TEKA. COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE – 2015, Vol. 15, No.3, 3-8

Evaluation of relief development of metal-bonded diamond wheel's working surface

V. Dobroskok[1], A. Shpilka[2], M. Morneva[3]

[1] *National technical university «Kharkiv polytechnic institute», e-mail: vldob@yandex.ua*
[2] *Poltava national technical Yuri Kondratyuk university, e-mail:andrei_shpilka@mail.ru*
[3] *Volodymyr Dahl East-Ukrainian national university, e-mail: morneva@gmail.com*

Received June 17 2015: accepted August 29 2015

Summary. The process of defining the relief development of metal-bonded diamond wheels working surface by morphometric analysis of its triangulation model is under consideration. The way of defining the relief development by arranging the height of the peaks of triangulation model is suggested.

Key words: diamond wheels, working surface, relief development, 3D model, triangulation, morphometric analysis.

INTRODUCTION

Abrasive-diamond processing of hard-to-machine materials is widely used both at intermediate and final stages of producing essential components. The most effective abrasive material is diamond, what is caused by its unique qualities and geometric parameters [1-5].

Metal-bonded diamond wheels are highly resistant and abrasion-proof [2, 3, 6]. While grinding their cutting abilities reduce due to smearing and smoothing of cutting relief [4, 7]. One of the factors that to a great extent define the effectiveness of grinding process is consistency of outcome indices of components processing for the whole length of processing. Stability of diamond grinding depends on keeping the necessary level of cutting relief development, wheel's working surface crossing and longitudinal profile [8].

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The correlation between the condition of diamond wheel's working surface and grinding effectiveness predetermines regulation of cutting relief at the stage of production [9, 10] and while grinding [11-15]. Restoring cutting properties of grinding wheels takes a considerable amount of production time for periodic adjustment of a tool, and for continuous maintaining requires special equipment. There appears a necessity to develop the techniques for objective and profound assessment of conditions of metal-bonded diamond wheels working surface relief.

Indicator (contact) method of studying diamond wheel's working surface is relatively easy to implement and gives adequate results in case of a fair number of repeated measurements [16, 17]. Using a sensing tool, consisting of tensometric bar with anchored diamond and current-carrying needles provides an opportunity to differentiate unevenness caused by grains and wheel bond [8]. However, such method does not allow receiving comprehensive information about relief geometry due to instability of contact between an indicator tip and the surface examined. Non-contact method with optical tool was used to measure the wheel wear [18]. In researches [11, 19, 20] for examining the wheel's working surface a binocular microscope was used, which enabled to examine the formation of cutting edges, appearing as a result of single-point diamond shearing while processing. However, the type of the examination results gained does not allow performing its efficient analysis. In the research [16] there is a description of the quantitative and qualitative evaluation of the pattern of single-point diamonds and wheel bond wear with the help of optical (MMR-4, MPD-1, MIM-8) and scanning electronic microscope (REM-200, Jeol-50A). Radial motion of microscope's focal plane regarding the tool's working surface and calculation of the number of single-point diamonds, which got into acuity zone on various heights with the pitch of 5μm took place. After reaching the bond surface on each level additional calculation of the number of the bond's protrusions and hollows, including craters from the single-point diamonds fallen out, was conducted. However, the tests in getting the bond average level and visual alignment of microscope's focal plane regarding it, proved relatively low accuracy in setting zero datum, which to a great extent was defined by individual features of a scientist.

Qualitative assessment of the surface topography can be conducted by spreading multi-layer coating of pair-contrast layers with the gross thickness equal to the height the outermost grains, on the working surface of diamond wheels [21]. The thickness of each level is even and constant normally regarding the working surface. The coating is cut on the level of the outermost grains, which provides getting a topogram. But this method is difficult to implement.

Current technologies allow developing the methods of data recording, which guarantee performing more efficient analysis of the development of diamond wheels working surfaces.

To evaluate the development of a diamond wheel working surfaces, the researchers used various parameters [16, 22]: the height of surface planarization, which is the distance between the line of protrusions and equidistant line, on which level the relative reference length of the profile is $t_p=50\%$; spectrum conversion operator, which is the ratio of profile spectrum density before and after processing; difference in the grain heights [22]. The possibilities of performing the analysis of the 3D model of the working surface, made by step-by-step photographing [24] or laser scanning [25] are considered potentially effective for evaluating relief development of metal-bonded diamond wheels working surface.

