wheel, metal-bonded, dressing efficiency, arc precision.

1. Introduction

The metal-bonded diamond grinding wheel has the characteristics of strong grinding ability, low grinding force, low grinding temperature, high grinding efficiency, small grinding loss, high holding strength to abrasive grains and low processing cost [1]. It is widely used in precision and ultra-precision grinding of hard and brittle materials. However, the metal-bonded diamond grinding wheel has poor self-sharpness and is easy to block. The exciting force caused by the eccentricity of the grinding wheel is easily generated, which affects the stability of the grinding process and the grinding surface quality. The shape of the grinding wheel is severely worn during the grinding process of the hard and brittle material, such as the silicon carbide ceramics, which seriously affects the precision of the workpiece. Therefore, the high-efficiency and high-quality finishing technology of the metal bond diamond grinding wheel becomes the key technology for achieving hard and brittle material grinding.[2]

Electric spark shaping can realize in-situ shaping and sharpening and easy to ensure grinding precision; be easy to operate and suitable for any grinding wheel with conductive material as bonding agent; generate low grinding force and suitable for the dressing process of grinding wheels with small diameter and very thin thickness. The method has the advantages of low cost, easy realization, less process parameters, easy adjustment and the like, which is the best choice for dressing of metal-bonded diamond grinding wheel. [3]

Eun-Sang Lee et al.[4] used the on-line electric spark sharpening technology in precise grinding of the Mn-Zn ferrite material, and the obtained results reveal that surface roughness was reduced and the surface was free of cracks, the grinding force was also reduced. J. Tamaki and K. Kondoh[5] proposed in-process electro-discharge dressing (IEDD) to achieve dressing of the grinding wheel and good dressing quality was gained. Xie Jin et al.[6] conducted an experimental study on Electro-contact discharge dressing (ECDD). The experimental results show that the factors affecting the morphology and protrusion height of the diamond abrasives are the discharge pulse current amplitude and pulse width. This dressing method is suitable for

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dressing after passivation of the coarse-grained grinding wheel.

Brian K. Rhoney et al.[7] proposed the wire electrical discharge machining technique (Fig.1), which uses the energy generated by the discharge between the electrode wire and the metal-based diamond wheel to remove the metal bond. Hu Dejin, Wang Yan et al.[8] proposed a gas-assisted discharge-assisted dressing technique that combines mechanical dressing of diamond pens with spark-discharge dressing in gas. The surface quality of the grinding wheel after the method is improved, and the wear of the diamond pen is reduced.

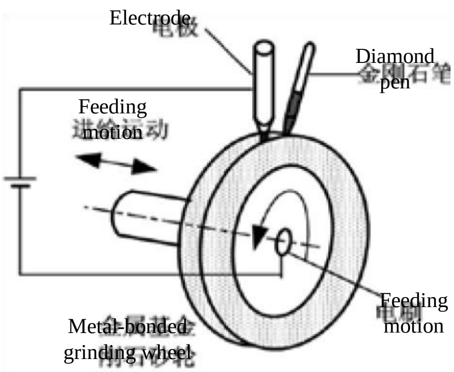

Fig.1 wire electrical discharge machining technique[7]

Cai Lanrong et al.[9] proposed a mist discharge repairing technology, which reduces the dependence on liquid media and conforms to the trend of green manufacturing. This technology can be applied to online trimming. Suzhou Electric Machine Tool Research Institute[10] developed a EDM forming machine that can be used to dressing diamond wheels with a maximum thickness of 100mm and a diameter range of 100~400mm. The finished diamond wheel has high forming precision and high durability.

In this paper, an in-position electric spark dressing device was designed for the arc-shaped metal-bonded diamond grinding wheel used in large-scale SiC ceramic aspherical grinding. The relevant process experiments are completed, which provides certain technical guidance for the in-position dressing of the metal-bonded diamond grinding wheel.

2. Structure Design of the Dressing Device

The forming arc of the grinding wheel is the working part. The arc profile wear is serious in grinding process of hard and brittle materials such as silicon carbide ceramics, which affects the performance of the grinding wheel. Therefore, it is necessary to ensure the arc of the arc profile after the dressing process. As the radius of the arc of the diamond grinding wheel is small, the trajectory formed by dressing electrode is an arc with the same radius of the grinding wheel arc, so as to achieve the purpose of dressing the grinding wheel arc. In the dressing process, the loss of the dressing electrode can be compensated to improve the accuracy of the arc contour. Therefore, it is necessary to consider the realization of the swing mode and the compensation of the dressing electrode loss in designing process. Fig.2 shows a schematic diagram of EDM device. The device is mainly composed of a stepping motor, a swinging rod, a V-shaped block and an electrode.

