SOME SPECIAL FEATURES OF THE ELASTIC-PLASTIC DEFORMATION OF THE COMPOSITE ELECTROLYTIC PLATINGS

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ABSTRACT

One brings the elastic particularises and figures of the deformation of composition of the iron-nickel and iron hedging's to the micropression. This information makes it possible to explain the mechanism elastic and plastic of the deformation of the hedging's under the various conditions of the friction of wear.

KEYWORDS: elastoplastic properties, galvanic coatings.

1. INTRODUCTION

Current problems in studying and controllin composite materials' physical and mechanical properties near the surface and in the superficial layers are conditioned by the fact that almost of the state-of-the-art processing methods, material strengthening and joining, and service properties of materials are connected to contact affecting and contact straining under conditions of friction, fatigue, gripping and wear [1].

One of material superficial properties study methods are Knoop hardness tests [1, 2]. The Knoop hardness test method can be qualitatively compared to tension evolution test when transition from simple test for rupture to registration of the continuous pressure diagram - straining has been made [2]. The Knoop hardness test method allows measuring a series of parameters describing physical and mechanical properties of material, traditional, and new, obtained only by these tests [1-13].

Theoretical studies of this method allow determining the following physical and mechanical properties in local volumes: an elasticity modulus, including micro bodies and thin coatings, taking into account straining of the basis; stress creeping and relaxation; hysteresis losses or convertibility of microflow during the repeated loading-unloading; effective superficial destruction energy or viscosity (for brittle materials). These characteristics are determined during non-destroying influence on objects, for example layered materials or details with coatings, local physical and mechanical properties which are problematic to determine by other, even destroying, testing techniques [2].

The Knoop hardness measured on unrestored imprint with registration of its depth under load (unrestored Knoop hardness) is not equal to the Knoop hardness measured by the restored (unloaded) imprint by means of the microscope (restored Knoop hardness) [1]. Their ratio is regarded as a parameter dependent on the type of the inter-atomic bond, material structure and determining character of its porosity and structure order, strengthening ability during straining [2].

The test method on Knoop hardness reveals new opportunities for definition of effective destruction superficial energy or viscosity. This method allows carrying out tests on coatings of the widest purpose from 1 micron and more. Thus, it is possible to determine not only strength and straining characteristics of coatings, but also an elasticity modulus, and also the extent of porosity [2].

2. INFORMATION

The important characteristic revealing more data about mechanical properties of material and its structure is the ratio of the restored and unrestored Knoop hardnesses of galvanic composition coatings [3-13]. The ratio of these two values of material Knoop hardnesses can be determined both theoretically [2] and experimentally [3-8].

For galvanic composition coatings the ratio of the restored and unrestored Knoop hardnesses depends on porosity [3-13]. The analysis of elastic straining in an imprint with the subsequent calculation of the ratio of restored and unrestored Knoop hardness is important to justify the test method on Knoop hardness. The ratios of restored and unrestored Knoop hardness, the important experimental character, and its deviations from a design value can characterise such a necessary parameter for materials and strengthening, superficial layers of coatings, as porosity. A series of articles [3-8] is dedicated to the analysis of this ratio.

The galvanic composition coatings obtained from electrolytes 2, 3, 4 [1, pages 59-60] were studied. As samples, there were used rollers of 30 mm in diameter, 0.5 mm – coating thickness and of 100 mm in length, which were processed at optimum regimes of study [1].

Restored Knoop hardness (**H**) of galvanic composition coatings was defined on a PMT-3 device. The unrestored Knoop hardness (**Hh**) of composition galvanic coatings was defined on an installation for micromechanical tests by a technique developed in branch VNIIMASH, Volzhsk [1].

These studies have shown that the changeable character of unrestored Knoop hardness (**Hh**, table 1) measured by the diving depth of the indenter, at all investigated coatings obtained under various conditions of iron coatings electrolysis, differs from values of restored Knoop hardness (**H**, table 1).

