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ANALYSIS OF THE TECHNOLOGICAL AND MORPHOLOGICAL PECULIARITIES OF BRONZED POWDERS PRODUCTION FROM THE SWARF WASTES

Об'єктом дослідження є технологія практичного одержання металевих порошків із стружкових відходів алюмінієвої бронзи з подальшим їх використанням у якості пігментів для поліграфічних процесів. В ході досліджень було виявлено, що розвинута поверхня стружкових частинок, багаточисельні дефекти у вигляді макро- і мікротріщин, розщеплень та пор, специфічний мікрорельєф є сприятливими передумовами для їх подрібнення. Експериментальні напрацювання тонкої структури показали, що в процесі подрібнення стружки за рахунок додаткової пластичної деформації щільність дислокацій і величина мікровикривлень кристалічної решітки порошкових частинок збільшується. Застосування прокатного комбайна з набором вібросит дало можливість використовувати в подальшому тонке подрібнення стружкових відходів. Дослідження форми і стану поверхні на оптичному і растровому мікроскопах надали необхідну інформацію для пояснення процесів, які відбуваються при подрібненні стружки. Отриманий результат показав, що мікродослідження зони стружкоутворення в БрАЖ 9-4 дало можливість вивчити механізм текстурування структурних складових альфа-фази, евтектоїда в утвореній стружці. Це дозволило прогнозувати характер змінення останніх при подрібненні. Аналіз характеру руйнування поверхні стружкових елементів алюмінієвої бронзи у процесах подрібнення дозволив підтвердити успадковування морфологічних, структурних та фізико-хімічних закономірностей останніх знов утвореними частинками порошку. А також можливість отримання дисперсного металевого пігменту для використання в поліграфії. Одержані позитивні результати надали змогу реалізувати експериментальні напрацювання з використання стружкових відходів кольорових сплавів для виготовлення металевих порошків. Завдяки цьому можливо вибіркове подрібнення стружкових частинок до потрібного розміру і використовувати отримані порошкові фракції по призначенню. Вказані відходи можуть бути вельми перспективним сировинним матеріалом для їх використання, незважаючи на масштаби утворюваних металевих стружкових відходів легованих кольорових металів і сплавів, особливо в умовах розвитку в Україні новітніх ресурсозберігаючих технологій.

Ключові слова: *бронзувальні порошки, стружкові відходи, прокатний комбайн, морфологічні ознаки, пластична деформація, тонка структура.*

1. Introduction

Improving the quality of printing and packaging products necessitates the use of various technological processes at printing enterprises, as well as the use of metallized materials to achieve the most popular effect among customers of the metallic luster of printing products. This effect allows the printing of metallized inks and bronzing. Metallic pigments used in bronzing are powders obtained using various technologies [1–3]. Metal particles are relatively recently used in printing, but the result makes itself felt [4–6]. If powder metallurgy occupies the first place by the percentage of use and occupies 90 %, then only 1 % is used in the printing industry [7]. This was enough to finish printing products to date. However, modern conditions for the development of printing products require a significant expansion of the use of metal powders to produce high-quality printing products [8–10]. In addition, chip waste can be used as metallic pigments. Aluminum bronze swarf are a morphologically beneficial material for the production of powders and spend no energy on the formation of chips. So, *the object of research* is the technology of practical production of metal powders from chip waste of aluminum bronze with their subsequent use as pigments for printing processes. And *the aim of research* is analysis of the morphological features of the БрАЖ 9–4 aluminum bronze swarf and determination of the possibilities for further use of the powder based on it in printing.

2. Methods of research

The deformation zones in the visible chip element, as well as in the region, ahead and accompanying the deformation, have a dark color. Microscopic studies [11] show that this is due to the high density of slip planes and, accordingly, dislocations. The process increases with increasing depth of cut. The zone of advanced strengthening of 1.03–1.45 mm is much greater than the depth of the hardened layer under the cutter 0.05–0.30 mm. The deformation degree of the structural components is not the same. Slip lines have a certain crystallographic orientation in different grains. Being in the initial state in the dispersion (10–30 mm) and disoriented to the zone of plastic deformation, the α phase is first drawn out in a plane normal to the direction of movement of the tool, and then returns in the direction of its movement. In this case, the surface layer acquires a fibrous structure.

The grain boundaries in the deformation zone partially or completely lose their shape (Fig. 1).

Fig. 1. Localization of plastic deformation

The technology for grinding chips of colored waste is described in [11, 12].

3. Research results and discussion

Being subjected to the impact of rotating parts in the attritor [11, 12], the swarf particles are divided into smaller elements. In the initial state, they have a wedge-shaped shape, and, due to the spin contact and surface deformation, the tops and ribs are crushed in the shredders, and the sharp profiles change to more rounded, sharp corners to obtuse ones. As a result, particles of columnar forms with a cross section close to trapezoidal are obtained. Although the chips are plastically deformed, that is, the material is significantly strengthened, during dispersion, dents are formed on the surface of the particles – areas with weakened intersections are formed. On subsequent impacts in these zones, capable of further plastic deformation, the concentration of defects becomes extreme and brittle fracture occurs due to micro and micro cracks that arise. As a result, particles are formed mainly in the form of an irregular quadrangle.

