# Porosity of products from electroerosive cobalt-chromum powders, obtained by additive technologies

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**Abstract.** The wide use of the EED method for processing metal waste into powders for the purpose of their reuse and application in additive technologies is hampered by the lack in the scientific and technical literature of full-fledged information on the effect of the initial composition, regimes and media on the properties of powders and technologies of practical application. Therefore, in order to develop technologies for the reuse of electroerosive powders and to evaluate the effectiveness of their use, complex theoretical and experimental studies are required. The purpose of this work is the study of the porosity of additive products from electroerosive cobalt-chrome powders. For the implementation of the planned studies, wastes of the cobalt-chrome alloy of the brand KHMS "CELLIT" were chosen. As a working fluid, butanol (butanol-1) was used. For the production of cobalt-chrome powders, a unit for EED of conductive materials was used. Dispersion parameters: voltage 100 V, capacity 48 μF, repetition rate 120 Hz. Therefore, two or more pores because of the absence on the thin section of the visible boundary of their division can be fixed as one large. In addition, the method gives the distribution of pores in one plane of the sample, where narrow and wide sections of the sample fall, while in the hydrostatic weighing method and mercury porosimetry the pore sizes are fixed at their narrowest cross section. A consequence of these factors is the displacement of the function and distribution in the region of large pores. The porosity was determined using an Olympus GX51 optical inverted microscope with software for quantitative image analysis. Prepared samples had no traces of grinding, polishing or dying of structural components. Based on the results of conducted studies of the porosity of additive products from electroerosive cobalt-chrome powders, it has been experimentally established that the porosity does not exceed 1,06%.

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## 1 Introduction

Typically, manufacturers of additive machines are suppliers of consumables, and these firms do not produce powders, but participate in their preparation for work on their machines. Powder is purchased at the manufacturers of powder materials, which produce material for a variety of needs of powder metallurgy. The purchased powder is subjected to screening and fractionation, the fractions are mixed in certain ratios and the packaging is packed in a sealed container. Thus, in particular, manufacturers of additive machines insure themselves against possible claims to the quality of powders on the part of consumers.

For domestic consumers, consumables are a serious problem. In connection with the underdevelopment of the Russian market, metal powder preparations for additive machines are mainly purchased abroad.

The main requirement for powders for additive machines is the spherical shape of the particles. Such particles are most compactly packed into a certain volume and ensure the "fluidity" of the powder composition in the supply systems of the material with minimal resistance. In addition, the powder should contain a minimum amount of dissolved gas. The microstructure of the powder must be uniform and finely dispersed (with a uniform distribution of phase constituents) [1-8].

Proceeding from the peculiarities of the methods for obtaining spherical powders with the aim of obtaining spherical granules of regulated granularity, the electroerosive dispersion technology, which is characterized by relatively low energy costs and ecological purity of the process, is proposed [9-11].

The main advantage of the proposed technology is the use of waste as raw materials, which is much cheaper than the pure components used in traditional technologies. In addition, this technology is powdered, which allows powder-alloys.

The wide use of the EED method for processing metal waste into powders for the purpose of their reuse and application in additive technologies is hampered by the lack in the scientific and technical literature of full-fledged information on the effect of the initial composition, regimes and media on the properties of powders and technologies of practical application. Therefore, in order to develop technologies for the reuse of electroerosive powders and to evaluate the effectiveness of their use, complex theoretical and experimental studies are required.

The purpose of the study is the study of the porosity of additive products from electroerosive cobalt-chrome powders.

## 2 Materials and methods

For the implementation of the planned studies, wastes of the cobalt-chrome alloy of the brand KHMS "CELLIT" were chosen. As a working fluid, butanol (butanol-1) was used. For the production of cobalt-chrome powders, a unit for EED of conductive materials was used. Dispersion parameters: voltage 100 V, capacity 48 μF, repetition rate 120 Hz.

