

Study of process of trueing diamond grinding wheels on metal bonds by method of free abrasive after processing of leucosapphire blanks

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Abstract. The problem of mechanical processing, in particular, grinding products from leucosapphire, is considered. The main problem with this treatment is the need to adjust the diamond tool. One of the methods of tool trueing using loose abrasive technique is considered. The results of a study on restoring the tool cutting ability, its shape and profile after straightening are given.

1. Introduction

Leucosapphire for optics and electronics is grown from the melt in a vacuum. The grown crystal is of irregular pear shaped [1]. Therefore, the manufacture of products includes a large number of blanking operations. Because of the high hardness, machining is possible mainly with a diamond tool [2,3].

In this connection, diamond processing operations (drilling, cutting, grinding, polishing) are of interest for technological science.

Leucosapphire has a high hardness, comparable with the hardness of diamond grains. Therefore, during processing, rapid wear and blunting of the cutting grains are observed.

At the same time, there are technological problems associated with the fragility of leucosapphire. In contrast to most structural materials, leucosapphire crystals shear when they are cut. According to the studies of T.B. Teplova. and Solovyov V.V. [3] at the finishing treatment of leucosapphire with a 7/5 μm diamond tool at a certain depth from the surface, large plastic deformations and a defective layer with a depth of 15-25 μm arise. Therefore, in the treatment of leucosapphire, grinding can be identified as microcutting (shearing), and polishing, as wear during plastic contact (low-cycle fatigue failure). The depth of the defective layer and the value of the chips depend on the cutting forces. In some cases, chips can lead to the appearance of microcracks, which quickly develop and can lead to destruction.

The main method of dealing with excessive cutting forces is to preserve the tool cutting properties. For diamond grinding wheels, to preserve these properties correction is necessary if the self-sharpening mode can not be realized. [4,5]

Since a diamond tool is used for cutting and grinding on a metal bond, its correction is difficult and requires special technological solutions. In practice, the most commonly used treatment is grinding bars or abrasive wheels, which requires high energy consumption and abrasive consumption. Electrochemical and electrophysical methods require the creation of special equipment, special implementation conditions. The methods of dressing with a free abrasive, which were developed primarily in Donetsk National Technical University, are of interest [6,7].



This method is relatively easy to implement, does not harm equipment and ecology, is effective. Its implementation with reference to diamond processing of sapphire is considered in the studies, the results of which are presented in this article.

2. Problem statement

Literature analysis has shown that there are various ways to implement the method of dressing with a free abrasive: abrasive in the gas atmosphere, abrasive in the liquid, abrasive in a semi-bonded state. For research, a method of a semi-bonded abrasive trueing was chosen.

The main purpose of the work was to test the effectiveness of the dressing method by free abrasive diamond grinding wheels on metal bonds used to treat leucosapphire.

For research, it is necessary to create technological equipment and develop appropriate methods, to solve questions on the choice of diamond grinding wheel trueing scheme on the basis of free abrasivemethod. Directly for the trueing implementation, it is necessary to design and manufacture the technological equipment.

To assess the effectiveness of the trueing process, it is necessary to develop methods for measuring the errors of the circle shape and its surface quality.

3. Investigation results

The process of grinding leucosapphire with diamond grinding wheels on a metal bond is characterized by considerable cutting forces and temperatures [8]. As a result, the circle working surfaces wear out, become "loaded" [9]; the grains become blunt and discolored. The photographs in Figure 1 show the characteristic appearance of a worn tool. On the circle surface there are areas on which grains are almost completely hidden in wear products or crumpled.

For the investigated process of grinding of leucosapphire with diamond wheels on a metal bond, the self-sharpening regime could not be achieved

