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The influence of vibrating processing on a variation of the chemical composition and properties of electrospark mattings on steel

Key words

Influence, vibrating processing, electrospark mattings, steel, structure, chemical composition, vibro-electric-dynamic, layer-type multi-phase system, meta-sletab, properties.

Summary

In this work, the influence of preliminary vibration stress on the stabilisation of structure and properties of the surface layer of steel compounds with electric-spark coatings is presented.

1. The influence of vibrating processing on a variation of the chemical composition and properties of electrospark mattings on steel

Electric-spark alloying of the surface of steel 30XГСА was carried out on manufacturing machine “ЭЛФА-541” with the application of various standard electrodes. Vibration treatment (VT) was carried out on manufacturing vibro-electric-dynamic standing ВЭДС-200 with base of 10^7 cycles. Changes within the chemical composition and structure of the alloyed layers have been studied by methods of light and scanning electronic microscopy with local X-ray

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analysis and by way of layer-by-layer X-ray phase analysis. Changes in these mechanical properties have been studied by methods of micro-hardness and high cycle fatigue.

Electric-spark alloying of 30XГCA steel leads to the formation on its surface of a layer-type multi-phase system, consisting of an actual coating and a transfer zone. It was found that the formation of an alloyed layer on the surface of 30XГCA steel, in conditions of transient heat, thermally impacts the air in such a way that it leads to the formation of a disperse (grain size 0.2...3.0 μ layer-type structure (Fig. 1) with high quantity of meta-sletab, which, in the case of application of chromium-based, nitride-based and titanium carbide-based electrodes leads to substantial (2-3 times) reinforcement of their surfaces (Table 1).

Table 1. Micro-hardness of electric-spark coatings of 30XГCA steel before and after alternating-sign loading

Material of electrode	Average values of micro-hardness, GPa			
	before VT		after VT	
	surface	transfer zone	surface	transfer zone
Chromium	6.99	7.30	8.45	9.87
Chromium + aluminium	6.87	7.12	7.08	10.38
Chromium + copper	4.53	3.85	3.11	2.66
Titanium nitride	6.66	7.63	7.83	13.70
Titanium carbide	4.65	5.46	8.61	9.77

The coating actually is an area of co-existence of two BCC-solid substitute solutions with an interlayer of inter-metallic phase (Fig. 2). A method of defining of the chemical composition of solutions and the calculation of grid parameters are suggested [1-2]

The definition of grid parameter a of BCC-solid solutions was carried out by the Neiman-Reilly extrapolation function on the basis of experimental data from X-ray structural phase analysis [3]. Using the distribution data of alloying elements by depth, the theoretical values of grid parameters were calculated according to the following formula:

$$a_{p-pa} = a_0 + \frac{\partial a_0}{\partial C_1} \cdot C_1 + \frac{\partial a_0}{\partial C_2} \cdot C_2 + \dots + \frac{\partial a_0}{\partial C_m} \cdot C_m ,$$

where a_0 – parameter of base grid, C_1, C_2, \dots, C_n – concentration of elements, dissolved in base grid, $\frac{\partial a_0}{\partial C_1}, \frac{\partial a_0}{\partial C_2}, \dots, \frac{\partial a_0}{\partial C_m}$ – tangent tilt of graphs of a (C_n) according to Vergard's law in corresponding binary systems.

