УДК 539.893.621.317.451 DOI 10.36910/775.24153966.2023.75.26

**N.O. Oliinyk[1], H.D. Ilnitska[1], G.A. Petasyuk[1], O.N. Sizonenko[2], G.A. Bazaliy[1], S.D. Zabolotnyi[1]**

## INFLUENCE OF IMPULSE PROCESSING WITH HIGH-VOLTAGE ELECTRICAL DISCHARGES AND FLOTATION SEPARATION ON THE PHYSICAL-MECHANICAL AND MORPHOMETRIC CHARACTERISTICS OF AC20 MARK SYNTHETIC DIAMOND POWDER WITH GRANITY 100/80

*[1] V.N. Bakul Institute for superhard materials of the National Academy of Sciences of Ukraine*
*[2] Institute of Pulse Processes and Technologies of the National Academy of Sciences of Ukraine*

***Studies of the powder of synthetic diamond grade AC20 with grain size 100/80 have experimentally shown that the use of high-voltage electric discharges in the manufacture of powders makes it possible to obtain powders that are more uniform in morphometric characteristics, powders with a large number of cutting edges and a large angle of their sharpening, which provides a higher abrasive ability . The use of flotation separation of diamond powder makes it possible to obtain diamond powder, which is characterized by an increased strength in static compression by 23.8%, increased uniformity in strength by 25.0%, and a significantly reduced number of inclusions. The results of the performed studies give grounds to assert that the use of powder treatment with high-voltage electric discharges and the use of flotation separation are effective technological methods for influencing the morphometric, physical and mechanical characteristics and technological properties of synthetic diamond powders. The use of these two methods opens up the possibility of selectively influencing the quality of the resulting powders.***

***Key words*****:** *synthetic diamond grinding powder, flotation, strength, morphometric characteristics*

**Н.О. Олійник, Г.Д. Ільницька, Г.А. Петасюк, О.М. Сизоненко, Г.А. Базалій, С.Д. Заболотний**

## ВПЛИВ ІМПУЛЬСНОГО ОБРОБЛЕННЯ ВИСОКОВОЛЬТНИМИ ЕЛЕКТРИЧНИМИ РОЗРЯДАМИ ТА ФЛОТАЦІЙНОГО РОЗДІЛЕННЯ НА ФІЗИКО-МЕХАНІЧНІ ТА МОРФОМЕТРИЧНІ ХАРАКТЕРИСТИКИ ПОРОШКІВ СИНТЕТИЧНОГО АЛМАЗУ МАРКИ АС20 ЗЕРНИСТОСТІ 100/80

***Дослідженнями порошку синтетичного алмазу марки АС20 зернистості 100/80 експериментально показано, що застосування оброблення високовольтними електричними розрядами при виготовлені порошків дозволяє отримувати порошки більш однорідні за морфометричними характеристиками, порошки з більшою кількістю різальних кромок та більшим кутом їх загострення, що забезпечує більш високу абразивну здатність. Застосування флотаційного розділення алмазного порошку дозволяє отримати порошок алмазу, що характеризується підвищеним показником міцності при статичному стиску на 23,8%, збільшеною однорідністю за міцністю на 25,0%, суттєво зниженою кількістю включень. Результати виконаних досліджень дають підставу стверджувати, що застосування оброблення порошку високовольтними електричними розрядами і застосування флотаційного розділення є дієвими технічними засобами впливу на морфометричні, фізико-механічні характеристики та технологічні властивості порошків синтетичного алмазу. Застосування цих двох методів відкриває можливість здійснювати вибірковий вплив на якість отримуваних порошків.***

***Ключові слова*****:***порошок синтетичного алмазу, флотація, міцність, морфометричні характеристики*

### Introduction

The production of modern abrasive tools requires high-quality synthetic diamond powders (PSD) that are uniform in their characteristics. Properties (PSD) are formed in the process of synthesis, chemical and physical processing [1]. Our studies have shown that pulsed high-voltage electric discharge (HVED) treatment of grinding powders and micro-powders of diamond makes it possible to obtain powders that are more uniform in terms of morphometric characteristics [2]. To improve the quality of PSA, sorting by various methods is used, including flotation separation [3-5].

