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THE INFLUENCE OF THE STEEL'S SURFACE QUALITY ON THE ELECTROLESS Ni-P COATINGS

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ABSTRACT

The method of autocatalytic reduction coating assures a precise reproduction of the coated surface. This is an advantage when the support surface has a complex geometry but also becomes a disadvantage because it requires a support without surface defects and without high roughness. Also the electroless method requires a special preparation of the support surface which should enhance its reactivity. This paper reveals the influence of different surface characteristics of the support on the quality of the coating.

Metallographic analysis has been done on the surface and transversal section of Ni-P coatings of different steel surfaces.

KEYWORDS: electroless method, Ni-P coatings, the morphology of the support, support steel

1. Introduction

Brenner and Riddel are known as the discoverers of the electroless nickel coating method, process first observed by Wurtz [1, 2] in 1844. Since Brenner and Riddel invention, the study of the electroless nickel coating method has continued to raise interest [3, 4]. The research has led to the development of the procedure first called by its inventors electrodeless, later electroless and now it is formally known as "autocatalytic reduction". Bretean [5], Paal and Frederici [6], Scholder and Heckel [7], Scholder and Haken [8] are among the researchers who studied this method. Nowadays this method is used to coat with several metals like: Cu, Co, Sn, etc., and several alloys like: Ni-P, Ni-B, Ni-P-Sn, etc., and several composite and nano-composite materials.

Nickel coating is the most common application of electroless coating. Through this method it is possible to achieve nickel coatings with different phosphorus concentrations. The Ni-P coatings done in acid baths can be classified based on the phosphorus content in several classes:

- with low phosphorus content, 2-5 %P;
- with medium phosphorus content, 6-9% P;
- with high phosphorus content, 10-12 %P.

Low phosphorus content will lead to improved hardness, improved resistance to wear, improved high temperature resistance, improved corrosion resistance in alkaline environments. Medium phosphorus content coatings have a nice shiny aspect, good hardness and wear resistance, moderate corrosion resistance. High phosphorus content coatings have very good corrosion resistance and a total lack of magnetic response [9].

Research have shown obvious advantages of the electroless method. These are [10, 11]:

- thin coatings with constant thickness;
- selective coatings on metallic surfaces catalytically active;
- complex shape coatings;
- coatings on non-conductive and semiconductive materials;
- the possibility to control and modify the properties of the coating (for example by incorporating a nonmetal);
- the control of the residual stress.

It is also known from the professional literature that the autocatalytic coating with nickel assures a good reproduction of the surface profile, this method being recommended for highly complex surfaces. Good reproduction of the surface profile can however cause problems related to surface defects [12] or to the surface roughness. In this material we intend to show the way the preparation of the support material and the morphology of the support steel surface influences the Ni-P coating.

2. Experimental research

For the experiment thin low carbon steel (0.25 wt.%) strips 0.4 - 1.0 mm were coated with different

degrees of surface finishing done through rolling and skin-passing with high to very low roughness.

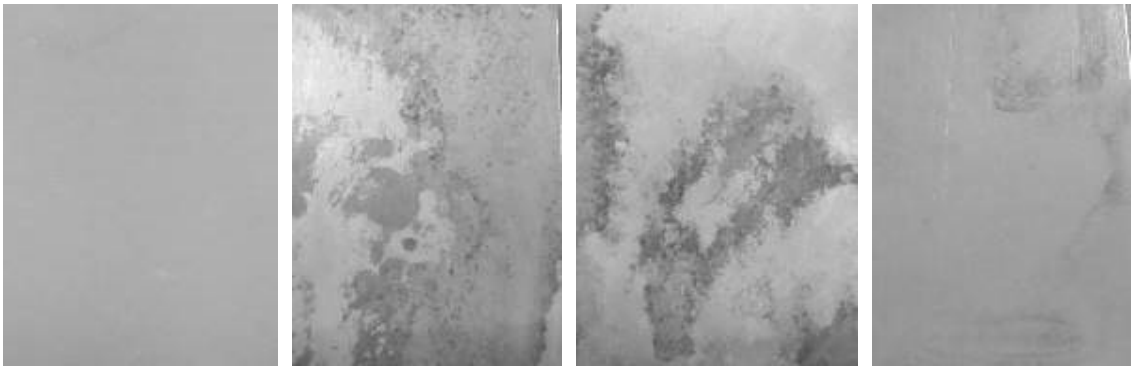
The Ni-P coating has been done in a baths with 25 [g/L] nickel sulfate, 23 [g/L] sodium hypophosphite, 9% [g/L] sodium acetate and 1 [g/L] lead acetate. The pH control has been done with NaOH and acetic acid solution. The Ni-P coatings have been obtained at 80-81 °C, pH = 4.5 and a bath spinning speed of 300 rpm, the immersion duration has been varied between 3 and 30 minutes.

