INFLUENCE OF CARBON ON THE FORMATION OF THE SURFACE LAYER IN THE PROCESS OF ELECTROEROSION ALLOYING OF STEEL WITH TUNGSTEN

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UDC 669.784:621.9.048.4

Electroerosion alloying is one of the promising methods of improving the properties of the working surfaces of parts.

In electroerosion alloying of carbon steels with electrodes of ferrochrome and a sintered carbide, the increase in carbon content in the steel being worked leads to an increase in microhardness and thickness of the alloyed layers [1].

However, information existing in the literature on the influence of carbon on the formation of the surface layer in electroerosion alloying is limited, and from the explanations given of the rules observed it is practically impossible to draw a conclusion as to the mechanism of the influence of carbon on the properties of the alloyed layers.

In connection with this, an investigation was made of the process of formation of the structure and properties of the surface layers formed in electroerosion alloying of the carbon steels 45, U8, and U13A with tungsten.*

Before electroerosion alloying, the samples were hardened and low-temperature tempered using the standard method for these steels.

The electroerosion alloying was done on an EFI-46 machine with an energy of a single discharge of 0.042 J.

Technical-purity tungsten 1.5-mm-diameter wire was used as the electrodes for alloying.

The increase in weight of the samples during the process was determined on an ADV-200 analytical balance (weighing accuracy ±0.1 mg).

Metallographic and microhardness analyses were made on a Neophot-2 optical microscope with an attachment for measuring the microhardness (with a magnification up to ×1200), micro-x-ray-spectral analysis of the surface alloyed layers was conducted on a Cameca MS-46 microanalyzer, and the x-ray diffraction analysis was made on a Dron-2.0 diffractometer.

The wear resistance of the surface-alloyed steel was determined on a wear machine with plane-parallel back-and-forth movement of the abradant (a block of high-strength cast iron after high-frequency induction hardening) on the stationarily fastened sample. Industrial-20 oil was used as the lubricant. The pressure on the rubbing pair was changed in relation to the degree of running-in of the rubbing surfaces. In the initial period it was 20 MPa; after 0.5 h, 50 MPa; after 1 h, 75 MPa; after 8 h, 100 MPa; after 16 h, 150 MPa; and after 23 h, 200 MPa, and then it was maintained at this level until the start of the period of intense wear of the samples (a total linear wear of the samples of more than 0.05 mm was considered intense).

The results of investigation of the kinetics of the increase in the weight of samples of 45, U8, and U13A steels in the process of electroerosion alloying are shown in Fig. 1. With an increase in carbon content in the steel, the time until the start of deerosion does not change (3.0·10^5 sec/m^2), but the value of the threshold of deerosion decreases — 37, 27, and 23 g/m^2 for 45, U8, and U13A steels, respectively.

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Fig. 1. Kinetic curves of the increase in weight (ΔW) of samples of the different steels (shown at the curves) in the process of electroerosion alloying with a tungsten electrode (energy of a single discharge 0.042 J).

Fig. 2. The distribution of microhardness (a) and tungsten (b) across the thickness of the tungsten surface-alloyed layers (h is the distance from the surface). The types of steels are shown at the curves. I/I₀ is the relative intensity of radiation.

This is apparently related to strengthening of the process of embrittlement of the surface-alloyed layers formed with an increase in the carbon content in the steel being treated, as the result of the increase in the level of residual stresses and the decrease in the dimensions of the areas of coherent scattering. To check this assumption, an x-ray diffraction analysis was made. On the diffractograms recorded from the alloyed surface with small and large angles of reflection, with an increase in carbon content in the steel and in the time of treatment of a unit of surface there was an increase in the width of the iron line.

The shift of the lines on the diffractograms in the direction of small angles and broadening of the (211)₉Fe line are an indirect indication of the increase in the level of residual stresses in the surface-alloyed layer with an increase in carbon content in the steel being treated.

In connection with this, the character of the kinetic curves presented in Fig. 1 may be explained as follows. With an increase in carbon content in the steel being treated, the stresses rapidly reach values equal to the tensile strength of the surface-alloyed layer, which leads to failure of it. The maximum on the kinetic curves, i.e., the threshold of erosion, corresponds to the start of failure. A further increase in the time of treatment of a unit of surface (more than 30·10⁴ sec/m²) leads to intensification of brittle fracture of the layer being alloyed and a decrease in sample weight.

The carbon content in the steel being treated has an influence on the phase composition of the alloyed layers. Increasing the carbon content leads to a reduction in the content in the surface layers of FeWO₄-type oxides (as the result of the deoxidizing action) and to an