A significant scientific and applied interest lies in the expansion of research on the study at a quantitative level of a wider range of characteristics and properties of synthetic diamond powders of the coarseness class used in abrasive tools, which can be adjusted using the methods of flotation separation and HVED processing.

The purpose of the work is to study the influence of HVED processing and flotation separation on the formation of morphometric and physical-mechanical characteristics of PSD produced by such methods.

### Method

Samples of AC20 diamond powder with a grain size of 100/80, which was synthesized in the Ni-Mn-C system, and the products of its HVED treatment and flotation separation (foam and chamber) were studied. The research was conducted in 2 stages. At the first stage of the PSD, the HVED was treated in distilled water with a pressure discharge channel of 800 MPa and a total treatment energy of 1000 kJ. After the chemical purification of the products of the HVED treatment, PSD of different grain sizes was produced. The next stage of the research was the flotation separation of the powder in one stage, followed by chemical purification of the resulting separation products from flotation reagents. The research used the following methods: chemical, magnetic, gravimetric; sieve analysis; methods of optical and scanning electron microscopy. Strength indicators during static compression were determined according to the index of grades according to the standard [6]. The content of intracrystalline metal inclusions was estimated by the value of the specific magnetic susceptibility. Strength indicators during static compression were determined according to the characteristics of grades according to the standard [6], uniformity in strength (the content of diamond grains in the sample of the fractions corresponding to the nominal grades of powder, which is determined according to the strength test passport of the powder sample). The size distribution of the powder particles was studied, using known methods, the specific magnetic susceptibility of the powder ($\chi$, $\cdot 10^{-8}$, $m^3/kg$) and the mass fraction of impurities in the form of non-combustible residue (%, by mass) were determined. The strength of grains under static compression was determined using the DA-2 device [7]. Morphometric characteristics (minimum ($F_{min}$, μm) and maximum ($F_{max}$, μm) Feret diameters, grain height (H), grain projection roughness ($Rg$), Feret elongation $F_{el}$, average grain diameter ($d_m$), convex image form factor $C_r$, was determined using the DiaInspect.OSM device [8]. The list and geometric interpretation of these characteristics, their conceptual meaning, are given in the descriptive and methodological materials of the manufacturing company for the DiaInspect.OSM device, in the original publications of its developers [8] and in the publications of the authors of this article [4, 9]. The specified characteristics describe the size ($F_{min}$, $F_{max}$, $d_m$) and shape ($C_r$,, $F_{el}$, of the grains. The indicator of the external specific surface ($F_{ess}$, $m^2/kg$) and the number of cutting edges ($n$, pcs.) and their sharpening angle ($\varphi$, degrees) were determined by known indirect analytical methods [9] using DiaInspect data of morphometric characteristics diagnosis. The results of the study were compared with the data of the PSD study obtained by traditional technology.

**Results and their discussion.**

From the products of HVED processing, powders of the grade AC20 with a grain size of 100/80 were produced, the amount of which was 52.9 wt. % of the original powder. In addition, powders with grain sizes of 80/63 – 28/14 were produced. In the future, PSD grade AS20 with a grain size of 100/80 was studied. DiaInspect photos of AC20 100/80 powder samples before (*a*) and after HVED treatment, chemical cleaning and powder production (*b*) are shown in Fig. 1.

*a)* *b)*

*Fig. 1.* **Samples of AC20 100/80 powder before (*a*) and after HVED treatment, chemical cleaning and powder production (*b*)**

The results of diagnostics of the morphometric characteristics of the specified samples of AC20 100/80 powder are given in the table 1.

The results of diagnostics of the morphometric characteristics of AC20 100/80 powder before (Fig. 1, a) and after HVED treatment (Fig. 1, b) showed that, in comparison with traditional technology, the use of HVED processing in the manufacture of powders allows obtaining powders that are more uniform in morphometric characteristics, which have a greater number of cutting edges, greater angles of their sharpening. The powder obtained with the use of HVED processing contains fewer impurities, its strength under static compression is in the range of values that are consistent with the requirements of the standard [6].