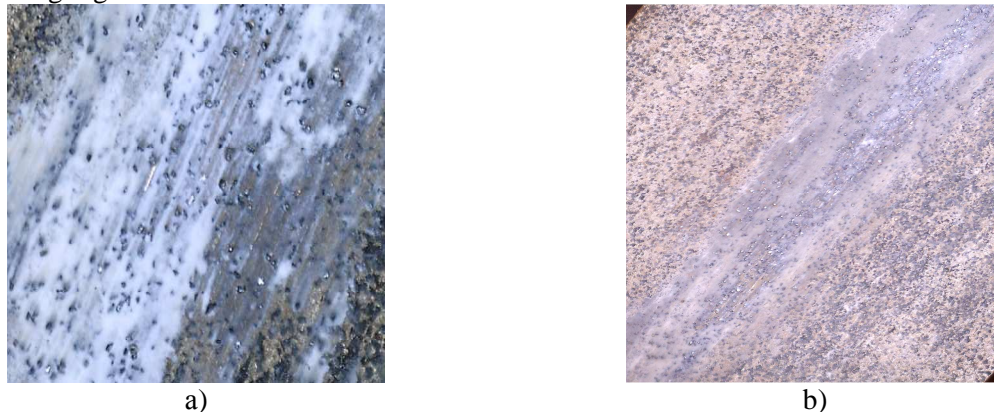


Figure 1. The states of the diamond wheel on the metal bond after grinding the leucosapphire: a) an increase of 40x; b) an increase of 5x

With the chosen trueing method, grains of abrasive are fed into the gap between the diamond wheel and the lapping. They are grasped around and move in this gap. In the process of rolling, the grain of free abrasive rubs a bundle, bending around the diamond grains, exposing them. The lap of soft material (cast iron, low-carbon steel) in shape is as close as possible to the wheel. The gap in the contact area is minimal, but sufficient for the movement of the grains of the ruling abrasive. The length of the working part of the lapping should provide the maximum possible duration of interaction of grains of abrasive with a bunch of a wheel. Figure 2 shows the wheel dressing scheme developed to study the process on a surface grinding machine.

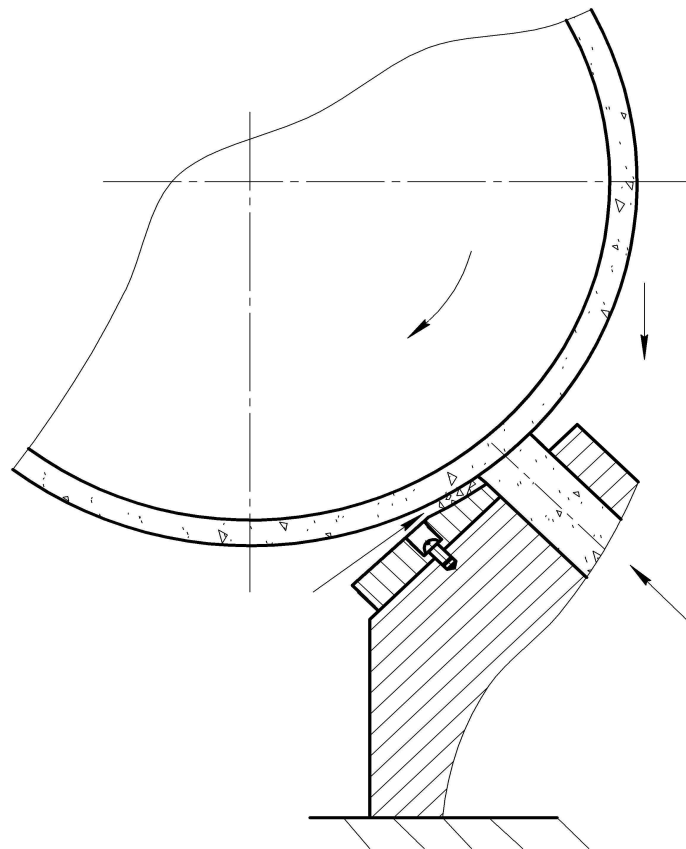


Figure 2. A scheme of truing a diamond grinding wheel on metal bond by the free abrasive method.

For truing by the method of free abrasive, a device was designed and manufactured that allows constant feeding of the bar with the abrasive to the dressing zone without having any drive. Cross movement is provided by manual movement of the surface grinding machine table.

The process takes place without longitudinal feed. The vertical feed is fed periodically as the lap wears off. Longitudinal feed should be continuous to eliminate edge effects ("filling" the edges of the wheel). The process was performed without the use of lubricants. A free abrasive is automatically fed into the truing zone in the form of a bar. The bar consists of an abrasive material and a soft ligament. As an abrasive, boron carbide was used, as a ligament - gypsum [6].

