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Methodological Features of Determining the External Specific Surface Area of High-Strength Synthetic Diamond Grinding Powders

Grigorii A. Petasyuk*

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

Abstract: A new indirect-analytical method for determining the external specific surface area of high-strength synthetic diamond grinding powders has been created. The method is based on the well-known from publications fractional-averaging approach to the indirect analytical determining of technological properties of high-strength synthetic diamond grinding powders. The main idea of the proposed new method is to take into account the features of the real 3D morphology of grains of such grinding powders. The possibility and expediency of using in similar problems in one sense of calculation, both a methodological scheme with an extrapolation-affine 3D grain model and a methodological scheme with actual 3D grain shape, have been substantiated. The proposed methodological scheme allows for the real morphology of grains of such grinding powders to be considered, which provides greater reliability of the indices of their technological properties obtained. The practical application of the proposed new method for determining the external specific surface area of the standard Ukrainian State Standard DSTU 3292–95 high-strength synthetic diamond grinding powder AC400 500/400 is illustrated. The new method we proposed was used as the basis for comparison. The value of the external specific surface area of the specified grinding powder calculated by this method was 4.3213 m^2/kg. Applying the commonly used method for this purpose gave the result of 4.1324 m^2/kg. The comparative analysis showed that the commonly used known method gives 1.046 times (4.37%) lower values of the external specific surface area for the specified grinding powder than the proposed new method. This indicates the advantage of the proposed new method for determining the external specific surface area of high-strength synthetic diamond grinding powders.

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1. INTRODUCTION

The specific surface area of superhard material (SHM) powders is an important quality attribute. The specific surface area factor affects the operational capabilities of such powders as an abrasive material, the processing performance, the particular powder consumption, and the quality of the processed surface. Its knowledge is necessary for the effective and rational use of abrasive powders in the form of pastes, suspensions, and various tools. The reference to the specific surface area in this article is intended to facilitate the practical diagnosis of this characteristic about high-strength synthetic diamond grinding powders, which at the same time will contribute to a more active involvement of this characteristic in the applied sphere. It should be noted that the direct determining of the total specific surface area index by traditional methods, as noted in the review [1], involves the initiation of complex physical processes and the presence of difficult-to-use measuring equipment, which is very laborious to perform. This is probably one of the main reasons for the current passive use of this characteristic in practice.

By definition, the specific surface area (F_{ss}) of a spatial-geometric solid is the ratio of the mass (m) of such a body to its surface area (S), i.e., $F_{ss} = m/S$. Thus, determining the specific surface area of such a body is reduced to finding its mass and surface area. Depending on the detail of the surface area of a 3D body, internal, external, and full surfaces are distinguished, and with it, the corresponding type (species) of the specific surface area according to its classification in well-known classical work [2]. We note the

*Address correspondence to this author at the V. Bakul Institute for Superhard Materials, National Academy of Sciences of Ukraine, Ukraine;
Tel: (+38) 098 – 752-7029; E-mail: petasyuk@ukr.net

following in the context of the practical implementation of the m/S ratio. If determining the mass of a 3D body is reduced to its weighing and does not pose any problems, then finding the surface area, in particular its internal component, poses significant difficulties, especially when it comes to the spatial body of the micron size range, which are of synthetic diamond grinding powders, particularly high-strength ones. However, when it comes to the external specific surface when the internal specific surface is not considered, this greatly simplifies the procedure for finding the index of this component of the total specific surface. This applies to both 3D bodies separately and to the set of such bodies, which is the case in the case of high-strength synthetic diamond grinding powders. Perhaps this is the main reason this type of specific surface is most often used in diamond powders. Therefore, it is the external specific surface that is the subject of consideration in this work.

