X-ray diffraction analysis of sintered products from electroerosion materials, obtained from Cr17 alloy waste

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Abstract. This article presents the phase composition study of sintered samples from electroerosion materials of the Cr17 alloy, obtained in lighting kerosene. It was established that the main phases in the sintered sample are FeCr0.29Ni0.16C0.06, Cr, Cr7C3.

1. Introduction
Nickel-free Cr17 stainless steel is a more cost-effective substitute for expensive nickel-containing corrosion-resistant and heat-resistant steels. Cr17 steel is ductile, durable and well welded, often used in annealed condition. The valves of hydraulic presses, conveyors for furnaces and drying lines, pipes, boilers are made from it.

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-operational technological process [1-7].

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

Carrying out the planned measures will allow to solve the problem of waste disposal and their further use and thereby reduce the cost of production of the final product.

The aim of the work was to carry out X-ray diffraction analysis of sintered samples from electroerosive materials of Cr17 alloy, obtained in lighting kerosene.

2. Materials and Methods
To obtain powder from Cr17 steel wastes (GOST 5632-72), an EED device, developed by the authors, was used [7]. Waste was loaded into a reactor, filled with a working fluid - lighting kerosene, 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.

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 (Figure 1).
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 given [8-15].

The phase composition of the sample was studied by X-ray diffraction on a Rigaku Ultima IV diffractometer in Cu-Kα radiation (wavelength λ = 0.154178 nm) using Soller slits (Fig. 2).

The diffraction spectrum for phase analysis is taken according to the θ-2θ scanning scheme with focusing according to Bregt-Brentano in the range of angles of 5 ... 100 deg. 2 θ. The shooting is
carried out in dotted mode with a scanning step $\Delta (2\theta) = 0.02 \text{ deg.}$, speed 0.6 deg/min, operating voltage 45 kV, current 200 mA [16-20].

3. Results
To refine the profile of experimental X-ray diffraction patterns, the PDXL RIGAKU software package was used. The background was subtracted by the Sonneveld–Wisser method, the experimental profile was smoothed by the Savitsky–Golay method, and the components $k_{\alpha 1}$ and $k_{\alpha 2}$ were separated by the Rachinger method. To describe the diffraction maxima, a superposition of the Gauss function and the Lorentz function was used. The phase composition was determined using the ICCD PDF-2 database (2014). The diffraction pattern and phase composition of the test sample are shown in Figure 3 and Table 1.

![Figure 3. X-ray diffraction pattern of the test sample.](image)

Table 1. The phase composition of the test sample.

| Chemical formula | Type of crystal lattice | Lattice parameters |
|------------------|-------------------------|-------------------|
| FeCr$_{0.29}$Ni$_{0.16}$C$_{0.06}$ | 225:Fm-3m cubic crystal lattice | $a = 3.605153 \text{ Å}$, $b = 3.605153 \text{ Å}$, $c = 3.605153 \text{ Å}$ |
| Cr | 229:Im-3m cubic crystal lattice | $a = 2.871221 \text{ Å}$, $b = 2.871221 \text{ Å}$, $c = 2.871221 \text{ Å}$ |
| Cr$_7$C$_3$ | 51:Pnmc orthorhombic crystal lattice | $a = 6.940538 \text{ Å}$, $b = 12.029685 \text{ Å}$, $c = 4.506928 \text{ Å}$ |

4. Conclusion
Based on the performed x-ray microanalysis, it was found that the main phases in the sintered sample of electro-erosion materials of the Cr17 alloy obtained in illuminating kerosene are FeCr$_{0.29}$Ni$_{0.16}$C$_{0.06}$, Cr, Cr$_7$C$_3$. The study will determine the most relevant application area of the obtained samples and improve the quality of scientific and technological developments.

5. References
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