The porosity study of sintered products from electro-erosive materials of alloy Cr13, obtained in butyl alcohol

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Abstract. The article presents the results of a study of the porosity of sintered products from alloy X13 electroerosive materials obtained in butyl alcohol. It is shown that when hardening electroerosive materials from alloy X13 by the method of spark plasma sintering, the porosity was 3.347%.

1 Introduction

The alloying process can significantly change the operational characteristics of the metal. A wide variety of chemicals can be added to the composition. The ferritic-martensitic class includes steel X13, which is characterized by high resistance to high temperatures and high humidity.

The main alloying element in the production of grade X13 (the characteristics of steel largely depend on the concentration of chemicals in the composition) is chromium. Its addition to the metal composition is carried out over a long period. The main characteristics of plastic are as follows:

1. Limited degree of weldability. The metal in question is characterized by a low degree of machinability. In most cases, the material is heated to increase the degree of weldability.
2. Heat resistance and low thermal conductivity are properties that significantly expand the area of the material under consideration. Corrosion-resistant heat-resistant steel X13 can be operated at temperatures up to 700 degrees Celsius. An increase in temperature to higher values leads to the fact that the properties of the material will significantly decrease: hardness, resistance to deformation, and others.
3. The hardness is maintained at the level of 126-197 MPa, depending on whether heat treatment was carried out.
4. The structure is prone to temper brittleness, it is possible to carry out cutting.

The properties of powder steels depend on their macro- and microstructure. The structural components of powder materials are metallic phases that form the basis of the material and non-metallic inclusions (for example, graphite, oxides, carbides, nitrides, etc.).

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The metal base of powder steels, like cast steels, is ferritic, ferrite-pearlite or pearlite-cementite, according to the Fe - Fe3C diagram.

Porosity can be considered as a set of communicating extended pores - channels that can be dead-end, isolated, and also come out to the surface and communicate with each other. To determine the shape of the pores and their distribution, thin sections are prepared in different directions in relation to the direction of pressing and the porosity is studied on non-etched or slightly etched thin sections.

Depending on the volumetric content of pores, powder steels are subdivided into impermeable (pore content less than 5-8%), semi-permeable (from 8 to 14% of pores) and permeable (porosity more than 12-14%). According to the production technology, they can be divided into: once and repeatedly pressed under static loads in closed molds at normal and high temperatures; steels obtained by combining cold pressing and sintering of highly porous blanks with subsequent dynamic hot pressing or hot forging; obtained by extrusion, rolling, explosive pressing, etc.

Structural powder steels are sintered materials used to replace cast and forged steels in the manufacture of machine parts and apparatus using powder metallurgy methods.

Powder steels are based on iron, the properties of which during sintering have a great influence on the formation of the structure and properties of steel. Along with powder steels, powder products can be made on the basis of one iron powder, as well as iron alloyed with other elements.

The widespread use of steel X13 in various industries leads to a large accumulation of its waste that requires processing. Currently, there are many ways to recycle metal waste for reuse. However, the disadvantages of the known methods are increased energy consumption, multi-stage process [1-6].

The most promising method for processing metal waste is the method of electroerosive dispersion (EED), which is distinguished by the environmental friendliness of the process and relatively low energy consumption.

Complex theoretical and experimental studies are required to develop technologies for the practical use of powder materials obtained from X13 alloy waste and to evaluate the effectiveness of their use. The aim of the work was to study the porosity of sintered specimens from alloy X13 electroerosive materials.

2 Materials and Methods

To implement the planned studies, the X13 alloy wastes were loaded into the reactor of the electrical discharge dispersion (EED) unit [7]. Butyl alcohol was used as a working fluid. The process was carried out with the following electrical parameters: the capacity of the discharge capacitors was 55 MKF, the voltage was 100 V ... 110 V, and the pulse repetition rate was 120 ... 130 Hz.

As a result, particles were obtained with an average size of 39 μm. The final porosity of sintered products is influenced by the modes of pressing and sintering [8-14].