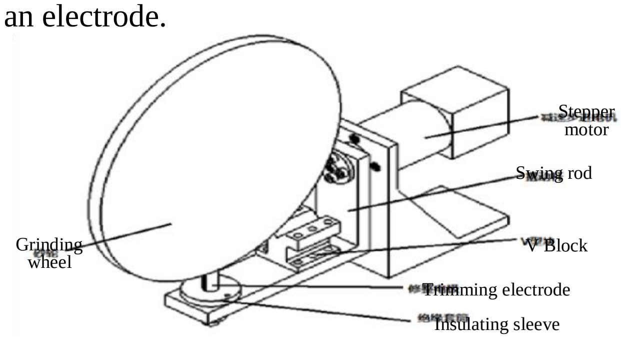

Figure. 2 Structure of the electric spark dressing device

During the dressing process, both the electrode and the grinding wheel are consumed, and the discharge gap needs to be compensated at this time. The electrode consumption is extremely small during the trimming process, so the electrode tip position can be fixed to the standard position before each dressing process. Therefore, it is necessary to set a positioning reference on the dresser, such as the V-shaped block shown in Fig.3. When positioning, a positioning shaft with a diameter of 8 mm is mounted on the V-shaped block, and the height of the shaping electrode is adjusted so that the top end of the shaping electrode is in contact with the positioning shaft. The grinding wheel compensation behavior is achieved by the downward feed motion of the grinding wheel. The point in time and distance of the compensation motion can be determined by observing the current value on the dressing power supply.

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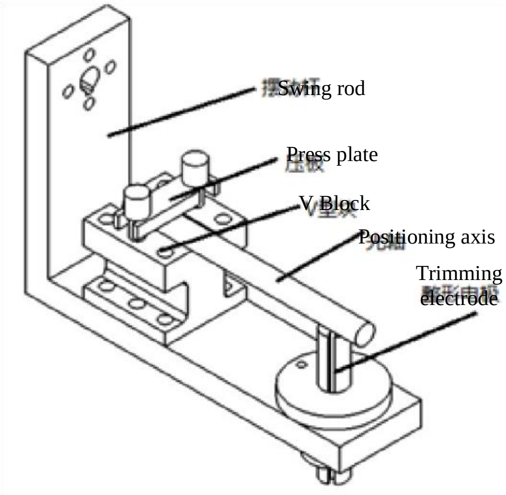

Figure. 3 Diagram of Electrode positioning

The electric spark shaping device fully utilizes the feeding function of the grinding head of the grinding machine which simplifies the structure, and improves the dressing precision. Therefore, it is used as the final shaping solution. Fig.4 shows the physical picture of the device.

Figure. 4 Physical picture of the electric spark dressing device

3. Experiments and Results

3.1 Establishment of experimental system

In order to study the dressing precision, the in-position dressing experiments of metal-bonded diamond grinding wheel were designed. The electric spark dressing system includes a DC pulse power supply, the electric spark dressing device, grinding wheel and dressing coolant.

Figure 4-1 shows the physical picture of the EDM experiment system. The grinding wheel is mounted on the spindle, while the shaping device is mounted on the table of the grinding machine. The DC pulse power supply provides pulse current for spark dressing. Positive polarity dressing is adopted, the positive electrode of the DC pulse power supply is connected to the grinding wheel, and the negative electrode is connected to the electrode. The coolant is added to the gap by a wet brush and a surface of the grinding wheel.

3.2 Experimental condition

In the process of EDM, the efficiency and the shape accuracy are quite different with different electrical parameters. In order to study the influence of different electrical parameter combinations on the dressing accuracy, two group of experimental parameters considering voltage, duty cycle and pulse period were set to compare the obtained circularity of the grinding wheel. The specific parameters are shown in Table 4-2.

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Table 1 List of Experimental parameters

Test number	Voltage(V)	Duty cycle	Pulse period(μs)	Dressing rate(rpm)
1	90	50%	60	3
2	60	50%	40	3

The roundness of the dressed grinding wheel cannot be directly measured. Therefore, the cutting grinding experiment is performed using the dressed grinding wheel, and the circular arc of the grinding wheel is indirectly reflected by detecting the circular arc groove. The arc was measured using a Talysurf PGI plus profiler.

3.3 Experimental Results

The dressed arc of grinding wheel is obtained by the profilometer, Fig.5 shows the results of the circular arc obtained by the Test number 1. From the test results, it can be seen that the overall shape of the arc is not ideal, and there is a big gap with the ideal arc. The bottom of the circular arc has obvious defects, comparing with the ideal circular arc. The bottom of the circular arc has obvious convexity, which is reveal that there exit a pit on the surface of the grinding wheel. The left and right

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parts of the arc groove have significant fluctuations. It can be seen that the largest arc error is 6 μm at the bottom.