OBJECTIVES

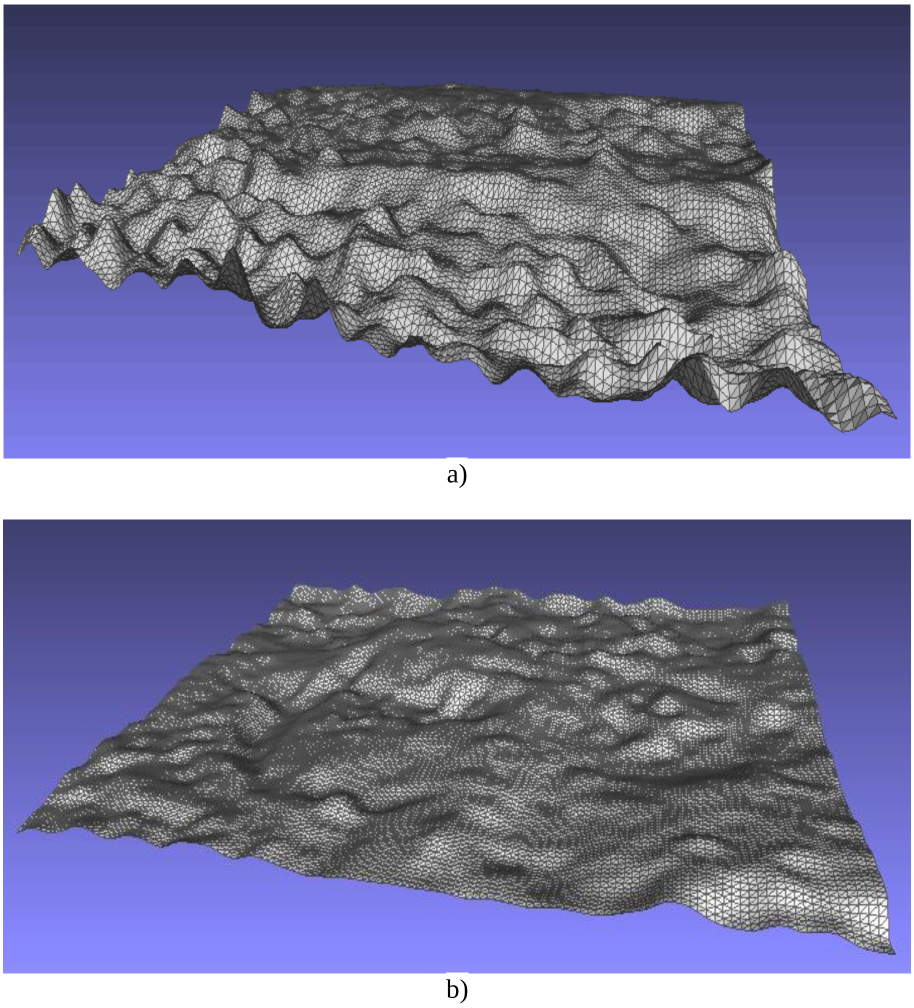
The aim of the publication is to consider the possibility of evaluating relief development of metal-bonded diamond wheels' working surface by the morphometric analysis of its triangulation model.

THE MAIN RESULTS OF THE RESEARCH

To perform the assessment of diamond wheels' working surface development 3D models, made by step-by-step photographing and subsequent processing of the pictures, were used. The point of the method is to simulate layer-by-layer scanning of the surface relief by sequential taking pictures while performing step-by-step movement of the focal depth zone of the microscope's optical system. Photography was performed with the digital USB-microscope Supereyes B008. The processing of the pictures and production of 3D models were made in the application HeliconSoft Helicon Focus Professional.

While modelling the patch of the wheel's working surface with the area relatively significant to provide representativity of geometric parameters of the relief elements located on it, was photographed. Evaluation of the representativity of the values of geometric parameters on the area of the diamond wheel's working surface under examination was performed by comparing 3D models of different areas of the same tool. The value of the pitches area was increasing gradually until the minimum difference of their relief statistic characteristics was reached.

Comparative analysis of 3D model of the working surface was performed for the initial diamond wheel ПП 300×20×32×5 АС4 100/80 М1, which working surface was formed by electroerosion, and for the same wheel after 15-minute grinding of the sample of hard alloy metal ВК8 (Fig. 1). Electroerosion exposure was conducted by the combined scheme. The formation modes: wheel speed 30 m/s, vertical feed 0,002÷0,007 mm/path, average current strength 5÷8 A, no-load voltage 50 V.



a)

b)

Fig. 1. Triangulation models of the working surface of the initial diamond wheel (a) and after 15-minute grinding (b)

Evaluation of the relief development of diamond wheels working surface with their 3D models was conducted with the help of the morphological analysis of their triangulation models [26] (Fig. 2).