The samples preparation for coating consisted of:

- chemical degreasing using a commercial product at 80-90 , followed by washing in hot water (80-90) and finally in cold water;

- pickling in hydrochloric acid 20% and washing in water at 90 to maintain constant the temperature of the coating bath when immersing the sample.

A large part of the nickel coating defects is caused by inadequate preparation of the surface of the support material. In Figure 1 (b, c and d) several macroscopic aspects of some coating defects are shown noticed on the surface of the steel strips caused by improper or insufficient surface preparation. The evaluation of the influence of the surface roughness on the Ni-P electroless coating has been done metallographically.



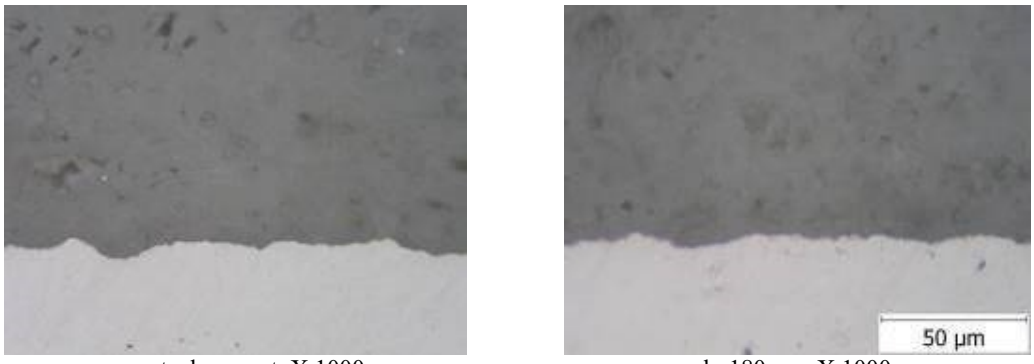
a b c d

Fig. 1. *(a, b, c, d) Macroscopic aspects of some surface defects*
a - correctly prepared sample; b, c and d - defects caused by improper surface cleaning (1:2)