2. METHODOLOGICAL SCHEMES FOR INDIRECTLY DETERMINING THE EXTERNAL SPECIFIC SURFACE AREA OF SYNTHETIC DIAMOND GRINDING POWDERS

A rather extensive review of methods for determining the specific surface area of dispersed materials, which include synthetic diamond grinding powders and components of the specific surface area, is given in the above-cited review [1]. A similar review of methods for determining the external specific surface area of synthetic diamond grinding powders was performed in [3]. The specified review also included information on modern means of establishing (diagnosing) the values of morphometric characteristics of such powders based on digital image processing. It is noted [3] that all known methods for determining the specific surface area are inherently indirect. Given this, a classification of indirect methods for determining the external specific surface area by methods for determining the surface area of grains into physical, chemical, and analytical ones has been made. A new extrapolation-analytical method for indirectly determining the external specific surface area of SHM abrasive powders, primarily synthetic diamond grinding powders, is proposed. The method is based on the extrapolation-affine 3D grain model of the specified grinding powders [4]. Today, this method is the most advanced among indirect-analytical methods for determining the external specific surface area. This advantage is provided by using the extrapolation-affine 3D grain model, which provides the most accurate determination of the volume and surface area of a real grain compared with other possible 3D models (analogs) [5]. However, despite such a significant positive advantage of the proposed extrapolation-analytical method, it allows for the possibility of further development (improvement).

Such an improvement consists in using the potential opportunity when applying this method to use not only the extrapolation-affine 3D model of the grain but also its actual 3D shape in one calculation session. An example of such a combined use of both the extrapolation-affine 3D model of the grain and its actual 3D shape when determining the degree of coating of high-strength synthetic diamond grinding powders can be found in [6]. A similar need arises in the case of the potential application of the extrapolation-affine method to high-strength synthetic diamond grinding powders. The fact is that the grains of this class of synthetic diamond grinding powders are mainly 3D solids in the form of octahedra, cuboctahedrons, and truncated octahedra, which is confirmed by our many years of experience in diagnosing the morphometric characteristics of such powders on the DiaInspect.OSM device [7]. This fact can also be confirmed by electronic photographs of grains of such grinding powders, which are illustrated in well-known publications [8-17]. Therefore, considering this feature simultaneously with using an extrapolation-affine 3D grain model would increase the reliability of the information on the external specific surface of such grinding powders.

Considering the above-mentioned feature of high-strength synthetic diamond grinding powders, in [18], it was proposed to use a new methodological scheme to determine certain indices of the technological properties of such grinding powders, in particular their external specific surface area. The main advantage of this fractional-averaging methodological scheme is the possibility of combined use in one calculation session of both the extrapolation-affine 3D model of the grain and its actual spatial forms (octahedron, cuboctahedron, and truncated octahedron). The main positive advantage of such spatial bodies is that they allow for an accurate analytical representation of the volume and surface area of the grains. In this case, grains whose 3D shape coincides with an octahedron, cuboctahedron, or truncated octahedron are separated into three separate fractions, respectively. The remainder of the grains constitute a separate fourth fraction. For high-strength synthetic diamond grinding powders, this fraction is usually less numerous in terms of the number of grains compared to the total content of the first three fractions. The volume and surface area of the grains of this fourth fraction are determined by the extrapolation-affine 3D grain model. The proposal to use the combined algorithmic scheme described above and the methodological approach based on it, as noted in [18], is completely new for diagnostics of the technological properties of synthetic diamond grinding powders. The key to the successful application of this innovation for high-strength synthetic diamond grinding powders is the availability of methodological tools for automated identification and quantitative assessment of the shape similarity of the projection of grains of synthetic diamond grinding powders [19]. The information obtained on the shape similarity of the projection of grains is an important component of the automated identification of the 3D shape of grains of high-strength synthetic diamond grinding powders. Considering these circumstances will increase the reliability of information regarding the external specific surface area of high-strength synthetic diamond grinding powders.

Practical application of the well-known extrapolation-analytical method of indirect-analytical determining the external specific surface area of synthetic diamond powders [4] involves replacing each sample grain with its extrapolation-affine 3D model. This feature is characteristic of both the extrapolation-affine method and other known indirect-analytical methods reviewed in [3]. Moreover, such replacement is carried out for each grain without exception. That is, it is mandatory. This applies to both grains of a far irregular (fragmentary) shape and grains of a clearly expressed regular shape (for example, ideal regular and semi-regular polyhedra). Such a lack of alternatives to the use of other, different from the extrapolation-affine, 3D grain models is a disadvantage of the extrapolation-analytical method. As already noted, this disadvantage is manifested in the diagnosis of the index of the external specific surface area of high-strength grinding powders of synthetic diamond.

