

METHODS FOR DETERMINING THE PROPERTIES OF COMPOSITE MATERIALS

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Abstract: The hardness of composite material depends on many factors such as the nature of the material, geometry of the penetrator, how to perform tests, etc. Deposition of composite material that have been testing has a Vickers hardness of nickel-phosphorus metal matrix in which they were embedded hard particles of silicon carbide. Footprint was obtained: perpendicular to the section (thickness) layer, in which case the depth of the layer is very large than the depth of the footprint and perpendicular to the surface layer, in which case the surface layer is very large relative to the footprint area.

1. INTRODUCTION

By definition, the hardness of an object is generally defined as the mechanic resistance of opposing to the penetration of another harder object, called penetrator or indenter.

This definition illustrates the fact that this size varies depending on several factors like the penetrator's geometry, the nature of the material, the way in which trials are made etc.

The hardness test consists in measuring the effect caused by a penetrator with well defined geometry, which leaves a imprint on the surface of test sample under the influence of a load (force). Several test developing methods are known, using various geometries for the indenter, depending on the nature of the tested material. Therefore, for metals and ceramic materials, especially for deposits of thin layers, the penetrator's geometry can be pyramidal with a square diamond base (Vickers, Knoop,) or equilateral triangular (Berkovitch) [3-5].

2. EXPERIMENTAL PART

2.1 Composite deposits hardness

Hardness tests were made on nickel-phosphor matrix electro-deposited layers and hard particles of silicon carbide, using the Vickers method. If an F load is applied on the sample surface, the pyramidal end leaves an imprint on surface A and Vickers hardness is defined in this case by the relation:

$$HV = F/A \quad (1)$$

In order to get the right accuracy, a square base pyramid is used whose opposite sides make a 136° angle between them.

In the case of hardness measurements made with a F load expressed in kilograms and d diagonal measured in millimetres we admit that (2),

$$S = \frac{d^2}{\sin 68^{\circ}} = \frac{d^2}{1,854} \quad (2)$$

and hardness becomes:

$$HV = 1,854 \frac{F}{d^2} \quad (3)$$

The forces applied when measuring the hardness and that lead to concluding results depend on the ratio between the imprint size and the layer thickness as well as on the way the imprint is made. The imprint can be achieved:

a) Perpendicularly on the layer section (thickness) [1,2]; in this case the layer depth is very large as compared to the imprint depth (figure 1)

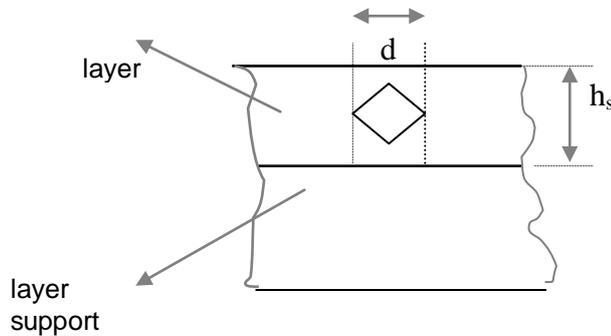


Fig. 1 Perpendicularly load applied on the layer section

and relation: (4) applies

$$d \leq 0,7 \cdot h_s \quad (4)$$

b) Perpendicularly on the layer surface; in this case the layer surface is very large as compared to the imprint surface (figure 2) and relations: 5-11 apply [1,2].

$$h = \frac{d}{2} \operatorname{tg} \alpha \quad (5)$$

$$h = \frac{d}{2} 0,374 = 0,187d; \quad (6)$$

$$h_s \geq \frac{0,187}{0,85} \cdot d_a \quad (7)$$

$$h_{\text{admis}} \leq 0,85 \cdot h_s, \quad (8)$$

h_s este grosimea stratului.