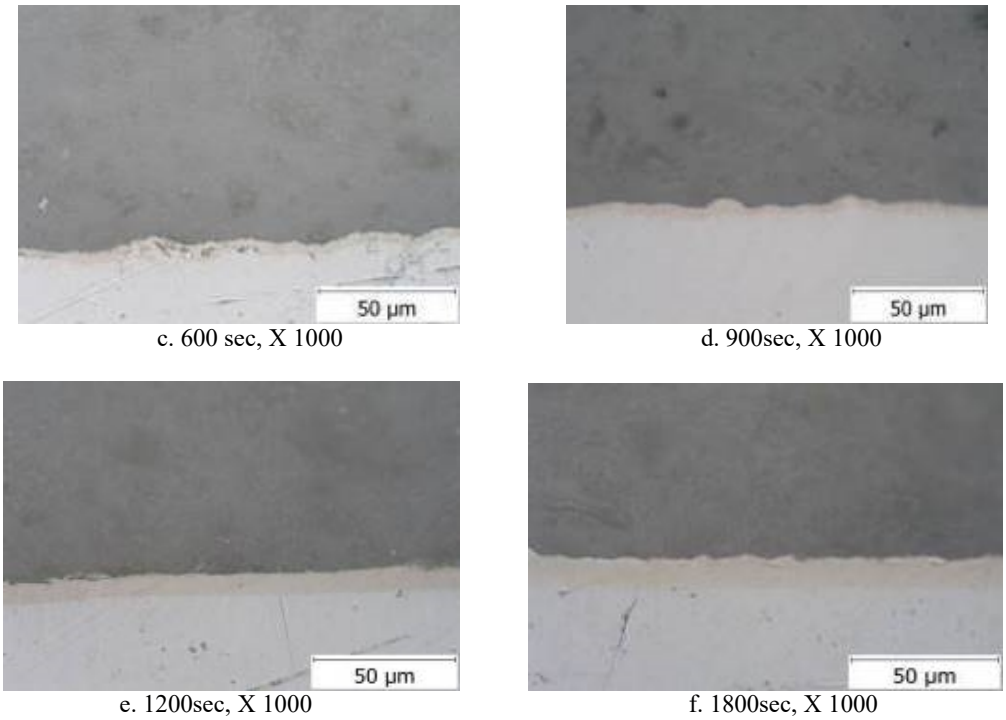
The coatings done on high roughness strips, obtained through cold rolling with 1.0 mm thickness, show at metallographic analysis (Figure 2) a difference in the aspect of the Ni-P layers depending on their thickness (caused by the different immersion durations).

At low immersion durations (180 to 600 seconds) the coated layers are very thin and discontinuous (Figures 2.b and 2.c). Increasing the duration leads to continuous layers (Figure 2.d) which start to reduce the roughness of the support (Figure 2.e). At durations of 1800 seconds, the Ni-P layer covers the asperities of the substrate (Figure 2.f). For the thin layers it can be seen that the surface contour is reproduced with high fidelity while at thicker layers the roughness is suppressed, the layers become uniform.

On very thin steel strips (0.4 mm) with fine surface with low roughness even the thin layers, of 2 µm, are uniform as it can be observed from Fig. 3.a.