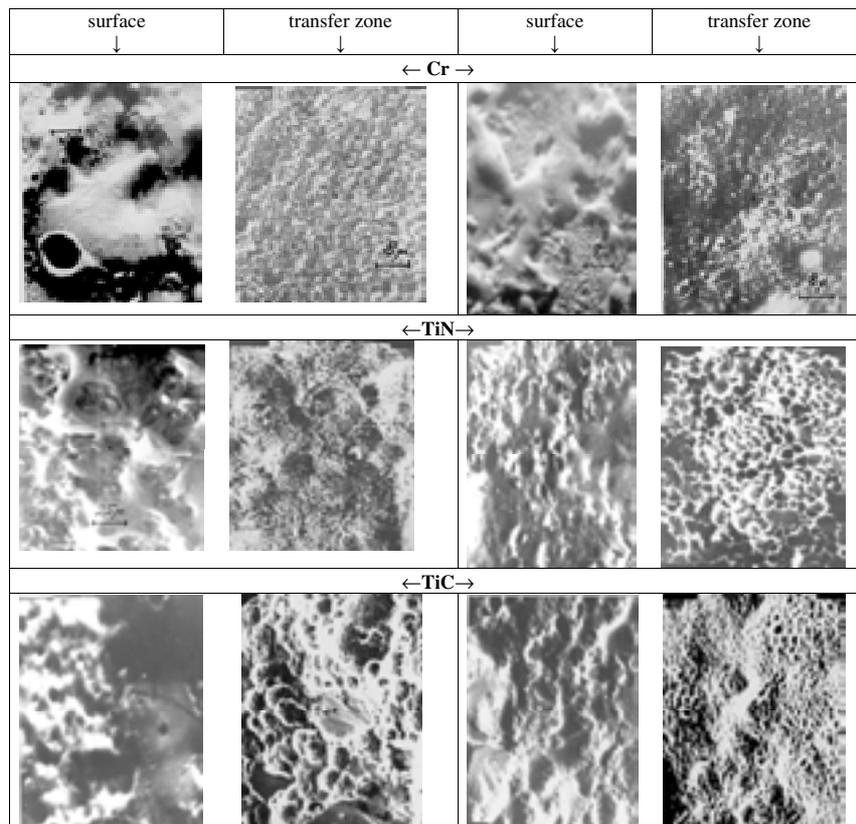


Fig. 1. Structure of electric-spark coatings surface and there transfer zones on 30X17CA steel before (a) and after (b) alternating-sign loading

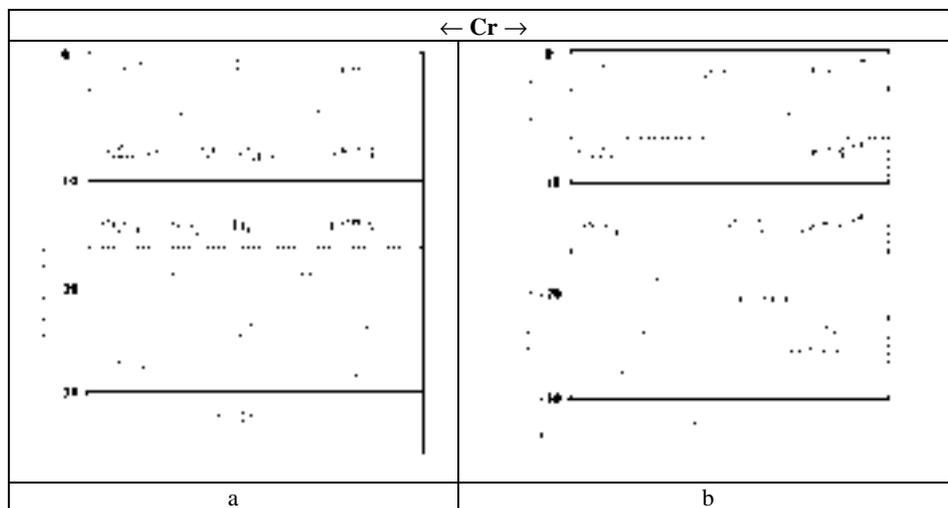


Fig. 2. Scheme of location of phases I electric-spark coatings on 30X17CA steel by depth before (a) and after (b) alternating-sign loading

An almost complete match of the experimental and theoretical values of the solution grid parameters were observed.

It was found that the distribution of the concentration of basic elements of the system (chromium, iron, manganese, silicon) by depth of alloyed layer of steel compound has non-a monotonous character. The increase of concentration of chromium, iron, and silicon in the transfer zone along with the penetration of iron and silicon into the coating were observed as well. (Fig. 3).