Dependences of unrestored Knoop hardness of iron coatings on current density (**Dк**, A/dm^2) and electrolysis temperatures (**T**, ^{0}C) have extreme values, which coincide with the existing recommendations at sampling conditions of electrolysis for obtaining optimum properties of coatings from the point of view of their wear-resistance [1].

The basic effect on change of unrestored Knoop hardness depending on electrolysis conditions is rendered with magnitude of coatings elastic straining (**hy**). The increased current density and decrease of electrolysis temperature, decrease the magnitude of microflow (**hп**) and promotes raise of elastic recovery values (**hy**) of an imprint (table 1).

Comparing the obtained results for various coatings, it is possible to note that under the selected electrolysis conditions the relative magnitude of the restored imprint (**hy**/**h**) at electrolytic precipitation, the iron obtained from organic electrolysis (table 1, electrolyte 2) changes within limits 6.9...21.2% and for iron – nickel alloy within 12...19% (table 1, electrolyte 2) at electrolytic chromium within 7.6...21.9% (table 1, electrolyte 3). The obtained data once again confirm that the electrolysis conditions render strong influence on peculiarities of elasto-plastic straining of coatings.

The studies have shown, that with an increase in current density (**Dк**) from 5 to 15 A/dm^2 at obtaining iron precipitations (table 1, electrolyte 2) the restored Knoop hardness (**H**) has essentially increased from 5700 to 6850 H/mm^2, with further increase in current density up to 30 A/dm^2, the restored Knoop hardness (**H**) has increased insignificantly from 6850 to 7250 H/mm^2. For iron-nickel coatings (table 1, electrolyte 3) with increase in current density (**Dк**) from 5 to 30A/dm^2, the restored Knoop hardness (**H**) has increased essentially from 5250 to 7000 H/mm^2, with the further increase in current density up to 80 A/dm^2, the restored Knoop hardness (**H**) has increased insignificantly from 7000 to 7800 H/mm^2.

For chromic coatings (table 1, electrolyte 4) with increase in current density (**Dк**) from 20 to 40A/dm^2, the restored Knoop hardness (**H**) has increased essentially from 7200 to 9200 H/mm^2, with further increase in current density up to 80 A/dm^2, the restored Knoop hardness (**H**) has increased insignificantly from 9200 to 9700 H/mm^2. With increase in electrolyte temperature at obtaining iron, iron - nickel and chromic coatings (table 1, electrolyte 2, 3, 4), the restored Knoop hardness (**H**) decreases.

In contrast to the restored Knoop hardness (**H**), the unrestored Knoop hardness (**Hh**) for iron, iron - nickel and chromic coatings has extreme character with increase in current density and electrolyte temperatures (table 1, electrolytes 2, 3, 4).

The maximum unrestored Knoop hardness (**Hh**) for iron coatings 7940 H/mm^2 is obtained at **Dк**=15A/dm^2 and **T**=40°C, for iron - nickel coatings the maximum unrestored Knoop hardness **Hh**=8130H/mm^2 is obtained at current density **Dк**=50A/dm^2 and electrolyte temperature **T**=40°C.

For chromic coatings the maximum unrestored Knoop hardness **Hh**=10260 H/mm^2 is obtained at current density **Dк**=60 A/dm^2 and electrolyte temperature **T**=55°C.

Table 1. Elastic-plastic properties of iron coatings.

