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A NEW ABRASIVE DISC DESIGNED FOR GRINDING GRANITE

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Abstract

The aim of the work is to develop a new effective design and material of the disc for abrasive machining of granite. The task was undertaken in order to shorten the time of the machining operation of surface grinding by ensuring a uniform post-machining surface roughness for a given cycle , shortening the time for a given grain group of abrasive segments. For the purpose of the task, an analysis of the effectiveness of the impact of the working surface of the disc of known geometric solutions and a new solution of the disc geometry was carried out. Recipes for material composition and technology for making prototypes of discs with a new geometry of abrasive segments were developed, for which laboratory tests were performed.

Keywords**:** grinding wheels, mineral surface treatment, impact effectiveness, diamond wheels, surface roughness.

Introduction

Natural stone is a material with a large number of varieties characterized by individual physical, mechanical and functional properties, as well as the richness of colors and possible surface textures with diverse dynamics of utility patterns. Expectations are directed at new technological solutions that increase efficiency, increase quality, increase work safety and reduce machining costs. At present, according to publications [1, 2], there is a great interest in the world economy and an increase in the production of tools manufactured on the basis of synthetic diamond powders with synthetic binders. Historical use of diamond as an abrasive material for processing basalt and granite was made as early as Ancient Egypt, as evidenced by the traces of cuts in the stone on the buildings in Giza. Egyptian sources inform that 3000 BC in the kingdom of the pharaohs, grains of natural diamond called amodeus were used as an abrasive , and powder obtained from grinding nut shells was used for polishing [3,4]. In 1953, Platen B in Sweden performed the first diamond synthesis, also in 1953 Generall Eletric launched the industrial production of synthetic diamonds. In 1965, the production of synthetic diamonds was mastered in Russia. Since the 90s, in its technical development, China has become the largest producer of diamond powders in the world, which has contributed to the reduction of their production costs and the price of the diamond powder itself. At present, the dominant direction in the development of grinding wheel technology for surface finishing works in the processing of granite are directions related to the dynamically developing research on the use of synthetic binders.

1. Granite surface treatment

Diamond tools for the surface treatment of stone slabs - granite, play a dominant role in the mechanization of grinding processes and performing supporting operations [1, 9]. The use of diamond tools for stone processing in Poland dates back to 1965. The beginnings of the development of the stone processing industry were related to the import of diamond tools, the leading role of which was played by Diamant Board from South Africa. At the end of the 70s of the last century, an important step in the development of abrasive tools production technology was the start of production of domestic diamond segments. The use of diamond tools brings certain benefits, which include: high efficiency, high quality of the product after machining. Optimum working parameters affect the efficiency, tool wear, and the quality of the machined surface, which, with the minimum number of disc passes over the workpiece, should ensure uniformity of the surface machining quality. The measure of the quality of granite slabs is the uniformity of roughness or the degree of polishing on the entire treated surface and the long-term preservation of the given texture features. The quality of diamond grinding discs depends primarily on the parameters set by the manufacturer, such as: disc diameter, dimensions and number of segments, their geometry, type, granulation and concentration of diamond, type and hardness of the binder. The quality of the tool segment is additionally expressed by the parameter of the holding force of the abrasive grain in the binder [15]. The main factors influencing the efficiency of grinding include the configuration of the arrangement of abrasive segments on the surface of the machining head. Material parameters of diamond segments, i.e. diamond powder granulation, diamond concentration in the abrasive segment, type of diamond powder, binder hardness and optimal kinematic parameters of work, were also considered as the leading factor of abrasive efficiency.

2. Grinding wheels with diamond abrasive on synthetic binders

Discs equipped with abrasive segments are used for the stone surface treatment process, examples of design solutions are presented in Tab. 1. In addition to the presented solutions for the construction of grinding wheels with diamond segments on a metallic bond, in the construction industry, when processing granite, solutions of discs with inserts of diamond segments on synthetic bonds, mounted on the base disc, are used.

