



DECORATIVE COMPOSITE LAYERS

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ABSTRACT

Part of the materials used in the chemical industry, metallurgical, machine construction, can be coated, as with time it occurs either a decrease of its properties, or even a process of advanced faulting, because of the stresses suffered.

The paper presents the structure of some composite coatings with the nickel matrix also pointing out their decorative aspect. The layer is obtained through electrochemical methods, using as a complementary phase carbure and oxide particles (Al_2O_3 , ZrO_2 , B_4C , SiC) with contents of cca. 4-6%. The maintaining times in electrolyte ranged from 10 to 60 minutes.

The macro and microstructural analysis had as objectives: the exterior aspect at composite depositions; the adherence of the film deposited at the support; the width of the deposition; the film compactity; the size, shape and orientation of the grains in the deposited layer; the distribution of the disperse phase in the metallic matrix.

The microstructures of the composite films $Ni+Al_2O_3$ and $Ni + SiC$, performed in cross and longitudinal sections, reveal a dispersion relatively uniform of the aluminum oxide particles and respectively, silicon carbure in the Nickel matrix, a uniform deposition, lack of pores, a good compactity, a very good adherence at the metallic frame

KEYWORDS: exterior aspect, composite coatings, nickel matrix, electrochemical methods, complementary phase carbure and oxide particles.

1. Introduction

The composite coatings are bi- or policomponent materials made of a matrix and a supplementary phase, and have characteristics that the initial components taken separately do not have. The composite is formed from a basic substance, an alloy or a chemical combination of a matrix and of complementary phases uniformly distributed in the matrix, as a result of a process of heterocoagulation of the phase particles on a support that needs to be protected, in the same time with their coating with the laid material that form the matrix of the composite coating. For these cases though, the bond between the coating layer and the base material has to be very stable and to correspond to some requirements. In between the layer and the base material, an interface zone is being formed, whose size can be adjusted by choosing the parameters of thermal treatment, when the processes of diffusion in contra-current are activated between the layer and the electrodeposited coating. This, besides the wished for properties, can

influence the general properties of the material that was started from (e.g.: fatigue resistance).

The difference among different types of materials and composite coating lies in the hardening action on the matrix and in the loading part, taken by the component parts. A highly practical interest arises from the *composite coatings resistant to weariness and corrosion*, as a perspective for enhancing the lifetime of the parts.

Up to now, there are settlements against the interdependence structure – properties, which justifies the research done in the field.

From the analysis of the experimental data, it comes out that a considerable strengthening of the wear resistance of the metals is obtained by the co deposition of some particles formed of oxides, borurs, carburs, nitrurs (that have themselves a high wear resistance, contraction stability, maximum resistance at plastic deformation) in a metallic matrix. The particles take over the friction load and distribute it uniformly in the matrix, ease the creation of a relief that ensures an even better storage of the lubricant film and reduces the deformation and the contraction



of the metallic base. The matrix retains the disperse phase particles in the composite and, having a high plasticity and tenacity, it creates a maximum resistance at friction. The matrix has to have enough stability and hardness to present the maximum wear resistance and it has to present itself under the shape of a continuous mass, in order to protect the particles from being comminuted.

2. Experiment

Remarks on the mechanism of incorporating the particles. The complementary phases present in the coatings are incorporated during the formation of these protective layers and by the quantity and the distribution mode, can influence decisively their physico-mechanical properties.

The material interactions and the structure of the composite materials obtained for certain conditions, by the synergetic effects can realize the wished for properties.

Among the base metallic matrix (Ni, for the present case) and the complementary phases (oxides, carburs) there are quite a few combining opportunities, out of which only some of them can be taken into account, as noticed from the research done.

The mechanism of incorporating the particles during the electrochemical deposition is not yet clarified. The transportation of the particles towards the surface can be done by convection and/or diffusion, depending on the hydrodynamic conditions and on the particles' size.

The electro migration can also be important depending on the load of the particles. Particles incorporation in the coating mass can imply a physical absorption or a chemoabsorption of the particles, or electrochemical reactions of the absorbed species at film's surface. Different models have been proposed in order to take into consideration these processes [3].

As an example, Gugliemi regards the deposition process as a succession of two stages: a slow, electrochemical, absorption stage and a chemical strong one.

The physical sense of the two stages has not yet received a clear explanation, and as for the model, problems related to agitation of the electrolyte are not considered [4].