Conditions of the electrolyte		Elastic-plastic properties			H, H/mm^2	Hh, H/mm^2	H / Hh	Hd, H/mm^2	H / Hd
Дк, A/dм^2	T, ^{0}C	hy, µm	hп, µm	h, µm					
5	40	0.172	1.828	2.0	5700	6420	0.888	6940	0.826
10	40	0.246	1.754	2.0	6700	7750	0.865	8360	0.801
15	40	0.260	1.740	2.0	6850	7940	0.862	8580	0.798
20	40	0.378	1.622	2.0	7050	6800	1.037	7340	0.960
30	40	0.400	1.600	2.0	7250	6620	1.095	7140	1.015
10	20	0.424	1.576	2.0	6950	6050	1.149	6980	0.996
10	60	0.138	1.862	2.0	5500	6150	0.894	6420	0.857

The dynamic Knoop hardness (**Hd**) calculated as the ratio of spent work (A, H·mm) to the strained volume (V, mm^3) of iron, iron-nickel and chromic coatings, has the same character at indicator indentation. An extreme value of dynamic Knoop hardness (**Hd**) is obtained under the same electrolysis conditions for iron, iron-nickel and chromic coatings, as for the unrestored Knoop hardness (**Hh**) (table 1, electrolytes 2, 3, 4).

Studies for definition of restored (**H**), unrestored (**Hh**) and dynamic Knoop hardness (**Hd**) of iron, iron-nickel and chromic coatings, and also ratios **H**/**Hh**, **H**/**Hd** with the change of electrolysis conditions (**Dк**, **T**) are reflected in table 1.

The ratio of the restored (**H**) to the unrestored (**Hh**) Knoop hardnesses of iron, iron-nickel and chromic coatings with change of current density (**Dк**) and electrolyte temperature (**T**) is extreme, as well as the ratio of the restored (**H**) to the dynamic Knoop hardness (**Hd**). With increase in current density (**Dк**) from 5 to 15 A/dm^2 at temperature **T**=40°C for iron coatings, the ratios **H**/**Hh** and **H**/**Hd** decreased from 0.885 to 0.862 and from 0.826 to 0.798. With further increase in current density from 15 to 30 A/dm^2 (**T**=40°C) the ratio **H**/**Hh** increased from 0.862 to 1.095 and **H**/**Hd** from 0.798 to 1.015 (table 1, electrolyte 2). For iron-nickel coatings with increase in current density from 5 to 50 A/dm^2 (**T**=40°C) the ratio **H**/**Hh** decreased from 1.059 to 0.910.

With further increase in current density (**Dк**) from 50 to 80 A/dm^2 (**T**=40°C) the ratio **H**/**Hh** increased from 0.910 to 1.376 (table 1, electrolyte 3). For chromic coatings with increase in current density (**Dк**) from 20 to 60 A/dm^2 (**T**=55°C) the ratio **H**/**Hh** decreased from 1.466 to 0.876. With further increase in current density (**Dк**) from 60 to 80 A/dm^2 (**T**=55°C), the ratio **H**/**Hh** increased from 0.876 to 1.498 (table 1, electrolyte 4).

With increase in electrolyte temperature from 20 to 60°C, the ratio **H**/**Hh** and **H**/**Hd** is extreme for iron and iron-nickel coatings (table 1, electrolytes 2, 3), and with increase in temperature of electrolyte from 40 to 70°C **H**/**Hh** and **H**/**Hd** is also extreme for chromic coatings (table 1, electrolyte 4). With an increase in electrolyte temperature from 20 to 40°C at obtaining the iron coatings (**Dк** =10A/dm2), the ratio **H**/**Hh** decreased from 1.149 to 0.865, and with further increase in electrolyte temperature from 40 to 60°C (**Dк** =10A/dm2) the ratio **H**/**Hh** increased from 0.865 to 0.894 (table 1, electrolyte 2).

For iron - nickel coatings with increase in electrolysis temperature from 20 to 40°C (**Dк**=50A/dm^2), the ratio **H**/**Hh** decreased from 1.531 to 0.910, and with further increase in temperature from 40 to 60°C (**Dк**=50A/dm^2) the ratio **H**/**Hh** increased from 0.910 to 1.140 (table 1, electrolyte 3).

For chromic coatings with increase in electrolysis temperature from 40 to 55°C (**Dк**=60A/dm^2) the ratio **H**/**Hh** decreased from 1.169 to 0.876, and with further increase in temperature from 55 to 70°C (**Dк**=60A/dm^2) the ratio **H**/**Hh** increased from 0.876 to 1.140 (table 1, electrolyte 4).

