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MICROSTRUCTURAL ANALYSIS OF THREE LAYER DEPOSITIONS WITH Ni AND Ti ON STEEL USING THE EDS METHOD

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ABSTRACT

The ESD method (electro spark deposition) is used to cover through deposition the active parts of machines, working in heavy abrasive wear moist environment as well as in a dry environment. The paper proposes the use ESD method for Fe-C alloys for obtaining thin layers system with physical-mechanical properties improved comparing to base material. Due to polar effect, the predominant transfer of anode's material (electrode) towards cathode (piece) assures the forming of the superficial layer with well-determined physical - chemical properties. In addition, in multiple layers case the deposit of a supplementary layer emphasizes the diffusion of the first deposited layer by anchoring more the coating.

KEYWORDS: ESD method, microstructure, layer

1. Introduction

Nowadays, coating procedures on metallic surfaces are spreadingly used in industry for improving exploitation performances of the pieces and mechanic structures.

Going from these relevant aspects from industrial practice, the researches made in different countries such as Japan, China [1, 3, 4], Ireland [2] emphasized a series of knowledge that refer to technologies and studies with fundamental and experimental character which lead to improving superficial layers properties by using the impulse electric discharges method. It is seen that the main causes that produce the necessity of replacing some system parts in automotive industry are the destructions of surface layer through wear, fatigue and corrosion (ex. piston rings for Diesel engine).

Thus, the properties of the metallic materials were improved [5, 6], in order to raise deposited layer's adherence to basic material, in coating of composite materials by using impulse electric discharges.

Hardening technology with impulse electric discharge has known an explosive development due to special properties of wear resistance of the obtained layer. There were made researches [7] referring to the applicability of coating method with impulse electric discharges on metallic materials used in marine transport by improving corrosion resistance in seawater. Also, it was emphasized the influence of heat treatments on the characteristics of the deposited layers obtained with vibrating electrode on materials used for cutting tools [8].

Obtaining a thin layers system with special properties (wear resistance, corrosion resistance, impact resistance) requires a correct choice of the adding material in strict correlation with physical-mechanical properties of the base material [9-11]. Taking into account that the main objective is to improve the wear behaviour by deposition of hard layers, appears as necessary, in order to achieve the objective, the generation of a thin layers system: anchor layer with comparable properties to the support material, and the surface layer with required properties.

The technology involves a method of deposition and alloying and thin adherent layer, based on impulse electric discharge technology on one side, with a total of up to 3 layers of electrode material successor of nickel and titanium, which gives the parts processed a wide range of properties (mechanical strength, surface hardness corresponding compressive stresses and martensitic structure of complex carbide layer), which reduces the effects of wear, having positive effects on the life of the product

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[12]. Durability of metal layers is the result of convolution of structural changes and thermo-mechanical fatigue.

2. Methods and materials

In order to obtain the thin layers, the ESD (electro spark deposition) method was used. This technology employs electricity stored in the capacitor to initiate an electrical spark between the cathode and the anode. The high temperature generated by the spark leads to the partial melting and mixing of the electrode and surface materials. Between two electric sparks, the amount of molten metal solidifies to form the surface layer. It must have a very good adhesion to the surface of the part and a good chemical and thermal compatibility with the substrate, as well as high qualities of resistance to wear and oxidation.

The deposition facility ELITRON 22 A [13], by ESD method, is the endowment of the laboratory Properties of metallic materials within the Faculty of Materials Science and Engineering in Iasi. The electrical diagram of the Elitron 22A type equipment is shown in Figure 1.

