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Cementation Characterization of xNC6 Steel by Micro Magnetiques methods

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Abstract :

Increase the hardness, the endurance and the life time of material can be realised by surface treatments and remetallings, the electromagnetic properties of steels depend on their composition, their microstructures and constraints applied. We can use the electric and magnetic parameters to evaluate their microstructure. The object of this work is the characterization of cementation by the non-destructive methods and the determination of physicochemical parameters. Sample of low carbon tenor steel was cemented with differents alternative. We studied these samples by micro magnetic NDT as eddy current (ET), Barkhausen Noise (BN) and hysteresis loop...
The treatment of these results will be able to inform us about the physicochemical aspect of these materials .This work allow to determine the surface layers by NDT methods

Keyword: NDT, Cementation,carbone, eddy current, remanence, corecitivity
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INTRODUCTION

In addition to the defect characterization, actual studies deal with the metallurgical evaluation of materials. The characterization of microstructures, mechanical properties, deformation, damage initiation and growth by Non-Destructive Evaluation (NDE) techniques plays a vital role in various industries because of the growing awareness of the benefits that can be derived by using NDE techniques for assessing the performance of various components

The method of reference chosen to compare the NDT results is the micro hardness profile. After cementing the carbon concentration decreases asymptotically of surface while going towards the heart. It is the same for hardness and as it is the profile of the hardness which conditions the behaviour of the parts in service, it is thus naturally with hardness that he is made call for the control of cementing.

The objective of this treatment is to obtain on the surface steel a layer from 0.3 to 2 mm from thickness with high percentage of carbon .The Content generally ranging between 0.6 and 0.9 %. This layer has a martensitic structure of great hardness (being able to reach 700 to 900 HV on the surface) and the residual stresses of compression are raised. After introduction of carbon on the surface, the face-hardened part undergoes a heat treatment intended to confer its properties of employment to him [1].

The conditions of hardening are selected to obtain the best compromise between the qualities wished for the layer and the sought characteristics in heart of the part; it must also minimize as much as possible the deformations due to the variations of volume associated with the transformation [2].

NDT APPROACH

According the state of art the eddy current testing (ET) has a strong application in the defect detection. The sensitivity to characterize defects and other parameters can be improved by an optimal choice of probes and operation frequency. This work discussed here is a study to materials structure characteristics and especially the cementation using eddy current techniques. The design of eddy current probes was optimized in order to increase their sensitivity and their resolution. Studies of the magnetic fields in the vicinity of a probe are suitable to characterize the field activity and to optimize the controlled measuring process and the probe size [3].

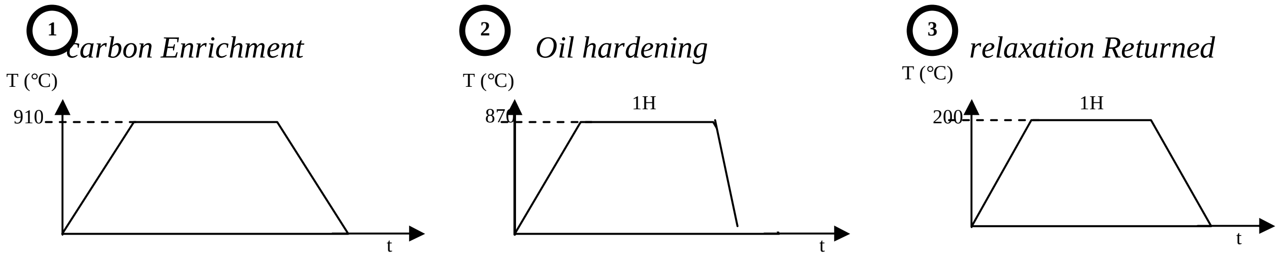
The magnetic Barkhausen noise (MBN) technique has attracted considerable attention in recent years as a possible non-destructive technique for evaluation of microstructural parameters such as grain size, carbide precipitates, inclusions, dislocation and characterizing the magnetic properties of steel. Barkhausen noise shows magnetizing discontinuities of ferromagnetic materials, such as alloys containing iron, Co, Ni [4].

In the application of variable magnetic field on the ferromagnetic material, many processes such as the creation and the annihilation of domain and the domain wall motion’s are observed. Each domain is strained along its direction of magnetisation , the magnetostriction phenomena occurs, if the domain wall motion’s are sufficiently rapid, the abrupt changes in local strain give rise to the generation of elastic waves, This phenomenon is observed for certain crystals when, one records the hysteresis loop B(H) which appears made up of a succession of marches[5]. These variations of magnetisation also appear by a signal of noise at the boundaries of a detecting reel placed near material.

