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STUDY OF PHYSICO-MECHANICAL PROPERTIES OF COMPOSITE IRON-NICKEL COATINGS AND THEIR IMPACT ON THERMAL RESISTANCE OF BOUNDARY LAYERS OF LUBRICANTS

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Articolul prezintă studiul proprietăţilor fizico-mecanice (Ae, Ap, A, he, Hh, Hd, P) şi rezistenţei termice (Tcr) a straturilor de graniţă de ulei de lubrifiere M12B în timpul frecării acoperirilor compozite de fier-nichel. S-a stabilit experimental că acoperirile de fier-nichel cu proprietăţi fizico-mecanice sporite (Ae, Ap, A, he, Hh, Hd, P) contribuie la sporire a rezistenţei termice (Tcr) a straturilor de graniţă de ulei de lubrifiere M12B.
Cuvinte-cheie: acoperire fier-nichel, lubrifiere, straturi, proprietăţi fizico-mecanice, rezistenţă termică, frecare.

The paper presents the study of physico-mechanical properties (Ae, Ap, A, he, Hh, Hd, P) and thermal resistance (Tcr) of boundary lubricating oil layers M12B during the rubbing of composite iron-nickel coatings. It was experimentally established that iron-nickel coatings with higher physical and mechanical properties (Ae, Ap, A, he, Hh, Hd, P) contribute to the increase of thermal resistance (Tcr) of boundary lubricating oil layers M12B.
Keywords: iron-nickel coatings, lubricating, layers, physic-mechanical properties, thermal resistance, rubbing.

1. INTRODUCTION

The relevance of research and testing of physical and mechanical properties of materials at the surface and in the surface layers due to the fact that the contact interaction and contact deformation associated with nearly all modern methods of treatment, hardening and metal compounds, but also service properties of metals in terms of friction, fatigue, seizure and wear.

One of their methods of testing the surface properties of materials-test macro hardness.

2. GENERAL INFORMATION

In recent years developed methods and devices, allowing obtaining a wealth of information about the properties of materials at macro indentation. Material test method allows macro indentation measure several important parameters characterizing the physical and mechanical properties of composite plating, traditional and new, obtained only when these tests. The method of investigation of physical and mechanical properties of the coating is based on recording the kinetic diagram of a spherical diamond indenter indentation. As the spherical diamond indenter was used synthetic diamond sphere with radius equal to 1 mm.

Subjected to testing composite iron-coating thickness of 0.5 mm, the diameter of the sample in this case is 30 mm.

Test method for macrohardness allows testing of the wide application of materials with a thickness of 1 mm or more. Thus it is possible to determine not only the strength characteristics of the material but also its elastoplastic properties.

Many researchers have studied the shape of the plastically deformable deformation zones, and in the nature of a screen where the fingerprint shown that the boundary area of plastically deformable nature of the deformation and the diameter d a fingerprint similar in shape to the part of a sphere for both metals and polymers.

We studied the deformation of deep and surface layers of materials under the indenter by applying a grid meridian section in the plane of the sample. We prove that the maximal deformation axis indentation depth of approximately half the radius of the print at the point of maximum shear stress. On the surface indentation deformation grow from the center of the contour near the circuit decreases and beyond change direction. Inverting the direction of deformation occurs due to the fact that the printout at some distance underneath the material undergoes axial compression and broadening in the radial direction.

This paper presents the study of physical and mechanical properties of Fe-Ni composite coatings by indentation spherical diamond indenter.

Experimentally determined: elastoplastic characteristics (**he**; **hp**, **h**); work spent on elastic (**Ay**), plastic (**Ap**), and the total deformation (**A**); unrestored (**Hh**) and dynamic (**Hd**) hardness, indentation load on a spherical diamond indenter (**P**), the volume of elastic (**Ve**), a plastic (**Vp**) and the total (**V**) of a deformable composite material of iron-nickel coatings produced from the electrolyte 4 [2]. The above characteristics were determined at the facility for the study of the hardness of materials in macro volume equipped with an inductive sensor and a differential amplifier to record chart indentation spherical diamond indenter and indentation recovery after unloading.