The development of diamond wheels' working surface relief was assessed by its triangulation model in the subsystem of morphometric analysis by "Peak Z coordinate" with the defined number of histogram bins as the parameter under examination (Fig. 3).

The values of proportional frequency are visualized by hovering a cursor over corresponding histogram column (Fig. 4).

As a result of morphometric analysis we received statistical characteristics and coordinates histogram for peaks Z of the triangulation model of the working surface of the initial wheel (Fig. 5, a) and the wheel after grinding (Fig. 5, b).

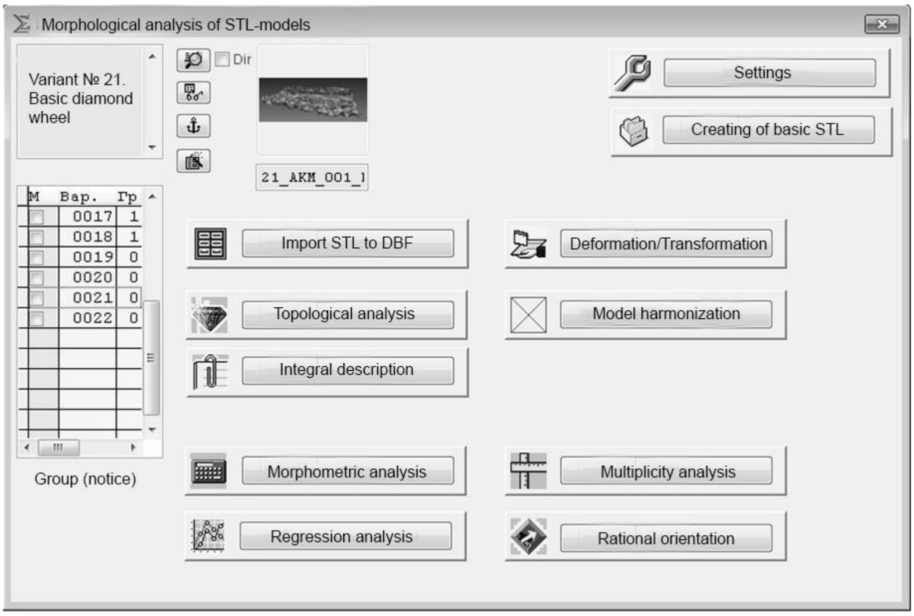


Fig. 2. Main screen of the system of morphological analysis

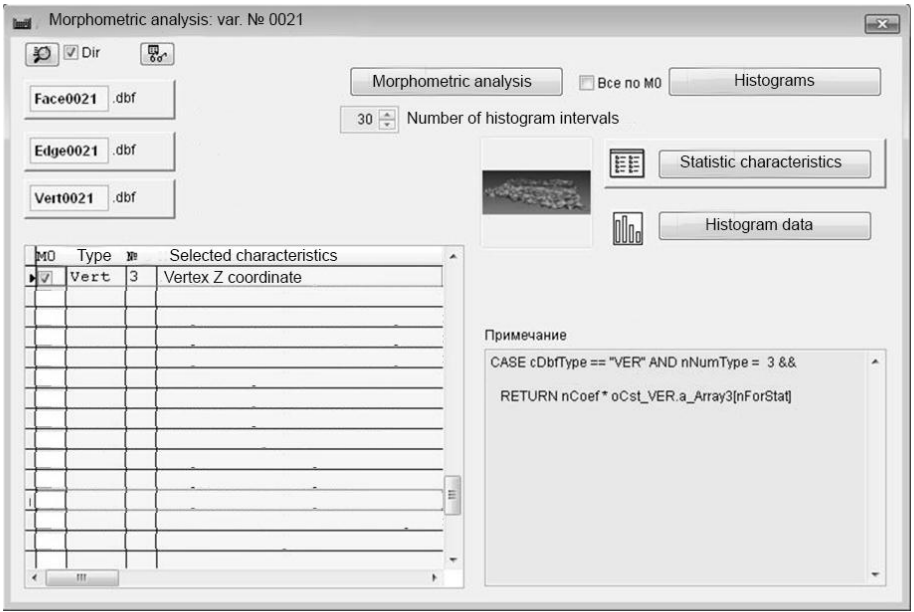


Fig. 3. Subsystem of morphometric analysis of triangulation model

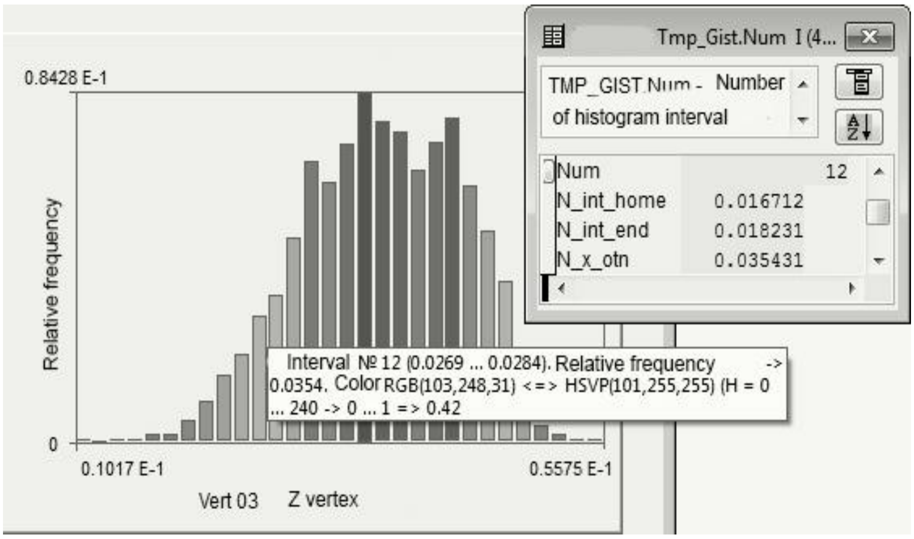
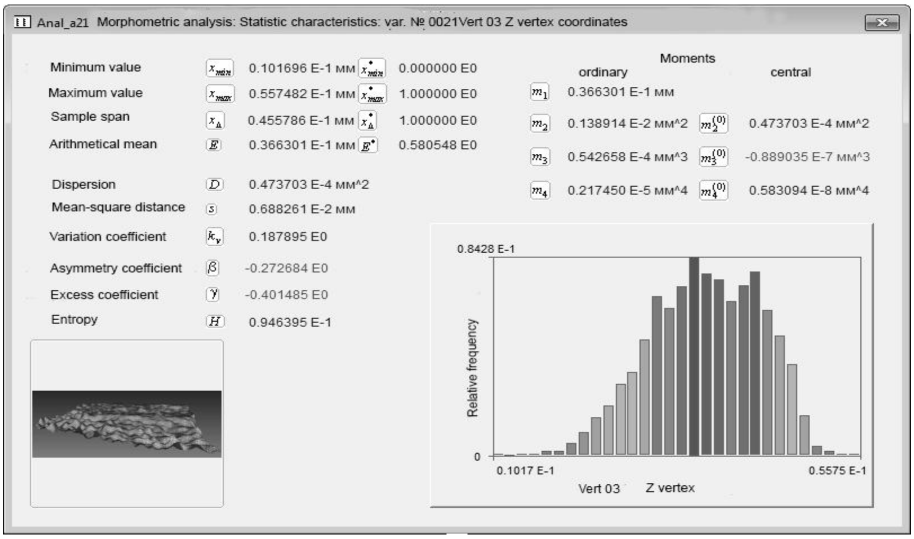
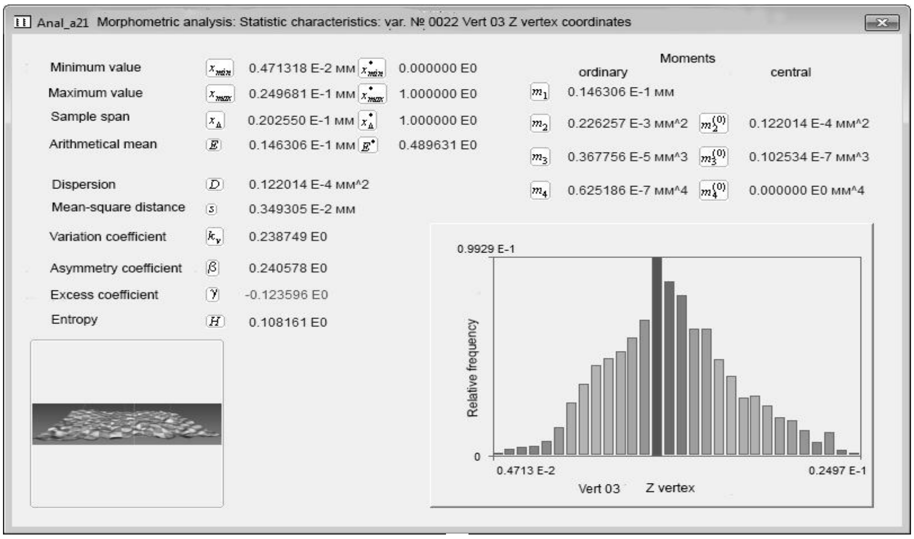


