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Use of Metastable States in the Formation of the Tribotechnical Properties of Eutectic Alloy on the Basis of Iron

Are examined the special features of the influence of metastable states on the processes of the formation of the tribotechnical properties of eutectic coating. It is shown that by changing the degree of the non equilibrium of thermodynamic state it is possible to govern their tribotechnical and corrosive properties.

Practically all using by person alloy-steel, cast irons, alloys on the basis of aluminum, titanium, copper, chromium, molybdenum, tungsten, etc., is located in the metastable state. The properties of these alloys, determined by the variety of metastable phases and structures, contain potential control capability of them by displacement paths of system from the position of thermodynamically equilibrium to the no equilibrium states [1-4]. With the advent of sources of the high concentration of energy (laser processing, the hot-gas methods of spraying, electroenergy ray, highly frequency induction heating so forth.) control capabilities of metastable phases and of the structures of alloys were substantially enlarged [5-7], in comparison with the traditional methods (volumetric hardening, annealing, leave, temperature aging). The use of such sources made it possible to realize high-speed temperature action into local volumes, which revealed new possibilities the combination of the different degree of metastable states and creation of the uncommon compositions of structural-phase compositions

The analysis of the results of the contemporary thermal and combined methods of working existing steels and alloys shows that the greater the variety in them of metastable states, the higher the control capability of their behavior, i.e., by properties [8].

During the rapid cooling from the liquid state in eutectic alloy the appearance of metastable phases is possible. Such phases come out the chemical connections, which exist on the appropriate phase diagram, but in another temperature-concentration region, (metastable phases of the first kind), or, connection not existing on this diagram (metastable phases of the second kind).

Thus, changing the rate of cooling of eutectic appears the possibility to govern their properties: mechanical, physical, chemical, operational. This possibility, for example, widely is used in practice during the selection of the optimum combination of the properties of eutectic steels and cast irons [9-11].

In cast eutectic alloy on the basis of transition metals with the refractory phases of introduction, as a result of the small mutual solubility, practically, are combined the initial properties of the phases, which form its [12,13]. The phases of introduction possess high thermodynamic stability, melting point, hardness, strength, elasticity, chemical- and wear resistance. The combination of the phases of introduction with the less solid, but more plastic metallic matrix gives unique properties to such eutectic. Thus, alloys on the basis of iron with refractory carbides and borides in the cast state (tab. 1) possess high wear resistance in combination with high corrosion resistance, strength, technological effectiveness [14]. They do not contain the scarce or expensive components. These properties open great possibilities for using the eutectic in the friction units of machines and mechanisms.

Because of higher enumerated special features eutectic alloy on the basis of iron with refractory carbides and borides combine in themselves the properties of the alloyed solid solution on the basis of γ-iron and the high strength and tribotechnical properties of the phases of introduction.

№	Alloy grade	Phase composition		number of phaseseutectic , mas. %
		Matrix	Hardener	
1	BTH	12X18H9T	TiB_2+VC	TiB_2-4,6; VC- 9,8
2	XTH	12X18H9T	TiB_2+CrB_2	TiB_2- 4,4; CrB_2- 7,5
3	XBC	30X13	VC	VC - 17

Table1. Structural-phase composition of the eutectic coatings

The use of tribotechnical materials in the cast state has limited application, since with the friction surface and near-surface layers work; therefore in the present work the purpose is set: by the control of different degree of the metastability of states in the eutectic coatings on the basis of iron, reinforced by refractory carbides and borides, to accomplish regulation of their tribotechnical properties.

Coatings of the above-indicated eutectic were obtained KIB (condensation, stimulated by ionic bombardment) and hot-gas methods. Advantageous use by a micro of drop component of the products of the arched dispersion of cast cathode in the method KIB makes it possible to transfer its phase composition from the cathode into the coating. Thus, it is possible to expect retention in the obtained coatings of the high tribotechnical and corrosive properties, inherent in eutectic alloy in the cast form.

It is necessary to note that distinction of the selected technologies, is the high rate of heating eutectic alloy, the short lifetime of fusion (fraction of a second) and the subsequent rapid cooling on a comparatively cold base layer. These special features lead to the appearance of the misbalance states, which are manifested in the form of a change in the mechanism of crystallization at the eutectic point. Instead of the colonial structures, inherent in cast state, are formed the structures of the thin conglomeration of phases (fig. 1), and it appears a larger quantity of metastable phases (tab. 2).