One of the main methods for determining porosity is a metallographic method with elements of qualitative and quantitative analysis of pore geometry (stereoscopic metallography). Using the methods of stereoscopic metallography allows us to calculate the specific surface area of large pores, the number of spherical pores per unit volume, the average distance between the pores, the average real diameter of spherical pores, etc. The metallographic method covers a wide range of pore size measurements corresponding to the resolution of the optical capacity (for the Olympus GX51 optical inverted microscope - 500 nm). When using a microscope, the main drawback is the lack of a clear distribution of pores, since their boundaries do not always fall in the plane of the section in connection with the random cross section during its manufacture. Therefore, two or more pores because of the absence on the thin section of the visible boundary of their division can be fixed as one large. In addition, the method gives the distribution of pores in one plane of the sample, where narrow and wide sections of the sample fall, while in the hydrostatic weighing method and mercury porosimetry the pore sizes are fixed at their narrowest cross section. A consequence of these factors is the displacement of the function and distribution in the region of large pores.

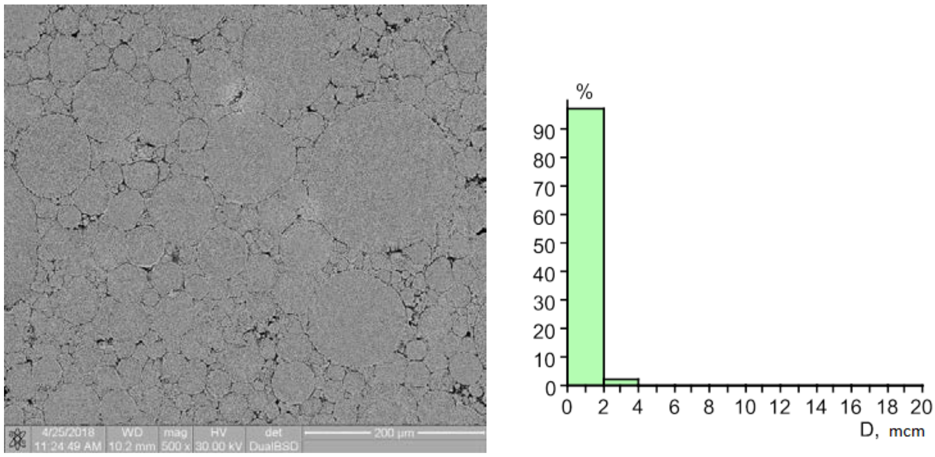
The porosity was determined using an Olympus GX51 optical inverted microscope with software for quantitative image analysis. Prepared samples had no traces of grinding, polishing or dying of structural components. The thin section was made by the cross section (fracture) of the whole product or part thereof with an area of < cm2. The "SIAMS Photolab" software, which is equipped with a microscope, was developed taking into account the specific application of digital microscopy and image analysis methods for metallographic analysis of compounds. The digital image of the material in shades of gray looks like a set of objects that have close color, brightness and morphometric characteristics. Accordingly, the automatic allocation of measurement information is associated with the inevitable capture of noise and interference. In order to ensure the reliability of the analysis results, the software has elements of the expert system: in an interactive mode, the operator is asked to select those of the automatically selected objects that, in his opinion, are microstructure defects. Since both individual pores and pores can be detected on the controlled surface, as well as microcracks, the operator with a continuous marker designates a pore chain, and single pores of creep and microcracks designate the marker as separate areas. The results of marking are used to form an expert conclusion and calculate the quantitative characteristics of microdamage. Based on the results of accumulated statistics, an automatic report is created in the automatic mode, which contains calculated data and information about the controlled area.

## 3 Results and discussion

The results of the porosity test of the sample by the metallographic method are given in Table 1 and in Figure 9.

**Table 1**. Porosity (metallographic method)

| Area of analysis, sq. μm | Porosity, % | $D_{min}$ | $D_{max}$ | $D_{med}$ |
|---|---|---|---|---|
| 501722,8 | 1,06 | 0,2 | 15,3 | 0,6 |




a) b)

**Fig. 1.** Results of the study of porosity: a) microstructure of sample x500; b) histogram of the distribution of pores by size

## 4 Conclusion

Based on the results of conducted studies of the porosity of additive products from electroerosive cobalt-chrome powders, it has been established experimentally that the porosity does not exceed 1,06%.

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