

AN OVERALL ASPECT OF Ni-P DEPOSITIONS

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ABSTRACT: Composite materials are currently used in many fields of activity. These materials have different compositions and show very good mechanical and technological properties. A field where these composite materials have applicability is that of metal coatings. In the present work, these composite materials are presented, how they are applied and how they manifest themselves on the materials on which they are deposited.

KEYWORDS: composites, corrosion, deposition, electrolysis, layers

1. INTRODUCTION

Nowadays, although technique and technology have evolved a lot, tools, machine tools and materials wear represent an important problem.

Also, a major topic is the phenomenon of corrosion, which negatively influences their operation. These two problems are so serious that it is estimated that a lot of money is lost worldwide every year due to the degradation of machines and structural failures of the materials from which they are built. Due to this fact, efforts are made from the design and material selection phase to adopt the best solutions and techniques in surface engineering, by which they try to find methods and solutions that can be modified and improved to reduce its degradation over time.

One way to approach and reduce, even eliminate the inconveniences related to material damage is for the surface to be covered with a layer that minimizes the influence of the environment and working conditions and thus prolongs the operating time and the life of the equipment.

Given this problem, the use of hard and resistant deposits on tools and implements that perform operations that result in pronounced wear, high loads or elevated temperatures has been found as a first solution. For example, in the cutting operation, an advantageous solution would be

to easily make a cutting tool from an inexpensive material, to which a thin layer of the more expensive and harder material is applied to the surface.

For this purpose, materials such as chromium, carbides, nitrides, borons, oxides, and carbon are used, which are deposited in starts that give special resistance to wear and corrosion, and have good mechanical and tribological properties.

The layers deposited on the surfaces can be obtained by a variety of methods that can be mechanical, physical, chemical and electrochemical[1].

The development of composite materials began in the 1930s when the first Cu-graphite-based composites appeared and were used in motor vehicle engines [2]. Until 1970, composite electrodepositions evolve rapidly and find their place in many fields [3]. There follows a period with a marked rise of electrodeposited Ni-P materials, and extensive research is being done in this regard [4-6].

At the beginning of the 20th century composite materials are found in various forms and are introduced in many applications. In particular, after 2005, multilayer Ni-P type nanocomposite materials, with different concentrations, obtained by hybrid deposition techniques are found [7, 8]. After 2010, composite materials are obtained their range of superior properties widens [9-13] and also the range of their applications expands.

Research in the field shows that several studies have attempted to explain the phenomenon of composite deposition. Thus, different electrolytic deposition and co-deposition models are proposed. We remember the model proposed by Gugliemi (1972) [14], the model proposed by Valdes and Cheh (1986) [15], 1987 Celis (1987) [16] also proposed a model of co-deposition, Fransaer in 1992 tried to explain the phenomenon of co-deposition [17], Hwang and Hwang (1993) [18], Bozinni et al. [19], in 1997, Shao et al. (2002) [20], Bercot et al. [21] also in 2002, Bahadomanesh et al. [22], in 2010.

There are researchers in the field that looked at reinforcing with composite materials such as carbon or glass fibers, which give a high resistance to bending, for example [28].

2. ABOUT NI-P ALLOY DEPOSITS

Ni-P alloy deposits due to good mechanical properties (hardness, wear resistance, friction resistance, fatigue limit, etc.), high corrosion resistance, good magnetic properties, high weldability, high conductivity, good machinability, etc., can be used in a wide range of domains [23-27]. Moreover, the properties of heat-treated Ni-P alloy deposits are similar to the properties of chromium deposits [28], which makes these chromium layers, due to environmental problems, replaceable by Ni-P ones.

This material enjoys high hardness and can be easily machined, which is why it can be used in diamond-turning operations. Ni-P alloy is a material that can be used as a diffusion barrier and as a base layer for gold-plated elements, which causes a considerable decrease in the thickness of the gold-plated layer. After applying heat treatment, the hardness of the electrodeposited layers increases.

Ni-P material depositions were originally done chemically, where layers of uniform thickness were obtained even on parts with complex shapes and geometries. The composition of the solution including several elements (absorbing agents, reducing agents, stabilizers, etc.), makes the use of this method industrially difficult and expensive. At the same time, these solutions are difficult to control and cannot be used in several manufacturing cycles because these solutions precipitate and generate large amounts of waste. There are other drawbacks of the method, including the use of a high temperature and a low deposition yield.