Since the newly formed particles inherit all micro and macro chips, and, therefore, have lower strength, as a result of the applied stresses, they are destroyed faster. But besides defects, they have their own background in the process of multiple load, new ones arise.

The most likely place for the initiation of cracks is the surface layers at the boundary of the particle, collapsing, squeezing the body, that is, in the places of the greatest shear stresses. Moreover, this process is facilitated by the already existing surface defects in the form of dislocations and microinhomogeneities.

Microscopic studies have shown that, in most cases, not one, but many cracks occur in particles that propagate predominantly in a zigzag manner, as a result of which they acquire a fragmentation shape. It should be noted that the powder obtained in the vibration machine has a surface more developed and saturated microinhomogeneities compared to the attritor powder [11, 12].

The microstructure of powder particles inherits the structural features of cast metal and chips. However, the depth and extent of the plastically deformed layers are greater. The microhardness of the alpha phase in the surface layers of the particles is 281–303 N, in the central – 230–270 N. Compared with the chips, the microhardness of the structural components increases on average 1.1–1.14 times during grinding, and compared to the cast metal 1.4–1.6 times. There is no significant difference in the hardness of the particles of the powder obtained in the attritor and in the vibratory grinders [12, 13].

The study of the fine structure shows that in the process of chip grinding, due to additional deformation, the dislocation density and the magnitude of the micro curvatures of the crystal lattice of powder particles increase [14].

The morphology of the swarf particles at different stages of grinding aluminum bronze swarf is shown in Fig. 2.

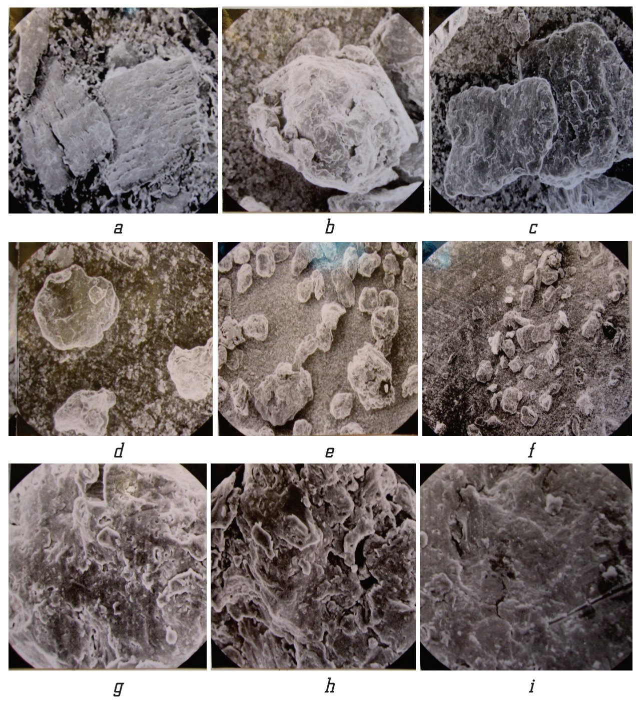

Fig. 2. Particle morphology at different stages of grinding aluminum bronze swarf on a rolling mill: *a–c* – 3–4 min (×201); *d–e* – 5–6 min (×241); *f–i* – 10 min (×781)

After receiving the bronzing powder, a bronzing paste is made. The composition of the mixture for bronzing: oil-resin varnish 1 liter and bronze powder 400–450 g. Bronze powder rubbed on a small amount of varnish. The mixture is diluted with the rest of the varnish to working viscosity. For the manufacture of a mixture of aluminum powder it takes 200–220 g per 1 liter of varnish.

For operation, the mixture is made in small portions, which should be immediately used, since during long-term storage there is a strong wetting of bronze particles that settle to the bottom of the vessel. In the future, when bronze particles are applied to the surface, the bronze will not float into the outer layer of the film and it will lose its luster and become dull.

4. Conclusions

The study shows that, due to the properties of the surface of the swarf particles in the form of numerous defects, the prospect of their further use as powders of certain fractions. The peculiarities of the rolling of swarf particles consist of the fact that: first, they form a tape of small strength, and second, it easily collapses in a conventional attritor [11, 12]. The frequency of such operations with the above sequences allows to obtain powders

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of very small fractions of 10–20 microns with minimal oxidation. Further research will focus on the production of smaller particles with a lower degree of oxidation and a large number of their optical properties, since this directly affects the economic leverage of printed products.

The studies conducted in this paper are devoted to the development of technology for producing powders of various fractions in the form of dispersed filler for brake linings for road and rail transport (particle size up to 1 mm). As well as bronzing powders for finishing printing products (fraction 50–70 microns) and ultrafine powders as metal pigments for the production of metallized dyes [12–14].

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