The improved extrapolation-analytical method for indirectly determining the external specific surface area of high-strength grinding powders of synthetic diamond is based on the possibility of combined use within the framework of one calculation scheme of both the extrapolation-affine 3D model of the grain and its actual spatial shape. In the case of high-strength synthetic diamond grinding powders, it coincides with spatial bodies of regular shape in the form of an octahedron, a cuboctahedron, or a truncated octahedron. The practical implementation of this method involves measuring the maximum and minimum Feret diameters, grain height, perimeter, and projection area of grains of their control quantity (sample), Feret projection elongation (F_{el}), and the relative fraction of the transparent portion of the grain projection in its total area (A_{lg}). Feret projection elongation of the grain is introduced as the ratio of the maximum and minimum Feret diameters [7]. By definition, the relative fraction of the light (transparent) part of the grain projection (A_{lg}) in its total area (A_{tot}) is entered as the ratio $A_{lg}=(A_{tot} - A_{Dark})/A_{tot}$, where A_{Dark} is the area of the dark part of the grain projection [7]. This characteristic, as well as the maximum and minimum Feret diameters of the grain projection, is diagnosed by the DiaInspect.OSM device. This device, which is based on digital image processing, is equipped with an optical microscope and a digital video camera, and the grain image is formed by a penetrating (direct) light flux. Crystals of high-strength synthetic diamond grinding powders are optically transparent bodies. When a crystallographic face is not perpendicular to the direction of light flux propagation, which occurs on the path of the light flux, part of the light is reflected. As a result, a less bright part of the projection image of grains formed at the corresponding location in the grain projection image compared to the image from the faces oriented perpendicular to the direction of the light flux. If there are two plane-parallel faces on the crystal surface, on one of which the grain analyzed under the microscope is located on the stage, and the light flux is directed perpendicular to these faces, then it almost completely passes through the corresponding part of the grain as a 3D body. As a result, the brightest (compared to other areas) part of its projection is reproduced in the image. At the same time, the larger the area of such a face, the greater the share of the corresponding bright part of the grain projection in its total area. The software of the DiaInspect.OSM device analyzes these component projections and displays them in numerical form. More complete information on the geometric and conceptual meaning of these morphometric characteristics can be found on the company's website, VOLLSTÄDT DIAMANT GmbH [7], and in the publications of its developers, for example, in [20]. Then, the geometric shape of the grain projection is identified, based on the results of which, taking into account the relative share of the transparent portion of the grain projection in its total area and the Feret elongation of the grain projection, the initial control sample of grains is divided into four fractions according to their 3D shape.

The first fraction is separated by grains that have a 3D octahedral shape (Figure **1**, ***c***). The octahedron has 8 faces in the form of equal-sized regular triangles. Therefore, the orthogonal [21] projection of such grains will always be a regular hexagon (Figure **1*d***). The index of the relative share of the transparent part of the projection in its total area (Area light, A_{lg}, in Figure **1*d***) the ratio of the areas of the hexagon

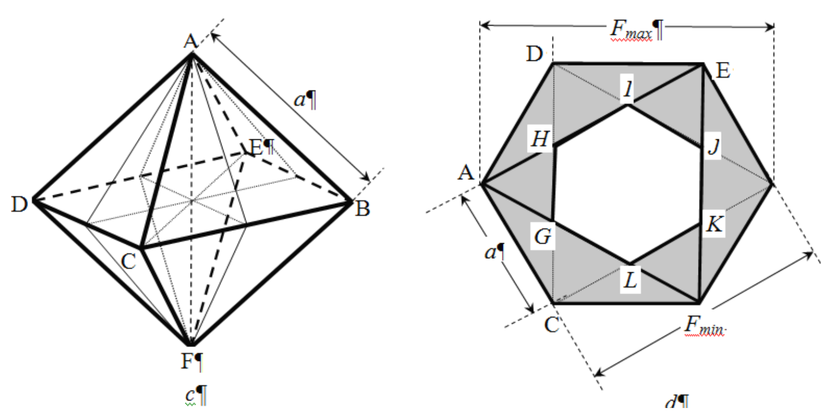

Figure 1: Octahedron as a 3D model of a grain of high-strength grinding powder synthetic diamond (c) and its orthogonal projection as a regular hexagon (d).