The dynamic hardness (**Hd**) was determined as the ratio of the total of (**A**) consumed for the total deformation of the material (**V**) the volume of deformable material all studied Fe-Ni coating. Important indicators in assessing the anti-friction properties of bearing materials is their ability to provide at the operating temperatures of the bearing and lubrication conditions instantaneous coefficient of friction and cause seizure and seizure in the destruction of the lubricating layer separating the friction surface [2]. For protection from seizure is important to assess the maximum allowable friction conditions, depending on the combination of the properties of materials and lubricants [2]. Studies have shown that the destruction of the boundary layer for the material and lubrication occurs when the contact zone a certain critical temperature constant for the combination of such material and grease. Thermal resistance of the boundary lubricant layer is estimated complex material and lubricating oil. These properties can be attributed to the ability of the interacting surfaces gripe adhesive bond with oil film on the surface, the ability to recover these bonds at fracture oxidability friction surfaces as well as the quality of the oxidized films [2].

Defined critical temperature boundary layer lubricating in friction materials used friction machine **MAST - 1** operates as a cone - ring sample [2]. On a conical pattern with an apex angle of 110°±1° composite iron-deposited coatings, which have been processed by grinding and polishing. Working on an annular surface sample was created as a result of pressing the same geometry of the cone on the press under load -dependent plasticity. In the case of low ductility materials (iron) treatment by a special ring shaped cutters mounted on the bottom hole sample. With a width of 0.2 mm was provided by the belt contact geometry, which is close to linear.

The magnitude of unit loads at the site of contact for selected sample sizes and design features of the machine **MAST–1** varied from $25 \cdot 10^{-3}$ N/m^2. The speed of rotation of the upper sample is 1 rot/min, which corresponds to $0.42 \cdot 10^3$ sliding speed for indicating the size of the sample. Bulk oil temperature was varied from 20 to 400°C.

Before testing, the samples were kept in the oil for one hour to form on their surface oriented layers oil. Burnishing the samples was carried out under a load of $10 \cdot 10^{-3} \div 15 \cdot 10^{-3}$N/m^2. On completion of the run-in to establish the position of judge of the pen recorder. Counter body was made of alloyed cast iron following chemical composition:

C_{total}=3.75%; $C_{binding}$=0.75%; Si=2.45%; Mn=0.65%; P=0.15%; Cr=0.25%; Ni=0.11%; Cu=0.75%; S=0.11%; Mo=0.4%.

Alloy cast iron made factory - rings made from the same cast. Proved that by varying the density of only **Dк** and electrolyte temperature can change physics - the mechanical properties of iron-nickel coatings (**Ae**, **Ap**, **A**, **Hh**, **Hd**, **P**).

3. DISCUSSION OF EXPERIMENTAL RESEARCH

Studies have shown that the investigated characteristics of composite iron-nickel coatings vary with the conditions of their receipt (**D_K**, **T**).

With increasing current density (**D$_k$**) of from 5 to 80 (×10^{-4} kA/m^2) at a constant temperature of electrolysis (40 ^{0}C), the elastic indentation depth (**he**) and the amount of elastic indentation of the coating material (**Vy**) increases, respectively, from 1.34 to 1.35 (micrometers), and from 40.34 to 57.17×10^{-7} (mm^3) Table 1. Dependence unreduced hardness (**Hh**), dynamic hardness (**Hd**), the load on the indenter (**P**) and the work expended on the elastic deformation of coatings (**Ae**) are extreme.

With increasing current density from 5 to 50 (×10^{-4} kA/m^2), hardness (**Hh**) increased from 3630 to 4470 (N/mm^2), the dynamic hardness (**Hd**) increased from 2422 to 2890 (N/mm^2), the load on a spherical diamond indenter increased from 45.6 to 56.1 (H), and the work spent on the elastic deformation Fe-Ni composite coatings (Ae) increased from 17.23×10^{-3} to 23.56×10^{-3} (N·mm). With a further increase in current density from 50 to 80 (×10^{-4} kA/m^2), the hardness (**Hh**) decreased from 4470 to 3320 (N/mm^2), the dynamic hardness (**Hd**) decreased from 2980 to 2215 (N/mm^2), the force of the diamond spherical indenter (P) decreased from 56.1 to 41.7 (N) and the work spent on the elastic deformation (**Ay**) Fe-Ni composite coatings decreased from 23.56×10^{-3} to 15.77×10^{-3} (N/mm).

Extreme hardness (**Hh**), a dynamic hardness (**Hd**), load on a spherical diamond indenter (**P**) and the work consumed by the elastic deformation of Fe-Ni composite coatings coincide with the existing guidelines for the choice of Electrolysis conditions for optimum Fe-Ni coating from the standpoint their wear resistance.