One of the criteria for the effectiveness of the truing process is productivity. To evaluate the effectiveness of dressing by the method of free abrasive diamond grinding wheels, several experiments were carried out by this criterion. In the course of studies by appearance, the removal of wear products, ligaments and opening of cutting grains were visually assessed depending on the duration of the dressing process. The experiments were carried out for wheels with a maximum degree of "loading", the further operation of which led to defects in the surface to be treated. The truing process was investigated in five experiments. Appearance assessment was carried out using an optical microscope, which provides the output of images on a computer. An example of the results of one of the studies is shown in Figure 3. The photographs show how traces of "loading" from the leucosapphire slime (white color) gradually disappear and the diamond grains are opened, and then the relief of the wheel develops. The photographs show that after 10-12 minutes, the truing cycle can be stopped. However, increasing the truing time to 15-20 minutes allows obtaining a developed relief of the wheel surface, which ensures the placement of sludge and the improvement of the grinding process.

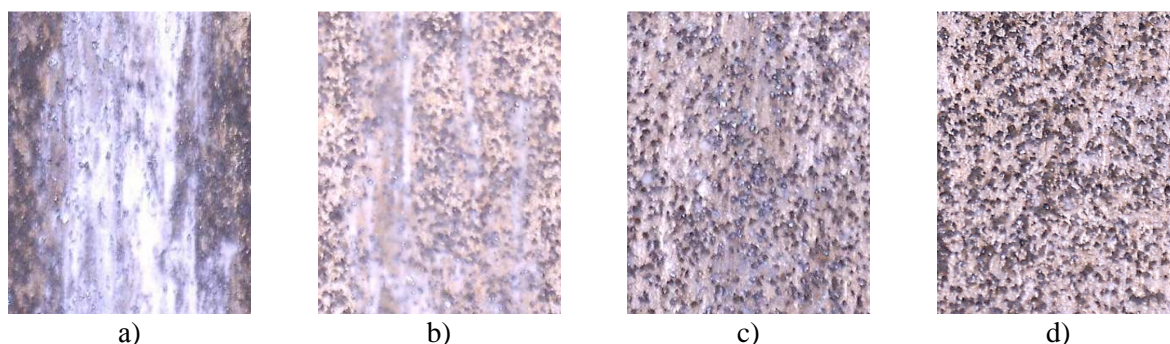


Figure 3. The process of trueing a diamond grinding wheel on a metal bond method by the free abrasive method: a) loaded diamond grinding wheel; b) the wheel after 5-7 minutes of trueing; c) the wheel after 10-12 minutes of trueing; d) the wheel after 15-20 minutes of trueing;

Electrospark and electrochemical trueing were performed as alternatives to the abrasive method [10]. Electrospark dressing produced approximately the same output, but graphitization of diamond grains was observed (probably because of high local temperatures). Electrochemical treatment gives a quality comparable with the method of dressing with a free abrasive, but the productivity is 1.3-2 times lower. In addition, electrochemical dressing requires the use of aggressive reagents that damage equipment and pose a hazard to personnel [10]. From the point of view of the effectiveness, the advantages of trueing with a free abrasive are obvious.

Another requirement to the trueing process is the ability to restore the shape of the wheel. To assess the effectiveness of trueing using this criterion, technological studies were also carried out. The profile along the wheel generatrix and in the radial direction was studied as a result of wear and during trueing.

Analysis of the wheel profile was carried out in several sections after processing and after trueing for 15-20 minutes (after removing the visually observed "loaded" areas).

The evaluation of the state of the generatrix of the diamond grinding wheel was carried out in 5 radial sections and in 7 axial sections with the help of a dial gauge indicator. The averaged results of measurements of the shape of the diamond grinding wheel at different stages of processing are shown in Fig. 4 and Table 1.

As the wheel wears out, the generatrix acquires the shape of a curve with a local maximum in the middle. Dimensional processing is essentially carried out with only one section, which degrades the quality of the surface and complicates obtaining the required accuracy. As a result of trueing, in the middle part of the wheel, cylindricity is restored, although "fillings" are observed on the wheel edges.

Table 1 The results of measuring the profile of a diamond grinding wheel at various stages of work

Work stage	Average values of the wheel profile height in different sections, mm						
	1	2	3	4	5	6	7
After treatment	0.007	0.020	0.031	0.038	0.021	0.010	0
After trueing	0.020	0.035	0.044	0.046	0.039	0.021	0

