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MODELING OF GEOMETRY OF WORKING BODIES OF MACHINES FOR SURFACE TREATMENT OF MINERAL MATERIALS IN CONSTRUCTION

Abstract:
The article presents the methodology of designing with the use of computer methods of geometric solutions of segments and their distribution on the base surface of the abrasive wheel and discs for processing plastic surfaces of concrete. The influence of kinematic parameters of machining machines on the effectiveness of the geometric influence of machining tools is discussed. Examples of computer simulations of design solutions of discs intended for finishing grinding in order to determine their effectiveness of geometric impact on the surface were presented.

Keywords:
Diamond segments, selection of segment geometry, segment arrangement, abrasive efficiency, effectiveness of abrasive impact.

Introduction

One of the directions of increasing the efficiency of technological processes is the analysis of the work of working tools of machines and technological devices [1–5]. In order to develop directions of searching for the rationalization of machining processes, the surface of building materials aimed at increasing the surface quality and reducing expenditure on the production of an increased amount of materials, while reducing energy demand. In order to meet the expectations of technological progress, the task was set to improve the geometric form of the working surface of the tools with the involvement of BIM in design processes.

Analysis of structural elements for surface treatment

The influence of the geometric form, their size and distribution in the form of abrasive diamond segments on the base surface of the disc with a diameter of (100 mm) result from technological conditions influencing the process parameters during the finishing grinding operation [6–10].

Understanding the geometric relationships has an impact on determining the effectiveness of the abrasive impact of the diamond tool on the surface on which it interacts with a variable geometry, guaranteeing the achievement of optimal efficiency in the grinding process determined by the characteristics of the material properties and the quality of the surface to which the tool is to lead. The analysis of the dependence was carried out on a model of a disc with a diameter of 100 mm, which had kinematic parameters corresponding to the devices used in practice. The working elements arranged on the base surface of the disc may have various geometrical forms, examples of solutions used in practice are shown in Figure 1.

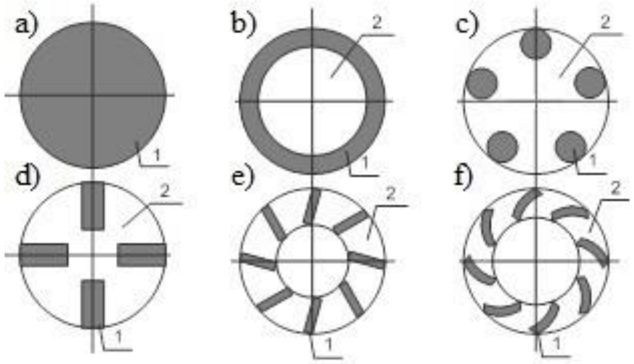

Figure 1 – Selected variants of the geometrical form of the friction surface and its arrangement in the form of the so-called diamond segment on the base surface of the disc: a) diamond segment in the form of a solid disc, b) diamond segment in the form of an annular working element, c) round diamond segments arranged on round base of the disc, d) rectangular diamond segments arranged symmetrically on the round base of the disc, e) rectangular working elements arranged at an angle in relation to the axis of the base of the disc, f) diamond segments of arc shape arranged on the surface of the ring of the circular base of the grinding wheel;
1 – abrasive segments, 2 – disc base [3]

Model for assessing the friction structure of a disc for grinding stone surfaces

The initial scheme for modeling the structure of the friction surface with circular segments of the disc was selected from the group of ring working tools, as in Fig. 1. Analysis of the modeling process when assessing the impact of kinematic loads on the grain in the diamond segment in which the grain was defined as the friction surface (ΔS_T). Working elements - diamond segments placed on the base disc can be given various geometric forms, their sizes and arrangement on the base surface can be changed. When all parameters, dimensions and forms are determined, they are assigned formulations in the calculation program, specifying the diameter of the segments, where for the characteristics of round diamond abrasive segments, as in Fig. 1, it will be important to enter the coordinates of their centers in the coordinate system (xy), the radius of the disc circle (R) and the number (ΔS_T) of elementary friction surfaces n (x1, y1 ... xn, yn) on the base surface of the segment. The example shown in Figure 1 shows an example of possible solutions for the surface structure of diamond disc tools. The calculation program allows you to define any geometric form and any size of the working elements, as well as its free arrangement on the surface of the dial.