GHIJKL and the hexagon ADEFBC) and the Feret elongation, which is introduced as the ratio of the minimum (F_{min}) and maximum (F_{max}) Feret diameters (Figure **1**, ***d***) lie in the intervals 0.320 ≤ A_{lg} ≤0.354 and 1.135 ≤ F_{el} ≤1.435, respectively. The limits of the specified intervals of change of the values of these dimensionless parameters were selected based on the analysis of the range of change of their values from the experience of our many years (since 2003) of diagnosing the morphometric characteristics of high-strength grinding powders of synthetic diamond using the DiaInspect.OSM device [7] in a wide interval of change of their grades and grain sizes and on the generalization of the results of such diagnostics. The need for such restrictions is due to the need (expediency) to take into account the possible deviation of the actual 3D shape of real grains from their ideal 3D shape caused by defects in grain (crystal) growth in the process of diamond synthesis. Note that this explanation fully applies to grains of the second and third fractions of the separated high-strength grinding powder of synthetic diamond.

The second fraction includes grains that have a 3D shape of a cuboctahedron (Figure **2**). The cuboctahedron has 14 faces: 6 faces in the form of equal-sized squares and 8 in the form of equal-sized regular triangles. In the case when the contact with the plane onto which the projection occurs along a face in the form of a square (Figure **2*e***), then the orthogonal projection of the cuboctahedron will be a square (Figure **2*f***) with the index of the relative share of the transparent part of the grain projection in its total area and the Feret-elongation in the intervals 0.4≤ A_{lg} ≤0.6 and 1.125≤ F_{el} ≤1.515, respectively. If the cuboctahedron contacts the plane onto which the projection is made along a face in the form of a regular triangle (Figure **2*g***), then its orthogonal projection will be a regular hexagon (Figure **2*h***) with the index of the relative fraction of the transparent part of the grain projection in its total area and the Feret-elongation in the intervals 0.157≤ A_{lg} ≤0.187 and 1.125≤ F_{el} ≤1.515, respectively.

The third fraction includes grains that have a 3D shape of a truncated octahedron (Figure **3**).

The truncated octahedron, like the cuboctahedron, the truncated octahedron has 14 faces: 6 faces in equal-sized squares and 8 – in the form of equal-sized regular hexagons. If a truncated octahedron contacts the plane onto which the orthogonal projection occurs along a face in the form of a square (Figure **3*e***), then its orthogonal projection will be a semi-regular octagon (Figure **3*f***) with the index of the relative fraction of the transparent portion of the grain projection in its total area and the Feret-elongation in the intervals 0.123≤ A_{lg} ≤0.166 and 1.1180≤ F_{el} ≤1.1600, respectively. If runcated octahedron contacts the plane onto which the orthogonal projection occurs along a face as a regular hexagon (Figure **3*g***) [8]. In that case, its orthogonal projection will be a semi-regular dodecagon (Figure **3*h***) with the index of the relative fraction of the transparent portion of the grain projection in its total area and the Feret-elongation in the intervals 0.123≤ A_{lg} ≤0.166 and 1.1180≤ F_{el} ≤1.1180, respectively.

Finally, the fourth fraction is formed by the remaining grains, which have a shape different from the three 3D shapes mentioned above. For grains of the fourth fraction, the information on the intervals of the values of the relative fraction of the transparent grain projection in its total area and the Feret elongation is not necessary since the 3D shape of the grains of this fraction is not identified.

