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ESD morphology deposition with WZr8 electrode on austenitic stainless steel support

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Abstract. Stainless steels are used to obtain mechanical parts, working in severe conditions with high dynamic loads in wet, chemically active environments. For this reason, these materials have good corrosion resistance in acidic or basic chemical agents. The main drawback is the relatively low wear and resistance to mechanical stress. This paper proposes a remedy by deposition of the hard thin films of tungsten electrode by spark electro-deposition method (ESD). Tungsten is an alfagen element and causes an increase for the mechanical properties at high and low temperatures for the austenitic stainless steels. Tungsten does not alter the corrosion resistance of stainless steels. The morphology for the obtained layers was analyzed using SEM, in 3D images, and profilographs.

1. Introduction

In industry, pumps, compressors, cutting machines, etc., works in difficult operating conditions. The surfaces of the moving parts are subject to static and dynamic mechanical loads, at various temperatures, in abrasive wearing and corrosive environment conditions. For this reason it is necessary to use protective coatings that improve the surface qualities of the parts by various deposition methods [1-3].

Stainless steels are used in almost all industrial domains and due to corrosion resistance characteristics, combined with its characteristics and surface processing possibilities, have led to increased interest in this class of materials. It presents a good corrosion resistance, so it can operate successfully in chemically aggressive environments, but do not withstand severe wearing. To remedy this situation, the paper proposes the use of additive materials based on tungsten, which are deposited by ESD method and increases the surface resistance to dynamic loads and severe wearing.

Electro-spark deposition is a microwelding process that is capable of depositing wear and corrosion resistance coatings to repair, improve, and extend the service life of the components [4].

In the electric discharge pulse deposition process, besides the great importance of the the mass transfer, the working process parameters and the physico-chemical characteristics of the whole surface, the deposition method presents a significant importance to the development of appropriate structures, especially the adherence and microallying of the metallic "drop" [5].

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2. Materials and Methods

2.1. Base Material
For the experiment was used as the base material, the austenitic stainless steel X2CrNiMo18 14 3, DIN 1.4435. This austenitic steel deforms very easily and is not appropriate for subsequent heat treatments, [6]. The chemical composition of this material was determined using the spectrometer equipment Foundry Master from the Department of Materials Processing Technology and Equipment at the Faculty of Materials Science and Engineering of Iasi. The percentage for each chemical element is shown in table 1.

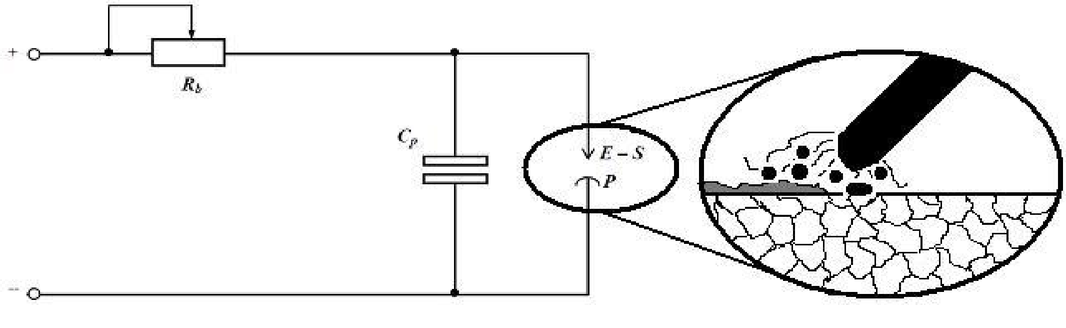
Table 1. Chemical analysis of the base material.

Chemical element	Fe	C	Si	Mn	Cr	Mo	Ni
%	balance	0,028	0,99	2,12	17,24	2,9	13,41

The samples from the X2CrNiMo18 14 3 were processed on a cutting machine obtaining the samples with the following sizes: 20mm long, 35mm wide and 4mm height. After cutting, these samples were prepared by successive grinding on metallographic paper to the 600-grain size. By grinding there is obtained a decrease of the surface peaks. If the deposition would be done on rough samples, a local burning of the peaks would occure. This local burning will cause several defects on the surface.