EXPERIMENTAL APPROACH

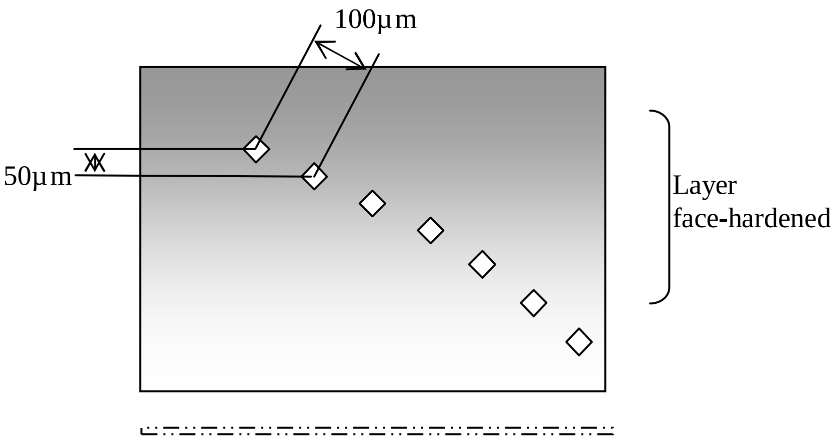
CEMENTATION

Cementing was carried out in three stages. The thermal cycles corresponding at the three stages are represented on the figure 1.



1- Diagrammatic representation of the treatments carried out

This test enables us to determine the evolution of in-depth hardness from surface. Measures of micro hardness are taken starting from the periphery towards the centre with a step of 50µm. the distance between two test have is of 100µm (Figure 2).



2- Filiation of micro hardness

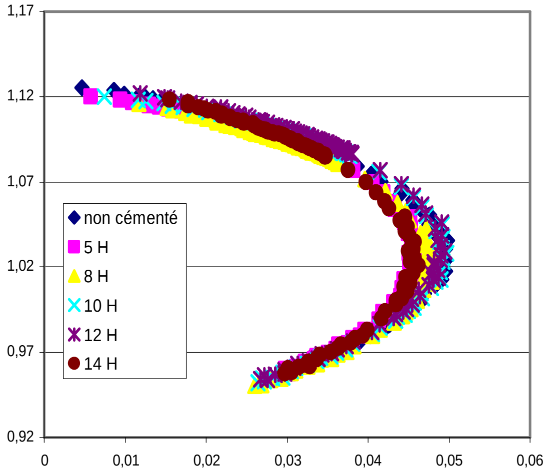
In this study, the steel treated are the 10NC6, 12NC6, 16NC6 and 20NC6 nuances .The time of cementation of each nuances is 5,8,10 and 14 hours. (tab1)

10NiCr6					
Maintaining time (h)	5	8	10	12	14
Cementation thickness (µm)	361	734	887	892	1047
hardness at 100 µm across the surface	798	773,9	785	767	811
Hardness at centre	354	357	355	347	362
16NC6					
Maintaining time (h)	5	8	10	12	14
Cementation thickness (µm)	473	836	888	890	1021
hardness at 100 µm across the surface	721	701	775	804	789
Hardness at centre	382	412	418	451	459

