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INFLUENCE OF THE UNCONVENTIONAL TREATMENT APPLIED TO A STEEL ON THE CORROSION EVOLUTION

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ABSTRACT

The study of an alloyed steel with Cr Mo with an important content of aluminum (0.9…1.2%), unconventionally treated in magnetic field, is attractive because of the durability which increases along with the improvement of the corrosion resistance. Through the thermo-magnetic treatments applied before thermo-chemical treatment, the mechanical properties of this material have been improved. The hardness of the superficial layers has been increased after thermo-magnetic and thermo-chemical treatment because of the superficial layers' characteristics obtained after the unconventional treatment. The behavior of steel in corrosion tests was used as criterion.

This paper is a review of personal research and presents the changes of corrosion resistance, using non-conventional treatments and corrosion tests for a Cr Mo alloyed steel, after thermo-magnetic treatment, respectively thermo-chemical treatment. The evolution of the superficial layer for non-conventionally treated steel during the corrosion tests was studied.

KEYWORDS: steel, superficial layer depth, unconventional treatment, corrosion

1. Introduction

The magnetic field can modify the residual stresses which were obtained by hardening/tempering treatment and the resistance of the corrosion process in marine medium or in fog. The resistance of corrosion depends on the treatments and the content of the carbon from the structure of the steel. The cooling within the magnetic field during the thermo-magnetic treatment regimes modifies the characteristics of steel, compared with the classic treatment results. During the improvement treatment of steel through thermo-magnetic treatment, the residual stresses realized by hardening decreases, the residual austenite quantity decreases too and the magnetic field has a positive effect on the mechanical and corrosion properties because the hardness of the steel and the corrosion resistance increase [1, 2].

If Aluminum and Chromium contents increase in the structure of steel, the residual austenite quantity decreases more rapidly. The martensitic quantity and the hardness of steels increase significantly, more than in the case of the steels with approx. the same content of Carbon but with a lower quantity of aluminum. As a consequence, the magnetic field intensity, the content of the Carbon and the content of the aluminum from steel have an important influence. Because of these aspects, the tendency of breaking decreases and the probability of the fragile breakage no longer exists.

An important quantity of aluminums in the structure of steel increases the thermo-magnetic treatment power and the results are the best. At the same time, the existence of aluminum content in the structure of steel causes some hardening problems which are countered by the Chromium existence [3].

2. Materials and experiment

The materials used for this study was a steel grade for the construction of machine parts which have the following principal components: 0.38 % C, 1.18 % Al, 1.38 % Cr, 0.17 % Mo, 0.5 % Mn, 0.058 % Cu, 0.25 % Si, 0.26 % Ni, 0.026 % P, 0.026 % S.

For the experimental program, samples (rollers) from steel were considered. The outer diameter of the rollers is of 40 mm and the inner diameter of the rollers is of 16 mm.

The first stage from the complex program of treatments consists in thermo-magnetic treatment.

The treatment t1 represents a Martensitic hardening process at 920 °C and high tempering at 620 °C, a classic treatment of improvement (Magnetic field intensity doesn't exist). The other treatment, t3, represents a hardening process (just cooling in water in strong alternative current (A.C.) of magnetic field and a high tempering process (just the cooling in water in strong A.C. magnetic field). The treatment t4 represents a hardening process with cooling in water, in direct current (D.C.) of magnetic field and high tempering process (just cooling in water, in D.C. magnetic field).

The second stage from the complex program of the treatments consists in applying the thermo-chemical treatment: a plasma (ion) nitriding at 530 °C, after thermo-magnetic treatment. The treatments were noted such as: Tca' = T3 = t3 + plasma nitriding; Tcc' = T4 = t4 + plasma nitriding, T1'= Tclassic, applied to the different samples from the same steel grade considered.

The corrosion tests were done to detect the evolution of the superficial layer using a fog chamber, testing time [1]. Experimental tests were done in a fog chamber using the following components: 27 g/L NaCl, 6 g/L $MgCl_2$, 1 g/L $CaCl_2$, 1 g/L KCl.