The extension of the electrolytic process of obtaining the Ni-P alloy was due to Brenner, who developed the electrolytes [29], and from here we can say that electrodepositions begin their real evolution.

The advantages that the electrolytic method imposes (use of an electrolysis solution with a simpler composition, high efficiency of the process, the possibility of changing the working parameters, obtaining deposits with varying thicknesses and uniform layers, etc.), make the method net superior to other procedures.

A particular interest of the electrodeposition method is the fact that layers of large thicknesses can be obtained in a relatively short time so that the electrolytic deposition processes will take less time, energy will be saved and the times required for cleaning and maintenance of installations will be eliminated.

The deposition process is carried out in electrolysis cells (figure 1), which is a relatively low-cost installation, in which the working parameters and conditions can be easily changed so that layers of various thicknesses and variable contents can be obtained [30].

The composition of the electrolyte has the constituents shown in figure 2. The electrolysis bath consists of $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$, H_3PO_3 , H_3PO_4 and Na_2SO_4 .

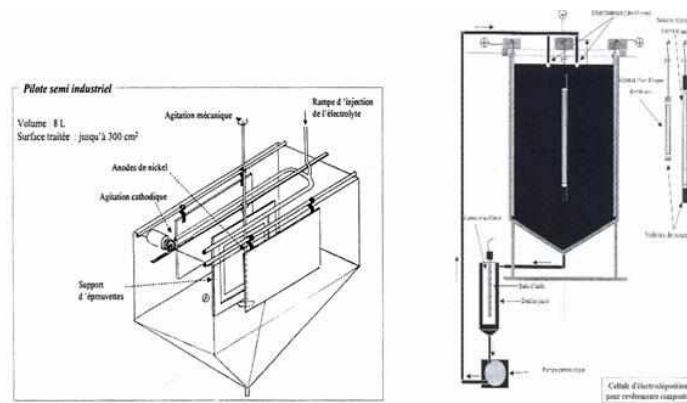


Figure 1. Types of electrolysis cells [30]

The variation of working conditions in the electrolytic method influences the

properties of the electrodeposited layer [31,32].

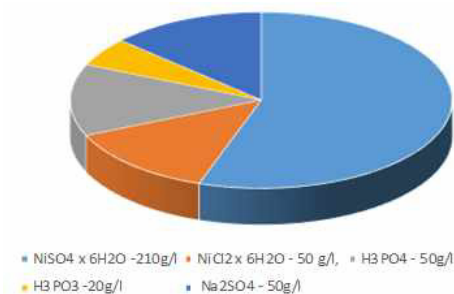


Figure 2. Electrolyte composition

Thus, changing the composition of the electrolyte, by varying the amount of phosphoric acid in the solution, influences the phosphorus content in the layer (fig. 3), in other words, it influences the structure of the layer. According to some authors [33-35] this dependence is explained as follows: for the content of less than 9% phosphorus or up to 2g/l phosphoric acid, the electrodeposited layer is crystallized, which corresponds to a solid solution supersaturated in nickel crystallized in the cubic system with centered faces.

If the phosphorus content increases to 17%, which corresponds to an amount of up to 8 g/l phosphoric acid, the Ni-P layer has a microcrystalline structure.

If the phosphorus content incorporated in the layer is in the range of 17-22%, which comes from a quantity of 8-25g/l phosphoric acid, the nickel solid solution supersaturated in phosphorus is amorphous. Depending on the amount of phosphoric acid in the electrolyte, the deposition yield can also be determined (figure 4)[30].

According to some authors, the efficiency of the cathodic current during the Ni-P material deposition process depends, in addition to the composition of the electrolytic bath, on the density of the applied current [36, 37], temperature [38], pH of the bath [39].

Another parameter that influences the layer thickness is the electrodeposition time. The longer the process, the thicker the obtained electrodeposited layer. In figure 5, the thickness of the layer was obtained by varying the time to 15 minutes, and the amount of phosphoric acid in the bath remained constant at 20 g/L.