Table 1

Elastic properties of hardness and Fe-Ni composite coatings

Electrolysis conditions		Hh, N/mm^2 (h=2μm)	Hd, N/mm^2	P, N	***Elastic properties of the Fe-Ni coating***		
Dk, ×10^{-4} kA/m^2	T,^{0}C				he, μm	Ap, N·mm	Ve, ×10^{-7} mm^3
5	40	3630	2422	45.6	1.134	0.01723	40.34
10	40	3670	2449	46.1	1.150	0.01767	41.47
20	40	3800	2534	47.7	1.172	0.01863	43.11
30	40	3980	2656	50.0	1.210	0.02017	45.93
40	40	4120	2746	51.7	1.240	0.02137	48.23
50	40	4470	2980	56.1	1.26	0.02356	49.80
60	40	4020	2683	50.5	1.28	0.02020	51.40
80	40	3320	2215	41.7	1.35	0.01577	57.17

Table 2

Plastic properties and hardness Fe-Ni composite coatings

Electrolysis conditions		Hh, N/mm^2 (h=2 μm)	Hd, N/mm^2	P, N	***Plastic properties of Fe-Ni coating***		
Dк, ×10^{-4} kA/m^2	T,^{0}C				hp, μm	Ap, N·mm	Vp, ×10^{-7} mm^3
5	40	3630	2422	45.6	0.8660	0.01316	23.57
10	40	3670	2449	46.1	0.8500	0.01351	22.67
20	40	3800	2534	47.7	0.8280	0.01357	21.50
30	40	3980	2656	50.0	0.7900	0.01361	19.56
40	40	4120	2746	51.7	0.7600	0.01369	18.11
50	40	4470	2980	56.1	0.7400	0.01384	17.17
60	40	4020	2683	50.5	0.7200	0.01212	16.26
80	40	3320	2215	41.7	0.6500	0.00904	13.25

Table 3

Elastic-plastic properties and hardness of Fe-Ni composite coatings

Electrolysis conditions		Hh, N/mm^2 (h=2 μm)	Hd, N/mm^2	P, N	***Elastoplastic properties***		
Dк, $\times10^{-4}$ kA/m^2	T,^{0}C				h, μm	A, N·mm	V, $\times10^{-7}$ mm^3
5	40	3630	2422	45.6	2.0	0.03040	125.51
10	40	3670	2449	46.1	2.0	0.03073	125.51
20	40	3800	2534	47.7	2.0	0.03180	125.51
30	40	3980	2656	50.0	2.0	0.0333	125.51
40	40	4120	2746	51.7	2.0	0.0347	125.51
50	40	4470	2980	56.1	2.0	0.03740	125.51
60	40	4020	2683	50.5	2.0	0.0337	125.51
80	40	3320	2215	41.7	2.0	0.02780	125.51

With increasing current density (D_k) - table 2, from 5 to 40 ($\times10^4$ kA/m^2) at a constant temperature of electrolysis (40 ^{0}C) of the plastic indentation depth (**hp**) and the volume of plastic indentation test material (**Vp**), respectively decrease from 0.866 to 0.740 (micrometers), and from 23.57×10^{-7} to 17.17×10^{-7} (mm^3). With increasing density of 5 to 50 ($\times10^{-4}$ kA/m^2) at a constant temperature of electrolysis (40^{0}C) hardness (**Hh**), a dynamic hardness (**Hd**) indentation load (P) has increased as in the previous case (Table 1) and the work expended in plastic deformation (**Ap**) Fe-Ni composite coatings increased from 13.16×10^{-3} to 13.84×10^{-3} (N·mm).

With a further increase in current density (D_k) at constant electrolysis temperature (40 ^{0}C) of 50 to 80 ($\times10^{-4}$ kA/m^2) hardness (**Hh**), a dynamic hardness (**Hd**), indentation load (**P**) and reduced as in the previous case (table 1), and the work expended in plastic deformation of Fe-Ni composite coatings decreased from 13.84×10^{-3} to 9.04×10^{-3} (N·mm).

And in this case, the extreme hardness (**Hh**), dynamic hardness (**Hd**), indentation load (**P**) and the work expended in plastic deformation (**Ap**) Fe-Ni composite coatings coincide with existing recommendations for choosing electrolysis conditions to obtain optimal properties Fe- Ni coatings in terms of wear resistance [2].