According to other authors, in the formation process of the composite films, appear the following important stages:

- the transportation of the disperse phase in the space near the electrode;
- holding these at catelectrode;
- heterocoagulation of the disperse phase particles at catelectrode;
- covering the particles with metal.

Celis and his team workers propose another mechanism of incorporating the particles that allows for the calculation of the included particles in the metallic matrix [5]. This model is described in the following lines as being valid for the codeposition of the alumina from the sulphat acid solution.

The co deposition rate of the ceramic particles in the metallic mass depends on the deposition speed of the metallic matrix and on the particles' flux existent towards the surface of the coating. The particle transportation towards the surface, which rises, is controlled mainly by convective diffusion in the case of nanometrical particles and under the cumulative effect of some convection and gravitational forces in the case of micrometric particles.

As a conclusion, the probability that the particles be retained during increasing the electrodeposited coating is dependent on its rising speed and from here on the density of the deposition current.

Depositions were obtained on a special installation with continuous agitation that ensured the maintaining of the disperse phase homogeneity in the electrolyte. For a good adherence between the support and the composite film, an intermediary layer (Nickel) was deposited on the metallic frame that ensured favorable conditions of electro crystallization for the composite film (Nickel + disperse phase).

The current density for obtaining the adherence layer was of 10-15 A/dm², for a period of time of 1-5 minutes.

2.1 Macro structural analysis

From the comparative analysis of the composite depositions obtained under the same conditions (figure 1), the following conclusions have been reached:

- the pure nickel layer electrodeposited on steel or copper frame presents a good compactity, a relatively fine and uniform granulation (fig. 1a);
- the composite films Ni + Al₂O₃, Ni + ZrO₂, Ni + SiC are characterized by a uniform granulation, relatively fine, a good compactity – compared to the deposition of Ni (fig 1b, 1c, 1d);
- the composite films Ni + B₄C present a coarse granulation, dendritic, with a low compactity, with large open pores (fig. 1.e.).