From the analysis of the literature [12, 13] regarding the assessment of factors influencing the work of the abrasive wheel during surface treatment, a variety of relationships for the effective surface treatment process are indicated. In the first stage of the work, the need to check the behavior of the new geometries of the abrasive wheel was defined as the initial task. The purpose of determining the effectiveness of the abrasive impact, depending on the abrasive elements for the construction of the circular geometry of diamond disc segments on synthetic bonds, was to carry out calculations of the influence of variables - dimensions and arrangement of abrasive segments on the base surface of the disc. Based on the analysis of the literature [12, 13], a preliminary hypothesis was put forward, according to which the abrasive efficiency of the grinding wheel is expressed by the uniformity of the distribution of grain cracks on the workpiece after passing the wheel on the square of the base surface with a side equal to the diameter of the wheel (D).

Table 1

Known design solutions for abrasive discs for surface treatment of stone slabs [2, 10, 14].

Photography	Name	Diameter (mm)	Diamond powder granulation
	Plastic strips	100	#50
	Peel off Velcro	100	#50
		100	#100
	Type ZL-16K	100	#50

The segments arranged on the circular base surface of the disc may have various forms and may be arranged in various ways. This indicates the legitimacy of seeking to increase the abrasive efficiency in new constructions by rationalizing the parameters of the relationship between the geometric form and the size of the abrasive elements of the segments. These activities should be preceded by the calculation of the geometric effectiveness of the impact of the new geometrical shapes of the friction elements of the discs with their assessment and verification on the abrasive test stand, verified by the post-machining roughness distribution on the machined surface, when assessing the disc's impact area across the width of its impact diameter.

3. Modeling the geometry of a grinding wheel for processing granite

Modeling of the geometry of the grinding wheel for granite processing indicates a variety of occurring phenomena and modeling methods, including the analysis of tools for an effective surface treatment process. As the first research task, the need to calculate the indicators of the geometric effectiveness of the impact on the machined surface of round diamond segments was determined.

A useful tool for the geometrical analysis of the construction of discs with given construction parameters is a computer program developed at the Częstochowa University of Technology [13, 16], which allows modeling of machining tools for specific parameters of the disc operation. The starting point in the modeling of the disc structure according to the method is to check the influence of the working geometry of the tool during the movement on the effectiveness of the impact on the machined surface. The methodology is very useful in determining the abrasive efficiency of grinding wheels.

The modeling program allows you to take into account all types of movement by formulating the path of disc displacements. The characteristics of the disc motion path include determining the position of the disc center and its kinematic parameters (speed of translational and rotational motion) at the beginning and at the end of the next stage of motion. A detailed description of the computer program for analyzing the effectiveness of the geometric impact of discs is described in publications [13, 16].

Conflict Setting

The aim of the work is to develop a new effective design and material of the disc for abrasive machining of granite.

Research Results

For the purpose of assessing the effectiveness of the impact of different disc geometry solutions, calculations were carried out and the effectiveness of the impact of the abrasive segments was compared, determining the value of the geometric impact efficiency (S_o) of the disc with a diameter of 100 mm, for 4 variants of the geometry of the rubbing segments as in Fig. 1-4, for each variant a disc with a diameter of 100 mm with an internal hole d = 15 mm, where 4 variants of abrasive segments were arranged on the full ring, assuming a kinematic load of ω = 960 rpm and a forward speed of V_p = 0.01 m/s. In the calculations, the effectiveness of the geometric impact S_g was determined , presented on the charts, for which the minimum, average and maximum geometric efficiency as well as the standard deviation index and the relative deviation index were determined.

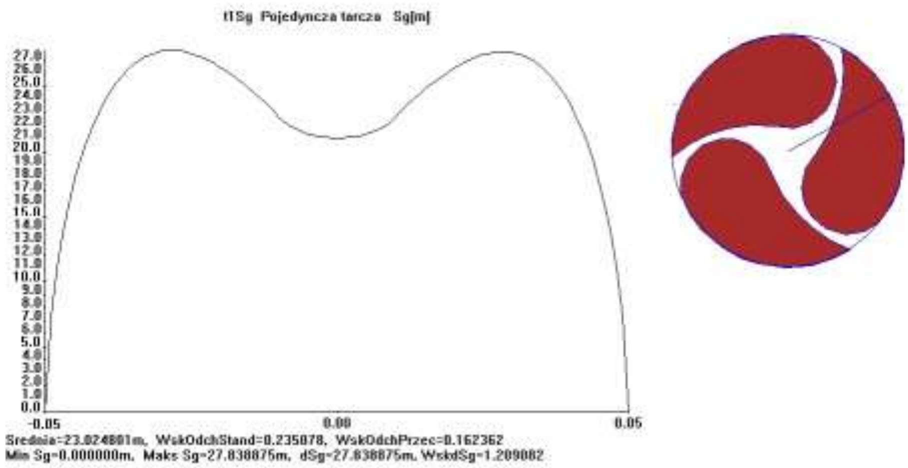


Fig. 1 Graph of the effectiveness of teardrop-shaped geometry on a 100 mm diameter disc

