EFFECTS OF THE NON-CONVENTIONAL TREATMENT IN MAGNETIC FIELD APPLIED ON A STEEL FOR GEARINGS

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Abstract. *An alloyed steel grade for machine parts construction used in industry have been considered and this material was subjected to a classical improvement treatment or a thermo-magnetic treatment before a plasma nitriding process – the last one being a thermo - chemical treatment. Studying the superficial layer, it was taken in consideration the distribution of the phases in case of the classic treatment procedure versus the case of the non-conventional treatment in magnetic field applied before plasma (ion) nitriding.*

Plasma nitriding applied after a non-conventional treatment in magnetic field to the steel used in industry, have been studied in this paper.

The samples have been tested using an Amsler stand for wear tests (dry friction) and the diffractometric analysis completed this study.This study is a short review of the researches realized in the last few years.

Keywords: *Steel, non-conventional treatment*

JEL classification: L62, Z21
UDC: 621.01:672

Introduction

The technical progress made it possible to use very hard materials in several fields like manufacturing pieces for the car industry, the pieces for railroad, in aeronautics and in the mechanical industries. For gearings, toothed wheels suffer special treatments to increase the hardness of the flanks of gearing, The studies are focused to obtain an increasing of the wear resistance using plasma nitriding.

Plasma nitriding is a thermo-chemical treatment with diffusion process and the interaction of the nitrogen with the basic material lead to structural constituents whose nature determines a major hardness of the nitrided layers. The thermo-chemical treatment modifies the grain limit and the resistance of the treated steel.

The magnetic field applied during the part of the improvement treatment of the steel grade lead to appear mechanical oscillations which can be considered as the effects of the Magnetostriction. The magnetic field applied leads to a decreasing of the residual austenite amount (Arez) during the annealing/hardening treatment of the gearing or tools steels, according to the literature [1, 2, 4].

The subject of ion/plasma nitriding mechanism has been studied by many researchers, for example: Kölbel (1965), Keller (1971), Hudis (1973), Roliński (1978); Karpiński (1979), Szabo and Wilhelmi (1984), Marchand (1989), Michalski (1993, 2000), Koloswary (Romania, 1995-2000); Preda A. and Levcovici D. (Romania, 2000), Walkowicz (2003).

The reason for the amount of work was the complexities of the phenomena occurring near the cathode.

Methods and material applied

For the experimental program, the samples have been realized as rollers from a steel grade for improvement treatment for machine parts construction with the following principal content: 0.42 % C, 0.02% Al, **1.02** % Cr, 0.17 % Mo, 0.68 % Mn, 0.22 % Cu, 0.33 % Si, 0.26 % Ni, 0.030 % P, 0.026 % S. The existence of the Molybdenum content in the composition of the steel induces a decreasing of the stiffening phenomenon.

The first stage from the complex program of treatments consisted of thermo-magnetic treatments. The second stage of the treatments consists in the applying the thermo-chemical treatment in plasma.

There are mentioned the following treatments which have been selected for different samples: Treatment T1 represents a hardening at 850°C and a high tempering treatment at 580°C, with cooling in water - being the classic improvement treatment followed by a plasma nitriding at 530°C; Treatment T2 represents a complete martensitic hardening in weak alternative magnetic field and a high tempering with cooling in water in strong magnetic field, followed by a plasma nitriding treatment at 530°C.

The temperature of plasma nitriding process was 530˚C.

After the treatments, the wear dry tests on Amsler Machine have been made.

Results obtained and discussions

After every hour of wear tests, the samples were subjected to diffractometric Analysis. In figures 1 and 2 were presented difractometric aspects regarding the plasma nitride layer in the cases of the treatments T1 and T2. It must be mentioned that the treatment T2 is a non-conventional treatment in magnetic field followed by plasma nitrided at 530˚C.