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

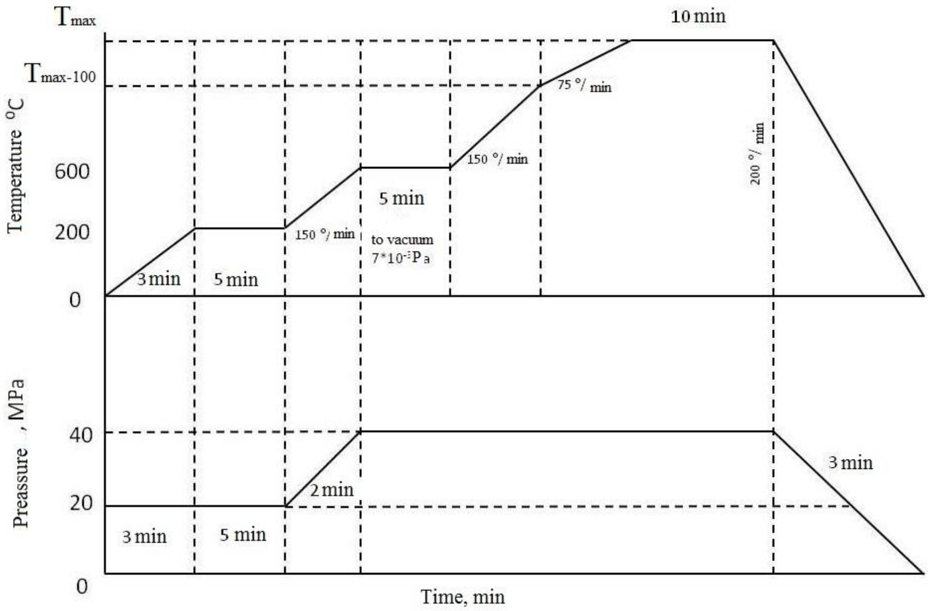

Fig. 1. Scheme of powder hardening by spark plasma sintering

Porosity was determined using an Olympus GX51 inverted optical microscope with quantitative image analysis software. The prepared samples had no traces of grinding, polishing, or chipping of structural components. The section was made along the cross-section (fracture) of the whole product or part of it with an area of less than 2 cm^2. The software “SIAMS Photolab”, which the microscope is equipped with, has been developed taking into account the specific application of digital microscopy and image analysis methods for metallographic analysis of compounds [15-20].

3 Results

A digital image of a material in grayscale looks like a set of objects with similar color, brightness and morphometric features.

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

Table 1. Porosity (metallographic method)

Area of analysis, sq. µm	Porosity, %	D_{min}	D_{max}	D_{med}
229332,0	3,34	0,1	15,3	0,6

In fig. 2 shows the microstructure of the obtained sintered sample at a microscope magnification of 1000 times.

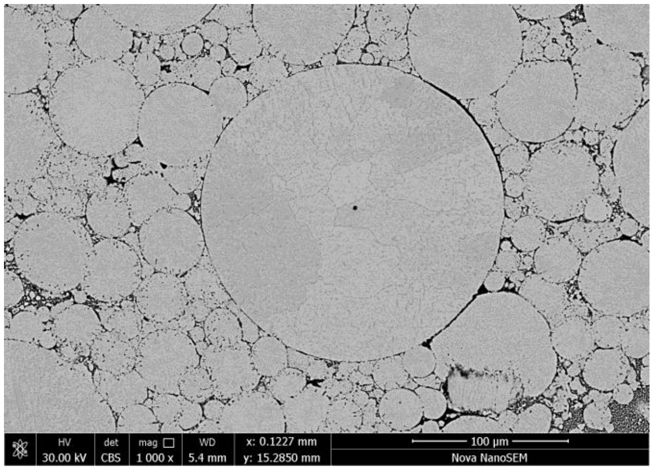

Fig. 2. Sample microstructure

The histogram of the pore size distribution is shown in Fig. 4

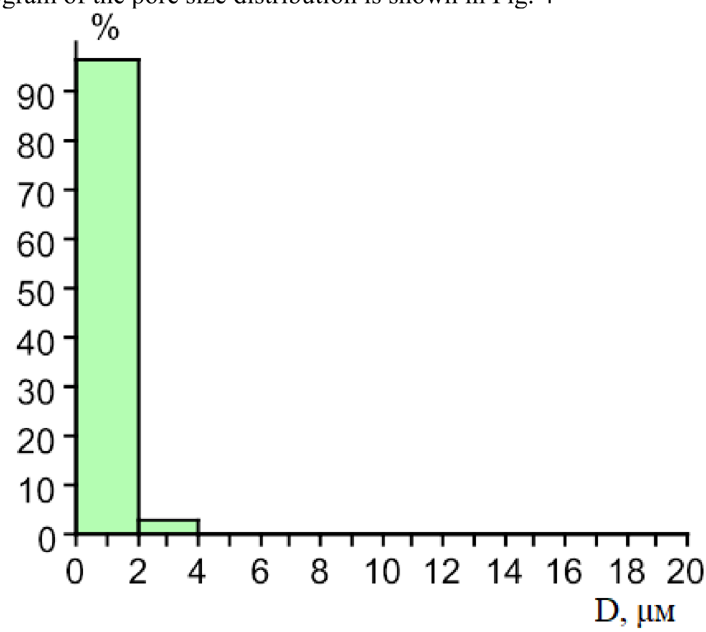

Fig. 3. Pore size distribution histogram

According to the presented histogram, more than 90% of the pores are less than 2 μm in size. D, μм

4 Conclusion

Based on the experimental studies carried out aimed at studying the porosity of sintered samples by the metallographic method, it was found that during spark plasma sintering using the SPS 25-10 spark plasma sintering system of electroerosive materials from X13 alloy wastes obtained in butyl alcohol, the porosity was 3.34%. It is noted that more than 90% of the pores are less than 2 microns in size. The research carried out will make it possible to determine the most relevant field of application of the samples obtained and to improve the quality of scientific and technical developments.

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