Graphs from the performed calculations of the geometric effectiveness of the impact of the rubbing surface of the segments against the machined surface indicate that the most effective solution in terms of the impact effectiveness has the variant as in Fig. 1, the graph S g in relation to the sensor lines shows high efficiency of the interaction of the working surface with the machined surface. It is intentional to point out that the round geometries of the segments of the diamond grinding wheels have an influence on the uniform distribution of the graph of the effectiveness of the action of round grinding wheels.

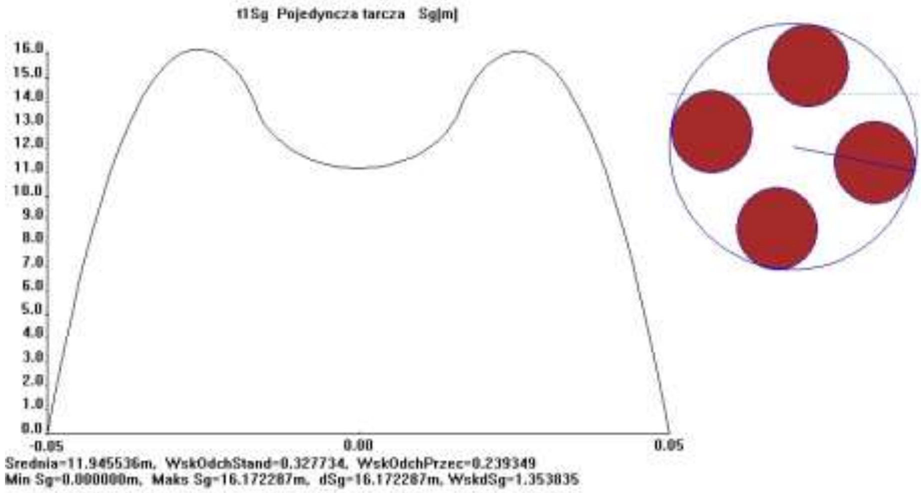


Fig. 2 Graph of the impact effectiveness of the geometry in the shape of circles arranged on a 100 mm diameter disc

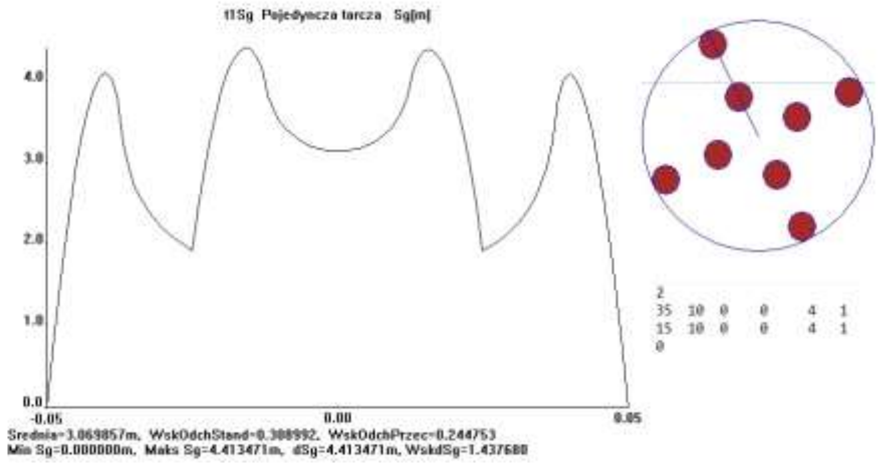


Fig. 3 Graph of the impact effectiveness of the geometry in the shape of circles arranged on a 100 mm diameter disc