$$h_s \geq \frac{h_a}{0,85} \quad (9)$$

$$d \leq \frac{0,85h_s}{0,187}; \quad (10)$$

$d \leq 4,55 \cdot h_s$; $d = d_a$ – diagonala ampreteii;

$$h_s \geq 0,22 \cdot d_a \quad (11)$$

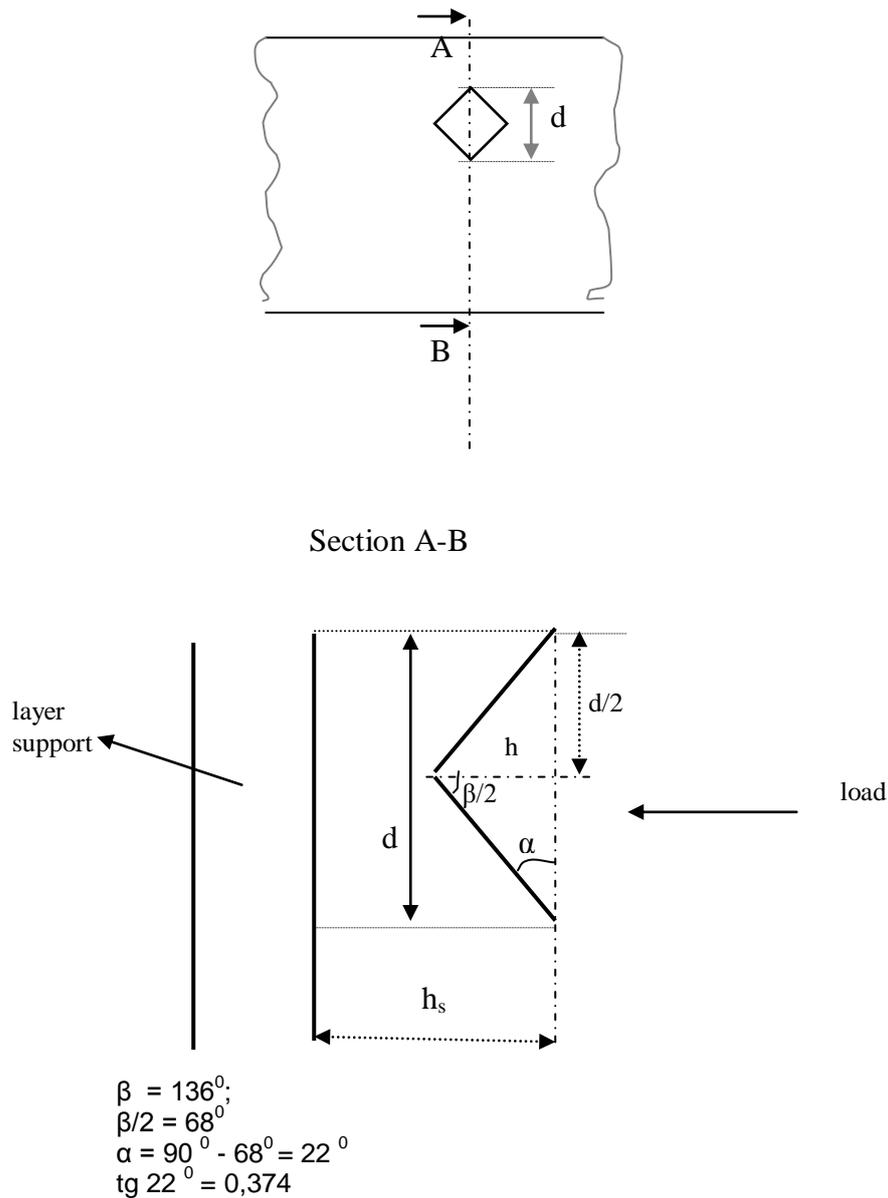


Fig. 2 Perpendicularly load applied on the layer surface

For Ni-P/SiC composites (noted P_xS_y), achieved in the first phase through the variation of H_3PO_3 concentration in the electrolyte, Vickers hardness resulted by perpendicularly applying variable loads from 15g to 500g on the layer surface. In the notation, P_xS_y , P_x is the content of phosphorous acid from the electrolyte and S_y is the content of silicon carbide particles from the suspension.

These tests are applied the relations 5 -11 and the values resulting from the tests comply with the relation established between the imprint size and the layer thickness.