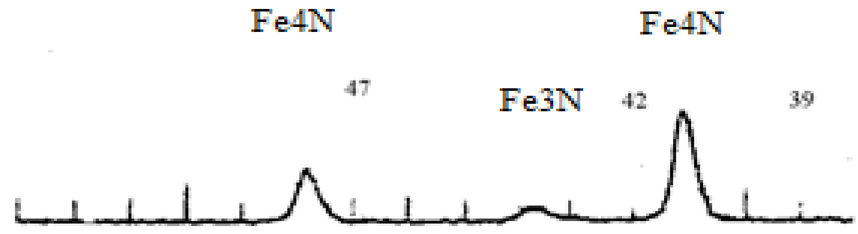

Figure 1. Diffractometric fragment corresponding to nitrided layer in case of T1 classic treatment

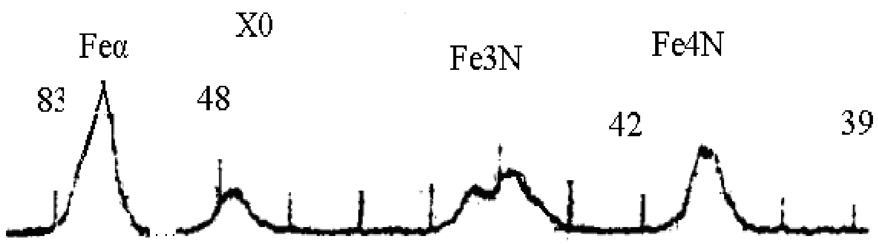

Figure 2. Diffractometric aspects corresponding to the samples subjected to non-conventional treatment T2

It can be observed that in the case of non-conventional treatments in magnetic field applied before plasma nitriding, the amount of Fe_3N and Feα (M) in superficial layer increased. This is a reason to observe that the non-conventional treatment – an improvement treatment in magnetic field – applied before thermo-chemical treatment determines the increasing of the hardmess and the wear resistance of the steel.

By analyzing diffractometrically (Figures 1 and 2) the samples treated with T2 before plasma nitriding, which underwent a complete hardening and a high tempering, with only the cooling in magnetic field (A.C.) with the H = 920 A / m (T2) the amount of martensite is highest compared to other samples (T1). The percentage of carbon (% C) being the average for the analyzed steel (up to 0.6%), the evolution of the degree of tetrahedral of martensite in certain processes or over time can be controlled by the evolution of the diffraction line (211) [1,2, 3].

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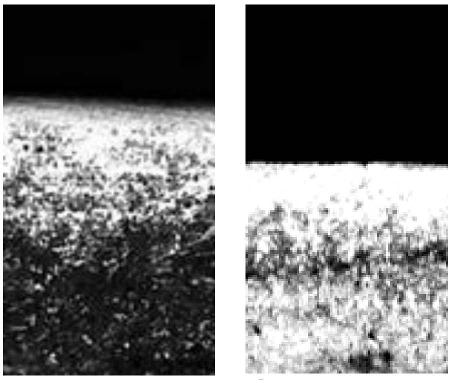
By analyzing diffractometrically (Figures 1-2) the samples treated with T2 before plasma nitriding, which underwent a complete quenching and high tempering, only the cooling in magnetic field (A.C.) with the H = 920 A / m (T2) the amount of martensite (Feα) is highest compared to other samples (T1).

The martensitic phase - in the range (44˚ - 45˚) - in the superficial nitride layer, besides the Fe_3N and Fe_4N phases, provides the layer with a good hardness and a wear resistance higher than the investigated samples treated classically. Martensite (Feα) is a tough constituent, and the martensite with nitrogen (phase α) is the most durable phase in the nitrided layer [2, 4, 6, 7].

Martensite is a solid carbon solution in Feα, which has a large amount of dissolved carbon, giving it a high hardness.In the process of martensitic transformation, not all austenite passes into martensite, so there remains an unformed austenite quantity - called residual austenite (Arez). After hardening, the residual austenite (Feγ) and the martensite (Feα) are found in the steel, which, diffractometrically, conduct in the diffractogram at spectrum of diffraction showing diffraction lines specific to both austenite and martensite.