Fig. 4. Histogram of proportional frequencies of the parameter under examination



a)



b)

Fig. 5. Statistical characteristics and histograms of proportional coordinates frequencies for peaks Z of the triangulation model of the working surface of the initial wheel (a); and the wheel after grinding (b)

Table 1. Statistical characteristics of the coordinate values for peaks Z of the triangulation models of the diamond wheel working surface

Statistical parameter	The wheel after electroerosion formation of working surface (Parameter 1 under examination)	The wheel after grinding (Parameter 2 under examination)	Parameters ratio of the models IP1/IP2
Minimum value of the peak Z coordinate x_{min}, mm	0,010	0,005	2
Maximum value of the peak Z coordinate x_{max}, mm	0,056	0,025	2,24
Sampling range x_{Δ}, mm	0,046	0,020	2,3
Simple average E, mm	0,037	0,014	2,643
Root-mean-square deviation S, mm	0,007	0,003	2,5
Coefficient of variation k_v	0,188	0,239	0,787
Coefficient of skew β	-0,273	0,241	-1,133
Coefficient of kurtosis' γ	-0,401	-0,124	3,234
Entropy H	0,095	0,108	0,88

Sampling range and root-mean-square deviation of the peak Z coordinate are 0,037 and 0,007 mm correspondingly for the model of the initial wheel, and 0,020 and 0,003 mm after processing, which proves the wear of diamond grains of the instrument's working surface after processing.

The analysis of the histograms of proportional coordinates frequencies for peaks Z of the triangulation model of the working surface of the initial wheel and the wheel after grinding allows making the following conclusion:

- the values of root-mean-square deviation and coefficient of variation of the peak Z coordinate have changed 2,5 and 0,787-fold correspondingly, which clearly demonstrates the increase in the variation of the parameter under examination;

- the mode of proportional coordinates frequencies for peaks Z of the model shifts to the area of lower coordinate values (relative frequency 0,0843 for the interval 0,0345÷0,0360 of the first model and 0,0993 for the interval 0,0135÷0,0142). The analysis of the data received proves the decrease in the relief development of the metal-bonded diamond wheel's working surface under examination after having processed hard alloy metal.

CONCLUSIONS

1. Conducted tests proved sufficient working efficiency of the suggested approach to evaluating the relief development of the metal-bonded diamond wheels' working surface by conducting morphometric analysis of its triangulation model by peaks Z coordinates.

2. Evaluation of the sampling range and histograms of proportional coordinates frequencies for peaks Z of the wheel's triangulation models after forming the working surface by elecroerosion and a blunt wheel indicates significant increase in the relative number of peaks with the average value of height coordinates, which proves smoothing the inequalities of the instrument's working surface relief in the process of grinding.

3. The approach considered predetermines rational choice of the method to form the tool's working surface and efficient way to assess its redress life.

REFERENCES

1. **Zakharenko I. 1981.** The diamond machining of carbide tools. Kiev: Scientific thought, 300. (in Russian).
2. **Semko M., Grabchenko A. 1978.** Fundamentals of diamond grinding. Kiev: Technics, 232. (in Russian).
3. **Popov S., Malevskiu N., Tereshchenko L. 1977.** Diamond-abrazyvnaya obrabotku of solid metals and alloys. Moscow: Mechanical engineering, 263. (in Russian).
4. **Semko M., Grabchenko A., Hodorevskiy M. 1980.** Diamond grinding of synthetic superhard materials. Kharkiv: High School, 192. (in Russian).
5. **Namba Y., Yamada Y., Tsuboi A., Unno K., Nakao H. 1992.** Surface Structure of Mn-Zn Ferrite Single Crystals Ground by an Ultraprecision Surface Grinder with Various Diamond Wheels. Annals of CIRP, 41/1, 347-351.

