The porosity study of sintered products from electro-erosive materials of alloy Cr17, obtained in lighting kerosene

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Abstract. The article presents the results of porosity study of sintered products from electro-erosive materials of alloy Cr17, obtained in lighting kerosene. It was shown that during the consolidation of electro-erosion materials from Cr 17 alloy by the method of spark plasma sintering, the porosity was 0.27%.

1 Introduction

Steel Cr17 in accordance with GOST 5632-72 is defined as nickel-free, chromium heat-resistant corrosion-resistant steel of the ferrite group. In the Cr17 alloy, there is practically no nickel (less than 0.01%); and molybdenum and titanium are completely absent. But its chemical composition provides steel with resistance to corrosion in environments with moderate aggressiveness and resistance to oxidation at high temperatures. A high percentage of chromium alloy provides strength and corrosion resistance. In addition, it contributes to an increase in the melting temperature, and gives the surfaces of products gloss. And the combination of a large amount of chromium with a low carbon number increases ductility.

The widespread use of Cr17 steel in various industries leads to a large accumulation of its waste requiring processing. Currently, there are many ways to recycle metal waste in order to reuse it. However, the disadvantages of the known methods are increased energy consumption, multi-operation process [1-7].

The most promising method of processing metal waste is the method of electro-erosive dispersion (EED), which is distinguished by the ecological purity of the process and relatively low energy costs.

To develop technologies for the practical use of powder materials, obtained from waste alloy Cr17, and to evaluate the effectiveness of their use, complex theoretical and experimental studies are required. The aim of the work was to study the porosity of sintered samples from electroerosive materials of Cr17 alloy, obtained in lighting kerosene.

2 Materials and Methods

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To implement the planned studies, the waste of the Cr17 alloy (GOST 5632-72) was loaded into the reactor of the electro-erosive dispersion unit (EED) [7]. Lighting kerosene was used as the working fluid (GOST 4753-68). The process was carried out with the following electrical parameters: capacity of discharge capacitors 55 μF, voltage 120 ... 130 V, pulse repetition rate 95 ... 100 Hz.

As a result, particles were obtained, whose average size is 28 microns. The final porosity of the sintered products is influenced by the pressing and sintering modes.

The powder was consolidated by spark plasma sintering using the SPS 25-10 spark plasma sintering system (Thermal Technology, USA) according to the scheme shown in (Fig. 1).

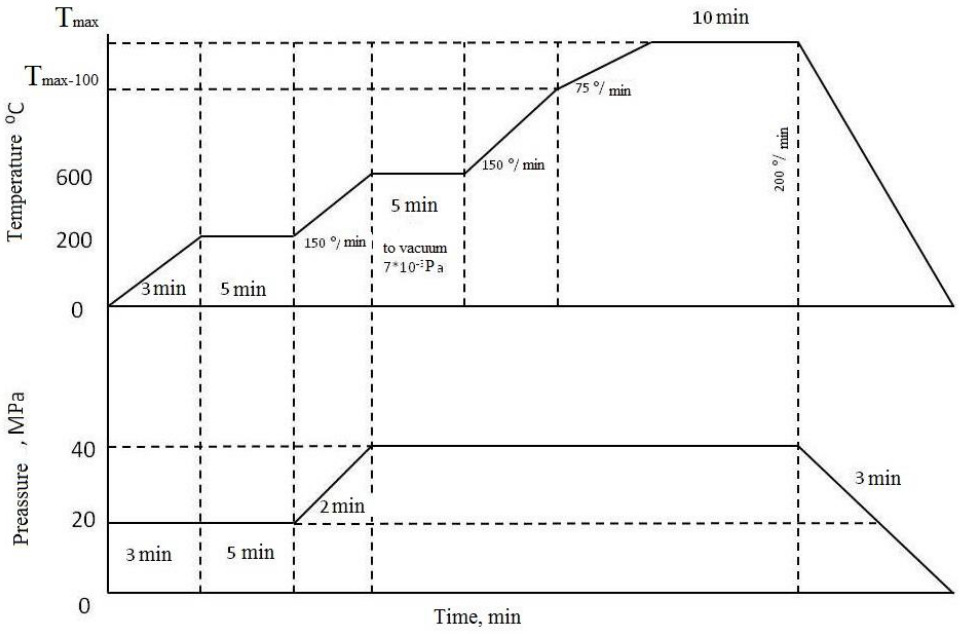

Fig. 1. Scheme of powder consolidation by spark plasma sintering.

The starting material was placed in a graphite matrix, placed under a press in a vacuum chamber. The electrodes, integrated into the mechanical part of the press, fed an electric current to the matrix and created spark discharges between the sintered particles of the material, providing intense interaction.