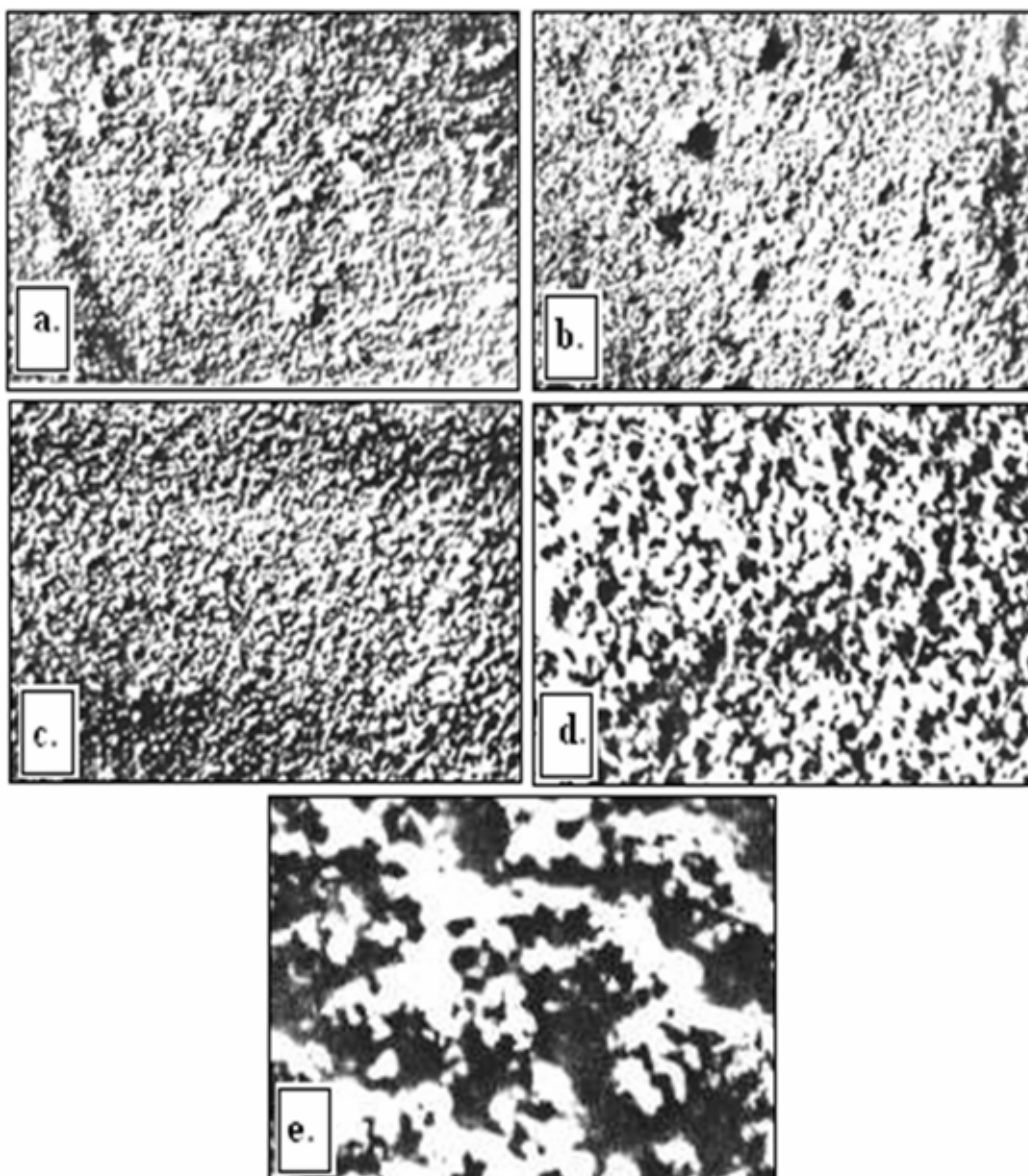


Fig.1. Macrostructure of the pellicles electrodeposited ($\times 50$):
a - Ni deposition; *b* - Ni + Al₂O₃ composite deposition; *c* - Ni + CSi composite deposition;
d - Ni + ZrO₂ composite deposition *e* - Ni + B₄C composite deposition.

2.2 The micro structural analysis

The microstructures of the cross sections, in the analyzed samples (support + layer for adherence + composite film) have shown a very good adherence of the deposition at the metallic support (figure 2). The width and the deposition surface aspect have been highlighted, as well as the quantity and the disperse phase distribution in the width of composite deposition.

2.3 Thickness of composite deposition

Depending on the deposition period and the current density, composite films have been obtained with widths ranging from 10 to 80 μm

(figure 3). Especially in the case of composite films Ni + B₄C, for widths higher than 30 μm , the aspect becomes coarse, dendritic, nonuniform.

Although the composite films Ni + ZrO₂ have a nice aspect, with a uniform deposition surface, with a fine granulation, a good adherence to the metallic frame, the microstructural analysis showed a strong unhomogeneity in distribution of the Zirconium oxyde particles in the Nickel matrix, under the shape of zonal agglomerating. This distribution can be explained by the tendency of ZrO₂ to form polymer species in water-like solutions, tendency that is growing as the environment acidity decreases.