The studies have shown, that unrestored (**Hh**) and dynamic (**Hd**) Knoop hardness, as well as ratios **H**/**Hh** and **H**/**Hd** are extreme with change of current density (**Dк**, A/dm^2) and electrolysis temperatures (**T**,°C) (table 1, electrolytes 2, 3, 4).

Extreme values of Knoop hardness **Hh** and **Hd** and ratios **H**/**Hh** and **H**/**Hd** coincide with the recommendations obtained by us earlier for iron, iron - nickel and chromic coatings from the maintenance of their optimum wear-resistance point of view [1].

Table 2. Elastic-plastic properties of iron-nickel coatings.

Conditions of the electrolyte		Elastic-plastic properties ¶			H, H/mm^2	Hh, H/mm^2	H / Hh	Hd, H/mm^2	H / Hd
Дк, А/$дм^2$	T, ^{0}C	hy, μm	hп, μm	h, μm					
5	40	0.240	1.760	2.0	5250	6050	0.868	6540	0.803
10	40	0.256	1.744	2.0	5500	6240	0.881	6740	0.816
20	40	0.278	1.722	2.0	6300	6430	0.978	6940	0.906
30	40	0.288	1.712	2.0	7000	6620	1.087	7140	0.980
40	40	0.288	1.712	2.0	7200	6800	1.059	7340	0.981
50	40	0.314	1.686	2.0	7400	8130	0.910	8460	0.875
60	40	0.354	1.646	2.0	7600	6620	1.148	7140	1.064
80	40	0.374	1.626	2.0	7800	5670	1.376	6120	1.275
50	20	0.380	1.620	2.0	8100	5290	1.531	5780	1.401
50	60	0.298	1.702	2.0	6900	6050	1.140	6540	1.055

Table 3. Elastic-plastic properties of chromium coatings.

Conditions of the electrolyte		Elastic-plastic properties ¶			H, H/mm^2	Hh, H/mm^2	H / Hh	Hd, H/mm^2	H / Hd
Дк, A/dм^2	T, ^{0}C	hy, μm	hп, μm	h, μm					
20	55	0.152	0.848	2.0	7200	4910	1.466	5300	1.358
40	55	0.306	1.694	2.0	9200	8130	1.132	8780	1.048
50	55	0.342	1.658	2.0	9500	9640	0.985	10400	0.913
60	55	0.364	1.636	2.0	9600	10960	0.876	11840	0.811
70	55	0.382	1.618	2.0	9750	8880	1.098	9600	1.016
80	55	0.418	1.582	2.0	9900	6610	1.498	7140	1.385

3. FINAL RECOMMENDATIONS

It is determined that unrestored (**Hh**) and dynamic Knoop hardness (**Hd**), as well as ratios **H**/**Hh** and **H**/**H** of iron iron-nickel and chromic galvanic composition coatings are extreme with change of current density and electrolysis temperatures.

Extreme values of unrestored (**Hh**) and dynamic (**Hd**) Knoop hardnesses and ratios **H**/**Hh** and **H**/**Hd** coincide with the recommendations obtained by us for iron, iron-nickel and chromic coatings from the point of view of maintenance of their optimum wear-resistance.

The obtained results (**Hh**, **Hd**, **H**/**Hd** and **H**/**Hh**) agree well with data obtained by the authors on definition of spent elastic, plastic, brittle failure and over-all work (**Ay**, **Апл**, **Ap**, **A**) necessary for straining of elastic-plastic and total volume (**Vy**, **Vп**, **V**) of iron, iron-nickel and chromic coatings at indentation with the record of kinetic diagram.

For the first time the obtained information will allows to explain the mechanism of an elastic and plastic straining of iron, iron-nickel and chromic galvanic coatings during testing in various conditions of friction and wear.

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