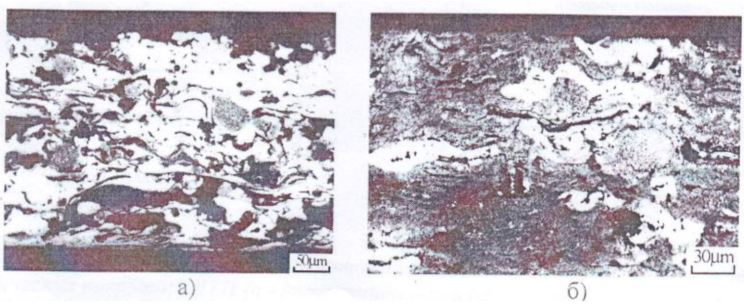

Fig.1. Structure of the gas-explosion eutectic coating VTN. a- initial (sprayed) state with a large quantity of regions of the thin conglomeration of phases (white layers); b- the annealing of coating with T=0,75Tpl, $\tau = 0{,}5$

The X-ray structural phase-shift analysis shows that in eutectic the coatings together with the equilibrium phases being investigated, which exist on the phase diagram, are formed the no equilibrium phases I and II kind (table 2).

A composition and a quantity of metastable phases determine the tribotechnical and corrosive properties of the studied coatings. The relationship between the equilibrium and non equilibrium phases (table 2) and also by structure and, therefore, by the properties of the obtained eutectic coatings is possible to govern via annealing.

№	eutectic	phase composition		
		initial	annealing 0,75 Тпл	
			0,5 h	5 h
1	BTH	$\alpha' + \gamma' + \gamma +$ $+ VC + TiC + VC' + CrB_2$	$\gamma' + VC + CrB_2 + \gamma + TiC'$	$\gamma' + \gamma + VC + VC'$
2	XBC	$\alpha + \gamma' + \gamma + VC' + Cr_{23}C_6 + Cr_3C_2$	$\alpha + \gamma' + VC' + Cr_3C_2 + Cr_{23}C_6$	$\alpha + \gamma' + VC' + Cr_{23}C_6$
3	XTH	$\alpha' + \gamma + TiC'$	$\alpha' + \gamma' + TiC'$	$\alpha' + \gamma' + TiC' + CrB_2 + TiB_2$

Table2. Influence of heat working on the phase composition of the eutectic coatings

In figure 2, it was given micro properties of the component initial (sprayed) and annealed eutectic hot-gas coatings. The high-temperature homogenizing with (0, 75 Tpl) leads to a change in the phase composition of coatings, latter it will lead to some change in their structure. (Figure 1, b). Furthermore, annealing changes the chemical activity of structural components of eutectic coatings (increase in the etch ability, in comparison with the initial, sprayed state) and high-temperature oxidizability.

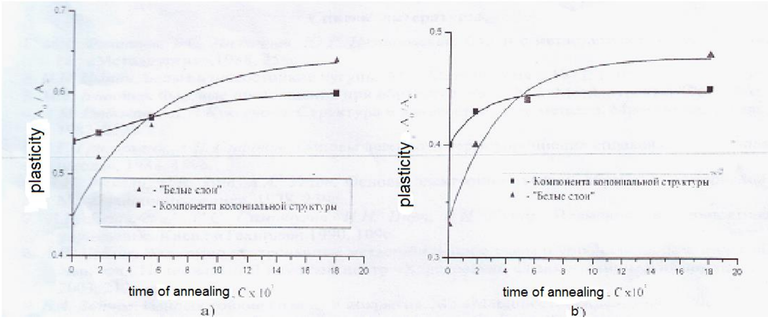

Fig.2. Change in the micro properties of structural components of the hot-gas eutectic coatings VTN (a- b- plasma) in dependence of the time of annealing at a temperature of 0, 75 Tpl

The formation of oxide films at high temperatures in air plays very important role in the tribotechnical properties, especially with the dry friction of slip.

The resultant of the friction oxide films, with their composition, structure, thickness, adhesion play the role of solid lubricant, change tribotechnical characteristics. Oxide films are capable of effectively decreasing the wear not only of coating, but also friction pair as a whole. Thus changing the degree of the non equilibrium of the state of the studied eutectic coatings it is possible to govern the tribotechnical properties of friction pair. This is very important quality, since, at present is known the very limited quantity of eutectic metallic systems (on the basis of lead), by tribotechnical properties of which it is possible to govern by changing the degree of metastable state. A drawback in such systems is low strength, that it does not make it possible to use them in the friction units with the high contact loads. Since under investigation eutectic coatings as the basis being contained solid solutions on the basis of iron, the strengthened by refractory phases introductions, contact loads in these coatings can be appreciably above. This makes it possible to use the assumed eutectic coatings for solving the wider circle of the tasks of tribotechnology.

Conclusions:

1) Hot-gas and KIB eutectic coatings on the basis of iron with refractory carbides and borides have non equilibrium structure and contain the metastable phases, which determine their tribotechnical properties with the dry friction of slip. The same principles can be used under the conditions of the presence of the lubricant between the friction surfaces.

2) By changing the degree of the non equilibrium of the thermodynamic state of the studied eutectic coatings (annealing) it is possible to govern their tribotechnical and corrosive properties.

3) The application of the studied eutectic coatings makes it possible to expand the circle of the tribotechnical tasks, connected with the decrease of the summary wear of friction pair under the conditions of the limited lubricant.

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