УДК 539.893.621.317.451 DOI 10.36910/775.24153966.2023.75.6

N.O. Oliinyk, G.D. Ilnitska, G.A. Petasyuk, G.A. Bazaliy

FEATURES OF THE PHYSICAL AND MECHANICAL CHARACTERISTICS OF DIAMOND POWDER, AC20 GRADE, GRAIN 100/80, AND THE PRODUCTS OF ITS FLOTATION SEPARATION

V. Bakul Institute for Superhard Materials National Academy of Sciences of Ukraine

The physico-mechanical characteristics of AC20 diamond powder with a grain size of 100/80 and the products of its flotation separation were studied. Separation was carried out in one stage. The work uses well-known methods of researching synthetic diamond powders. Static strength was investigated using the DA-2 device, morphometric characteristics were investigated using the DiaInspect. OSM device. It was established that the use of flotation separation of AC20 diamond powder with a grain size of 100/80 allows to obtain diamond powder with an increased strength index under static compression by 23.8%, increased uniformity in strength by 25.0%, a significantly reduced proportion of impurities and inclusions, and morphometric characteristics close to the original powder.
Key words: *synthetic diamond grinding powder, flotation, strength, morphometric characteristics*

Н.О.Олійник, Г.Д. Ільницька,Г.А. Петасюк, Г.А.Базалій

ОСОБЛИВОСТІ ФІЗИКО-МЕХАНІЧНИХ ХАРАКТЕРИСТИК ПОРОШКУ АЛМАЗУ МАРКИ АС20 ЗЕРНИСТОСТІ 100/80 ТА ПРОДУКТІВ ЙОГО ФЛОТАЦІЙНОГО РОЗДІЛЕННЯ

Досліджено фізико-механічні характеристики порошку алмазу марки АС20 зернистості 100/80 та продуктів його флотаційного розділення. Розділення проведено в одну стадію. В роботі використано відомі методики дослідження порошків синтетичного алмазу. Статичну міцність досліджено з використанням приладу ДА-2, морфометричні характеристики досліджено з використанням приладу DiaInspect. OSM. Встановлено, що застосування флотаційного розділення алмазного порошку марки АС20 зернистості 100/80 дозволяє отримати порошок алмазу з підвищеним показником міцності при статичному стисканні на 23,8 %, підвищеною однорідністю за міцністю на 25,0 %, суттєво зниженою часткою домішок та включень, морфометричними характеристиками близькими до вихідного порошку.
Ключові слова: *порошок синтетичного алмазу, флотація, міцність, морфометричні характеристики*

Introduction

Modern engineering technologies require the use of high-quality and uniformity synthetic diamond powders.

It is known that the quality of diamond powders is mainly determined by the conditions of synthesis, the chemical and physical treatments used in the extraction of diamond raw materials and the production of powders have a significant impact on them [1].

Improving the quality of the powder is achieved by various methods of its sorting. For example, flotation separation (flotation) is used.

Doctor of Technical Sciences Bogatyreva H.P. conducted and published the most famous studies devoted to the application of the method of flotation separation of synthetic diamond powders. It has been shown that using the flotation distribution of diamond particles it is possible to sort synthetic diamond powder by strength [2].

It is known that the process of flotation separation is based on differences in the energy state of the surface of powder particles. The process is carried out with the use of a small amount of flotation reagents (Morah's salt solution as an agitator and fatty acid emulsion as a collector). Diamond particles with a smoother (less energetic) surface adsorb apolar fatty acid dimers due to Van der Waals forces.

Particles with a developed defective surface (more energetic) - adsorb polar dimers due to "hydrogen bonding".

As a result, smoother particles fall into the foam product, and rough particles into the chamber.

The presence of iron ions of Mohr's salt in the pulp increases the selectivity of fatty acid action due to greater adsorption of iron ions on the rough surface of diamond particles, which contributes to the adsorption of polar dimers and fatty acid ions [2, 3].

The method of flotation separation is used for powders with an average particle size of 0.1–0.04 mm and less than 100 μm [4].

A significant interest of the work lies in the study of the characteristics and properties of synthetic diamond powders, which are used in abrasive tools and can be adjusted by the flotation method [2, 5, 6].

The purpose of the work is to study the physical and mechanical characteristics of the products of flotation separation of diamond powder, which is intended for use in abrasive tools.

Research methodology

The diamond powder synthesized in the Ni-Mn-C system was studied. Powder grade - AC20, grain size 100/80

The products (foam and chamber) obtained as a result of flotation separation of the original powder were studied.

The process is carried out in one stage. Separation products are chemically purified from flotation reagents. In the paper, the strength indicators were determined during static compression according to the DSTU 3292-9 method using the DA-2 device [7].