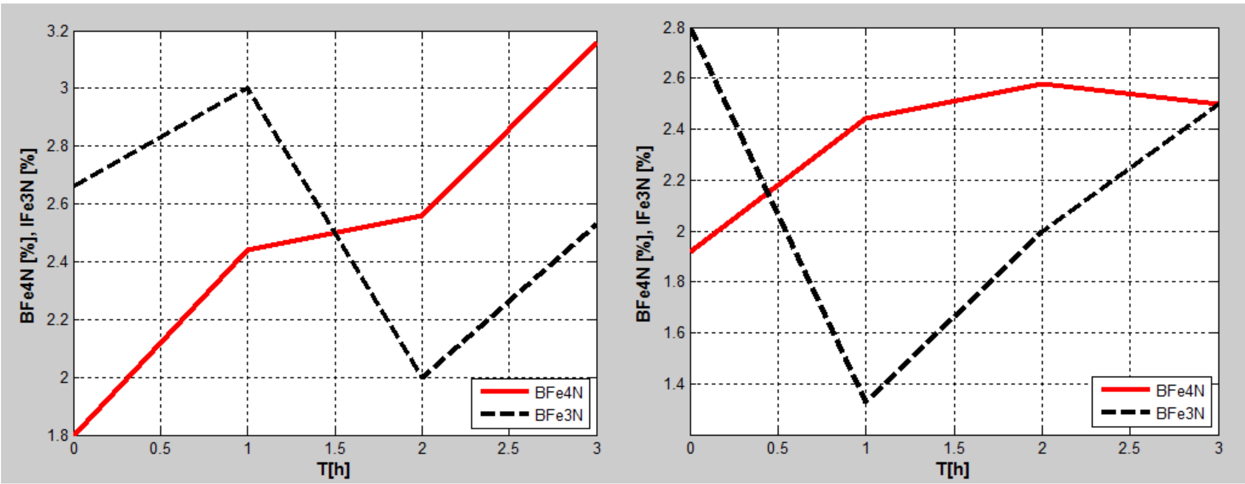
The thickness of the white (nitrided) layer increased in the cases of non-conventional treatments T2 (see figure 3).

The morphology of the nitrided layers depends on the core microstructure resulting from the transformation of chromium carbides into chromium nitrides. Microstructures must be stable during the nitriding treatment.



a). b).

Figure 3 Microstructures of the superficial layers: a). Nitrided layer which corresponds to classic treatment T1; b). Nitrided layer which corresponds to treatment T2, (x100) Nital attack 2% [2].



a). b).

Figure 4. Internal tensions of second order (B_{Fe4N}; B_{Fe3N}) in the superficial layer after plasma nitriding process, *for samples*: a). subjected to T1 treatment, during three hours of wear tests for Q = 750 N, ξ = 10%; b). subjected to T2 treatment, for Q = 750 N, ξ = 10%.

In figure 4 (a, b), internal tensions of second order in the nitrided layers have been represented and the differences are majors, comparing the classic treatment effects with the non-conventional treatments effects (T2).

Conclusions

Due to friction wear tests, it was possible to study the depth distribution of the Fe_3N and Fe_4N phases in the superficial layer. The distribution of Fe_3N and Fe_4N phases on the plasma nitrided layer is uneven, which demonstrates that the nitriding process does not flow uniformly, being influenced by several factors, especially the nature of the nitrided material.

At the same time, a change in the distribution of the Fe_4N phase comparing to Fe_3N in the superficial layer is observed. Thus, at the classically treated sample, the distribution is cyclic, the greater evolution is at the Fe_4N comparing to Fe_3N phase, which gives the superficial layer a hardness and resistance to wear (Fe_4N phase being a hard phase, more than Fe_3N). In the T2-treated sample case, the evolution of the Fe_3N and Fe4N phases in the plasma nitrided layer is evenly increasing - in the case of Fe_4N - which is a positive thing regarding the increase of the wear resistance and the hardness of the nitrate layer, while the evolution of the distribution the Fe_3N phase is down.

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