According to the obtained results (Table 1), the use of HVED processing leads to obtaining powders with a smaller average grain size, a more rounded and isometric grain shape, stability and homogeneity at the level of powder grains, which is made according to traditional technology. This powder has a greater number of cutting edges and a greater angle of their sharpening. Physico-mechanical characteristics of AC20 powder with a grain size of 100/80, produced according to traditional technology and with the use of HVED processing are given in the table. 2

According to the analysis of the characteristics presented in Table 2, it can be seen that the powder obtained with the use of HVED processing contains fewer impurities, which is confirmed by a decrease in the specific magnetic susceptibility and an increase in the specific electrical resistance. Its strength under static compression is lower than the strength of the powder obtained by traditional technology, but does not exceed the strength interval for AC20 powder according to DSTU 3292-95 [6].

The results of the study (stage 2) of PSD characteristics obtained during the flotation separation of AC20 powder with a grain size of 100/80 into foam and chamber products are most fully described in our previous works [5,10]. It was established that the interval of distribution of diamond particles in size is 30-160 µm; in the range of 80-125 microns there is the largest number of particles (99.32%) of the original powder, (99.01%) of the foam product, (98.96%) of the chamber product.

*Table 1*

**Average values, stability, and uniforomity of morphometric characteristics of AC20 grade powder with 100/80 grain size, produced according to traditional technology and using HVED processing**

| Characteristic | Manufacturing method | | | |
|---|---|---|---|---|
| | Application of HVED processing | | Traditional technology | |
| | average | unifomity/stability | average | unifomity/stability |
| $F_{max}$, µm | 131.51 | 0.6064/0.2077 | 134.74 | 0.6824/0.3416 |
| $F_{min}$, µm | 102.55 | 0.6177/0.2130 | 102.74 | 0.6624/0.3340 |
| $C_r$ | 1.2542 | 0.7817/0.5461 | 1.2923 | 0.7474/0.6238 |
| $F_{el}$ | 1.2926 | 0.6117/0.4424 | 1.3185 | 0.5821/0.5068 |
| $d_m$, µm | 117.03 | 0.6148/0.2257 | 118.74 | 0.6989/0.3530 |
| $n$, pcs | 12 | — | 11 | — |
| φ, degrees | 112,67 | — | 108,00 | — |

*Table 2.*

**Characteristics of the initial powder of the AC20 grade with a grain size of 100/80 and those made from it using the HVED processing of the AC20 powder with a grain size of 100/80**

| Characteristics | AC20 grade powder with a grain size of 100/80 | |
|---|---|---|
| | Traditional technology | Application of HVED processing |
| Mass fraction of impurities, by mass % | 0,98 | 0,80 |
| Specific magnetic susceptibility,·$10^{-8}$, $m^3$/kg | 0,63 | 0,29 |
| Specific electrical resistance, Ohm•m | 1,5·109 | 1,0·1010 |
| Strength under static compression, N | 17,9 | 13,5 |
| Form factor | 1,18 | 1,09 |

The number of PSD particles (their mass) in the foam product is much smaller than in the chamber product and differs by 6.5 times.

The physico-mechanical and morphometric characteristics of the foam product compared to the chamber product are characterized by a 3.1% reduction in the external specific surface area, a low content of impurities and inclusions by 79.8%, increased static compression strength by 23.8%, and uniformity in strength 25.0%. The morphometric characteristics of the chamber product of flotation separation are close in value to the characteristics of the original powder. The curves of particle distribution according to the strength index during static compression of the original powder and flotation separation products are close in appearance, but the mathematical linear approximation of the curves shows that the tangent of the slope angle of the curves is different. The tangent of the angle of inclination of the distribution of the foam product is 1.86, the chamber product is 1.60, and the initial powder is 1.68. Therefore, the distribution of the powder of the foam product according to the strength of the grains during static compression is the most homogeneous.

