THE CORRELATION OF THE RESTORED AND UNRESTORED MICROHARDNESS OF THE WEAR-PROOF IRON-NICKEL PLATINGS

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ABSTRACT

Considering the correlation of restored and unrestored microhardness and wear-resistance of iron-nickel plating.

KEYWORDS: restored and unrestored microhardness.

1. INTRODUCTION

The correlation of the restored and unrestored material hardness is an important characteristic, widening data of mechanical properties of a material and its structure [1-6].

This correlation depends upon the ratio of hardness of the material to module of its elasticity and the altitude of the roller of produced by the material pressed off the imprint.

Examining the hardness *Hh* (unrestored microhardness) measured by the depth of the imprint and the hardness *H* (restored microhardness) measured by transverse size of the unloded imprint, attention should be focused on the fact that the latter is measured with regard to the roller, whereas the imprint depth is measured from the initial plane of the specimen.

2. INFORMATION

The ratio of these two hardness values being an important index of the physical and mechanical properties of the material, may be defined theoretically if the altitude of roller around the imprint and elastic deformations in it are known:

$$\frac{H}{H_h} = \left[1 - \frac{C}{\sqrt{F}} \left(h_H - W_K \right) \right] \tag{1}$$

where:

C - coefficient of the indentor shape;

F - transverse size of imprint;

h_H - height of the imprint’s bulge;

W_K - normal displacement.

For porous materials the ratio of *H/Hh* depends on porosity, since the material under the imprint becomes denser. Compression of material, represented in terms of the relative decrease of the imprint volume $\Delta V/V$ compared to the volume of the dense material, is subordinated to the following regularity:

$$\Delta V/V = \rho \tag{2}$$

where ρ is density of the material

The density of the material ρ may be calculated by the results of Top of Form diagrams of pressings in two indentors with different angles of grinding [1].

For dense materials the possibility to measure the altitude of the roller by the correlation *H/Hh*, allows us define the empirical correlation between the hardness and extension diagrams. In pressing the pyramid, the roller around the imprint is thoroughly investigated in articles [4, 5].

Its maximal altitude (in the middle of the square imprint sides), depends mainly on the capability of the material for strain hardening and varies for different materials from 1.5% to 20% of imprint depth.

3. ELASTIC DEFORMATIONS

Elastic deformations in the imprint can be determined by the method of the elasticity theory. In the reference literature the use of Vickers's pyramid provides the same deformation in pressing in and the elastic deformation does not change the size of plastic imprint diagram.

This circumstance simplifies the examination of the correlation between surfaces, measured along the diagonal and by the depth of imprint, since it is necessary to consider only the altitude of roller and normal elastic deformation on the outline of imprint.

In connection with the facts outlined above, the relation between the hardness *(Hh)* calculated by the depth of imprint and the hardness *(H)* calculated by the transverse size $\sqrt{F} = C \cdot h$ of the unloaded plastic imprint, which may be written as:

$$\frac{H}{H_h} = \left(1 - C \cdot V_H + \frac{C \cdot W_K}{\sqrt{F}} \right)^2 \qquad (3)$$

where: $V_H = h_H / \sqrt{F}$ – relative altitude of bulge, h_H - roller height.

4. MECHANICAL PROPERTIES OF MATERIALS

It has been proved that the correlation *H/Hh* practically does not depend on the character of pressure distribution in the imprint, but it is determined only by average pressure, standardized to the given contact elasticity modulus [1].

The analysis of elastic deformations in the imprint with the subsequent calculation of the restored and unrestored hardness correlation is significant for determining the physic and mechanical properties of materials.

The correlation *H/Hh* is an important experimental parameter, and its deviation from the computed value may characterize such a necessary index for the materials and strengthening layers and platings as porosity. A number of papers are dedicated to the analysis of this correlation [1, 6].

Iron-nickel electrolytic sediments from the electrolyte were researched [7, table 6, page 61]. Rollers of 30 mm in diameter, 0.5 mm in plating thickness and 100 mm in length were used as specimen, which were processed under optimum conditions of grinding [7].

5. THE EXPERIMENTAL STUDIES

The restored microhardness *(H)* of iron-nickel platings was determined by means of PMT-3 device.

The unrestored microhardness Hh of iron-nickel platings was determined on the unit for the micromechanical tests using the procedures developed at the branch of VNEEASH, in Volzhsk [7].

The research performed showed that with an increase in the current density from 5 to 50 A/dm2, while obtaining iron-nickel sediments (fig. 1) the restored microhardness *(H)* increased substantially from 5250 to 7000 H/mm2.