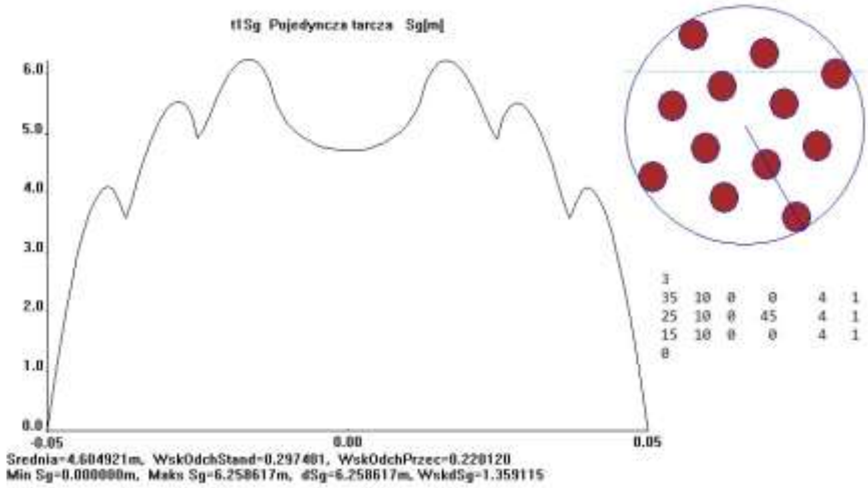


Fig. 4 Graph of the impact effectiveness of the geometry in the shape of circles arranged on a 100 mm diameter disc

Taking into account the technological conditions and economic efficiency, it is also advisable to conduct research in the field of shaping circular abrasive segments with their use to find rational relationships to increase the efficiency of the grinding process.

Evaluation of granite surface roughness after impact with discs

In the tests, the abrasive efficiency of the disc was checked in terms of the distribution of roughness after a trace left on the polished surface of a granite plate along the full diameter of the disc at a length of 10÷50 mm.

The measurement of the roughness distribution was determined from the center of the disc in 5 sections of 8 mm on the full length of the radius of the grinding disc, as in Fig. 5.

Fig. 5 Measurement of roughness distribution

After abrasive treatment were used in the assessment . Measurable parameters are used to assess surface roughness , such as:

R_a – mean authentic deviation of the profile from the mean line [μm],

Rz - the average height of the profile roughness in 10 points for the 5 highest and 5 lowest measuring points along the measuring length [μm] ,

R_{max} - the highest height of the measurement unevenness from the lowest point to the highest measurement point [μm],

The measurement of the profile after the work of the new disc design was carried out with an electronic measuring tool from Mitutoyo , type JS-21. The results of measuring the roughness of prototypes and known structures are summarized in Tab. 2 of the post-machining trace of new design and material solutions for grinding wheels for granite processing. The effect of the target was tested on 3 samples for each type of target. The impact of the abrasive process was carried out without the use of coolant for each disc for 30 s without the sliding motion.

The roughness measurements show that the original prototypes of grinding wheels have an even distribution of roughness in relation to industrial structures. Due to the lack of feed during the experimental tests of the impact of grinding wheels on the machined surface of a polished granite plate with an initial roughness of $R_a = 0.21$ μm , the depression left after the impact of the tested prototypes of the wheels was larger than industrial structures, which results in a high parameter of R_a .

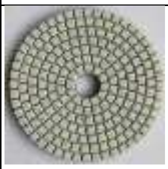
Table. 2

Shield type	Hardness [HLD]	S_g [m]	Ra [µm] _				
prototype of the shield with a polyester resin binder	560	15.66	3.43	3.55	3.59	3.58	3.60
prototype of the shield with epoxy resin binder	550	15.66	3.56	3.59	3.61	3.61	3.62
industrial construction of the disc on a polyester resin binder	630	13.55	3.28	2.33	2.25	2.29	1.07

The collective results of calculations of the average geometric effectiveness of the impact of the shields (PR1÷PR3 and Ak) along with the characteristic parameters of the geometric analysis are summarized in the Tab. 3.

