Increase of linear size uniformity of synthetic diamond grinding powder

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Abstract. It has been shown in article that increase of powder uniformity is achieved by carrying out additional sorting of powders in the sizes and form of grains. The sorting process includes the following stages: chemical rounding of diamond grains by strong oxidants; special grain size classification on sieves with mesh sizes corresponded to geometrical progression of twentieth (R-20) and fortieth (R-40) number series; additional separation of diamond grains in narrow graininess by grain form. Diamond powder of AC6 100/80 series has been produced by this technology, as a result of that the content of basic fraction runs up 85 %.

1. Introduction

Increase of efficiency of diamond tools applied in material engineering is important problem today. One of the problem solutions is an increase of quality of diamond powders applied in tooling due to more accurate control of synthesis mechanism as well as technological regimes of powder production.

Diamond is most progressive tool material, especially in the fields where exacting requirements to workpiece quality as well as working accuracy and roughness of workpiece surface of details are demanded. One of the most effective instruments to achieve higher class of workpiece surface and to increase diamond tooling wear-resistance is an increase of size uniformity of granulometric composition and form of diamond grains of powder applied in tooling.

Using diamond powders with higher size uniformity is especially effective in those industry branches where precise form and high grade of workpiece finish are required [1-3].

On the basis of studies carried out in the ISM\(^2\) it have been ascertained that for increase of efficiency of abrasive wheels in polishing of cut glass the special diamond powders are required. These powders have the following properties: uniformity by linear sizes (length (a) and width (b) of grain projection), content of main fraction by grain size is upwards of 80% and form factor (a/b) is at the most 1.3.

The production engineering of such diamond grinding powders of various grain sizes has been developed in the ISM. The process includes the following stages: grain size separation on sieves with mesh sizes corresponded to geometrical progression of twentieth (R-20) and fortieth (R-40) number series with \(\sqrt[20]{10} = 1.122\) and \(\sqrt[40]{10} = 1.059\) ratio correspondingly; special chemical processing and

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separation by grain form on vibrating table [4-6]. The powders produced by this technology are uniform by linear sizes, by strength as well as content of volume and surface defects.

2. Experimental methods
Experiments have been carried out with various diamond grinding powders synthesized in the Ni–Mn–C system. The average grain sizes are 400/315, 125/100 and 80/63 μm. The diamond powders have been studied with the object to the uniformity of some basic characteristics (strength, grain composition etc.).

It is suggested to assess the powder uniformity by the concentration of grits whose characteristic in the given property corresponds to the mean (nominal) characteristic of the powder under study. Here we discuss the uniformity of diamond powders with respect to the basic technical characteristics: strength (Cun.str.) and grain composition (Cun.lin.size).

We have studied the diamond powders in the following sequence. At first, grain size separation on sieves with mesh sizes corresponded to geometrical progression of twentieth (R-20) number series. Produced narrow fractions of 125/115 and 72/63 have been processed by special chemical treatment of strong oxidants, after that the powders have been separated by grain form on vibrating table.

In all produced fractions we have determined strength (P, N), main fraction content (%), coefficient of strength uniformity (Cun.str., %) [6], form factor (Cf = a/b), coefficient of linear size uniformity (Cun.lin.size, %) – a ratio of number of average size grains ((a+b)/2) to number of all grains.

3. Results and discussion
3.1. Results of additional sieve classifying
The results of studies of properties of diamond grinding powders of AC125 400/314, AC6 125/100 and AC15 80/63 series after additional sieve classifying on R-20 sieves are presented in Table 1.

| Grain size | P, N | Series | Main fraction, % | Cun.str., % | Cf, conv. units | Cun.lin.size, % |
|------------|------|--------|-----------------|-------------|-----------------|-----------------|
| 315/355    | 218.4 | AC125  | 95.2            | 46.5        | 1.11            | 44.6            |
| 355/400    | 216.7 | AC125  | 93.4            | 47.8        | 1.09            | 47.2            |
| 400/315 init. | 211.5 | AC125  | 82.5            | 32.0        | 1.18            | 33.6            |
| 125/115    | 7.2   | AC6    | 90.0            | 25.1        | 1.32            | 35.4            |
| 115/100    | 6.4   | AC6    | 92.0            | 24.4        | 1.31            | 32.6            |
| 125/100 init. | 6.8   | AC6    | 72.0            | 14.5        | 1.44            | 24.4            |
| 80/72      | 11.2  | AC20   | 92.0            | 22.1        | 1.40            | 39.6            |
| 72/63      | 10.9  | AC20   | 92.0            | 18.5        | 1.39            | 37.5            |
| 80/63 init. | 10.8  | AC20   | 72.0            | 12.6        | 1.42            | 14.7            |

As appears from the above the strength uniformity of diamond grinding powders of 125/115 narrow class (from 125/100 standard grain size) increases from 14.5% to 25.1%, whereas linear size uniformity increases from 24.4% to 35.4%. The similar results have been obtained for powders of 400/315 and 80/63 grain sizes.