Increasing further the current density to 80 A/dm^2 the restored microhardness *(H)* increased insignificantly from 7000 to 7800 A/dm^2. The unrestored microhardness *(Hh)* had an extreme nature.

Current density when increased from 5 to 50 A/dm^2 the unrestored microhardness *(Hh)* increased from 6050 to 8130 H/mm^2. Increasing further the current density from 50 to 80 A/dm^2, the unrestored microhardness *(Hh)* decreased from 8130 to 5670 H/mm^2.

The same characteristic has the dynamic microhardness calculated as the ratio of consumed work (A, kgf·mm) to the deformed volume of iron-nickel plating in pressing the indentor (V, mm^3).

Increasing the current density from 5 to 50 A/dm^2 the dynamic microhardness *(Hd)* increased from 6540 to 8460 H/mm^2.

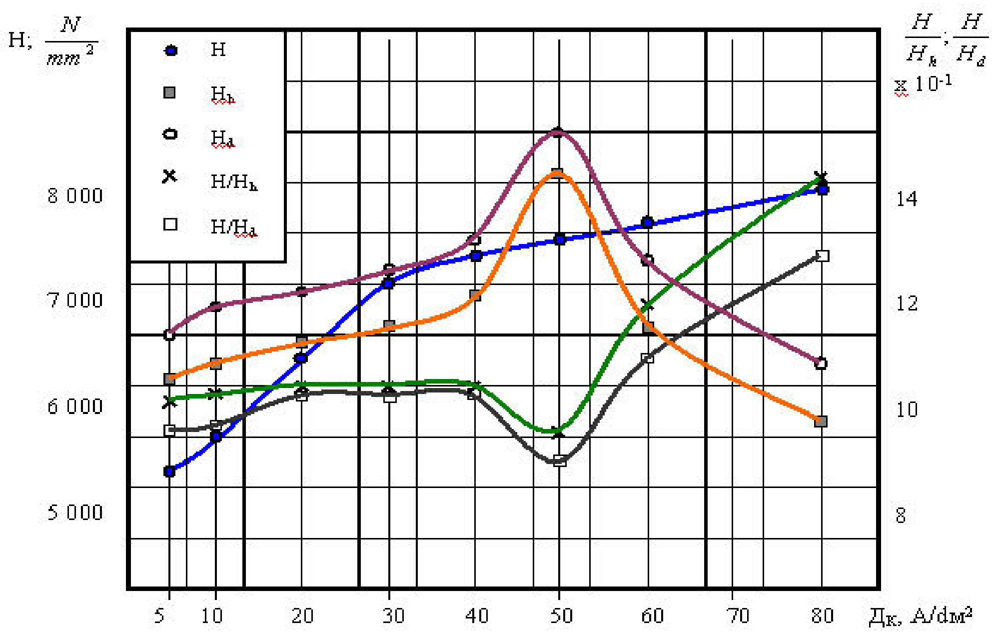

Fig. 1. Influence of current density on restored *(H)* and unrestored *(Hh),* dynamic microhardness and the correlation *(Hd)* and *H/Hh* of *H/Hd* iron-nickel platings.