The peculiarity of such separation is that it is carried out at the level of dividing the results of diagnosing the morphometric characteristics of the control sample of the grinding powder into four groups (fractions). At the same time, in the process of such separation, four separate files of the results of the initial diagnosis of the entire grinding powder are formed; that is, a kind of virtual separation is carried out. Subsequently, the quantitative analysis of the external specific surface area of high-strength grinding powders of synthetic diamond is performed separately for each of the four selected grain fractions. In this case, the numerical files mentioned above formed from the results of the initial diagnosing of the entire grinding powder are used as the initial data. Then, further generalization of the indices of the external specific surface area obtained for each of the four-grain fractions of the control sample of the grinding powder is performed.

The 3D shape of the grains of the first fraction is identified with an octahedron, and the index of the external specific surface area (F_1) of the powder of this fraction is determined by the following relationship,

$$F_1 = \frac{3\sqrt{6}}{a\rho}, \tag{1}$$

where a is the length of the edge of the octahedron, ρ is the density of the grinding powder material. The length of an octahedron edge can be expressed through the morphometric characteristics of the octahedron projection as a 3D grain shape, in particular through the minimum Feret diameter (F_{min}), by the dependence: $a = F_{min}$. This dependence was obtained on the basis of the analytical-geometric analysis of the octahedron and its orthogonal projection (Figure **1*c*** and **1*d***, respectively).

The 3D shape of the grains of the second fraction is identified with a cuboctahedron, and the index of the external specific surface area (F_2) of the powder of this fraction is determined by the following relationship

$$F_2 = \frac{6(3+\sqrt{3})}{5\sqrt{2}b\rho}, \tag{2}$$

where b is the length of the edge of the cuboctahedron. The length of the edge of the cuboctahedron can be expressed

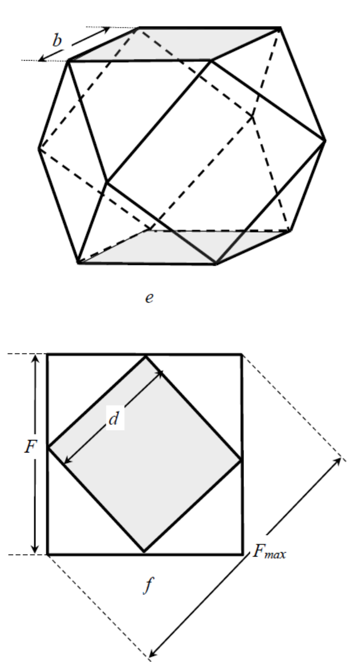

Figure 2: Cuboctahedron as a 3D model of a high-strength grinding powder of synthetic diamond grain and its orthogonal projections: e – when the cuboctahedron is located on a face in the shape of a square, the projection shape is a square (f); g – when the cuboctahedron is located on a face in the shape of a regular triangle, the projection shape is a regular hexagon (h).

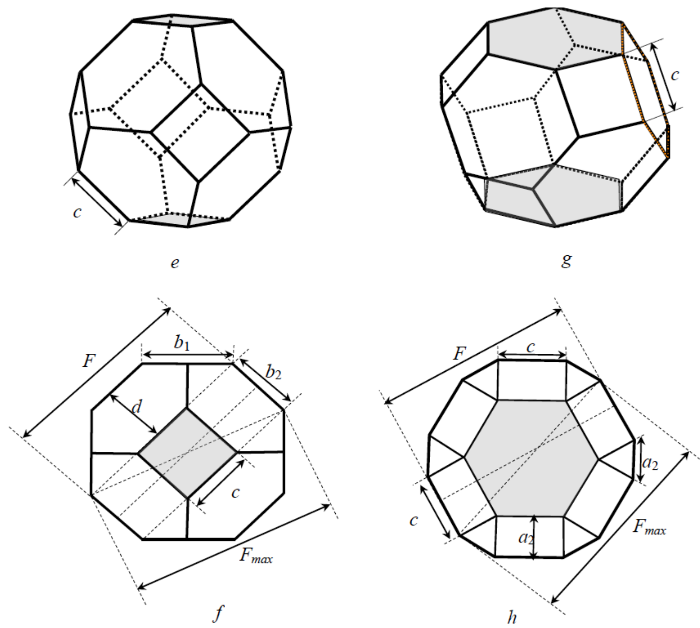

Figure 3: Truncated octahedron as a 3D model of a grain of high-strength grinding powder synthetic diamond and its orthogonal projections: *e* – when the truncated octahedron is arranged on a square face, the projection is in the form of a semi-regular octagon (*f*); *g* – when the truncated octahedron is arranged on a regular triangle face, the projection is in the form of a semi-regular dodecagon (*h*).