2.2. Deposition Material
The electrode used for deposition is WZr8, ISO 6848 AWS A5.12 and contains ZrO2 (0,70...0,90%), impurities ≤0,20%, and W for balance. The electrode is white marking type. This type of electrode shows good weldability properties, acts as low melted tip contamination and has good anti-corrosion properties, creating a relatively smooth surface (with small roughness). It also produces a stable electric arch and presents good resistance at pulling the soft areas of the electrode.

2.3. Deposition Material
ESD deposition method is used to cover the installations components, which operate in severe conditions as abrasive wearing in wet or dry environments. In wet environments beside the mechanic loads, the parts must work in high chemically active environments. The electrical discharge method, in gas, as a method to obtain a surface layer, is based on the polarization effect and the material transfer from the anode (electrode) to the cathode (part). Installation used for depositions is Elitron 22A, [7].



a) b)

Figure 1. Processing of metal surfaces by electrical discharge impulses: a) Electrical diagram of the processing device: Cp = capacitor , Rb = variable resistance , E-S = electrode coupled to the anode, P = part coupled to the cathode ; b) Surface processing diagram.

The two schemes, electrical diagram and working principle of processing by the electric discharge pulse are shown in Figure 1. Electrical diagram represents a generator, a part, which is coupled as cathode, and the anode as the deposition electrode.

The processing of the surface begins by approaching the electrode to the sample. At the critical distance, piercing triggers the electrical discharge pulse. In most of the cases, the discharge is continuous and is finished when the two electrodes are touching each other.

After piercing the interval between the electrodes, due to the energy accumulated in the condenser Cp, at the contact surface of the electrodes, strong heated areas appear (local melting and evaporation points), causing electrical errosion of electrodes (part and electrode itself).

Different depositions were made on a support of austenitic stainless steel. Depositions with one and two layers were studied, pointing to the morphology and surface characteristics obtained after coating.

3. Results and Discussions

Electrode substrate and parts surfaces make physical contact in small areas, involving just a small number of points from the surface. In these contact points electrical current is extremely intense, a large amount of energy causes the metal to melt and even quickly vaporize, [8-10].

It will increase heat and will ionize the gas between the electrode and the substrate. At the end of this period, many charged particles are generated, such as free electrons, ions and other particles, which fulfills the criteria of a pulsed discharge at low voltage. When the metal melts at contact points, it will occur a pitting (indentation) between the electrode and the substrate. Furthermore, a non-uniform electric field is created between the anode (electrode) and the cathode (substrate). The resistance of air between the two electrodes is pierced and the discharge occurs.

W-ZR 8 electrode creates thin hard layers on the steel surface. Moving the electrode holder in semicircular patterns melts locally the surface, including in the formed microbath the tungsten and nitrogen atoms absorbed from surrounding atmosphere and the plasma arc.

Tungsten sublimation temperature is lower than that obtained in the electric discharge (≈10000°C), obtaining a plasma cloud where chemically active W, easily absorbed is present, forming on the surface of molten metal complex carbonitrides Ni, Mo and Cr, which are tough and stable.

Another feature that gives extra hardness for the outer layer is the solidification ultraspeed, which forms on the outside a vitrified amorphous structure well anchored in the surface layer.

Morphology analysis shows the presence of the solidified wavy areas formed from droplets. Full investigation of the samples coated by the ESD method was made on a scanning electronic microscope SEM, model VEGA II LSH, [11].

3.1. One Layer Deposition

The ignition of the arc between the two electrodes causes the appearance of a thermal flux effect that leads to the melting of the electrode tip. As the temperature varies by a paraboloid shape, initial electrode material will melt so that the electrode tip will gain an inner shape, which is exactly as the shape of the temperature field.

The molten area is deposited on the material with a relatively high speed in the form of droplets pulse, which due to the deposition rate, presents concave meniscus in the middle and microdroplets fast cooled on the outer areas.

