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STUDY REGARDING GRAVIMETRICAL CORROSION OF THE SUPERFICIAL LAYERS OBTAINED THROUGH ELECTRICAL DISCHARGE

Mihaela BARHALESCU[1], Maria DINESCU[2], Rovena PASCU[2],
[1]Constanta Maritime University,
[2]National Institute for Laser, Plasma and Radiation Physics
email: barhalescum@yahoo.com

ABSTRACT

The experimental research was made on superficial layers laid-down through electrical sparking on the steel carbon OLC 45 probes, the used electrode being made from a corrosion resistant material (Copper).

The probes was immersed 285 days in static see water at the environments temperature.

The corrosion speed was determined through gravimetrical method; the superficial layers subjected to the corrosive agent were analyzed by optical metallographic and atomic force microscopy.

KEYWORDS: superficial layers, corrosion resistance

1. Introduction

The spark micro alloying method is based on the material transfer effect from electrode to the surface of the treated piece during the electrical discharge in the gaseous environment between electrode and piece. The basic requirement is the electrical conductivity of the piece and electrode [4].

After being subjected to such a treatment, the piece surface will be covered with a layer made by electrode material, named white layer. Under this layer is a diffusion zone formed by the basis material where the electrode material has diffused.

The electric spark method's basic requirement is the electrical conductivity of the piece and electrode. This fact determines the use of metals, metallic alloys, metal-ceramic materials and fireproof compounds as electrodes and piece.

The electric spark processing begins by bringing the electrode (anode) near the piece electrode (cathode) and when the distance becomes smaller than the percolation threshold, an impulse electric discharge forms which ends when the electrodes touch. The last phase of the process begins when the pressure (given by removing the vibrating electrode) between the electrodes, and ends when the electric circuit breaks off, at a distance greater than the percolation threshold (which equal to the amplitude of vibration). Using the RC impulse generator, when the electrodes separate, an electric spark may or may not appear. Even if an electric spark appears, it will produce a negligible electrode erosion effect.

During the spark, at the electrodes surface localized centers of melt and evaporation develops, leading to electrodes erosion. Due to polar effect, the predominant transfer of eroded anode material to the cathode provides the forming of the superficial layers of diffusion (alloying) and deposition (white) with well determined properties.

After discharge, at a certain time, the anode electrode is removed from the cathode piece, switching off the electric circuit; then the process is resumed, finally leading to compositional and structural changes of the superficial layer of the cathode [3].

The characteristics of this layer can vary over large limits as a function of electrodes material, environment composition between the electrodes and parameters of the impulse discharge (the discharge energy and vibration amplitude of the anode electrode).

2. Experimental research

The experiments were done on carbon steel parallelepiped samples OLC 45 with the surfaces of 0.00127512 m^2, subjected to superficial micro alloying. We use copper electrodes.

After the superficial treatment, the parallelepiped samples have been suspended with an synthetic line (nylon), of $\phi = 0{,}2\,mm$, in a plastic material tube at 4 cm above the tubes liquid level (sea water), being immersed 285 days in static sea water at the environments temperature [1].

The samples where the superficial treatment was made through impulse electrical discharges have been individually weighted on the analytic balance at different time intervals, determining the corrosion process speed [5].

The superficial layers, subject to gravimetrical corrosion, have been analyzed through optical metallographic microscopy, using the computers QX3 Intel Play microscope.

The fine determining of the topography surfaces exposed to the action of the corrosive environment was made using the atomic force microscope (AFM).

3. Results and discussions

At long immersions of the probes in sea water, the exposed surface suffers modifications in the way of puncture of the superficial layer deposited and corrosion is taking place in dots after penetration corrosive agent.

The speed corrosion variation, based on the immersion time [2] is presented in figure 1.

The experimental results obtained, lead to the following conclusions:

The OLC 45 steel sparked with the copper electrode, is corrosion resistant, having the estimated scale of 4 (according to STAS 9684-82), the corrosion speed between 0.21 – 1.0 g/(m^2.zi) in comparison to the steel used as original probe which has the estimated scale 5, and the corrosion speed between 1.0 – 2.1 g/(m^2.zi).

On the superficial layers subjected to sea water, initially you can observe a progressive increase of the corrosion speed, because of the oxygen absorption. After the effect of microorganism, the corrosion drops to an almost stationary value. This is because of the fact that microorganisms eliminate oxygen from the surfaces, but an anaerobic corrosion still persists.

Metallographic analysis was made on the samples surface, after they were removed from environment, washed and cleaned of all corrosion products.