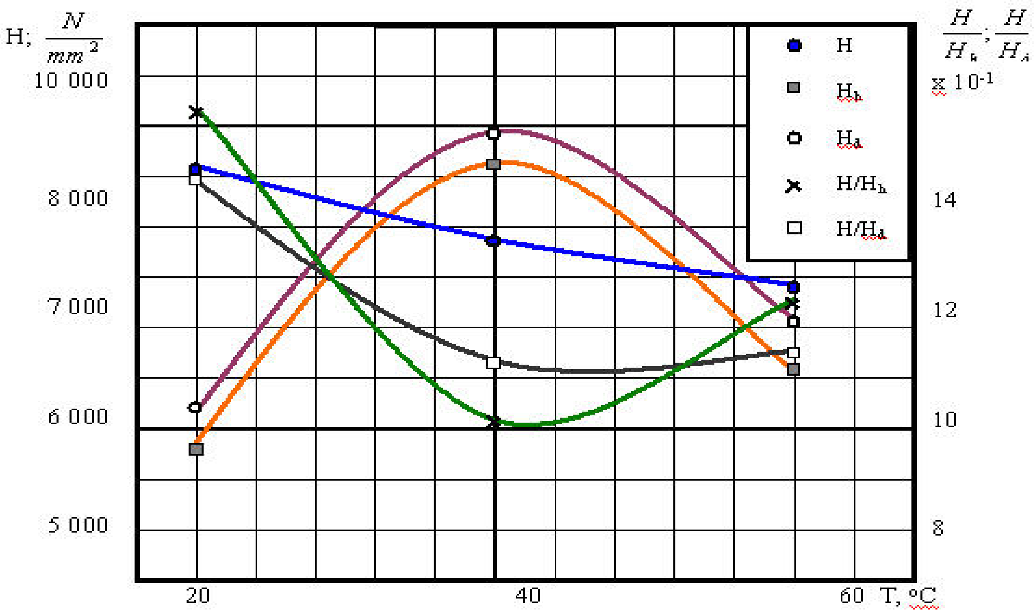

Fig. 2 Influence of the electrolyte temperature on restored *(H)* and unrestored *(Hh)*, dynamic microhardness *(Hd)* and the correlation *H/Hh* of *H/Hd* iron-nickel platings.

With further increase in the current density from 50 to 80 A/dm^2 the dynamic microhardness *(Hd)* decreased from 8460 to 6120 H/mm^2.

The correlation of the iron-nickel platings restored microhardness *(H)* to the unrestored microhardness *(Hh)* with an increase in the current density from 5 to 80 A/dm^2 is of extreme character as well as the correlation of the restored microhardness *(H)* to the dynamic microhardness *(Hd)*.

With an increase in the current density, when obtaining the iron-nickel platings, from 5 to 50 A/dm^2 the correlation *H/Hh* decreased from 1.059 to 0.910, while *H/Hd* decreased from 0.981 to 0.875.

With further increase in the current density from 50 to 80 when obtaining the iron-nickel platings, the correlation *H/Hh* increased from 0.910 to 1.376 while the correlation *H/Hd* increased from 0.875 to 1.275.

Research on determining the restored *(H)*, unrestored *(Hh)* and dynamic microhardness *(Hd)* of iron-nickel platings, as well as the correlations *H/Hh* and *H/Hd* with the change in the temperature of electrolysis (from 20^{o}C to 60^{o}C, at Дk =50 A/dm^2) are shown in figure 2.

At an increase in the temperature of the electrolysis from 20^{o}C to 60^{o}C, the restored microhardness *(H)* decreased from 8100 to 6900, while the unrestored *(Hh)* and dynamic microhardness *(Hd)* had an extremal character.

When increasing the temperature of the electrolysis from 20^{o}C to 40^{o}C the unrestored microhardness *(Hh)* increased from 5290 to 8130, while the dynamic microhardness *(Hd)* increased from 5780 to 8460, the correlation *H/Hh* decreased from 1.531 to 0.910 and the correlation *H/Hd* decreased from 1.401 to 0.875.

With the further increase in the temperature of the electrolysis from 40^{o}C to 60^{o}C, the unrestored microhardness *(Hh)* decreased from 8130 to 6050, the dynamic microhardness *(Hd)* decreased from 8460 to 6540 while the correlation *H/Hh* increased from 0.910 to 1.140 and the correlation *H/Hd* increased from 0.875 to 1.055.

The research has shown that the unrestored *(Hh)* and dynamic microhardness *Hd* as well as the correlations *H/Hh* and *H/Hd* have an extreme character when current density from 5 to 80 A/dm^2 and temperature of electrolysis from 20^{o}C to 60^{o}C changed.

The outer limits of microhardness *Hh* and *Hd* and the correlations *H/Hh* and *H/Hd* coincide with the obtained previously recommendations, for the iron-nickel platings [7] from the point of view of providing their optimum wear-proof.

The greatest microhardness *Hh* and *Hd* and the greatest correlations *H/Hh* and *H/Hd* are obtained at a current density Дk = 50 and a temperature of electrolysis T=400^{0}C (fig. 1 and fig. 2).

6. FINAL RECOMMENDATIONS

The obtained results coincide well with obtained by us data regarding the spent elastic, plastic, brittle failure and the general work (*Ay, An, Ap* and *A*) necessary for the deformation of the elastic, plastic and total volume (*Vy, Vn, V*) of iron-nickel platings in pressing in the indentor with the record of kinetic diagram.

The for the first time the information obtained will make it possible to explain the mechanism of the elastic and plastic deformation of wear-proof iron-nickel platings when tested under varied conditions for friction and wear.

A larger research in this aria will allow us to determine the mechanisms which initiate destruction and limit the wear proof capacity of the galvanic wear proof iron-nickel platings under the condition of the contact loads.

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