One-layer depositions shows a relatively high roughness due to the deposition variations like the gas absorbed the edge drops, meniscus inner droplet area due to deposition dynamics, adherent droplets, material overlapping, etc.

An important role has a coefficient of expansion of W, which is very small compared to that of the substrate causing microcracks. Heat transfer coefficient and mass transfer coefficient of the electrode and the substrate material influence the surface quality.

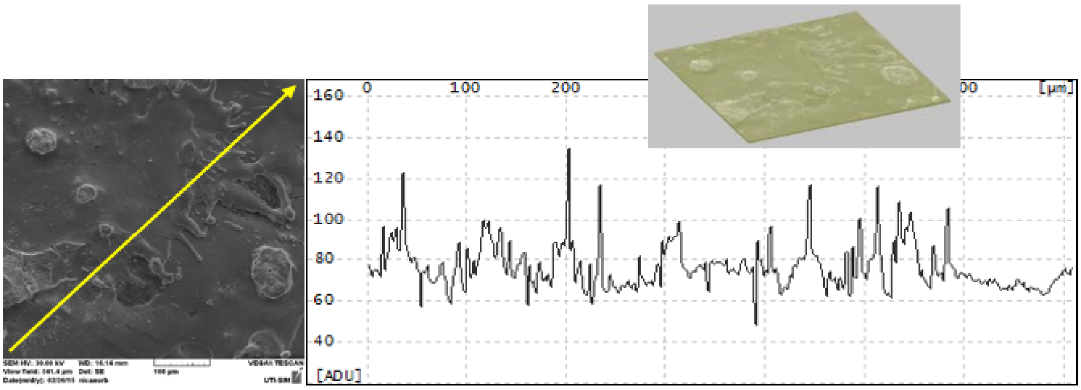


Figure 2. SEM image, and the 3D profilograph; 100µm.

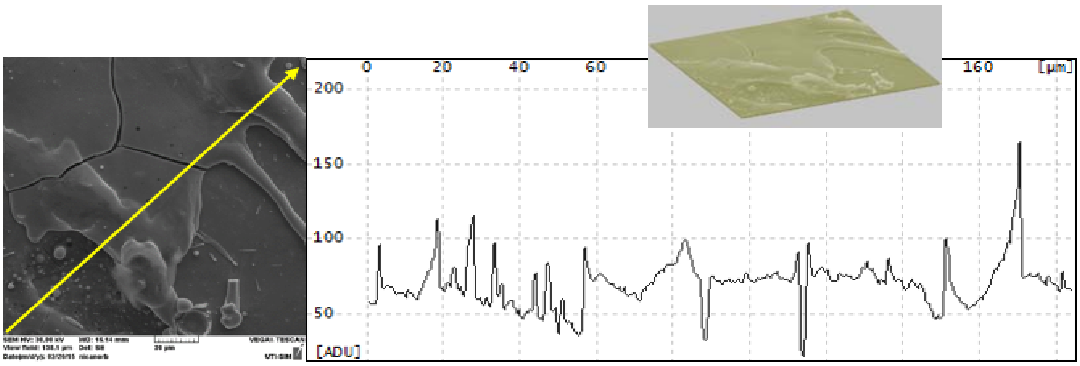


Figure 3. SEM image, and the 3D profilograph; 20µm.

One-layer depositions shows a relatively high roughness due to the deposition variations like the gas absorbed the edge drops (Figure 2 and Figure 3), meniscus inner droplet area due to deposition dynamics, adherent droplets, material overlapping, etc.

An important role has a coefficient of expansion of W, which is very small compared to that of the substrate causing microcracks. Heat transfer coefficient and mass transfer coefficient of the electrode and the substrate material influence the surface quality. Zirconium facilitates the dissolution of tungsten in the metal resulting in fluidization of drops and the compaction of the deposited layer.

3.2. Two Layers Deposition

When submitting two layers, some of the drawbacks of coating with a single layer diminishes.