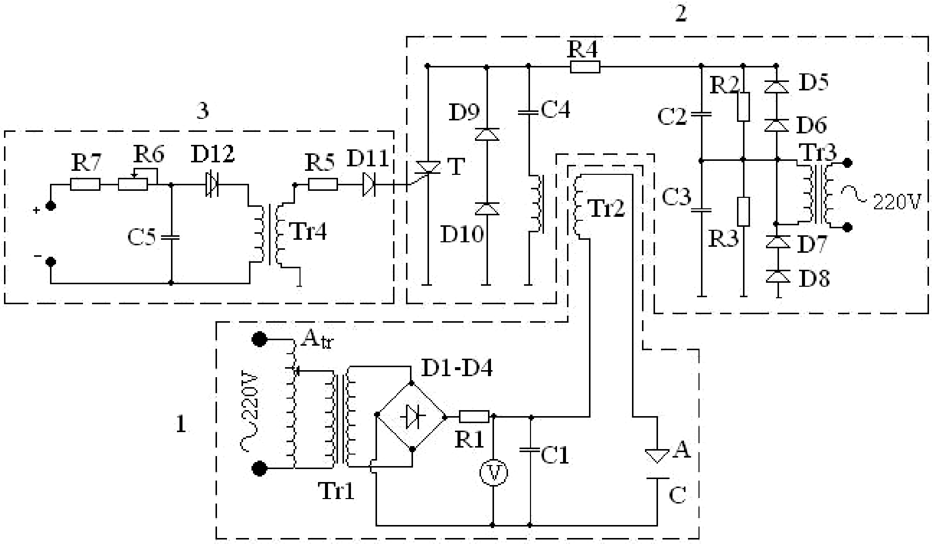

Fig. 1. *Electrical scheme of the deposition device, type Elitron 22A*

For the experiment, 42CrMo4 alloy weak steel base material, EN 10083-1 has been used, whose chemical composition was determined with the Foundry Master spectrometer [14]. It was chosen as the base material because the alloying elements, such as chromium and molybdenum, increase the quality, hardness, wear resistance, corrosion resistance and ensure good and stable mechanical properties at high temperatures.

Additive Ti and Ni electrodes were used as addition materials [15].

Table 1. *Chemical composition of 42CrMo4 alloy weak steel, %*

Element	Fe	C	Si	Mn	P	Cr	Mo	Ni	Al
Percent	95.7	0.477	0.185	0.331	0.023	1.20	0.193	1.36	0.239

The material of the electrodes strongly influences the alloying process by the ESD method, the influence being manifested both by the difficulty of deposition or by its ease and by the quality of the deposited surface (by quality understanding adhesion, roughness, layer thickness, presence of oxides, etc.).

3. Heterogeneous deposition with Ni/Ti/Ni

The Ni/Ti/Ni triple layer deposition creates relatively compact surfaces, with microdrops and microcracks due to the gases absorbed at the surface even from the liquid drop of the "droplets" deposited, Figure 2. It is observed that the splashes and craters due to the gases are especially characteristic of the deposition with nickel. The presence of the titanium in interstitial position creates the possibility of reducing this defect. EDX analysis shows by distribution, the massive presence of both titanium and as well as nickel, both having a very good coverage throughout the surface.

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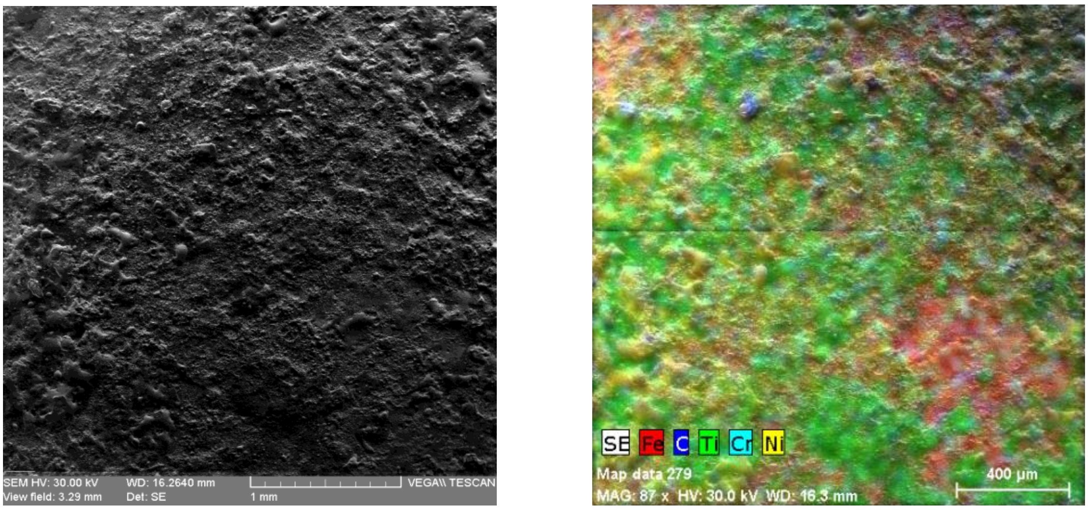
The chemical analysis of the studied surface shows a presence of nickel of 27.99% by volume and titanium of 26.74% by volume, Figure 2b.