3.2. Results of chemical processing and separation by grain form
The results of studies of properties of diamond grinding powders of AC6 125/115 and AC15 72/63 series after chemical processing and separation by grain form on vibrating table are presented in Table 2.
Table 2. Properties of diamond grinding powders of AC6 125/115 and AC15 72/63 series after chemical processing and separation by grain form on vibrating table.

| Grain size | № of separat. product | P, N | Series | Main fraction, % | C_un.str., % | C_r, conven. units | C_un.lin.size, % |
|------------|------------------------|------|--------|------------------|--------------|-------------------|-----------------|
| 125/115    | 1                      | 10.5 | AC6    | 93               | 33.1         | 1.27              | 39.6            |
|            | 2                      | 8.4  | AC6    | 92               | 28.6         | 1.44              | 33.1            |
|            | 3                      | 4.5  | AC6    | 89               | 21.4         | 1.75              | 28.6            |
|            | Initial                | 7.2  | AC6    | 90               | 24.4         | 1.32              | 35.1            |
| 72/63      | 1                      | 11.8 | AC20   | 93               | 34.5         | 1.39              | 45.6            |
|            | 2                      | 11.0 | AC20   | 94               | 31.2         | 1.46              | 34.6            |
|            | 3                      | 9.6  | AC20   | 92               | 17.8         | 1.71              | 22.1            |
|            | Initial                | 10.9 | AC20   | 92               | 18.6         | 1.39              | 37.5            |

As appears from the above the strength of diamond powder of AC72/63 series increases from 10.5N to 4.5N that is correlated with an increase of form factor and at the same time the strength uniformity increases from 14.5% (initial powder) to 31.2% (finished product). The linear size uniformity increases from 24.4% (initial powder) to 30.6% (product of number 1).

3.3. Results of diamond abrasive wheel test in-polishing of cut glassware surface

Diamond powders of AC15 80/63 series produced by form factor sorting have been used for production of abrasive wheels with B2-01-1 metal-polymeric binder. The wheels have been tested in-polishing of cut glassware surface.

The following operating indices of efficiency have been studied at work of these abrasive wheels: relative ($q_p$) and specific ($q_v$) removal of diamond (wear-resistance of the wheels) and roughness of finished surface ($R_a$). The indices have been determined by the procedures [7].

For verification of results reproducibility the sorting of AC15 80/63 diamond powders, production of abrasive wheels with these powders and polishing tests of these abrasive wheels have been carried out repeatedly.

The results of these tests are presented in Table 3.

Table 3. Correlation between characteristics of diamond grinding powders of AC15 80/63 series and grinding wheel efficiency (results reproducibility).

| Sample | Main fraction, % | C_r, conven. units | C_un.lin.size, % | $q_p$, mg/g | $q_v$, mg/g | $R_a$, μm |
|--------|------------------|--------------------|------------------|--------------|--------------|-----------|
| 1      | 92               | 1.1                | 45.6             | 11.52        | 308.93       | 0.17 / 0.18 |
| 2      | 94               | 1.2                | 38.7             | 18.79        | 274.33       | 0.19 / 0.20 |
| 3      | 92               | 1.3                | 35.3             | 21.16        | 168.19       | 0.15 / 0.20 |
| 1      | 93               | 1.1                | 46.2             | 11.23        | 303.97       | 0.28 / 0.32 |
| 2      | 92               | 1.2                | 37.3             | 18.76        | 273.90       | 0.20 / 0.22 |
| 3      | 92               | 1.3                | 36.1             | 20.82        | 163.96       | 0.15 / 0.18 |

As appears from the above when coefficient of linear size uniformity increases by 10%, the removal of diamond decreases by 1.5-1.8 times and roughness of finished surface diminishes by 1.4-1.6 times.

The results of tests of abrasive wheels with grinding powders of various series are presented in Table 4.
Table 4. Correlation between characteristics of diamond grinding powders of various series and grinding wheel efficiency.

| Series, Grain size | Sample | Technological characteristics | Operating characteristics |
|-------------------|--------|--------------------------------|---------------------------|
|                   |        | Main fraction, C6, C_un, lin.size, % | Cun, % | q_p, mg/g | q_v, mg/g^3 | R_a, μm |
| AC20 80/63        | 1      | 93 | 1.1 | 56.7 | 8.88 | 129.65 | 0.18 |
|                   | 2      | 94 | 1.2 | 46.2 | 22.50 | 328.50 | 0.24 |
|                   | 3      | 92 | 1.3 | 55.4 | 25.40 | 370.84 | 0.29 |
| AC6 100/80        | 1      | 88.6 | 1.25 | 43.2 | 3.58 | 60.01 | 0.12 |
|                   | 2      | 80.5 | 1.29 | 39.6 | 4.11 | 73.29 | 0.15 |
|                   | 3      | 73.1 | 1.36 | 32.1 | 5.02 | 129.65 | 0.16 |
| AC6 80/63         | 1      | 88.6 | 1.25 | 43.2 | 4.12 | 70.54 | 0.14 |
|                   | 2      | 80.5 | 1.29 | 39.6 | 5.34 | 84.12 | 0.15 |
|                   | 3      | 73.1 | 1.36 | 32.1 | 7.09 | 145.34 | 0.25 |

As appears from the above when main fraction content increases, wear-resistance of the wheels increases too and relative removal of diamond q_p decreases.

4. Conclusion

1. Production of diamond powders uniformed by strength characteristics and linear sizes is provided by classifying processes. It is the result of using increasingly advanced methods of diamond separation by corresponding physical-mechanical characteristics of regular synthetic diamond crystals.

2. As a result of carried out studies the following correlation dependences have been determined: as main fraction content and diamond grain form factor are increased the wear-resistance (q_p, q_v) of abrasive wheels is increased too, while roughness of finished surface (R_a) is decreased.

Maximal reduction of specific diamond consumption in grinding is amount to 2.5 times for diamond of AC20 series and 1.4 times for diamond of AC6 series, while roughness of finished surface is decreased by 1.6 and 1.3 times correspondingly.

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