**Conclusions**

Using the example of AC20 synthetic diamond powder with a grain size of 100/80, it was experimentally shown that the use of high-voltage electric discharge treatment in the manufacture of powders allows obtaining powders that are more homogeneous in terms of morphometric characteristics, which have a greater number of cutting edges and a greater angle of their sharpening, which provides a higher abrasive ability. The use of flotation separation of diamond powder makes it possible to obtain diamond powder characterized by an increased strength index under static compression by 23.8%, increased homogeneity in strength by 25.0%, and a significantly reduced number of inclusions. The results of the conducted research give reasons to assert that the use of high-voltage electric discharge treatment and flotation separation are effective technical means of influencing the morphometric and physical-mechanical characteristics, which affects the technological properties of synthetic diamond powders. The use of these two methods opens up the possibility of selective influence on the quality of the obtained powders.

**References**

1. Novikov, N.V., Nevstruev, G.F., Il'nitskaya, G.D., et al. (2006). Quality assessment of superabrasive powders, Part Part 2. Practical application of the new method for assessment of quality characteristics. Superhard Materials, No. 6, pp. 58-67 [in Russian].
2. Syzonenko O.N. (2013). The effect of pulsed processing of synthetic diamond micropowders with high-voltage electric discharges on their quality improvement/ O.N. Syzonenko, G.D. Ilnytskaya, N.A. Oleynyk, G.A. Bazaly, E.I. Taftay, E.V. Lypyan, A.S. Torpakov // Impulse processes in the mechanics of solid media: materials of the X International Scientific Conference. - Mykolaiv: KP "Mykolaiv Regional Printing House", August 19-22. 138-141 [in Russian].
3. Bohatyreva, G. P. (1972). Sorting of diamonds by strength by flotation. Synthetic diamonds, 3, 23–25 [in Russian].
4. Bohatyreva G. P., Petasyuk G. A., Bazaliy G. A., & Shamraeva, V. S. (2009). On Morphometric Uniformity of Diamond Micron Powders. *Journal of* Superhard Materials, *31*(2), 126–134.
5. Oliynyk N.O., Ilnytska G.D., Bazaliy G.A. (2023). Changes in the physical and mechanical characteristics of AC20 diamond grinding powder with a grain size of 100/80 under the influence of flotation separation // Modern issues of production and repair in industry and transport: Materials of the 23rd International Scientific and Technical Seminar, March 15–16, 2023 – Kyiv: ATM of Ukraine.. – C. 81–83 [in Ukrainian].
6. Synthetic Diamond Powders. General Technical Specifications. (DSTU 3292–1995). (1996). UkrNDNTs [in Ukrainian].
7. Loshak M., Aleksandrova L., Kosenchuk T. (2013). Density of diamond crystals for static loading. Metrology and devices. N2 (40). 11–15 [in Russian].
8. DiaInspect.OSM. Automated particle analysis for superabrasives and surface analysis 2010. Operation guide Version 1.2.8. Received https://vdiamant.de/ languages/diainspect-osm.html.
9. Petasyuk G.A., Bogatyreva G.P. (200). Extrapolation_Analytical Method for Determination of Outer Specific Surface of Powders of Superhard Materials. Journal of superhard materials. 30 (6) 375–383.
10. Oliynyk N.O., Ilnytska G.D., Petasiuk G.A., Bazalii G.A. (2023.). Peculiarities of physical and mechanical characteristics of AC20 diamond powder with a grain size of 100/80 and products of its flotation separation // Materials and technologies in engineering (MTI-2023): engineering, materials, technologies, transport: collection of scientific reports of the international conference, Lutsk, Ukraine, 16 - May 18, 2023 - Lutsk: Vezha-Druk, 191–194 [in Ukrainian].

**Reviewer:** Volodymyr MECHNIK**,** Doctor of Science, Leading Researcher, V.N. Bakulsky Institute of Superhard Materials of the National Academy of Sciences of Ukraine