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Title **CHANGES IN THE DEFECT STRUCTURE AND PHYSICAL AND MECHANICAL PROPERTIES OF IRON AND STEEL AS A RESULT OF EXPOSURE TO A HIGH-SPEED PLASMA JET**

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CHANGES IN THE DEFECT STRUCTURE AND PHYSICAL AND MECHANICAL PROPERTIES OF IRON AND STEEL AS A RESULT OF EXPOSURE TO A HIGH-SPEED PLASMA JET

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Abstract: The article deals with the complete technological procedure for the manufacture of knives, developed on the basis of an analysis of the results of laboratory studies of the process of cutting food materials with cutting plates of various configurations, as well as an installation for the preparation of thin plate knives.

Keywords: sharpening, cutting edge, knife holder, grinding wheel, grain size, blade microgeometry, durability, pilot plant.

Introduction

The article presents the results of studies obtained on samples of iron and steel 40X fused by a pulsed plasma jet with a different number of pulses and alloyed with eroding Mo electrodes; WC-Co and Ti (as well as various atmospheres including nitrogen).

On the example of α-Fe (alpha iron) and armco iron and steel 40X, it is shown that treatment with a plasma jet in the melting mode leads to a change in the defect structure (complexes, dislocations and twins), as well as to alloying of the near-surface layer of iron with Mo; WC-Co and Ti with the formation of new phases (FeMo, Fe7Mo6, Fe6W6C and W6C6Co, TiFe2, TiFe), a penetrated layer 40-60 μm thick with quenching from a liquid and solid state, which leads to an increase in hardness, an increase in wear resistance, an increase modulus of elasticity and "possibly" to increase the corrosion resistance in acidic environments.

In fig. 1a, b show the energy spectrum of backscattered ions (protons 1.745 MeV) obtained from a sample of α-Fe, fused by 20 pulses with an eroding electrode made of Mo (a) and concentration profiles of Mo elements; Fe; O; C and N in modified layer (fused) α-Fe. [1]

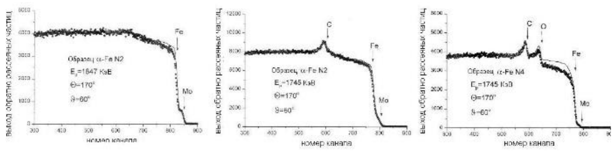


Fig. 1. a - RBS energy spectrum obtained using + 4He with an energy of 1.847 MeV for an α-Fe sample after pulsed plasma treatment (the number of pulses is 10, θ = 170˚, v = 60˚); b - energy spectrum obtained by the method of elastic resonance of protons with Ep = 1.745 MeV to determine the concentration of carbon and nitrogen on an α-Fe sample (the same mode); c — energy spectrum obtained by elastic resonance of protons with Ep = 1.745 MeV to determine the concentration of carbon and oxygen for α-Fe treated with a pulsed plasma jet (the number of pulses is 20). N0 is the channel number.

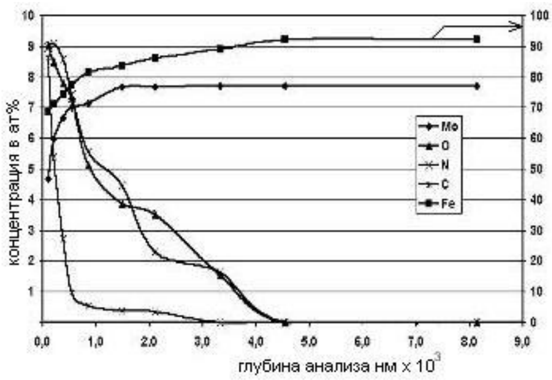


Fig. 2. Concentration profiles obtained from the energy spectra of the elements Mo, Fe, O, C, N in an α-Fe sample treated with a pulsed plasma jet (n = 10 pulses).

The hardness of the plasma-treated α-Fe area with an eroding Mo electrode increased to 750 ± 40 kg / mm2 in some areas, and on average increased to 250 ± 27 kg / mm2, with the initial α-Fe hardness 90 ± 12 kg / mm2

The next figure, Fig. 2a, b, c, shows the microstructure of the material (α-Fe) after fusion with a plasma jet with an eroding WC-Co electrode. As can be seen from the figure, the grain size is inhomogeneous, there is a scatter of grain sizes from 20 to 200 mkm, but large grains with a size from 150 to 200 mkm in the investigated area are less than 50% (Fig. 3a).

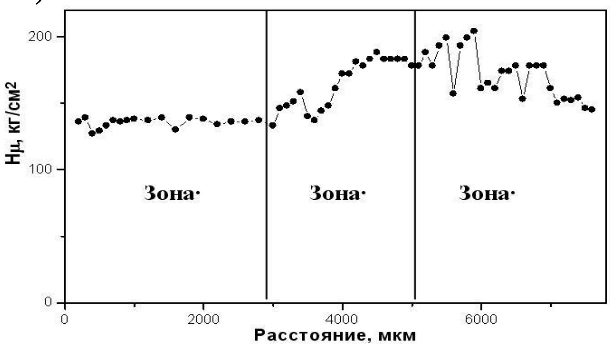
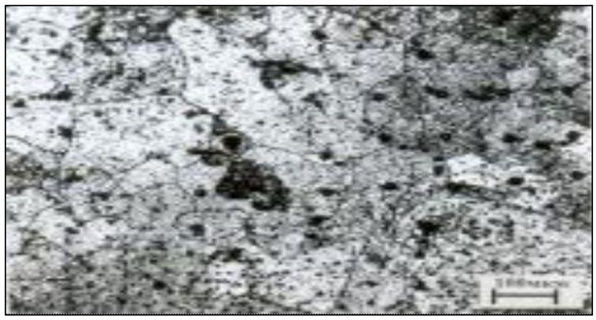


Figure: 3 Change in microhardness along the length of the sample (when processing with plasma in 3 passes). In fig. 3a-c show the heat affected zone. The maximum grain size reaches 150 microns. In the area melted by the plasma jet (3b), there is a surface with large black spots that are interspersed with the consumable electrode material (W, Co, Mo, Cr) - Fig. 4a, b [2, 3].