The dependence between the applied load and the electrolyte variation through the alteration of the phosphorous acid concentration on the composite deposits hardness is rendered in figure 3:

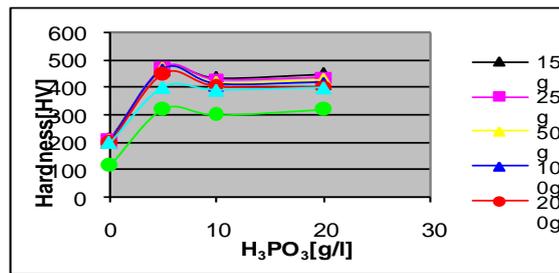


Fig.3 Deposits hardness variation depending on the applied load and the phosphorous acid content in the electrolyte

For this series of tests we notice that the measured micro hardness is altered depending on the phosphorous acid according to three fields of composition:

For small contents of phosphorous acid in the electrolyte ($[H_3PO_3] < 5 \text{ g/l}$ -1st field of composition), deposits hardness increases along with the increase of the phosphorous acid content; for contents of H_3PO_3 between 5 and 10g/l (the 2nd field of composition), hardness decreases and then from $[H_3PO_3] = 10\text{g/l}$ (the 3rd field of composition) hardness has higher values.

We also notice that the higher the load is the more hardness decreases. For loads up to 200g hardness does not have very high variations (especially in the 1st and 2nd fields). When applying the 300g load, hardness begins to decrease, and for the load of 500g hardness decreases significantly.

This hardness variation can be the result of structural transformations that occur as a consequence of the variation of the phosphorous content in the layer. At the increase of the phosphor content, micro structural alterations occur that express themselves through progressive structural evolution of the layer from crystallized state to amorphous state.

In the 1st field, hardness increase is due to the decrease of crystallites sizes, and the deposited layer has a crystallized structure.

In the field where micro hardness decreases (the 2nd field), there is structural disorder where a micro-crystallized phase coexists with a nano-crystalline phase.

In the 3rd field of composition, over-saturated deposit of phosphor becomes nano-crystalline and does not result in significant hardness increase, which remains almost constant.

Passing from a crystalline structure to an amorphous structure can be interpreted as an increase of the volume of inter-crystalline phases at the edge of granule very disorganized as compared to crystalline phases.

In the second phase, electro-deposited layers of composite material Ni-P/SiC resulted through the variation of the content of silicon carbide particles, the content of phosphorous acid being constant, and Vickers hardness resulted with the same variable loads of 15g-500g, placed perpendicularly on the layer thickness.

The dependence between the content of SiC particles and the hardness of deposits and the load is rendered by the diagram from figure 4.

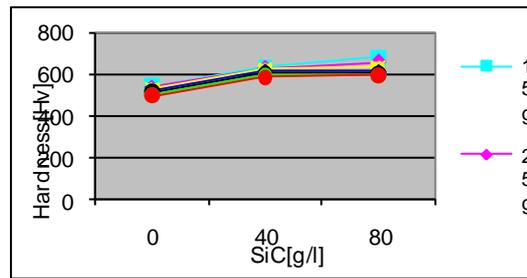


Fig. 4 Hardness variation depending on the content of SiC variation particles and load

Studying the curves from figure 4, we notice that, by introducing the particles in suspension and increasing their content, deposits hardness increases. For smaller loads, this variation is not high, the curves that give this dependence remaining grouped which means that hardness measurements have complied with the necessary measurement conditions.

2. CONCLUSIONS

The micro hardness of deposited layers depends on the content of phosphorous acid from the electrolyte and therefore on the percentage of phosphor from the layer.

Depending on the content of phosphorous acid from the electrolyte and the content of phosphor from the layer, hardness varies depending on three composition fields: in the first field, deposits hardness increases linearly along with the increase of the content of phosphorous acid, in the second field, hardness decreases, and then in the third field it increases again. A peak results in the first field of composition for a content of 5g/l H_3PO_3 , 8,4%at.P respectively.

In the first field, hardness increase is due to the decrease of crystallites sizes, and the deposited layer has a crystallized structure. In the second field there is a mixed area consisting of a micro-crystallized phase and a nano-crystallized phase and we notice a small hardness decrease, and in the third field the deposited layer becomes nano-crystalline and hardness remains almost constant.

Applying variable loads, several types of hardness result whose values decrease with the increase of the load.

The micro hardness tests made on the deposits resulted through the variation of the content of silicon carbide particles and constant content of phosphorous acid in the electrolyte have confirmed the idea that introducing the particles of silicon carbide causes layer hardening, more precisely, the more the content of silicon carbide particles increases, the harder the layer becomes.

By applying increasing loads, we achieve types of hardness whose values depend on these loads, in order for hardness to decrease once the load increases.

For smaller loads, this variation is not high, the curves that give this dependence between the load and layer hardness remain grouped, which denotes that hardness measurements have complied with the necessary measurement conditions.

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