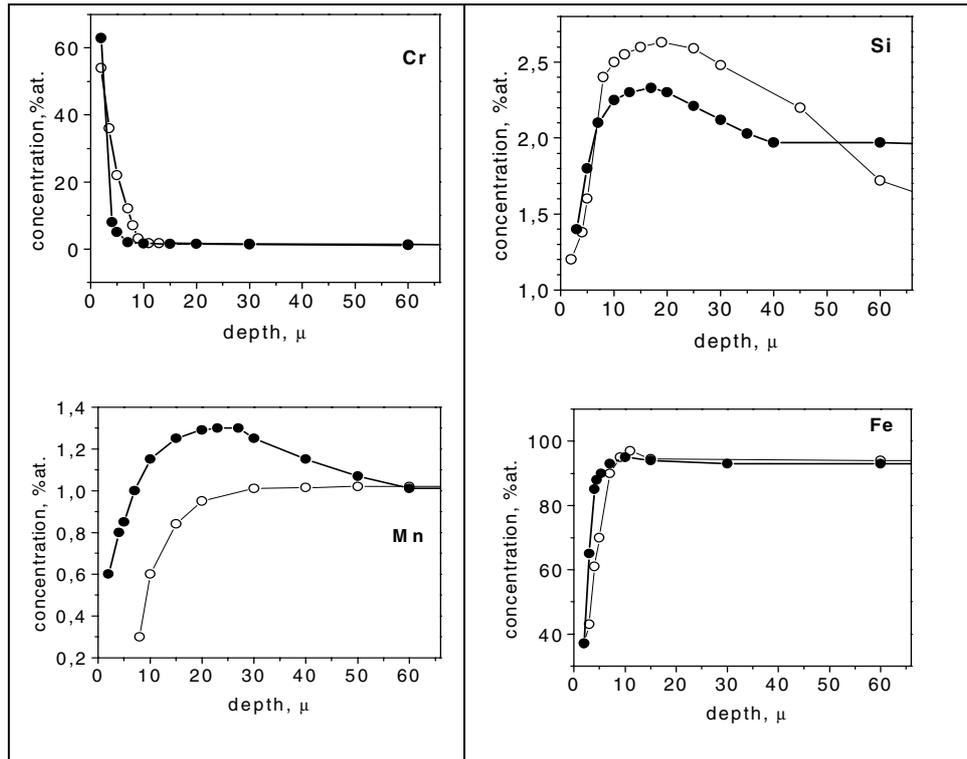


Fig. 3. Distribution of alloyed layer of chromium electric-spark coatings of basic alloying elements by depth before (●) and after (○) alternating-sign loading

With the help of layer-by-layer X-ray structural analysis, the phase composition of surface and subsurface layers of steel compounds [4] treated with electric-spark alloying with the application of chromium-based, nitride-based titanium carbide-based electrodes as well as after recurrent electric-spark alloying of chromium coatings by copper and aluminium have were studied. It was determined that the alternating-sign loading of steel compounds with electric-spark chromium-based, nitride-based and titanium carbide-based coatings as well as in the case of recurrent alloying of chromium coatings by

aluminium leads to changes in the structure of the surface and subsurface alloyed layers. The increase of the dispersivity of structure as well as the appearance of a large number of small (of size 0.1-0.5 μ) particles on the surface and on the transfer zone (Fig. 1) are observed. The reinforcement of coating and transfer zone has taken place (Table 1).

After cyclic loading the redistribution of basic elements of the system (iron, chromium, manganese, silicon) in the surface and subsurface layers of the alloyed area of steel compounds with chromium electric-spark coatings have taken place (Fig. 3), which led to substantial changes in the phase composition of the studied layers of electric-spark coatings. It is noted that the formed phases that occurred, unlike deformed ones, are more thermodynamically stable and possesses a higher symmetry of crystal grid (Fig. 2).

We detected that, in chromium electric-spark coatings under the effect of cyclic loading, the chemical composition of BCC-solid solutions has changed. The grid parameter of chromium-based solution 2, located on the surface of the coating, has increased at the expense of the dissolution of manganese in it. The grid parameter of α -iron-based solution 1, located in the area of the mating of the coating and transfer zone, has not changed, which is connected with the condition of the mating of crystal grids of layers: matrix -- solution 1-- inter-metallic σ -FeCr -- solution 2.

In all the analysed electric-spark coatings, the increase by a factor of two of the intensities of interferential lines located between solid solutions of a coating as well as constancy of parameters of grids of solid solutions located on the boundary of mating of coating and transfer zone have been indicated.

Thus, high cyclic alternating-sign loading of steel compounds with electric-spark coatings of different compositions leads to the deformation-stimulated disperse reinforcement of surface and subsurface layers in the case when the particles of solid phases are present in the coating. In such a case, cyclic treatment leads to the stabilisation of the alloyed layer at the expense of the formation of more thermodynamically stable phases in the system than the initial ones. In "soft" plastic copper-containing coatings, alternating-sign loading leads to a reverse effect and to a loss of strength within the alloyed layer. The alternating-sign plastic deformation of steel compounds with electric-spark coatings, which is increasing the energy of the system, creates a prerequisite for bringing about new and more stable phases with a high melting point temperature and formation point temperature, analogous to those conditions that have been observed in the alloys which have been heated up to high temperatures.

The processes and methods discussed above are experimentally qualified; therefore, they deserve fair attention and consideration for future use in the development of new technologies, and these methods will serve to further improve and advance activity in the area of electric-spark coatings and in the properties of steel.

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