Development of innovative approach to diagnosis of coated abrasive surface

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Abstract. One of the most important performance criteria when machining parts is the surface quality, which depends on many parameters, in particular on the state of a cutting tool. However, a cutting tool eventually loses its cutting ability, and therefore, its timely diagnosis is necessary to exclude scrap in the form of a poorly machined surface. There are many methods for measuring the wear of a cutting tool, including direct and indirect ones, which allow monitoring the condition of a cutting tool and timely dressing or replacing it. At the same time, existing methods are not applicable for all types of tools, or do not provide complete information about their condition. This fully applies to a coated abrasive, the condition of which is determined, as a rule, visually or by the quality of the machined surface. Based on this, the study aimed at developing a new approach to the diagnosis of a coated abrasive face is of great relevance and practical value.

1. Introduction

Among the main methods of machining materials with a coated abrasive, the key one is grinding with a sanding belt (Figure 1), which consists of a cloth backing 1, grinding grains 2, deposited on one side of a cloth backing and bounded with an adhesive 3. Position 4 indicates a press roller, and arrows indicate the direction of rotation of a belt (V) and a feed (S).

Figure 1. Belt grinding pattern
The performance of sanding belts is significantly affected by cutting elements - abrasive grains included in their composition, namely: grade, grain size, shape and orientation on the backing surface [1-5].

The currently used technology for the production of abrasive materials does not provide the uniform grain shape. The abrasive grains produced by crushing the ingot significantly differ from each other not only in terms of shape, but also in their characteristics [3].

Sanding belts, as a rule, are made with a simple pouring of the abrasive onto the backing surface, as a result of which the abrasive grains occupy a chaotic position on the belt surface. More favorable working conditions of grains are achieved by their orientation in the electrostatic field.

The orientation of grains along their major axis relative to the sanding belt surface allows the most efficient use of elongated grains ensuring their strong fixation in the bond [4, 5]. In addition to creating the optimal working conditions, the grain orientation contributes to better removal of wear products from the cutting zone.

The sanding belt surface is characterized by the following parameters: the shape and size of the abrasive, the number of grains per unit surface area, the distance between the grains and their depth. The grinding process is also influenced by the grade and uniformity of the abrasive material, as well as the properties of the bond. The listed characteristics are monitored during the manufacturing process of the tool.

One of the parameters of a sanding belt is the number of active grains per surface unit. Currently, there are theoretical and practical methods for determining the number of active grains [6-9].

In accordance with one of the existing methods, the number of active grains is determined through the equation of the lengths of the arcs of contact between the part and the grinding wheel and the equation of the number of grains acting in the contact arc. This method is relatively easy to use; however, it allows determining the number of active grains, only within the limits of contact between the grinding wheel and the part.

It is known that not all grains on the grinding wheel face are involved in the cutting process [4, 5]. According to another method, it is proposed to determine the number of active grains using a specific formula containing 8 parameters. The second method is more complex and time-consuming than the previous one, but it allows determining the number of active grains on the entire grinding wheel face.

There are other alternative methods for estimating the number of grains on the sanding belt surface using mathematical expressions to determine the average probability of the number of active (working) grains per unit surface of the contact between the belt and the part.

A practical method to accurately determine the number of active grains is foil rolling method. To assess the initial state of the sanding belt surface, it is necessary to take prints of the abrasive grains. Based on the analysis of the prints, it is possible to evaluate the parameters and the relief of the sanding belt surface.

2. Methods and research

To determine the number of active grains of a coated abrasive, a method was developed that allows counting the number of active grains using the MatLAB software. The method is as follows:

- A coated abrasive is scanned.
- The resulting digital image is processed in a software environment such as Photoshop to obtain a grayscale mode (monochrome) (Figure 2).
- The processed digital image is imported into the MatLAB software environment as a variable, which is presented in the form of a table (matrix/array).
- Based on the data fed into the MatLAB software environment, layer contour plots/surface plots are constructed.
- The graphs having been plotted; the axes limits are set at the desired depth in the editor of the properties of the axis of the graph (Figure 3).
- The number of vertexes/peaks is calculated (vertexes/peaks are the active grains involved in cutting).
3. Results and discussion
To test the operability and adequacy of the proposed method for determining the number of active grains, it was compared with the method of foil rolling.

A coated abrasive with a size of 30x50 mm and grit No. 40 was used for this purpose. The test coated abrasive was fixed on a table and a packet of 5 carbon paper sheets with a density of 20 g/m² was placed on top of it. Then the test coated abrasive was pressed and rolled along with a steel roller. As a result, a cast of the most prominent (active) abrasive grains was obtained (Figure 4).
Active grains were counted manually. The rolling method showed that the number of active grains is 1233 (82 grains/cm$^2$).

When implementing the proposed method, the studied coated abrasive was scanned in advance (Figure 5) to obtain the smallest error in the results after rolling.

![Figure 5. Scanned coated abrasive (in grayscale)](image)

In accordance with the previously described research methodology, based on the scanned surface, a surface graph was plotted (Figure 6).

The graphs having been processed; it was estimated that, with a limit of 100 pixels, the number of grains is 1272 (84 grains/cm$^2$).

The number of active grains obtained by the proposed method coincides with the known method of foil rolling, so we can assume that the new method can be successfully used to determine the number of active grains.

![Figure 6. 100-pixel surface graph](image)

4. Conclusion
The analysis shows that currently there are no efficient and accurate methods for monitoring a coated abrasive face. The existing methods are quite laborious, time consuming and, in addition, do not provide sufficient accuracy. The proposed approach based on the use of modern software allows avoiding the above disadvantages and can be recommended for determining the number of active grains of a grinding tool in order to predict its further operability and other performance criteria.
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