Well-known methods, which were developed at the V.M. Bakul Institute of Information Technology, determined the size distribution of powder particles, the specific magnetic susceptibility of the powder (χ, ·10-8, m3/kg) and the mass fraction of impurities in the form of non-combustible residue (%, by mass).

Morphometric characteristics were determined using the DiaInspect.OSM device [8].

The minimum (Fmin, μm) and maximum (Fmax, μm) Feret diameters, grain height (H), grain projection roughness (Rg), external specific surface index (Fpt., m2/kg) were determined.

The conceptual meaning of these characteristics is presented in the methodological materials of the manufacturer of the DiaInspect.OSM device [8] and in the publications of the authors of this article, for example, in [3, 9].

Results of the work and their discussion.

The results of the study of the distribution of particles of the original powder and flotation products by size are presented in Fig. 1.

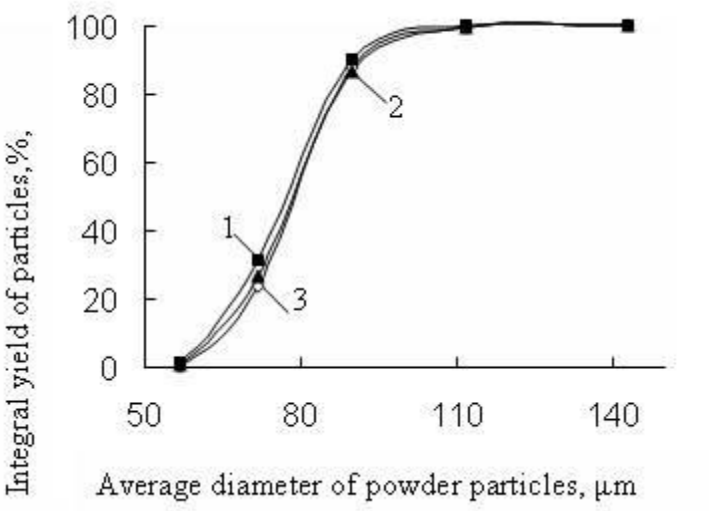

Fig. 1. **Integral distribution of particles of the initial powder and flotation products (1 - chamber product, 2 - foam product, 3 - initial powder) by size.**

It follows from the results (Fig. 1) that the size distribution of the particles of the original powder and flotation products is almost completely different.

The interval of distribution of diamond particles by size is 30-160 microns. The largest number of particles of the original powder (99.32%), foam product (99.01%), chamber product (98.96%) is in the range of 80-125 microns.

Physico-mechanical and morphometric characteristics of the original powder and the products of its flotation separation are given in table. 1.

The results show that the number of particles in the foam product is much smaller than in the chamber product. The mass of foam and chamber products differs by 6.5 times.

Compared to the chamber product, the foam product is characterized by a reduced specific surface area, a low content of impurities and inclusions, increased strength under static compression and uniformity in strength.

The morphometric characteristics of the products of flotation distribution are close in value to the characteristics of the original powder.

Distribution by grain strength during static compression of particles of the original powder and flotation products is presented in Fig. 2.

It follows from the results that the distribution of particles of the original powder and products of flotation distribution are close.

Table 1.

Characteristics of the initial powder of the AC20 grade **with a grain size of 100/80 and the products of its flotation separation**

Indexes	AC20 diamond powder, grain size 100/80	Powder separation products	
		Foam product	Chamber product
Mass fraction of the powder sample, %	100	13,41	86,55
Specific magnetic susceptibility, (average value), χ, ·10-8 m3/kg	0,810	0,002	0, 780
Mass fraction of impurities - non-combustible residue, % by mass	1,48	0,20	0,99
Strength index under static compression, N	13,0 [6]	16,5	12,5
Uniformity in strength, %	16,0	20,0	14,0
Fmax, μm (average value / uniformity of the indicator)	133,71 / 0,692	137,74 / 0,7197	138,59 / 0,7211
F_{min}, μm (average value / uniformity of the indicator)	102,83/0,7017	104,63 / 0,7258	105,09 / 0,7154
Rg, (average value / of the indicator)	1,0569 / 0,7588	1,0615 / 0,7450	1,0609 / 0,7317
$F_{pt.}$, m2/ kg (average value)	20,70	21,90	21,23