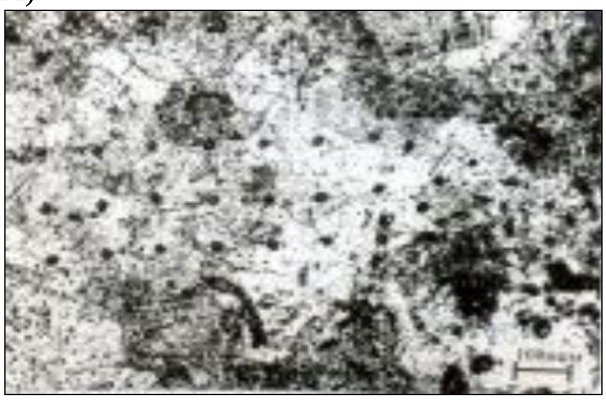
In those areas where the grain boundaries of the material are visible, the microhardness increased by 100% in comparison with the initial state of α-Fe. The average size of visible grains does not exceed 50 microns. Thus, under the influence of the plasma treatment, the grain changed.

The nanoindenter's measurements of the hardness of individual dark areas (inclusions) or areas with fused elements of the consumable electrode showed that the hardness reaches very high values, but a significant scatter of these values was found from 870 ± 50 kg / mm2 to 1480 ± 80 kg / mm2. The friction wear resistance of the cylinder on the plane increased 1.7 times as compared to the original α-Fe.

Figure 4 shows sections of a 40Kh steel section after treatment with a plasma jet with 10 pulses in an N atmosphere with a Ti consumption electrode.



A)



b)

Figure: 4. Metallographic structure of the sample surface in 2 zones: in the initial zone I (a) and in the transition zone II (heat-affected zone of the pulse-plasma jet) (b)

The thickness of the modified layer is 42.5 μm (as a result of melting and mixing in the liquid phase, Fig. 5a). Microanalysis carried out using EDS and a thin section showed a gradual decrease in the Ti concentration in the depth of the layer, and N was found only in the surface layer with a thickness of no more than 2 μm, and with a concentration of ~ 1 wt%.

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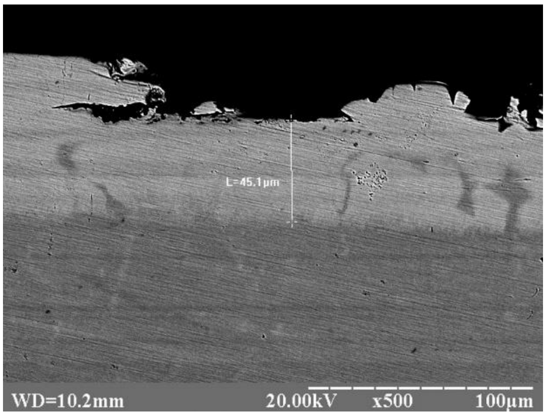
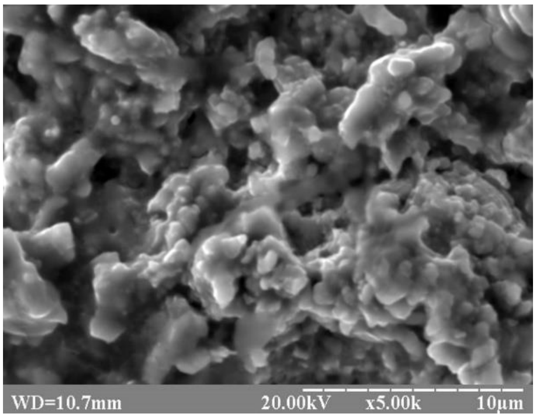
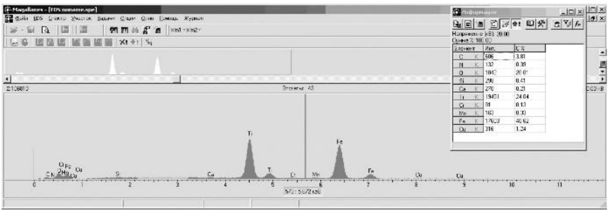


a)



b)



v)

Figure: 5 Image of a cross-sectional section of a 40X sample melted by a plasma jet in three pulses (a), the surface of the same sample, obtained using SEM (b), and an energy dispersive spectrum obtained from the sample surface (c). In fig. 5b shows an image of 40X steel after fusion with a plasma jet. Evaluation of the dislocation density using X-ray analysis, and preliminary results obtained using TEM analysis of the defect structure, showed that the dislocation density reaches (1.2-2.5) x 1010 cm-2.

In fig. 5c shows the energy-dispersive X-ray spectrum from which it is clearly seen that Ti (24%), Fe (40%), O (29%), C (3.8%) and other impurities introduced from the walls of the plasmatron chamber are found in the near-surface layer. and its nozzles.

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