through the morphometric characteristics of the projection of the cuboctahedron as a 3D grain shape, in particular through the minimum Feret diameter (F_{min}), by the dependence: $b = F_{\min} / \sqrt{2}$. This dependence was obtained based on the analytical-geometric analysis of the cuboctahedron and its orthogonal projection (Figure **2*e***, **2*f***, respectively).

The 3D shape of the grains of the third fraction is identified with a truncated octahedron, and the index of the external specific surface area (F_3) of the powder of this fraction is determined by the following relationship

$$F_3 = \frac{3(1+2\sqrt{3})}{4\sqrt{2}c\rho} \tag{3}$$

where ***c*** is the length of the edge of the truncated octahedron. The edge length of a truncated octahedron can be expressed through the morphometric characteristics of the projection of the truncated octahedron as a 3D grain shape, particularly through the minimum Feret diameter (F_{min}), by the dependence: $c = \sqrt{3}\,F_{\min} / 5$. This dependence was obtained on the basis of the analytical-geometric analysis of the truncated octahedron and its orthogonal projection (Figure **3*e*** and **3*h***, respectively).

For grains of the fourth fraction (N_4 – the number of grains of this fraction), an extrapolation-affine 3D grain model is adopted, and the external specific surface index (F_4) of this fraction of the grinding powder is found by the extrapolation-analytical method [3]. Taking this into account, the generalized external specific surface index (F_{oss}) of the high-strength grinding powder of synthetic diamond is generally determined by the following dependence

$$F_{\text{oss}} = F_1 w_1 + F_2 w_2 + F_3 w_3 + F_4 w_4 \tag{4}$$

where F_1, F_2, F_3, and F_4 are the external specific surface indices of the selected grinding powder fractions; w_1, w_2, w_3, and w_4 are the weight coefficients. They are taken as follows: $w_1 = N_1/N$, $w_2 = N_2/N$, $w_3 = N_3/N$, $w_4 = N_4/N$, where N_1, N_2, N_3, and N_4 are the number of grains found in each of the four received (selected) grinding powder fractions, respectively; N is the total number of grains in its control sample.

3. RESULTS AND THEIR DISCUSSION

A comparative determining of the external specific surface area of the standard according to regulatory documents [22, 23] of the high-strength synthetic diamond grinding powder AC400 500/400 by various methods was carried out. As such methods, the well-known extrapolation-analytical method [3] was used (mandatory replacement of the actual spatial shape of all sample grains with their extrapolation-affine 3D model regardless of whether its actual spatial shape is correct or incorrect), and the improved version of this well-known method proposed here. The powder sample was taken after thorough mixing in accordance with the requirements of the standard for the specified superhard dispersed material [22].

Implementing the proposed method for determining the external specific surface area of high-strength synthetic diamond grinding powders involved several steps. The first of them was used to diagnose its morphometric characteristics using the DiaInspect.OSM device [7] for a sample of grains in 245 pieces. The DiaInspect-photo of the grains of the diagnosing sample of grains of the control grinding powder is shown in Figure **4**. From the full list of morphometric characteristics diagnosed by the device mentioned above. The following are used for the methods compared here: maximum and minimum Feret diameters, grain height, Feret elongation, perimeter, and grain projection area, and total and relative share of the transparent part of the grain projection area in its total area. More complete information on the geometric and conceptual meaning of these morphometric characteristics can be found on the website of the VOLLSTÄDT DIAMANT GmbH company [7] and in the publications of its developers, for example, in [20]. Then, automated identification and quantitative assessment of the shape similarity of the projection of the grains of the initial grinding powder was carried out using the search-analog method [19]. The results obtained are presented in Table **1**, namely, the differential shape similarity indices ($f_k^{(д)}$,%), the