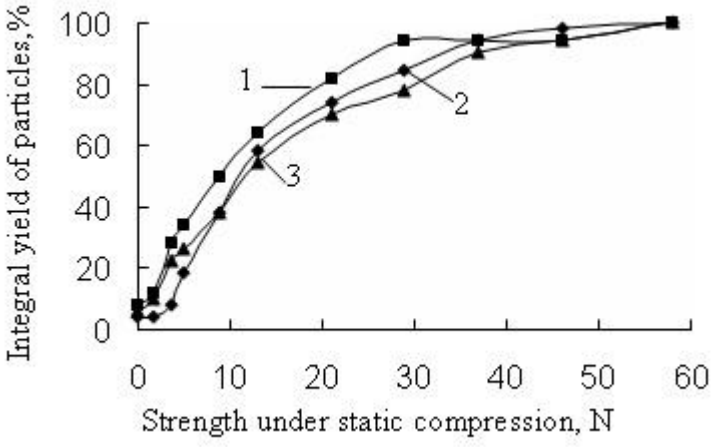

Fig. 2. **Integral distribution of particles of the original powder and flotation products (1 - chamber product, 2 - foam product, 3 - original powder) according to the strength of grains during static compression**

The mathematical linear approximation of the distribution curves shows that the tangent of the slope angle of the curves differs. 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 particles of the foam product according to the strength of the grains during static compression is the most uniform.

Conclusions

The application of flotation separation of AC20 diamond powder with a grain size of 100/80 allows to obtain a diamond powder characterized by an increased strength index under static compression by

23.8%, an increased homogeneity in strength by 25.0%, a significantly reduced number of inclusions compared to the initial values powder.

Compared to the chamber product, the foam product is characterized by a reduced specific surface area, a low content of impurities and inclusions, increased strength under static compression and uniformity in strength.

The morphometric characteristics of the products of flotation distribution are close in value to the characteristics of the original powder. The distribution of particles of the powder of the foam product according to the strength of the grains during static compression is the most uniform.

References

1. Bogatyreva, G.P., Oleinik, N.A., Nevstruev, G.F., Ilnitskaya, G.D., Basaliy, G.A. (2004) Vliyaniye sposobov dezintegratsii almazno-grafitovogo materiala na pokazateli kachestva almaznogo syr'ya i poroshkov [The influence of methods of disintegration of diamond-graphite material on the quality indicators of diamond raw materials and powders]. *Porodorazrushayushchiy i metalloobrabatyvayushchiy instrument – tekhnika i tekhnologiya yego izgotovleniya i primeneniya – Rock cutting and metalworking tools - equipment and technology of its manufacture and application* (5nd Issue, p. 169–173). ISM im. V.N. Bakulia NAN Ukrainy.

2. Bogatyreva, G.P. (1972). Sortirovka almazov po prochnosti flotatsiyey [Sorting of diamonds by strength by flotation]. *J. Sinteticheskiye almazy – Synthetic diamonds*, (3), p. 23–25.

3. Bogatyreva, G.P., Petasyuk, G.A., Bazalii, G.A., Shamraeva, V.S. (2009). On Morphometric Uniformity of Diamond Micron Powders**.** *J. Superhard Materials,* 31(2), p. 126–134.

4. Bogdanov, O.S., & Olevskiy. V.A. (Eds.). (1982). *Podgotovitel'nyye protsessy: Spravochnik po obogashcheniyu rud [Preparatory processes: Handbook of ore dressing*]. Nedra.

5. Oliynyk, N.O., Ilnytska, G.D., Bazaliy, G.A. (2023). Zmina fizyko-mekhanichnykh kharakterystyk shlifporoshku almazu marky AS20 zernystosti 100/80 pid vplyvom flotatsiynoho rozdilennya [Change in the physical and mechanical characteristics of diamond grinding powder of the AS20 grade of 100/80 under the influence of flotation separation]. *Suchasni pytannya vyrobnytstva ta remontu v promyslovosti i na transporti – Modern issues of production and repair in industry and transport* (p. 81–83). ATM of Ukraine.

6. *Poroshky almazni syntetychni. Zahalni tekhnichni umovy [Synthetic diamond powders. General technical conditions]*. (DSTU 3292-95).(1997). Kyiv: Derzhstandart of Ukraine.

7. Loshak, M., Aleksandrova, L., Kosenchuk, T. (2013). Mitsnist krystaliv almazu za statychnoho navantazhennya [Strength of diamond crystals under static load]. *Metrolohiya ta prylady – Metrology and instruments,* 2 (40). P. 11–15.

8. DiaInspect.OSM. Automated particle analysis for superabrasives and surface analysis 2010. Operation guide Version 1.2.8. https://vdiamant.de/ languages/diainspect-osm.html.

9. Petasyuk G.A., Bogatyreva G.P. (2000). Extrapolation-Analytical Method for Determination of Outer Specific Surface of Powders of Superhard Materials. Journal of superhard materials. 30 (6) 375–383.

Reviewer: Pavlo BARVITSKY, candidate of technical sciences, researcher at researcher at the V. Bakul Institute for Superhard Materials National Academy of Sciences of Ukraine.