It is known in the specialized literature [28, 30, 32, 38, 39] that the hardness of the Ni-P material can be increased by varying the phosphorus content in the layer, therefore by varying the amount of phosphoric acid in the electrolysis bath and by applying thermal treatments at various temperatures (190 °C and 420 °C)[30,39].

Field studies [30,40] show that the Vickers hardness of Ni-P material varies along three domains depending on the

percentage of phosphorus in the layer and the applied load.

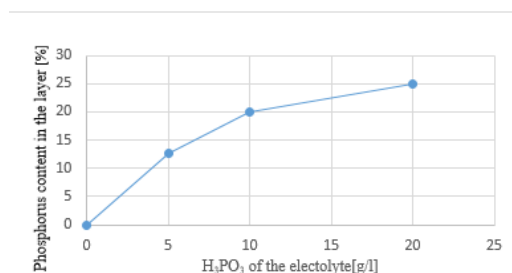


Figure 3. Dependence between the phosphorous acid in the electrolyte and the phosphorus content in the layer

Figure 6 demonstrates this dependence, showing the three areas of variation.

Obtaining the Ni-P material by electrodeposition remains a rather promising topic because the properties of other materials can be improved by the co-deposition of other particles such as SiC, TiN, TiO₂, Al₂O₃, SiO₂, WC, etc.

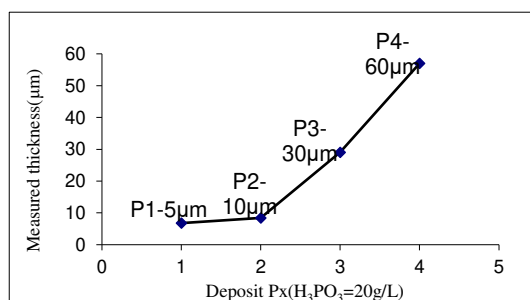


Figure 5. Average measured deposit thickness

3. CONCLUSION

In various industrial fields, the presence of the phenomenon of corrosion wear is noticeable. To prevent the occurrence of this phenomenon or to improve wear resistance, one can resort to the application, on the working surfaces of various tools, materials, machines and equipment, of some layers made of wear-resistant materials. Types of such materials were mentioned in the present paper, highlighting the process of obtaining them and the method of application. One of these materials is Ni-P, which has very good mechanical properties. It gives the surfaces on which it is deposited, performance qualities, due to its very high hardness and

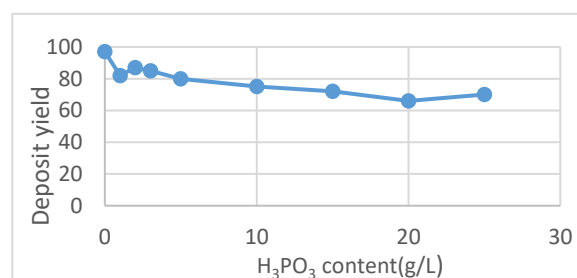


Figure 4. Dependence between the amount of H₃PO₃ and yield

of different sizes (even nanoparticles).

Studies in the field have shown that the addition of micron and submicron SiC particles in the electrolyte causes Ni-P/SiC electrodepositions resistant to wear and corrosion [30, 43, 44].

In particular, SiC particles have been widely used due to their mechanical properties and economic cost.

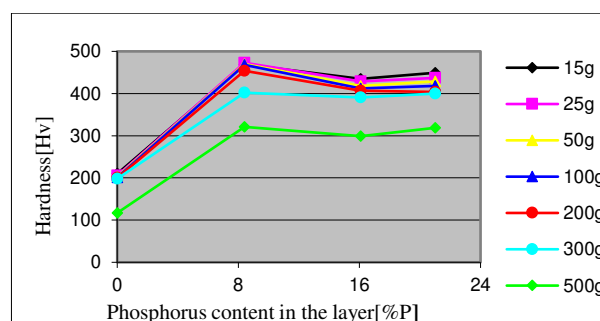


Figure 6. Dependence of hardness in relation to the applied load and the phosphorus content in the layer

corrosion resistance. Obtaining the Ni-P material by electrodeposition remains a rather promising topic because the properties of other materials can be improved by the co-deposition of other particles such as SiC, TiN, TiO₂, Al₂O₃, SiO₂, WC, etc of different sizes (even nanoparticles).

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