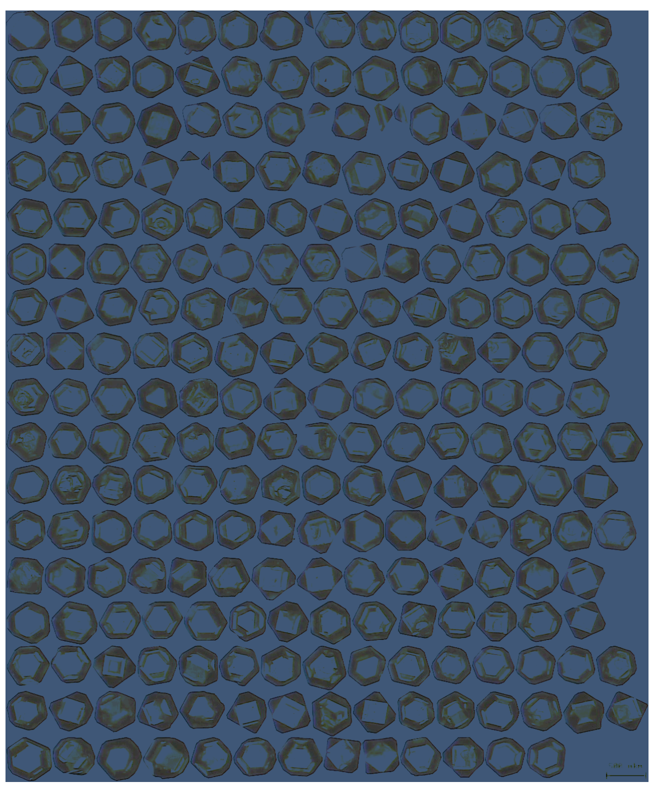

Figure 4: DiaInspect-photo of the grains of the diagnosing sample of grains of the control grinding powder AC400 500/400.

Table 1: Indices of differential shape similarity ($f_k^{(\text{д})}$,%), the absolute number of grains of a given 3D shape (N, pcs.) and the relative error of form replacements ($\Delta_k^{(\text{д})}$,%) of the projection of grains of high-strength synthetic diamond grinding powders AC400 500/400

Basic forms of projection	$f_k^{(\text{д})}$, %	*N*, pcs.	$\Delta_k^{(\text{д})}$, %
Oval-like figures	0.00	0	0.00
Rectangle	0.00	0	0.00
Rhomb	1.22	3	35.73
Isosceles trapezoid	1.22	3	10.80
Square	6.53	16	10.89
Regular pentagon	0.00	0	0.00
Regular hexagon	11.43	28	11.49
Regular octagon	0.00	0	0.00
Triangle	0.41	1	27.07
Parallelogram	0.00	0	0.00
Semiregular dodecagon	69.80	171	6.70
Semi-regular octagon	9.39	23	6.09

Table 2: Number of grains in each of the four selected fractions, weight coefficients and external specific surface area index

Fractions of grinding powder according to 3D grain shape	Number of grains	weight coefficients	External specific surface area determining by various methods		Relative error, %
			proposed method (base of comparison)	extrapolation-affine method [3]	
octahedron	7	0,0286	4,0820	4,1657	2,05
kubooctahedron	37	0,1510	3,9283	4,2272	7,61
truncated octahedron	194	0,7918	4,0100	3,7922	5,43
the rest of the grains	7	0,0286	—	15,2544	—
grinding powder AC400 500/400 in total			4,3213*	4,1324	4,37

*) Averaged external specific surface area (averaging is performed using the weighted average method)

Table 3: Number of grains in each of the four selected fractions, external specific surface area determining by different methods, and relative error of determining

Fractions of grinding powder according to 3D grain shape	Number of grains	method for determining the external specific surface area		Relative error, %
		extrapolation-affine method [3]	proposed method (base of comparison)	
octahedron	7	4,1657	4,0820	2,05
kubooctahedron	37	4,2272	3,9283	7,61
truncated octahedron	194	3,7922	4,0100	5,43
the rest of the grains	7	15,2544	—	—
All grains	245	4,1324	4,3213	4,37

absolute number of grains (N), and the relative shape similarity error ($\Delta_k^{(д)}$, %) of the projection of grains of grinding powder AC400 500/400.