It was established the influence of the corrosion conditions on the superficial layers, determining the mass loss (Δm_1) after 100 hours, the mass loss (Δm_2) after 200 hours and (Δm_3) after 300 hours of corrosion process, for each treatment regime.

3. Results and discussion

In Figure 1 was presented the evolution of the micro-hardness values in the ion nitrided layer versus the treatments; the micro-hardness values were measured at 0.02 mm distance from the surface of the samples [1].

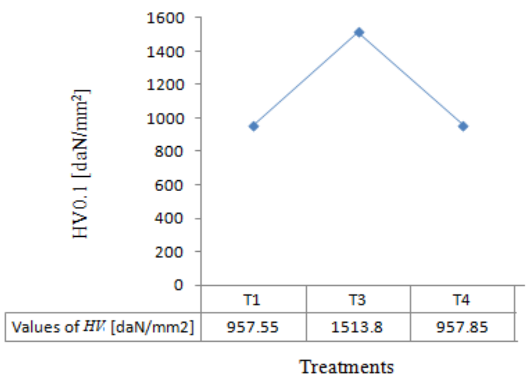

Fig. 1. *Micro-hardness values at 0.02 mm distance from the surface of the ion nitrided layer versus the treatments*

In Figure 2 were presented the depths of the superficial layers evolution versus the treatment applied to steel with 1.18% Al.

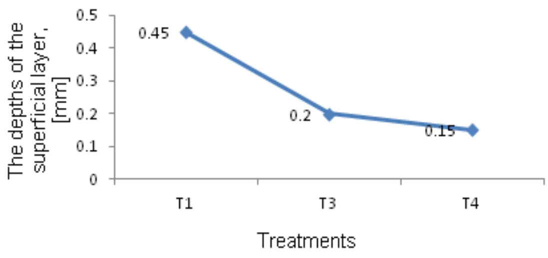

Fig. 2. *The depth of the superficial nitrided layer versus the treatment*

The results of the corrosion process were presented in Figures 3, 4 and 5 [1].

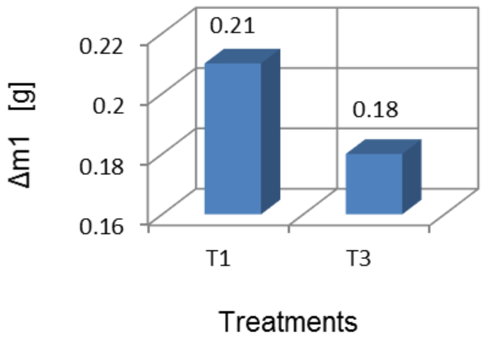

Fig. 3. *The evolution of the Mass loss (Δm_1) after 100 hours of corrosion process vs. treatments*

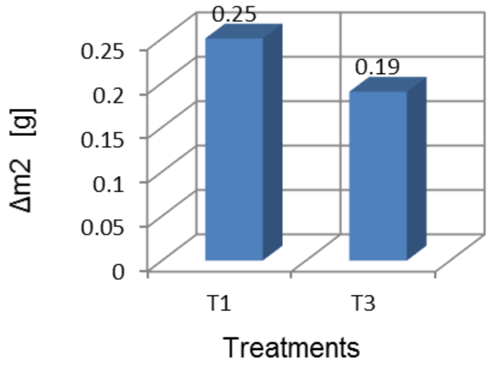

Fig. 4. *The evolution of the Mass loss (Δm_2) after 200 hours of corrosion process vs. treatments*

In Figure 6 was presented the evolution of the Mass loss value in the case of T1 treatment applied to steel versus duration of the corrosion process.

In Figure 7 was presented the evolution of the Mass loss value in the case of T3 unconventional treatment applied to steel versus duration of the corrosion process.