a. steel support, X 1000 b. 180 sec, X 1000

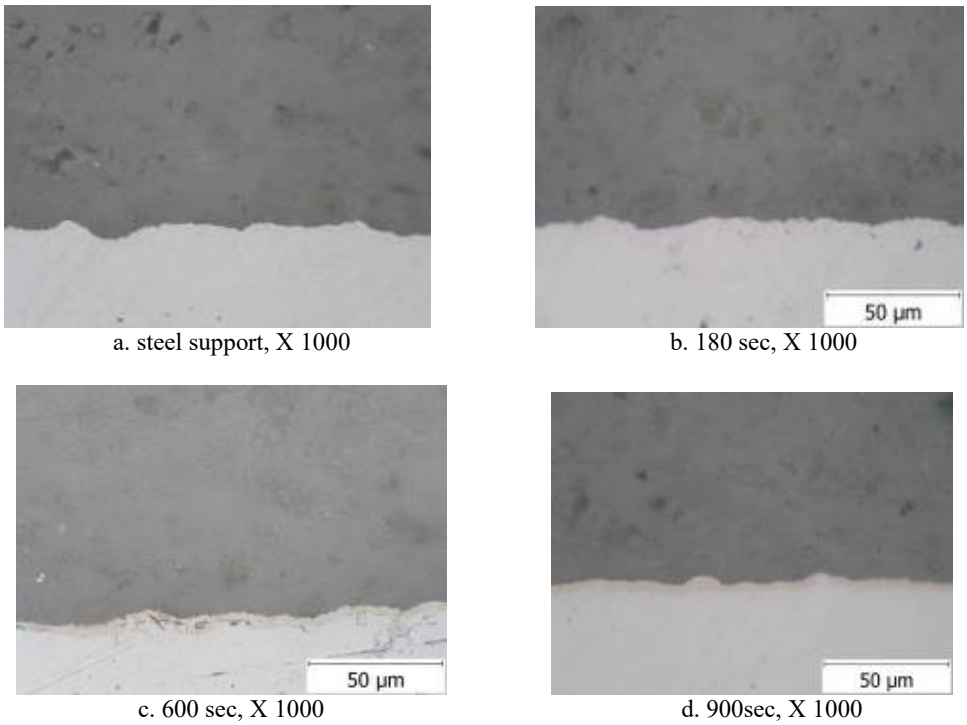


c. 600 sec, X 1000 d. 900sec, X 1000

e. 1200sec, X 1000 f. 1800sec, X 1000

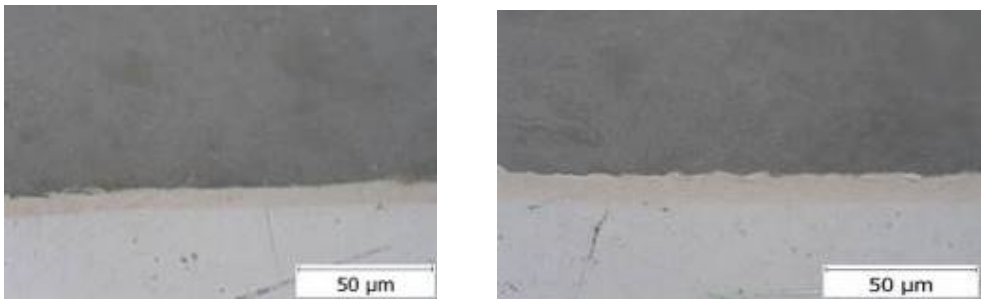
Fig. 2. *The influence of the roughness of the surface on the coated layer at different immersion durations into the coating bath*

Increasing the immersion duration for these surfaces maintains the uniform aspect of the coating and can only be differentiated by their thickness (Figures 3. b, c and d).



a. steel support, X 1000 b. 180 sec, X 1000

c. 600 sec, X 1000 d. 900sec, X 1000



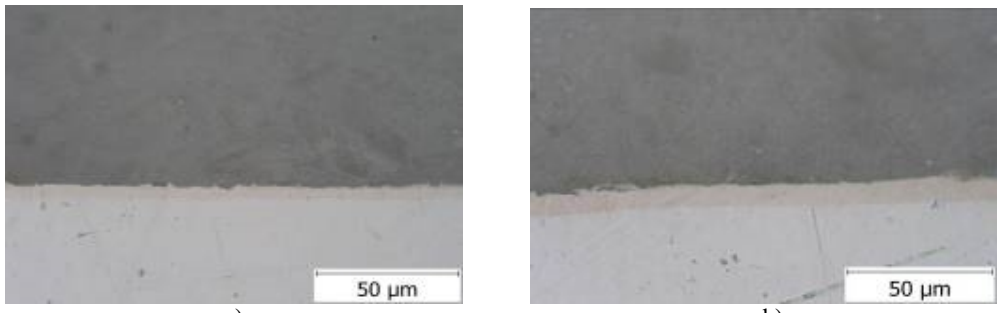
e. 1200sec, X 1000 f. 1800sec, X 1000

Fig. 3. *The influence of a smooth support surface on the coated layer at different immersion durations into the coating bath*

A good adherence of the coated layer is a quality requirement for any type of coating. A week adherence leads to detachment of the coating and this will no longer insures the protection role of the surface or the enhancement of other properties (wear resistance, hardness, etc.).

The adherence can be tested through different standard methods, taking into consideration the novelty of these coating methods there are no specific testing techniques. In this context we chose to evaluate the adherence through microscopic analysis.