In order to carry out an effective interaction of the working surface with a disc tool, the disc operation was analyzed at a speed (n = 960 rpm), which was additionally introduced into translational motion (V_p = 0.01 m / s), which results from the described characteristics of machines cooperating with such the working element for the surface treatment of granite for finishing grinding with a disc of grain size 40/45 #. The stationary field, called the elementary surface of the processed plane (ΔS_p), is subjected to the action of various points (ΔS_T) of the abrasive influence of the working elements, which affect the resultant velocity (W_{or}), which is variable in terms of size and directions of the resultant work element. In the case of considering the interaction from the surface of the friction segment with circular friction elements, the calculation scheme illustrating the determination of the resultant velocities influencing the selected segment areas (ΔS_T) interacting from the disk surface on different elementary points of the processed granite surface (ΔS_p) is presented. The calculation scheme is presented in Figure 2.

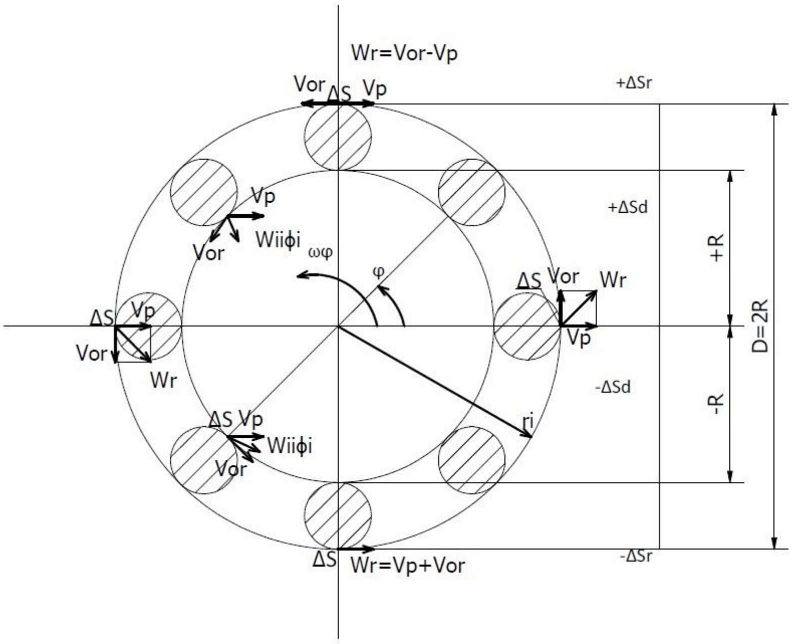

Figure 2 – Changes of the resultant velocities $W_r = V_p + V_{0ri}$ ($r_i = 0 ... R$), affecting the outer circular diamond segments of the machined surface on the line of the path of the center of the disc (ΔS_o), distant from this line on distance d (+ ΔS_d and -ΔS_d) and a distance equal to the radius R (+ ΔS_R and ΔS_R) of the disc rotating at the speed ω_o and translating at the speed V_p

The numerical value of the peripheral speed of the annular friction segment results from ($V_{or} = V_0 \cdot r_i$). The value of this speed decreases as the value of the disc radius is decreased; $r_i > 0$, where on the outer circumference of the working disc $V_{or} = \omega_0 \cdot R$. The vectors of this velocity are perpendicular to the radius (r_i), the direction of the velocity vector is consistent with the direction of rotation of the disc. For the case under consideration, the resultant speeds change direction, which affects the abrasive ability. The passing points of the friction surface of the disc through the stationary elementary field (ΔS_p) of the processed surface are subject to the action of a variable value of the resultant velocity, where:

$$W_r = \sqrt{V_p^2 + (\omega_0 R)^2} \tag{1}$$

from W_0 to W_p, and their direction deviates towards V_p for elementary points $r_i = R$ to $r_i = 0$ in the first translational phase, with opposite deviations for the second phase of movement. Extreme elementary fields subjected to the action of the target lying at a distance of +R (ΔS_R) and -R (-ΔS_R) from the trajectory lying on the target axis will be under constant influence in the resultant range $\overline{W}_R = \overline{V}_p + \overline{V}_{0R}$, which for ($\Delta S_R$) are $W_R = V_{0R} - V_p$, and for -ΔS_R have the value $W_R = V_{0R} + V_p$.

Elementary fields of the treated surface will be under the action of resultant velocity variables according to the equation (2):

$$W_{R\varphi} = \sqrt{V_p^2 + V_{0R}^2 - 2V_p V_{0R} \cos\varphi}, \tag{2}$$

to the resultant decreasing values determined from the dependence (3):

$$W_{ri\varphi i} = \sqrt{V_p^2 + V_{0ri}^2 - 2V_p V_{0ri} \cos\varphi_i} \, . \tag{3}$$

Summing up the resultant velocities of all points of the working surface of the disc with their simultaneous multiplication by the contact distance to the area of the machined surface, we obtain the length of the contact line of the disc in relation to the machined surface (granite slab).

The presented methodology of the kinetic influence of the influence on the points of the friction elements of the disc allows to calculate the indices of the geometric effectiveness of the influence from all elementary disc areas (S_g) in relation to the treated surface. The sensor line set up in the program allows to determine the given time quantum (Δ_t), for which they are remembered by the sensors – contact times (ΔS_T) on the basis of which the length of the line is calculated $L_i = (V_p + V_{0ri\varphi i})\Delta_t$, where values of the set parameter $\overline{V}_p + \overline{V}_{0ri}$, with the position of the center of the dial for the position of the next sensor. The program takes into account the influence of the elementary working field (ΔS_T), only the elementary points defined for diamond segments, this approach allows you to choose the desired total length of the working tool influence line on a given point of the machined surface (ΔS_p). The result of the calculations are graphs of the effectiveness of the geometrical interaction of the shield, which is generally expressed in the relationship (4):

$$S_g = \sum_{i=1}^{n} \cdot L_i \text{ [m]}, \tag{4}$$

according to this dependence, the line of interaction of all the grains of the diamond surfaces of the working segments of the disc, defined as the geometry of the friction surface, as well as the standard deviation index, is calculated.

The function of the objective of optimizing the geometric impact of the considered structure of the grinding wheel with the adopted and analyzed geometric forms of the friction segments, with the given kinematic parameters for the wheel in question, is defined as the standard deviation index from the average geometric ability to influence the treated surface, according to the theoretical assumptions presented above, which is determined from dependencies (5):

$$\sigma = \frac{\sqrt{\frac{1}{n}\sum_{i=l}^{n}(S_{gi} - \overrightarrow{S_g})^2}}{\overrightarrow{S_g}}. \tag{5}$$

Useful for the analysis of diagnostics in the search and evaluation of the work of grinding wheels is, above all, the possibility of building a graph of the distribution of the effectiveness of the geometric impact for the analyzed geometry of the abrasive segments arranged in a given order on the base surface of the wheel over its full diameter. This approach is largely useful for selecting the rationalization of the geometric form of the shield structure. In solving the task of the wheel modeling process, the starting point was to analyze the wheel abrasive work simulation process with the determination of the effectiveness of the geometric impact of the friction surface on the treated surface, for examples of discs with working elements commonly used in practice and of a new design. Based on the calculations, a graph of the effectiveness of the geometric interaction (Sg) for the discs subjected to the interaction with the rotational speed n = 660 rpm and the progressive speed Vp = 0.01 m / s was built. The calculation results are shown in Figures 3 and 4.