With increasing current density (**D_k**) in table 3, from 5 to 80 ($\times10^{-4}$ kA/m^2) (at a constant temperature of electrolysis (40^{0}C) total indentation depth (h) and the total amount of material pressed into coatings (V) are constant, and are respectively 2.0 (μm) and 125.51×10^{-7} (mm^3).

With increasing current density (**D_k**) from 5 to 50 ($\times10^{-4}$ kA/m^2) at a constant temperature of electrolysis (40^{0}C) hardness (**Hh**), a dynamic hardness (**Hd**) indentation load (P) increases in both the previous cases (tables 1 and 2) and consumed by the deformation work Fe-Ni composite coatings (a) is increased from 30.4×10^{-3} to 37.4×10^{-3} (N·mm). With a further increase in current density (**D_k**), electrolysis at a constant temperature (40 ^{0}C) of 50 to 80 ($\times10^{-4}$ kA/m^2) Hardness (Hh), a dynamic hardness (**Hd**), at indentation load spherical diamond indenter (**P**) decreases both preceding case (table 1 and 2) and total work expended by deforming Fe-Ni composite coatings decreased from 37.4×10^{-3} to 27.8×10^{-3} (N·mm).

And in this case, the experimental values of hardness (**Hh**), dynamic hardness (**Hd**), indentation load spherical diamond indenter (P) and the work spent on the total deformation of Fe-Ni composite coatings (**A**) coincide with current recommendations for choosing electrolysis conditions for optimum properties of Fe-Ni composite coatings in terms of wear resistance.

With increasing temperature electrolysis (**T**) for obtaining Fe-Ni composite coatings (Table 4) of 20 to 60^{0}C (at $Dk=50\times10^{-4}$ kA/m^2), the elastic component of the depth of the indentation (**hu**) decreased from 1.52 to 1.028 μm, print volume (**Ve**) also decreased from 72.5×10^{-7} to 33.15×10^{-7} mm^3. With increasing temperature electrolysis from 20 to 40^{0}C, hardness (**Hh**) has increased from 3320 to 4470 (N/mm^2), dynamic hardness (**Hd**) increased from 2215 to 2980 N/mm^2, indentation load on the diamond spherical indenter (**P**) increased from 41.7 to 56.1 (N), the work spent on the elastic deformation of Fe-Ni composite coatings (**Ae**) increased from 21.13×10^{-3} to 23.56×10^{-3} (H·mm), and the volume of print on elastic deformation of coatings (**Ve**) decreased from 72.5×10^{-7} to 49.8×10^{-7} (mm^3).

Table 4

Elastic properties of hardness and Fe-Ni coating.

Electrolysis conditions		Hh, N/mm^2 (h=2 μm)	Hd, N/mm^2	P, N	***Elastic properties of the Fe-Ni coating***		
Dk, x10^{-4} kA/m^2	T,^{0}C				he, μm	Ae N·mm	Ve, ×10^{-7} mm^3
50	20	3320	2215	41.7	1.52	0.02113	72.50
50	40	4470	2980	56.1	1.26	0.02356	49.80
50	60	3630	2422	45.6	1.028	0.01563	33.15

With further increase of the electrolysis temperature (**T**) of 40 to 60^{0}C, a hardness (**Hh**) was reduced from 4470 to 3630 (N/mm^2), the dynamic hardness (**Hd**) decreased from 2980 to 2422 (N/mm^2), the force on a spherical diamond indenter (**P**) decreased from 56.1 to 45.6 (H**)**, and the work spent on the elastic deformation (**Ae**) Fe-Ni composite coatings decreased from 23.56×10^3 do 15.63×10^{-3} (N·mm).

In this case, the experimental values of hardness (**Hh**), a dynamic hardness (**Hd**), at indentation load spherical diamond indenter (**P**), the work expended in elastic deformation Fe-Ni composite coating (**Ae**), depending on the electrolysis temperature (**T**) at constant current density (**Dk**=50×10^{-4} kA/m^2) coincide with current recommendations for choosing electrolysis conditions to obtain optimal properties of Fe-Ni composite coating with the point of view of their optimum wear resistance [2].

With increasing temperature electrolysis (**T**), upon receipt of Fe-Ni composite coating (Table 5) of 20 to 60^{0}C (when **Dk**=50×10^{-4} kA/m^2) plastic components.