The next step was the virtual division of the initial grinding powder into the four fractions mentioned above according to the criteria of the identified grain projection shape, according to the index of the relative share of the transparent part of the grain projection in its total area and the Feret elongation index. The number of grains in each of the four fractions selected according to such criteria is given in the corresponding column of Table **2**. Based on this information and considering the total number of grains in the control sample of grinding powder, the weight coefficients for all four fractions of the control sample of grinding powder were determined and are given in Table **2**.

Then, the external specific surface index of the control grinding powder was determined using a new (combined) method. For this, the external specific surface indices of the first three fractions were first calculated, the grains of which had a 3D shape of an octahedron, a cuboctahedron, and a truncated octahedron, respectively. The index of the external specific surface area of the grains of the last fourth fraction was determined by a known indirect analytical method [3]. The results obtained for all four fractions were averaged by the method of finding the weighted average. The resulting value is given in Table **2** and is the index of the external specific surface area obtained by the proposed new method. It turned out to be equal to 4.3213 m^2/kg. Then, the same indices of the external specific surface area of the initial grinding powder AC400 500/400 as a whole and its individual fractions were determined using a known indirect analytical method [3]. The results are given in Table **2**. In the case of the grinding powder as a whole, the index of the external specific surface area determined by this method was equal to 4.1324 m^2/kg. The obtained value of the external specific surface area is close to the value obtained by the new method and is taken as a basis for comparison. Therefore, there are grounds to conclude that the well-known generally used method [3] is also capable delivers (providing) quite reliable values of the external specific surface area of grinding powders synthetic diamond.

4. CONCLUSIONS

Comparative analysis of the external specific surface area indices for the entire grinding powder as a whole (Table **2**), obtained by different methods, shows that the known method gives an underestimated value of the external specific surface area index – by 1.045 times (4.37%). Suppose a similar comparative analysis is carried out for individual fractions of the control sample of grinding powder, namely for fractions with grains in the 3D shape of an octahedron, a cuboctahedron, and a truncated octahedron. In that case, the specified nature of the relationship takes place only for the last of the specified three fractions. But since this fraction is the most numerous in terms of the number of grains in it, it has the maximum weight coefficient. This, in turn, ensures the predominant influence of the external specific surface area index of this particular fraction on the similar characteristic of the grinding powder as a whole. This circumstance can confirm the expediency of using the weighted average as a generalization tool in the improved version of the extrapolation-analytical method proposed here.

The method proposed here for determining the external specific surface area of high-strength synthetic diamond grinding powders may be useful in determining the coating thickness of synthetic diamond grinding powders of this class, as well as grinding powders of other abrasive materials. The general methodological scheme for such (i.e., using the external specific surface area) determining the coating thickness is described in [24].

Unfortunately, the author did not have the opportunity to compare his results with the results known from the literature. We did not find such results from the literature for the high-strength grinding powder of synthetic diamonds of the AC400 500/400 brand considered in the manuscript. On the other hand, even if we found such results, for an objective comparison we would need to calculate using our method specifically for the grinding powder AC400 500/400, which appear in this well-known publication. For this, we need this powder to obtain the initial data necessary to apply our method.

In the future, the research outlined in the article should continue to develop even more advanced (compared to the extrapolation-affine) 3D grain models of synthetic diamond grinding powders. The main requirement for such 3D models should be the ability to determine the volume and surface area of real diamond grains by analytical or approximate numerical methods. At the same time, the necessary methods and algorithms should be developed for this. This will allow us to move away from the gradation into certain groups of synthetic diamond grinding powders when determining their external specific surface area.

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