a) b)

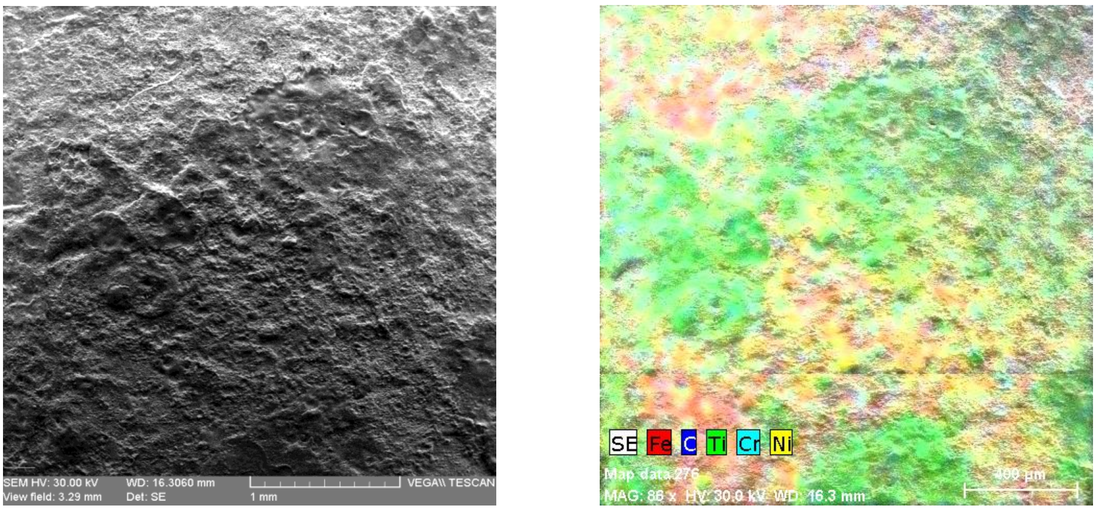
Fig. 2. *Microstructures analysed at SEM; a) deposition with Ni / Ti / Ni on steel, SE, 1000X; b) EDX analysis for the distribution of the elements on the surface*

It is observed that the titanium has a high percentage even though it is an intermediate layer, due to its microalloying properties by dissolving in the metallic microbe.

4. Heterogeneous deposition with Ti/Ni/Ti

The Ti / Ni / Ti triple layer coating creates relatively smooth surfaces, with a slightly waved appearance due to superimposed molten "drops", with fine cracks and relatively few in number, with no obvious burns, no material overlaps, adhesions or other surface defects, Figure 3.

The effects of gas bubbles are no longer visible as in the Ni deposits a layer, which is due to the partial re-coating of the intermediate Ni layer in the coating. Surface EDX analysis shows by distribution a deposition with heavy Ti, Ni and Fe appearing on small areas by splashing and by microalloying the metal drop of the molten "drop", Figure 3b.



a) b)

Fig. 3. *Microstructures analysed at SEM; a) deposition with Ti/Ni/Ti on steel, SE, 1000X; b) EDX analysis for the distribution of the elements on the surface*

There is a presence of 30.43% by volume of iron, 28.94% by volume of titanium and 14.41% by volume of nickel. Also, a massive oxygen presence of 24.71% by volume is observed, due to surface oxidation because the deposition was done in ordinary atmosphere without protection.

5. Conclusions

The triple layers create compact deposits with a heavier microalloying, so that the layer grows, but not so much.

This is possible because there is an intermediate layer created from the melting of the support material with the additive material which generates very good mechanical properties (hardness, adhesion).

The thin layer hardened through impulse electric discharges method is splitted into an exterior layer with a strongly modified structure at the surface and an interior layer (diffusion layer) with the properties corresponding to basic material and added material.

The thin layers system hardened presents cracks that are advantageous to lubrication process (during exploitation) by protecting basic material of excessive wear.

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