Table 5

Plastic properties and hardness Fe-Ni composite coating

Electrolysis conditions		Hh, N/mm^2 (h=2μm)	Hd, N/mm^2	P, N	***Plastic properties***		
Dk, кA/m^2	T, ^{0}C				hp, μm	Ap, N·mm	Vp, ×10^{-7} mm^3
50	20	3320	2215	41.7	0.480	0.00667	7.22
50	40	4470	2980	56.1	0.740	0.01384	17.17
50	60	3630	2422	45.6	0.972	0.01877	29.64

Table 6

Elastoplastic properties hardness and Fe-Ni composite coatings

Electrolysis conditions		Hh, N/mm^2 (h=2μm)	Hd, N/mm^2	P, N	***Elastoplastic properties***		
Dk, kA/m^2	T, ^{0}C				h, μm	A, N·mm	V, ×10^{-7} mm^3
50	20	3320	2215	41.7	2.0	0.02780	125.51
50	40	4470	2980	56.1	2.0	0.03740	125.51
50	60	3630	2422	45.6	2.0	0.03040	125.51

Extrusion depth (hp) increased from 0.48 to 0.972 (μm) and the volume of print for plastic indentation (**Vp**) increased from 7.22×10^{-3} to 29.64×10^{-3} (mm^3).

With increasing temperature electrolysis from 20 to 40 hardness (**Hh**), dynamic hardness (**Hd**), indentation load on the diamond spherical indenter (P) increased in value as in the previous case (table 4), and the work expended in plastic deformation (**Ap**) is Fe-Ni composite coatings increased from 6.67×10^{-3} to 13.84×10^{-3} (N·mm).

With further increase in temperature electrolysis (**T**) from 40 to 60^0C hardness (**Hh**) dynamic hardness (**Hd**), indentation load on the diamond spherical indenter (**P**) decreased in value as in the previous case (table 4), and the work expended in plastic deformation of Fe-Ni composite coatings (**Ap**) decreased from 13.84×10^{-3} to 13.77×10^{-3} (N·mm).

With increasing temperature electrolysis (**T**) of 20 to 60^0C in the preparation of Fe-Ni composite coating at a constant current density (Dk=50×10^{-4} kA/m^2), the total indentation depth (h) of the diamond and the amount of spherical indenter indentation (**P**) under elastoplastic indentations are constants and are, respectively, 2.0 (micrometers) and 125.51×10^{-3} (mm^3) table 6.

With increasing temperature electrolysis (**T**) of 20 to 40^0C at a constant current density (Dk=50×10^{-4} kA/m^2) hardness (**Hh**), a dynamic hardness (**Hd**), at indentation load spherical diamond indenter (**P**), increasing meaningfully as in the previous case (Table 4 and 5) and the work spent on elastoplastic indentations Fe-Ni composite coatings with indentations increased from 27.8×10^{-3} to 37.4×10^{-3} (N·mm). With further increase in temperature electrolysis (**T**) from 40 to 60^0C (at Dk=50×10^{-4} kA/m^2), hardness (**Hh**), dynamic hardness (**Hd**), indentation load on the diamond spherical indenter (**P**) decreased in value as in the previous cases (table 4 and 5), and the work spent on the elastic-plastic deformation.

Elastoplastic properties and hardness of Fe-Ni composite coatings decreased from 37.4×10^{-3} to 30.4×10^{-3} (N·mm). As in the previous cases (see table 4 and 5) with the increase in the electrolysis temperature (**T**), hardness (**Hh**), a dynamic hardness (**Hh**), load on a spherical indentation diamond indenter (**P**) and the work consumed by elastoplastic deformation of Fe-Ni composite coatings is experimental.

To study the thermal stability of the boundary layers in the test sediments having different physical and mechanical properties derived from one electrolyte, experiments were conducted with iron-nickel alloy rubbing against alloyed iron in the presence of oil **M12B** (tables 1 and 2).

Investigated iron-nickel coatings produced at a current density of 20×10^{-4}, 50×10^{-4}, and 80×10^{-4} kA/m^2, electrolysis temperature of 20, 40 and 60 °C and P_H=0.8÷1.0.