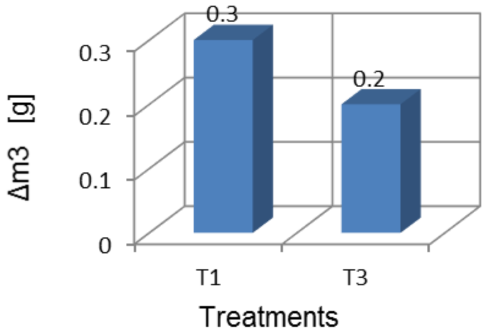

***Fig. 5.** The evolution of the Mass loss (Δm_3) after 300 hours of corrosion process vs. treatments*

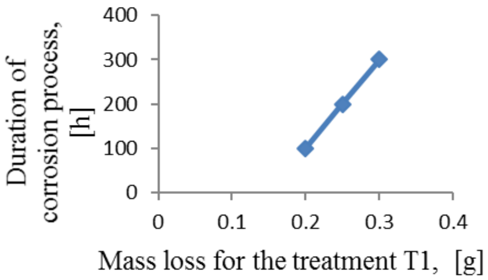

***Fig. 6.** Mass loss evolution for T1, after each hour of corrosion process*

Considering Figures 6 and 7, the mass loss had higher values in the case of classic treatment (T1) than in the case of the unconventional treatment (T3). For this reason, the unconventional treatment improved the resistance of the corrosion for the steel with 1.18% Al.

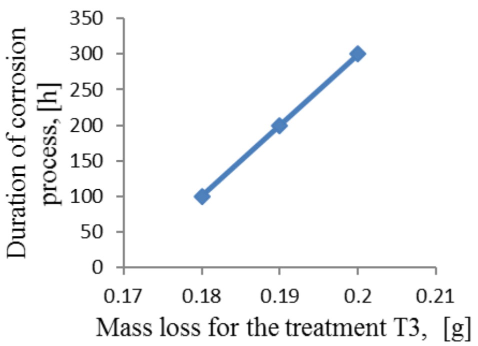

***Fig. 7.** Mass loss evolution for T3, after each hour of corrosion process*

Considering Figures 6 and 7, the mass loss had higher values in the case of the classic treatment (T1) than in the case of the unconventional treatment (T3). For this reason, the unconventional treatment improved the resistance of the corrosion for the steel with 1.18% Al.

The properties of the nitrided superficial layer depend on the nature of nitrides phases. With the increasing of the temperature of the nitriding, the nitriding duration is reduced, but decreases the hardness of the superficial layer because of the coalescence of the nitrides of alloying elements.

Inside, in the superficial layer thermo-chemically treated with plasma nitriding, there are the following important phases: $Fe_\alpha(M)$, Fe_3N and Fe_4N. The phase Fe_2N (ξ)- has a rhombic structure (the deformed structure of the phase ε) and small values of the hardness. This phase did not appear in the structure of the steel considered.

The explanation is that phase Fe_2N (ξ) is stabile in equilibrium with ammonia until to maximum 450 ˚C [2-4]. The nitriding treatments have been carried out at 530 ˚C, a temperature higher than 450 ˚C. This phase was decomposed and disappeared from the superficial layer. The micro-hardness and the wear resistance of the steel increase because of this situation.

The distributions of the phases in the depth of the nitrided superficial layers is uneven. That is why the nitriding process is not uniform [1-3, 5]. The quantity of the $Fe_\alpha(M)$ phase (martensite phase) and nitrides of chromium increase in the T3 treatment case. As a consequence of this phenomenon, both the wear resistance and the corrosion resistance increase.

4. Conclusions

The evolution of the superficial layer for the unconventionally treated steel during the corrosion tests was studied. If applied to a magnetic field (an unconventional treatment), the micro-hardness of the superficial layer for the material with higher contents of aluminum and chromium has higher values.

Aluminum and chromium contents influence the characteristics of the superficial layers. The nitrides of these elements concentrate in the form of small particles at the grain size limits (boundary) of residual austenite and prevents their growth during heating at heat treatment. The corrosion resistance increases in the cases of the thermo-magnetic treatments applied.

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