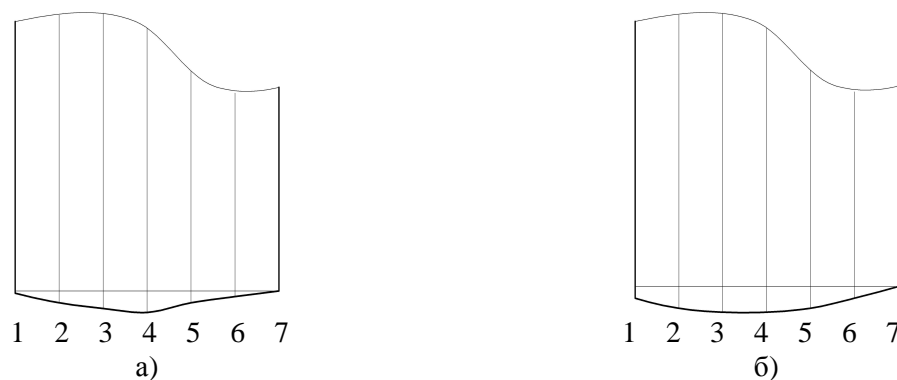


Figure 4. Study of the genetratrix shape of the diamond grinding wheel at various stages of work: a) profile after processing; b) profile after trueing with the method of free abrasive;

The analysis of the wheel radial runout was performed in 16 radial sections in each of the 5 axial sections with the help of a dial gauge indicator. The averaged results of measurements of the diamond grinding wheel at various stages of work are shown in Fig. 5 and in Table 2.

Table 2 Results of measuring the shape of diamond grinding wheel at various stages of work

Work stage	Average values of the wheel profile height in different sections, mm							
	0	3	5	7	9	11	12	13
After treatment	0	-0.008	-0.014	-0.003	-0.004	-0.024	-0.015	-0.019
After trueing	0	-0.001	-0.001	0	0	-0.019	-0.008	-0.007

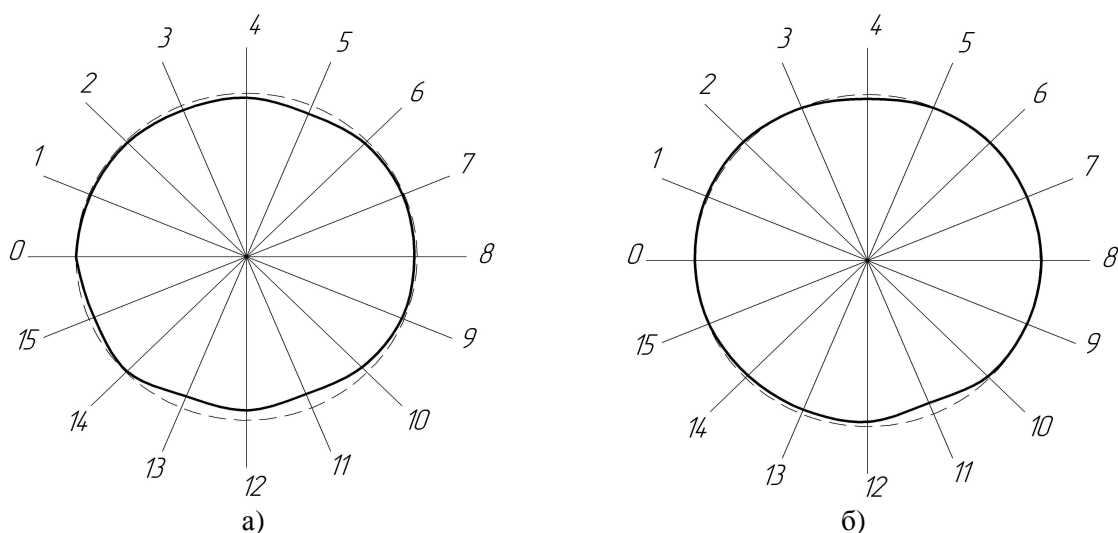


Figure 5. The wheel shape: a) after treatment; b) after trueing

When worn out, the radial beating of the wheel increases. Local maximums in this case exceed 0.02 mm.

As a result of trueing, the beats are reduced. The maximum value of the observed beating decreased by 21%. In this case, in practically all the sections the beat is less than 0.01 mm.

4. Conclusions

The free abrasive trueing method allows cleaning "loaded" fragments of a diamond grinding wheel on a metal bond. At the same time, new diamond grains are opened without damage to their sharp edges.

The free-abrasive trueing method provides a performance that is no worse than an electric spark trueing.

This method of trueing allows restoring the wheel geometric shape, both in the radial and axial directions. In this case, the restoration of the shape is slower than the opening of the cutting grains.

When using the adopted trueing scheme, "fillings" are likely to appear on the wheel edges.

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