Conclusions

The method of analyzing the work of abrasive wheels intended for finishing grinding allows to calculate the geometric effectiveness, which in turn allows to analyze the effectiveness of the abrasive interaction of their impact depending on the given geometric form of the abrasive segments distributed on the base surface of the disc, the calculated length of the contact path of the diamond grain relative to the elementary surface distributed over sensor line length allows to determine the contact length (S_g) of the abrasive grain, which results from the segment geometry.

The conducted simulation analysis of the effectiveness of the geometric interaction of flexible discs formed with diamond segments on synthetic binders showed that the computational average effectiveness of the geometric interaction for the structure is in the range S_g = 11.86÷13.55m, which

is useful information in the next stage of shaping the parameters tools for the concentration of abrasive grain contained in diamond segments when analyzing the system from a distance from the axis of the wheel.

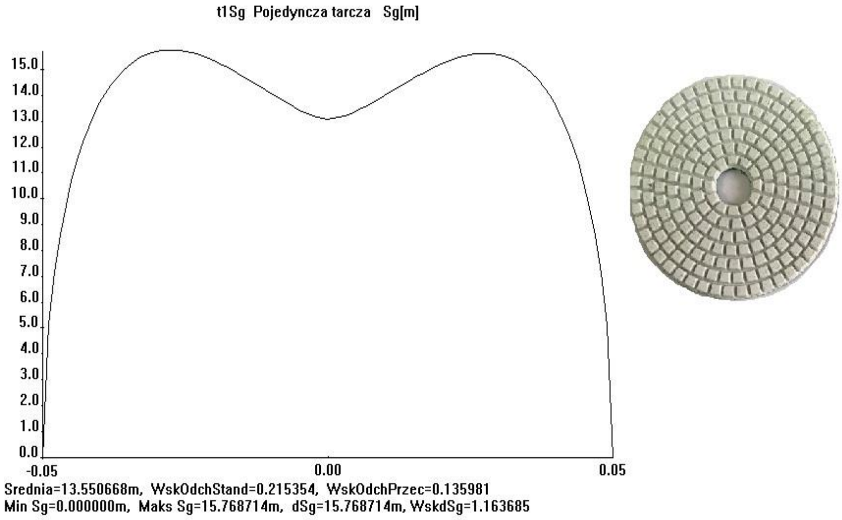

Figure 3 – The results of the simulation of the effectiveness of the working surface impact for the construction of the grinding wheel known on the market with the geometry shown on the right

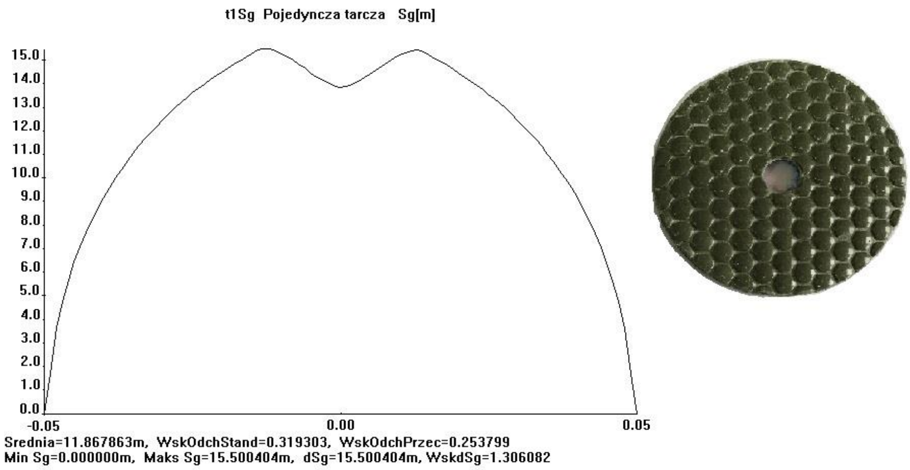

Figure 4 – The results of the simulation of the effectiveness of the working surface impact for the construction of the grinding wheel known on the market with the geometry shown on the right

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