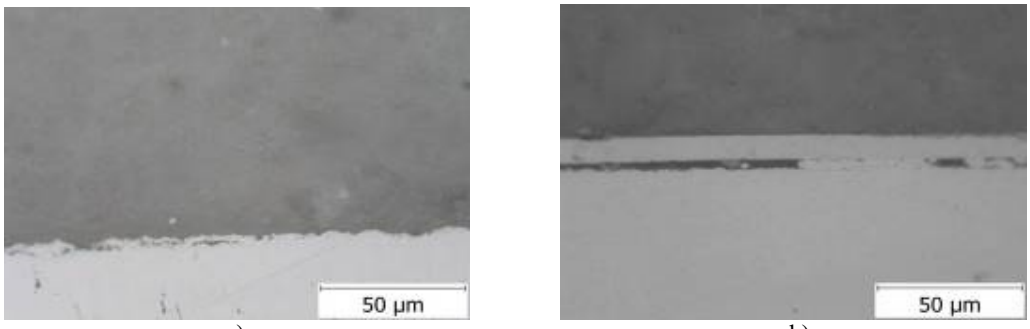
A very good adherence both for thick and thin layers has been noticed by observing the continuous interface between the coating and the support surface, as it can be seen in Figure 4.



a) b)

Fig. 4. *Good adherence of thin (a) and thick (b) layers demonstrated by the continuous interface between the coating and the support surface*

If the support surface has not been adequately prepared, between the support and the coating cavities and discontinuities appear which indicate weak adherence or total lack of adherence (Figure 5).



a) b)

Fig. 5. *Inadequate adherence of the layers, a - weak, b - total lac*

3. Conclusions

On very thin steel strips (0.4 mm) with fine surface and low roughness, even thin Ni-P protective coatings, 2 µm in thickness, are uniform. coatings on rough surfaces reproduce the surface of the support material with high fidelity. Increasing the immersion duration leads to continuous layers which start to reduce the roughness of the support.

A very good adherence of the layers has been noticed proven by the continuous interface between the coating and the support surface. The main factor which can affect the adherence is the surface preparation. If the samples' surface has not been adequately prepared, between the Ni-P coating and the support cavities and discontinuities can be noticed which imply weak adherence or total lack of adherence.

References

[1]. Hari Krishnan K., John S., Srinivasan K. N., Praveen J., Ganesan M., Kavimani P. M., *An Overall Aspect of Electroless Ni-P Depositions-A Review Article*, Metallurgical and Materials Transactions A, Vol. 37A, June 2006, p. 1917-1925.

[2]. Wurtz A., Comp. Rendus Acad. Sci., 1844, vol. 18, p. 702.

[3]. Reidel W., *Electroless Nickel Plating*, ASM international, Metals Parks, Oh. 1991, p. 68-69.

[4]. Khin Myo Latt, *Effects of surfactants on characteristics and applications of electroless nickel-phosphorous deposits*, Chapter 2, Literature Review, Master of Engineering Thesis, 2003, http://scholarbank.nus.edu.sg/handle/10635/13503.

[5]. Bretean P., Bull. Soc. Chim., 1911, vol. 9, p. 515.

[6]. Paal C., Frederici L., Ber. Deutschen Chem. Gesellschaft, 1931, vol. 64B, p. 1766.

[7]. Scholder R., Heckal H. Z., Unorganische Allgemeine Chemie., 1931, vol. 198, p. 329.

[8]. Scholder R., Haken H. I., Ber. Deutschen Chem. Gesellschaft, 1931, vol. 64B, p. 2870.

[9]. ***, *Electroless Nickel Plating. A Guide*, Artistic Plating Company, Inc. Milwaukee, WI 53212.

[10]. Morton Schwartz, *Deposition from Aqueous Solutions: An Overview*, p.506-616. http://www.tau.ac.il/~chemlaba/Files/1.pdf.

[11]. Lee Hyland, *Electroless Deposition of Group Eight Metals*, Thesis of University of Hull, October 1995.

[12]. Mainier B. F., Cindra Fonseca M. P., Tavares S. S. M., Pardal J. M., *Quality of Electroless Ni-P (Nickel-Phosphorus) Coatings Applied in Oil Production Equipment with Salinity*, Journal of Materials Science and Chemical Engineering, 2013, 1, 1-8, www.scirp.org/journal/msce.