6. **Semko M., Vnukov Y., Grabchenko A. 1979.** High electric powered diamond grinding tool materials. Kiev: High School, 232. (in Russian).
7. **Hudobin L., Unyanin A. 2007.** Minimization of clogging of grinding wheels. Ulyanovsk, 298. (in Russian).
8. **Dobroskok V. 1986.** Increase stabylnosty process control putem shlyfovanyya a working surface relief diamond circular. Dis....kand. techn. sciences, Rostov on Don, 253. (in Russian).
9. **Zaharenko I. 1980.** Diamond tools and machining processes. Kiev: Technics, 215. (in Russian).
10. **Reznikov A. 1981.** Thermal physics processes of machining. Moscow: Mechanical engineering, 279. (in Russian).
11. **Maslov E. 1974.** Theory grinding materials. Moscow: Mechanical engineering, 320c. (in Russian).
12. **Yakimov A., Parshakov A., Svirshev V., Larshin V. 1983.** Managing the process of grinding. Kiev: Technics, 184. (in Russian).
13. **Dobroskok V. 2001.** The scientific basis for the formation of the working surface of the circle conductive ligaments during grinding. Dis....doct. techn. sciences, Kharkov, 447. (in Russian).
14. **Dornfeld D., Liu J.J.B. 1993.** Abrasive Texturing and Burnishing Process Monitoring Using Acoustic Emission/ Annals of CIRP, 42/1, 397-400.
15. **Krol J., Belkov M. 2014.** Study dynamics machining centre SF68VF4. TEKA Kom. Mot. i Energ. Lublin: OL PAN, XIV(2), 59-67.
16. **Grabchenko A. 1985.** Expansion of technological possibilities of diamond grinding. Kharkov: High School, 184. (in Russian).
17. **Zubarev Y., Mihanoshin M. 2004.** Mathematical justification of methods of measuring the wear of abrasive. St. Petersburg: Tools and Technology, 21-22, 59-63. (in Russian).
18. **Mutsyanko V. 1987.** Fundamentals selection of grinding wheels and prepare them for use. Leningrad: Mechanical engineering, 134. (in Russian).
19. **Loladze T. 1982.** The strength and durability of the cutting tool. Moscow: Mechanical engineering, 320. (in Russian).
20. **Czeslaw Nizankowski. 2012.** Application of the Lurie indicator to the evaluation of the abrasive capabilities of grinding wheels made of submicrocrystalline sintered corundum, with various abradant compositions. Advances in Manufacturing Science and Technology, AMST, Rzeszów, 36(4), 61-72.
21. **Dobroskok V., Drozhzhin V., Grabchenko A., Mihaylov A. 1983.** The method study of surface roughness. Auth. Cert. 1054669 USSR, МКИ G 01 B 5/28. № 3360097/15-28. (in Russian).
22. **Mikhailov A. 2009.** Basics of synthesis of functionally-oriented technologies engineering. Donetsk: DonNTU, 346. (in Russian).
23. **Tsehin A. 2011.** Improving the performance of grinding wheels on bakelite bond through the use of classified in the form of grain. Dis....kand. techn. sciences, Kemerovo, 176. (in Russian).
24. **Dobroskok V., Shpilka A., Kotliarov V. 2014.** Getting triangulation terrain model of the working surface of grinding wheels. Cutting and tools n technological systems.Kharkov: NTU «KhPI», Vol. 8, 85-92.
25. **Grabchenko A., Dobroskok V., Fedorovich V. 2006.** 3D modeling of diamond abrasive tools and grinding processes. Kharkov, 364. (in Ukrainian).
26. **Grabchenko A. 1999.** Workflows high technologies in mechanical engineering. Kharkov, 436.
27. **Dobroskok V., ShpilkaA., Morneva M., Shpilka N. 2014.** Increase in efficiency of electric powered diamond grinding of conductive material by regulating longitudinal profile of grinding wheels. TEKA Kom. Mot. i Energ. Lublin: OL PAN, XIV(2), 26-33.

ОЦЕНКА РАЗВИТОСТИ РЕЛЬЕФА РАБОЧЕЙ ПОВЕРХНОСТИ АЛМАЗНЫХ КРУГОВ НА МЕТАЛЛИЧЕСКОЙ СВЯЗКЕ

В. Доброскок, А. Шпилька, М. Морнева

Аннотация. Рассмотрен вопрос определения развитости рельефа рабочей поверхности алмазных кругов на металлической связке путем морфометрического анализа ее триангуляционной модели. Предложено развитость рельефа определять по распределению высоты вершин триангуляционной модели.

Ключевые слова: алмазный круг, рабочая поверхность, развитость рельефа, 3D модель, триангуляция, морфометрический анализ.