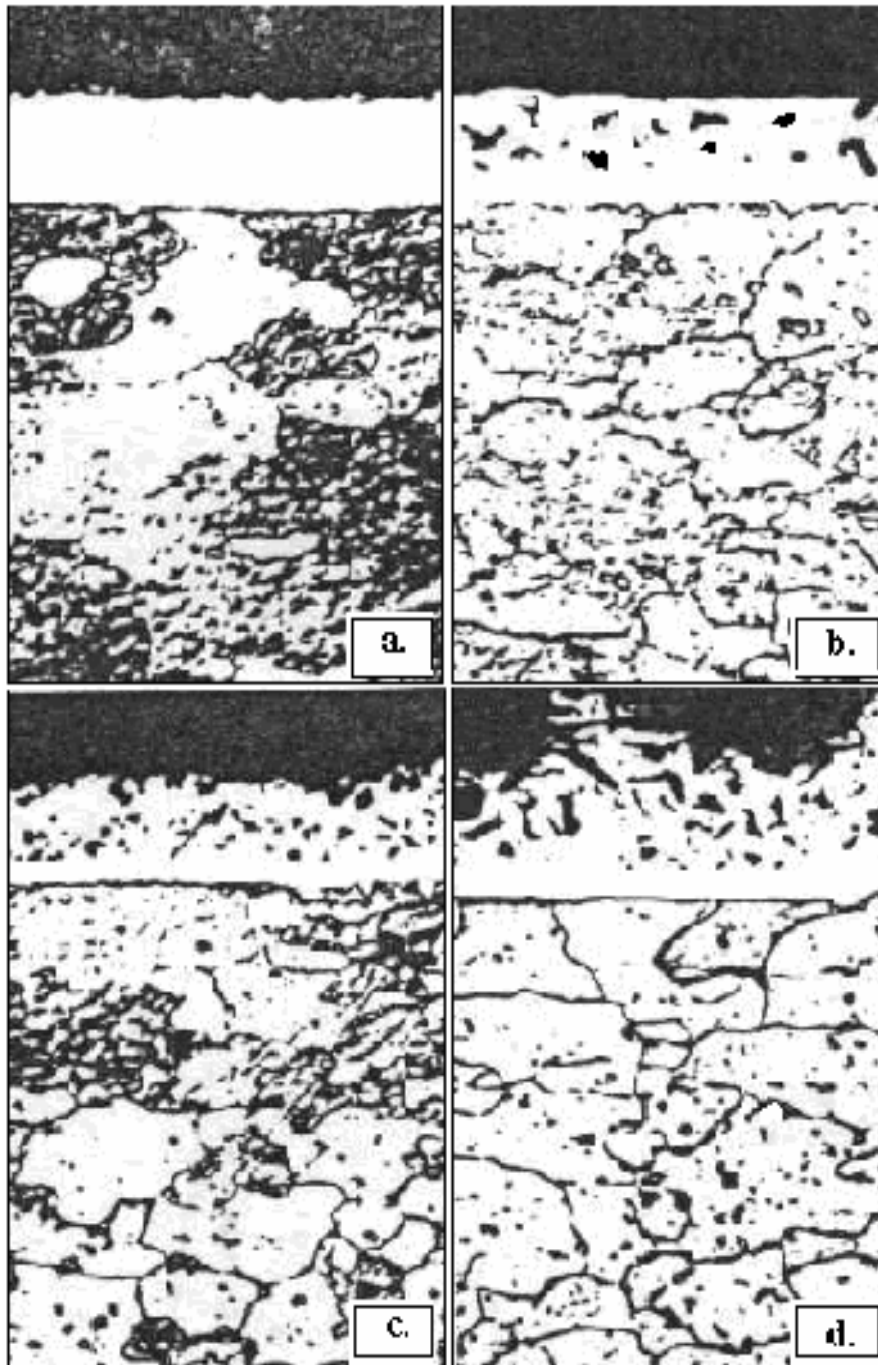


Fig.2. The microstructure of the electrodeposited films ($\times 250$) : a – Ni deposition; b – composite deposition Ni + Al_2O_3 ; c - composite deposition Ni + CSi; d - composite deposition Ni + B_4C .

4. Conclusions

Depending on the deposition period and the current density, composite films have been obtained with widths ranging from 10 to 80 μm . Especially in the case of composite films Ni + B_4C , for widths higher than 30 μm , the aspect becomes

coarse, dendritic, nonuniform.. The microstructures of the composite films Ni+ Al_2O_3 and Ni + SiC, realized in cross and longitudinal sections, reveal a dispersion relatively uniform of the aluminum oxide particles and respectively, silicon carbure in the nickel matrix, a uniform deposition, lack of pores, a good compactity, a very good adherence at the metallic frame (fig. 2 b, 2c);

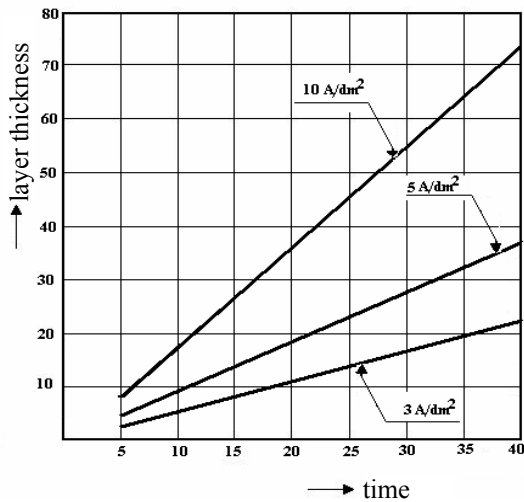


Fig. 3. Influence of the electrodeposition parameters – current density, time on the thickness of the composite deposition Ni+ SiC

The microstructures of the composite films Ni + B₄C, highlight when increasing the deposition period, a pore-material with non uniform indented aspect, but, with a relatively uniform distribution of the particles of boron carbide in the nickel matrix (fig. 2d).

Although the composite films Ni + ZrO₂ have a nice aspect, with a uniform deposition surface, with a fine granulation, a good adherence to the metallic frame, the micro structural analysis showed a strong unhomogeneity in distribution of the zirconium oxide particles in the nickel matrix, under the shape of zonal agglomerating. This

distribution can be explained by the tendency of ZrO₂ to form polymer species in water-like solutions, tendency that is growing as the environment acidity decreases.

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