Table 7

Physical and mechanical properties of iron-nickel coatings and thermal resistance of the boundary lubricating oil layers M12B in friction coatings alloyed iron

Electrolysis conditions		***Work expended on the deformation of coatings***			H_h N/mm^2 (h=2μm)	H_d N/mm^2	P, N	T_{cr}, °C
Dк, $\times10^{-4}$ kA/m^2	T, °C	A_y N·mm	A_p N·mm	A N·mm				
5	40	0.0172	0.0132	0.0304	3630	2422	45.6	---
10	40	0.0127	0.0135	0.0312	3670	2449	46.1	---
20	40	0.0186	0.0132	0.0318	3800	2534	47.7	100
30	40	0.0202	0.0132	0.0334	3980	2556	50.0	---
40	40	0.0214	0.0132	0.0346	4120	2746	51.7	---
50	40	0.0235	0.0134	0.0373	4470	2980	56.1	220
60	40	0.0202	0.0121	0.0323	4020	2683	50.5	---
80	40	0.0188	0.0090	0.0278	3320	2215	41.7	100

Table 8

Physical and mechanical properties of iron-nickel coatings and thermal resistance of the boundary lubricating oil layers M12B in friction coatings alloyed iron.

Electrolysis conditions		***Work expended on the deformation of coatings***			H_h N/mm^2 (h=2μm)	H_d N/mm^2	P, N	T_{cr}, ˚C
Dк, $\times 10^{-4}$, kA/m^2	T, ˚C	A_y N·mm	A_p N·mm	A N·mm				
50	20	0.42011	0.0067	0.0278	3320	2215	41.7	140
50	40	0.0235	0.0148	0.0373	4470	2980	56.1	220
50	60	0.0156	0.0138	0.0294	3630	2422	45.6	170

It was established experimentally that the friction alloy iron-nickel alloy cast iron for selected coatings are characterized by the conditions under which the transition occurs from smooth sliding to interrupt (the critical temperature). The cover with less physical and mechanical properties (**Ay**, **Ap**, A, **Hh**, **Hd**, **P**, table 7 and 8), the critical condition occurs at lower temperatures, oil **M12B**.

Thus, when the friction on the alloyed iron from iron-nickel alloy, received at a current density of 20×10^{-4} and 80×10^{-4} kA/m^2 (at T=40 °C), respectively, the critical condition occurs at an oil temperature of 10 and 100 °C. while coating obtained at a current density of 50×10^{-4} kA/m^2 (at T=40 °C), promote the preservation of the boundary layer lubrication to 220 °C.

Rubbing against iron-alloyed iron in sediments obtained from (a current density of 50×10^{-4} kA/m^2) temperature electrolysis 20, 40, 60 °C also comes the transition from smooth sliding to intermittent. We cover lower physical and mechanical characteristics (**Ae**, **Ap**, **A**, **Hh**, **Hd**, **P**), the critical condition occurs at lower temperatures, oil M12B (table 8).

Thus, when the friction on the cast iron alloyed coating obtained from electrolysis at temperatures of 20 and 60 °C (at **Dk**=50×10^{-4} kA/m^2), the critical state occurs at the oil temperature respectively of 140 and 170 °C, while the temperature of the coating obtained by electrolysis 40 °C (with **Dk**=50×10^{-4} kA/m^2), contribute to the preservation of boundary lubrication

Physical and mechanical properties of iron- nickel coatings and thermal resistance of the boundary lubricating oil layers **M12B** at friction coatings alloyed iron.

The experiments showed that, ceteris paribus, iron -nickel coatings with higher physical and mechanical properties (**Ae**, **Ap**, **A**, **Hh**, **Hd**, **P**) contribute to the thermal resistance of the boundary lubricant layers and improved their anti-friction properties. These models are stored, regardless of the type of material used rider and lubrication [2].

4. CONCLUSION

Found unrestored hardness (**Hh**) and the dynamic hardness (**Hd**), the work spent on elastoplastic deformation (A) have the extreme nature of changes in the conditions of electrolysis (**Dk**, **T**) for the study of iron-nickel composite coatings.

Experimental values not restored hardness (**Hh**), dynamic hardness (**Hd**), indentation load diamond spherical indenter (**P**), the work spent on plastic (**Ap**) and elastic-plastic deformation (**A**) coincides with our earlier recommendations for iron-nickel composite coatings with the point of view of their optimum durability.

Physical and mechanical characteristics (**Hh**, **Hd**, **P**, **Ap**) iron-nickel composite coatings have a good correlation with temperature resistance

Boundary lubricating oil layers **M12B** rubbing against alloyed iron.

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