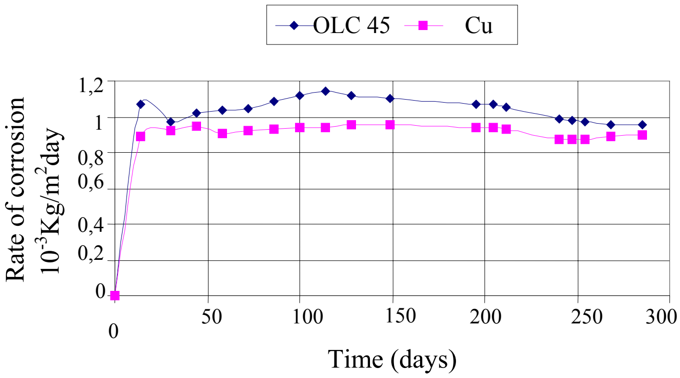

***Fig.1**. Rate of corrosion*

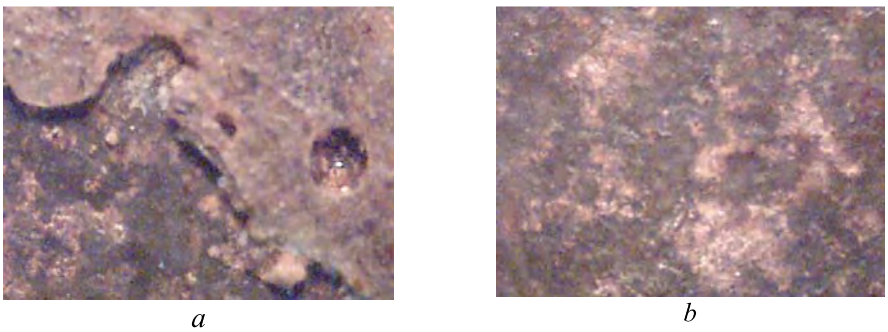

***Fig.2.** OLC 45 steel samples sparked with Cu electrode – 60:1*
Working regime 2

On the OLC 45 steel samples spark with copper electrode can be seen formations of copper superimposed, over the zones of material allied with copper.

From metallographic analysis we can observe pores, craters and discontinuity of a layer copper

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deposited, after interaction with the corrosive agent.

In figure 2.b, can be seen zones where the layers is uniformly deposited did not allow corrosive agent to interact with the material basis.

The "wave-mode" from the AFM microscope on the probes superficial treated with the Cu electrode present the surface relief through color zone. The light color zones are the highest zones.

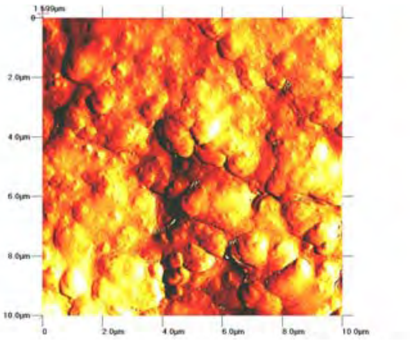

Fig. 3. *Superficial treated probe with Cu electrode "wave-mode" image – 2d on an scanned area of 10x10 µm*

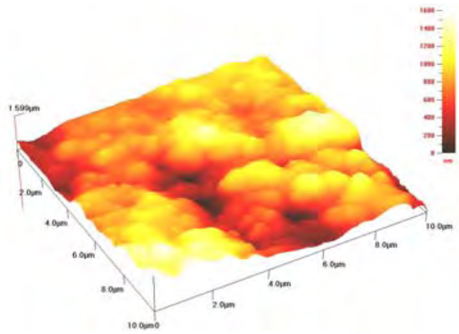

Fig. 4. *Superficial treated probe with Cu electrode "wave-mode" image – 3d on a scanned area of 10x10 µm*

The presented images show that layers on the sample surface are not uniform. It has discontinuity which allowing corrosive environment to attack the substrate material.

Wave-mode images on the scanned surface of 10 µm^2 and presented in three dimension as in the figure 4, emphasizes the appearance of some dark color zones which denote the discontinuity of the layer deposited, these areas represent a possible way of access of the corrosive agent to the probes material.

The presented images are not in according with the thickness of the residue layer. The 1.599 µm dimension refers to the distance between the lowest area of the layer and the highest one.

4. Conclusions

The superficial layer deposited through Cu electrode sparking, proves a improved corrosion resistance to see water compared to the base steel, specially for long term tries, when the corrosion speed is stabilizing remaining almost constant.

From optical metallographic analysis superficial layers subjected to sea water, is observe zones where the layer is uniformly deposited did not allow corrosive agent to interact with the material basis.

In these zones, weren't any corrosion effects. Zones where defects appeared are most attacked, resulting reaction products after the corrosion.

The investigations though atomic force microcopy made on the probes tested for long term corrosion, accentuate the compact and homogenous surfaces areas which had not permitted the corrosive agent to interact with the base material.

The wave-mode images present the discontinuities of the superficial layers deposed, which represent a possible access way of the corrosive agent to the probes material.

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