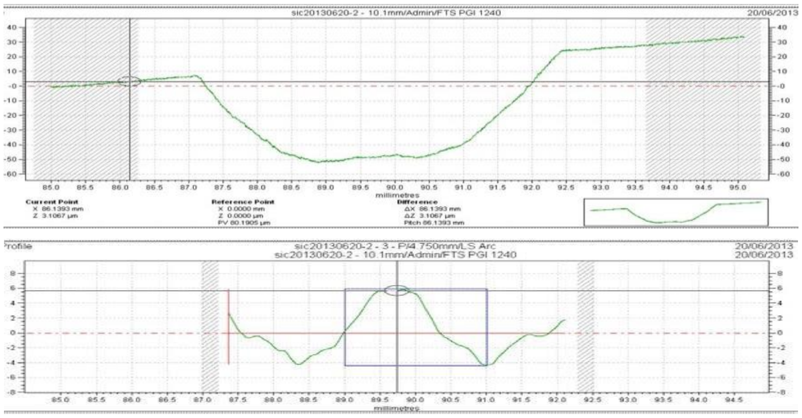

Figure. 5 Experimental result with Test No.1

Fig.6 shows the results of the circular arc obtained by the Test number 2. It can be seen from the inspection chart that the profile of the arc is greatly improved compared with the previous one. There still defects at the bottom of the arc, but the profile on both sides of the arc groove is ideal. Although the error at the bottom of the arc is up to 7.5 μm, the error of the arc surface on both sides is mostly within 2 μm.

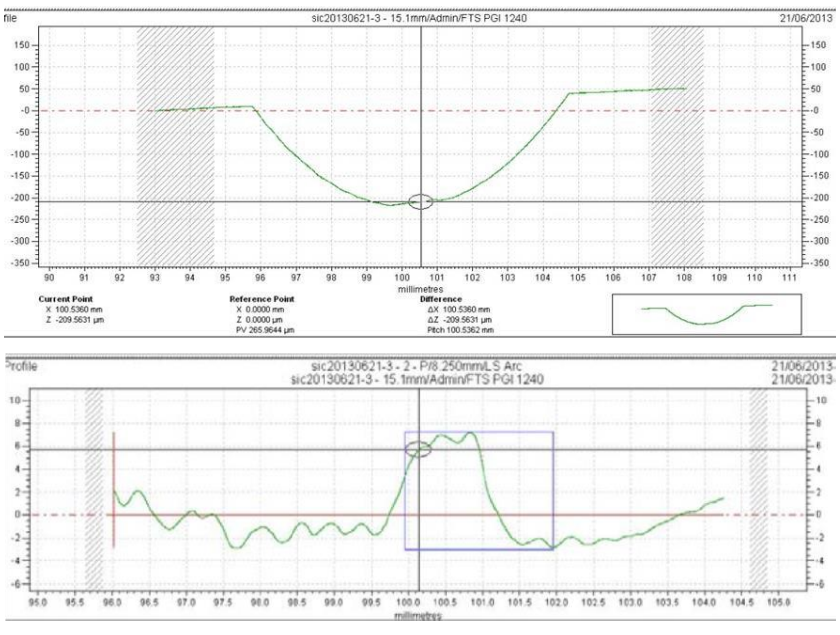

Figure. 6 Experimental result with Test No.2

From the comparison of the above two experiments, it can be concluded that when a large electrical parameter is selected, the electrode and the grinding wheel are not sensitive to the discharge gap, and it is difficult to ensure high dressing accuracy. When a smaller electrical parameter is used, the electrode and the grinding wheel are more sensitive to the discharge gap, and a higher dressing accuracy can be ensured. Therefore, when performing spark dressing, large electrical parameters can be used first to obtain higher dressing efficiency. And small electrical parameters should be used to obtain higher dressing precision.

4. Conclusion

For metal-bonded diamond grinding wheel, an electric spark dressing device was developed. The effects of different shaping parameters (pulse voltage, duty cycle
Published by Francis Academic Press, UK -82- 83 and period) on dressing accuracy of were studied by in-position spark dressing experiments. The following conclusions were drawn:

1. EDM technology can achieve high-quality and high-quality in dressing of metal-bonded diamond grinding wheel;
2. High dressing efficiency can be achieved with larger electrical parameters while high dressing accuracy can be gained with smaller electrical parameters.

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