Tab. 3

Collective results of calculations of the geometric mean effectiveness of the shields (PR1÷PR3 and Ak) along with the characteristic parameters of the geometric analysis [own study]

Lo.	Surface structure	Impact effectiveness indicators				The share of the geometry of the working surface of the disc structure	
		Set parameters n (rpm)	Average impact efficiency Sg (m)	Standard deviation index σ	Relative deviation index	Active segment area P_{as} [cm^3]	Total area of excavated material removal channels P_{ku} [cm^3]
PR1		660	11,310	0,305	0,221	58,20	19,51
PR2		660	11,867	0,319	0,253	59,15	18,56
PR3		660	13,560	0,253	0,153	59,71	18,00
Ak		660	15,655	0,338	0,245	41,76	33,60

Based on the results of the numerical tests and the collected key data on individual disc designs, i.e. the active surface of the segments and the total area of channels for the removal of excavated material and the supply of coolant, it was found that the solution proposed by the author of the shape and arrangement of segments on the working surface has a higher geometric efficiency. impact by 13.38% from the PR3 shield, which has the highest parameter (S_g) among the analyzed industrial shields. Moreover, it should be noted that the mentioned shield (PR3) has the lowest standard deviation index (σ = 0.253) among all the analyzed cases. However, it is related to having the largest active surface of the segments, P_{as} = 59.71 cm^2. When analyzing the original solution (Ak), a slightly higher standard deviation index was noticed (σ = 0.338) in relation to the analyzed discs used in the stone industry (PR1÷PR3). This is correlated with having a lower active surface of the segments by an average of 41.33% compared to industrial machining discs, and at the same time a larger surface for removing the excavated material and supplying coolant during operation by an average of 55.63%. It should be noted that the standard deviation indicator itself in the analyzed case is not a key parameter for assessing the geometric effectiveness of the grinding wheel. The presented results from the numerical tests confirm the rational selection of the geometry of the working segments and their arrangement on the base surface of the abrasive disc.

Conclusion

The performed calculations of the geometric effectiveness of the interaction indicate the desirability of conducting further research for the geometry of the circular friction segments that fit into the teardrop surface.

Calculations of the effectiveness of the geometrical impact of discs with round segments show a high impact value, which was confirmed by the measurement of post-machining surface roughness, instrumental tests on five measurement sections, each 8 mm long, on the length of the disc radius D = 50 mm, for which a homogeneous roughness distribution was demonstrated, which is R_a = 3.61 μm , with synthetic diamond powder grains of grain size 40/45#, with 25% concentration of grain deposited in segments on a polyester binder with a hardness of 460 HLD.

The new construction and material solution of the grinding wheel has a more even distribution of post-machining roughness and has a higher effectiveness of impact compared to the currently used construction and material solutions in industry.

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ՆՈՐ ՀՂԿԱՄԱՇԻՉ ՍԿԱՎԱՌԱԿ ԳՐԱՆԻՏԻ ՀՂԿՄԱՆ ՀԱՄԱՐ

Պավել Ռայչիկ
Չեսրախովայի տեխնոլոգիական համալսարան

Ներկայացված է գրանիտի հղկող մշակման նոր արդյունավետ կառուցվածքի և սկավառակային հղկամաշիչ նյութի մշակումներ: Խնդիր դրվել էր նվազեցնել մակերևույթի մեխանիկական մշակման ժամանակը: Առաջարկվել է սկավառակի երկրաչափական բնութագրերի նոր լուծում: Մշակվել է նյութերի բաղադրության և հղկող հատվածների նոր երկրաչափությամբ սկավառակների նախատիպի պատրաստման տեխնոլոգիա: Բերվում է լաբորատոր փորձարկումների տվյալների վերլուծություն:

Բանալի բառեր. հղկող սկավառակ, հանքանյութով մակերևույթիմշակում, ալմաստե սկավառակ, մակերևույթի խորդուբորդություն:

НОВЫЙ АБРАЗИВНЫЙ ДИСК, ПРЕДНАЗНАЧЕННЫЙ ДЛЯ ШЛИФОВАНИЯ ГРАНИТА

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Пердставлена разработка новой эффективной конструкции и материала диска для абразивной обработки гранита. Задача поставлена с целью сокращения времени механической обработки операции плоскошлифования за счет обеспечения равномерной шероховатости поверхности. Предлагается новое решение геометрии диска. Разработана технология изготовления прототипов дисков с новой геометрией абразивных сегментов. Приведен анализ результатов лабораторных испытаний.

Ключевые слова: шлифовальные диски, минеральная обработка поверхности гранита, алмазные диски, шероховатость поверхности.

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