The advantages of spark plasma sintering technology are the uniform distribution of heat throughout the sample; high density and controlled porosity; lack of need for binding materials; uniform sintering of homogeneous and dissimilar materials; short cycle time; manufacturing of the part immediately in the final form and obtaining a profile close to the specified [8-15].

Porosity was determined using an Olympus GX51 inverted optical microscope with software for quantitative image analysis (Fig.2).

Fig.2. Olympus GX51 Optical Inverted Microscope.

One of the main methods for determining porosity is the metallographic method with elements of qualitative and quantitative analyses of pore geometry (stereoscopic metallography). The use of stereoscopic metallography techniques allows to calculate the specific surface area of large pores, the number of spherical pores per unit volume, the average distance between pores, and the average real diameter of spherical pores [16-20].

3 Results

The prepared samples had no traces of grinding, polishing or chipping of structural components. A thin section was made over the cross section (kink) of the whole product or part of it with an area of less than 2 cm^2. The SIAMS Photolab software, which the microscope is equipped with, has been developed taking into account the specifics of using digital microscopy and image analysis methods for metallographic analysis of compounds.

The results of the sample porosity study by metallographic method are shown in Table 1.

Table 1. Porosity (metallographic method).

Area of analysis, sq. μm	Porosity, %	Dmin	Dmax	Dmed
3788639.6	0.27	3.2	27.1	4.1

Figure 3 shows the microstructure of the obtained sintered samples with a magnification of the microscope 1000 times.

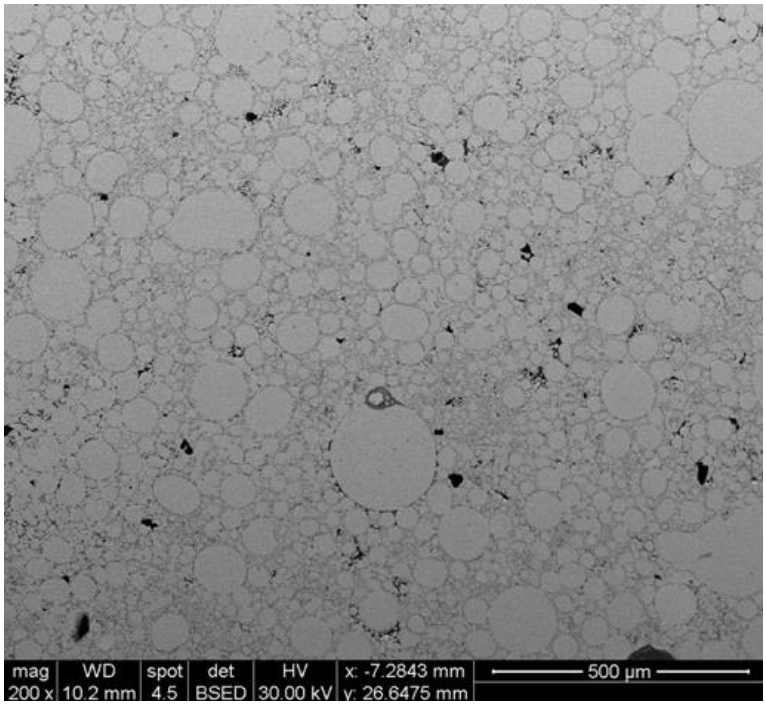

Fig.3. The microstructure of the studied sintered sample.

A histogram of pore size distribution is shown in Fig. 4.

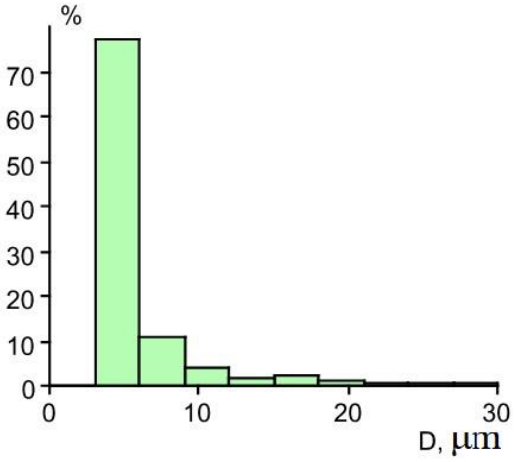

Fig.4. Pore size distribution histogram

According to the presented histogram, more than 90% of the pores have a size of less than 10 microns.

4 Conclusion

On the basis of experimental studies, aimed at studying the porosity of sintered samples by the metallographic method, it was found that when consolidating by spark plasma of

sintering electro-erosive materials from Cr17 alloy wastes, obtained in lighting kerosene, the porosity was 0.27%. It is noted that more than 90% of the pores have a size of less than 10 microns. The study will determine the most relevant area of application of the obtained samples and improve the quality of scientific and technological developments.

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