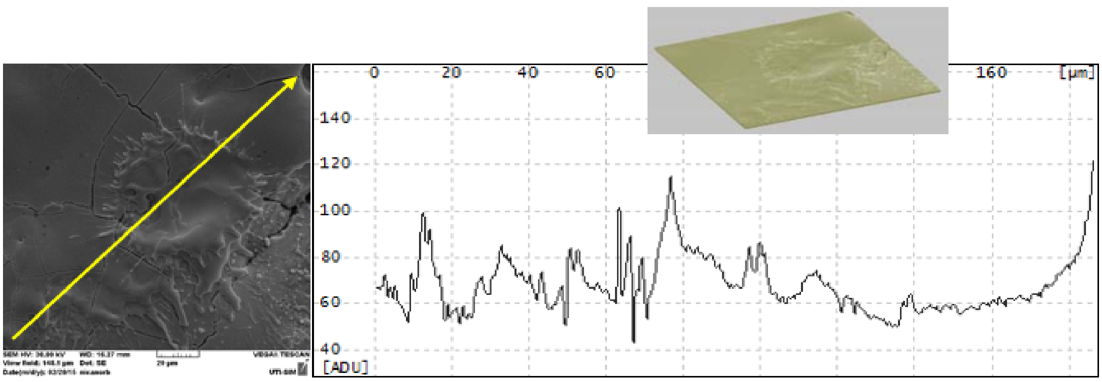


Figure 4. SEM image, and the 3D profilograph; 100µm.

Thus splashing drops made of the first layer are remelted and the bumps due to dynamics droplets forming attenuates. The surface microcracks are closed by remelting.

The concentrations of the surface layers elements modifies due to the increasing of the amount of deposited mass.

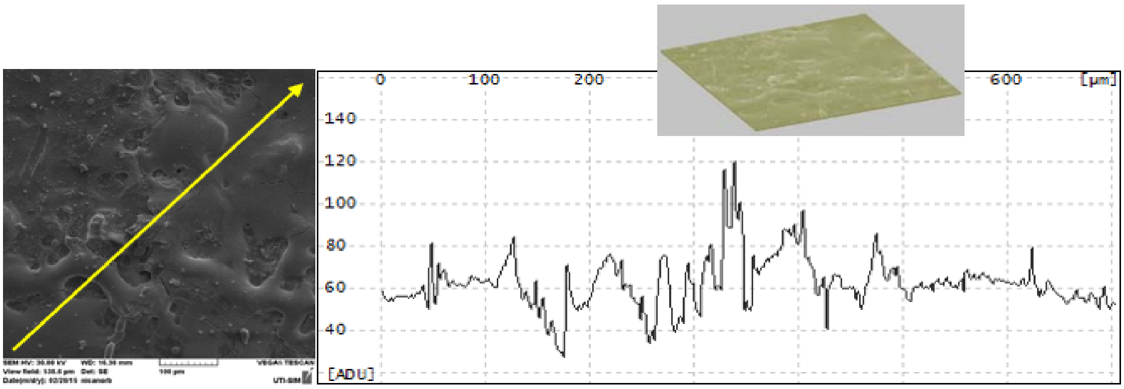


Figure 5. SEM image, and the 3D profilograph; 20µm.

Comparing the two scales magnification profilographs for coatings with one and two layers can be observed an accentuated surface smoothing in the two layers case, (Figure 4 and Figure 5). This can be observed also with 3D images.

4. Conclusions

Depositions on stainless steel with WZr8 by vibrating electrode method forms hard layers, increasing the reliability of the parts used in aggressive corrosive environments for wet and dry friction mechanical drives.

Due to the thermo-physic characteristics of tungsten, it hardens the surface of the piece mainly by melting and solidifying with the vitrification structure, the layer obtained presents an amorphous structure and high hardness.

Single layer deposition presents problems related to the unevenness of the surface, showing areas with microcracks, material overlapping, droplets and partially dissolved gases.

The second layer deposition creates a noticeable smoothing of the surface, achieving an uniform appearance, without microcracks, by reshaping areas uncovered or partially covered from first layer.

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