Raster electron microscopy of electroerosion titanium-tungsten-cobalt powders

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Abstract. One of the promising methods for producing nanopowders, from virtually any conductive material, including cemented carbide, is distinguished by relatively low energy costs, harmlessness and environmental cleanliness of the process, the absence of mechanical wear of equipment, obtaining powder directly from pieces of cemented carbide of various shapes in one operation, obtaining particles of predominantly spherical form is the method of electroerosive dispersion (EED). The purpose of this work was to study the shape and morphology of the surface of powder particles obtained by electroerosive dispersion of solid waste T30K4 in alcohol using a scanning electron microscope. On the basis of the conducted research, it was established that the shape of the powder particles obtained by EED dispersion of solid waste grade T30K4 in alcohol is determined by the form in which the material is ejected from the well in the EED process. It is noted that spherical particles are obtained by crystallization of molten material (liquid phase), and fragmentation-shaped particles are obtained at brittle fracture. It is established that particles with a regular spherical or elliptical shape prevail in the powder.

1. Introduction

At present, progress in the area of product quality and increase in the productivity of technological processes is associated with the use of nanopowders. In the near future, nanotechnology and nanodispersed materials will determine the fate of technological progress. The rapid development of powder metallurgy and a continuously expanding nomenclature of nanomaterials and their products, stimulate the study of their structure and properties [1-10].

One of the promising methods for producing nanopowders, from virtually any conductive material, including cemented carbide, is distinguished by relatively low energy costs, harmlessness and environmental cleanliness of the process, the absence of mechanical wear of equipment, obtaining powder directly from pieces of cemented carbide of various shapes in one operation, obtaining particles of predominantly spherical form is the method of electroerosive dispersion (EED) [11].

The process of EED is the destruction of conductive material as a result of local exposure to short-term electrical discharges between the electrodes and (or) alloy particles (electrical erosion of the material). In the discharge zone, under the action of high temperatures, heating, melting, and partial evaporation of the material occur. Liquid material and vaporous material is released into the working fluid and solidifies in it to form individual particles.

To obtain a high temperature in a limited area of small volume, a large concentration of energy is required. Achieving this goal is carried out using pulsed voltage, and EED is carried out in a liquid
medium (working fluid), which fills the gap between the electrodes, called the interelectrode gap (IEG).

Due to the fact that any smooth surface has its own macro- or micro-relief, there will always be two points between two electrodes, the distance between which will be less than between other points of the surfaces of the electrodes. When an electric current source is connected between the electrodes, a current begins to flow, and an electric field arises, the intensity of which in the area where the gap between the electrodes is minimal will reach the maximum value. The location of this area depends on local protrusions, irregularities on the electrodes, on the presence and size of electrically conductive particles in the interelectrode gap.

The physicomechanical properties of powders, obtained by electro-erosion dispersion from tungsten-containing wastes, due to which they can find application in technological processes of tool manufacturing, are determined by their particle size, X-ray structural, chemical composition, shape and surface morphology, microhardness of particles.

The shape of the powder particles and the state of their surface depends on the method of production and has a great influence on the bulk density and compressibility, as well as on the density, strength and uniformity of the compacts. The smallest bulk density and greatest strength are pressed from powders with a dendritic particle shape. On the contrary, powders with spherical particles have a maximum bulk density, but are poorly pressed. To obtain compacts with sufficient strength, high pressures are required. Powders with a scaly form are very poorly compressed, and the presses obtained from them are prone to cracking and delamination. Fibrous powders are poorly pressed and are used mainly as reinforcing (hardening) additives in the creation of fibrous materials.

Proceeding from the above, it follows that the solution of the problem associated with the processing and reuse of tungsten-containing waste in the production of new solid carbide plates with high performance properties is possible, when solving a number of interrelated scientific problems of theoretical and experimental nature, which determines the relevance and scientific value of research in this direction.

The purpose of this work was to study the shape and morphology of the surface of powder particles, obtained by electroerosion dispersion of solid waste T30K4 in alcohol, using a scanning electron microscope.

2. Materials and methods
To obtain powder from tungsten-containing wastes by the method of electroerosive dispersion, an installation for EED of conductive materials was developed by the authors.

As a material for dispersion, waste of sintered hard alloy T30K4 was used, and alcohol was used as a working fluid. As a result of the local impact of short-term electrical discharges between the electrodes, the waste material was destroyed with the formation of dispersed powder particles.

To study the shape and morphology of microparticles, images were taken on a Quanta 600 FEG scanning electron microscope. Using scanning electron microscopy, it is possible to directly analyze powder particles with a sufficiently high resolution. In a raster electron microscope, a large depth of focus is achieved, which makes it possible to observe a three-dimensional image of the structure under study. The microscope “Quanta 600 FEG” allows to obtain images of various objects with magnification exceeding 100,000 times, with a large number of decomposition elements (pixels). It is designed to perform various studies with minimal time spent on the preparation of objects, ensuring their observation with an exceptional depth of field.

3. The study of the assess the wear resistance of electro-spark coatings
The obtained images on a Quanta 600 FEG scanning electron microscope are shown in Figure 1-4.

It is seen that particles with regular spherical or elliptical shape prevail in the powder. They are obtained by crystallization of the molten material (liquid phase). Particles formed during the crystallization of a boiling material (vapor phase) have an irregular shape, an order of magnitude smaller than the particles forming their liquid phase, and usually agglomerate with each other and on
the surface of other particles. In the process of EED such particles are most susceptible to chemical and phase changes. It is shown that the shape of the powder particles is determined by the form in which the material is ejected from the well in the EED process.

It is established that particles, ejected from the well in the solid state (solid phase), are formed under the action of the shock waves of the discharge channel and under the action of thermal stresses, as well as particles of the solid phase are formed during brittle fracture of sharp facet and edges of the dispersed material during its mixing in the process of EED. Such particles, as a rule, have an irregular fragmentation form, sometimes with melted facet and edges.

Figure 1. Snapshot of powder particles, obtained EED in kerosene (increase 5 000)

Figure 2. Snapshot of powder particles, obtained EED in kerosene (increase 10 000)
Figure 3. Snapshot of powder particles, obtained EED in kerosene (increase 40,000)

Figure 4. Snapshot of powder particles, obtained by EED in kerosene (increase 100,000)
4. Conclusion
Thus, on the basis of the conducted studies, it was established that the shape of the powder particles obtained by electroerosive dispersion of solid waste grade T30K4 in alcohol is determined by the form in which the material is ejected from the well in the EED process. It is noted that spherical particles are obtained by crystallization of molten material (liquid phase), and fragmentation-shaped particles are obtained at brittle fracture. It is established that particles with regular spherical or elliptical shape prevail in the powder.

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