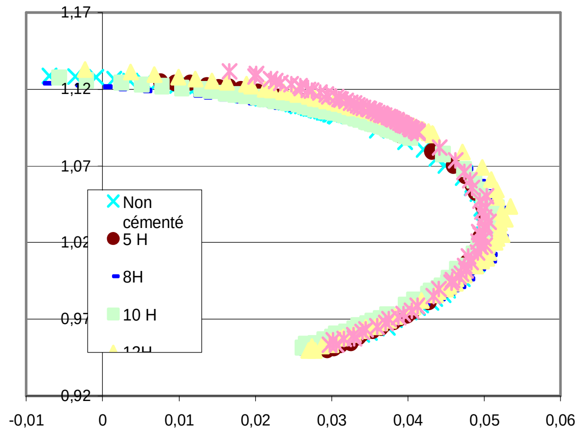
Table-1 characteristic of X NC6 sample

RESULTS AND INTERPRETATION

Eddy currents Results



a-10NC6

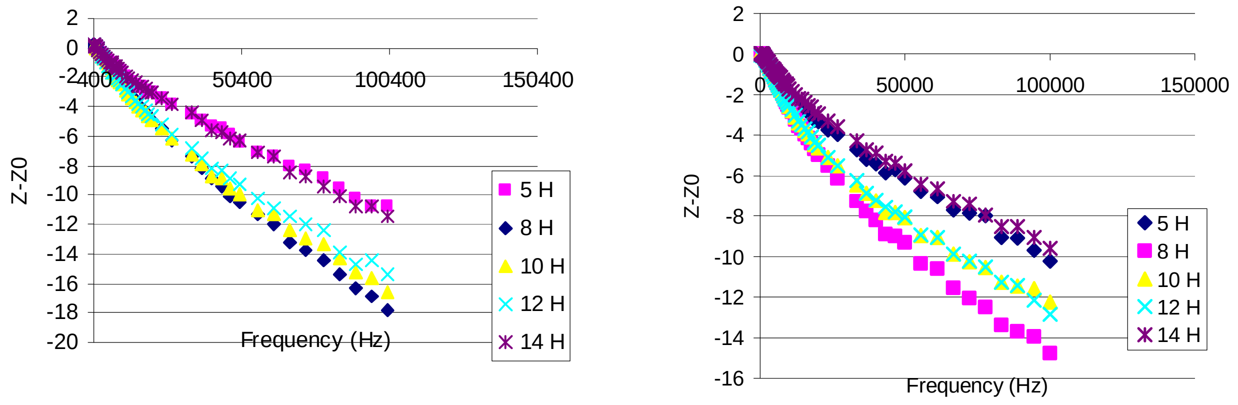


b-16NC6

3- Impedance diagrams of steels in a-10NC6 and b-16NC6

The study of the impedance variation according to the treatments carried out shows that changes on the new microstructures obtained can be found.Any metallurgic modification of structures lead to a variation of impedance. Eddy current techniques evaluation has shown that impedance diagram have a high sensitivity to the treated steel (as noted above) due to diffusion phenomenon figure 3. The results obtained by eddy current method shows that each sample has a different structure. The microstructures were examined by optical microscope.

The variation of ΔZ depends on the frequency and cementation thickness[6]. We notice for the three nuances that the evolution of the impedance according to the thickness of cementing differs from one frequency to another. The effect of skin, characteristic essential of the eddy currents, plays a role essential in the interpretation of the results, this effect tends to concentrate the flow of the currents induced more and more on the surface when the frequency increases. The figure 4 show that the trajectory obtained of the impedance according b to the cementation time follow the same evolution as the macro hardness profile .

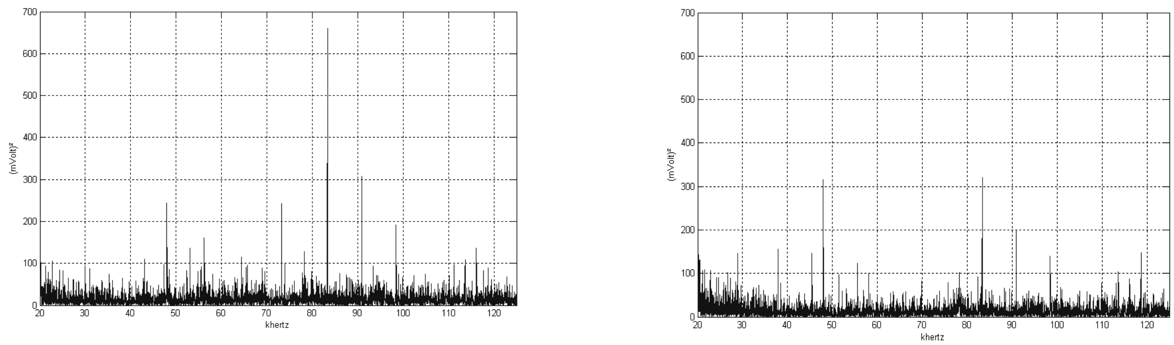


a)10NiCr6 b)16NiCr6

4- Variation of Z-z_0 according to the frequency
(Z: frequency of the sample considered Z0: frequency of the sample untreated)

BN and hysteresis Results

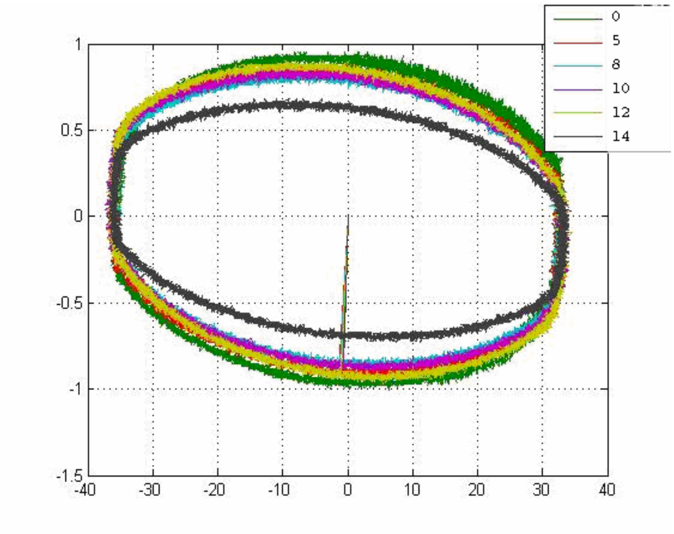
The result obtained by BN method show that each sample has a different structure (figure 5) . The treatment of cementing creates a gradient of chemical composition (percentage of carbon) which cause after hardening a gradient of residual stresses (residual stress concentration of compression on the surface) and components micro structural (variation of the rates of martensite, bainite, residual austenite or pearlite) from the surface to the heart. These variations influence NDT magnetic measurements in particular BN and it is difficult to analyse results



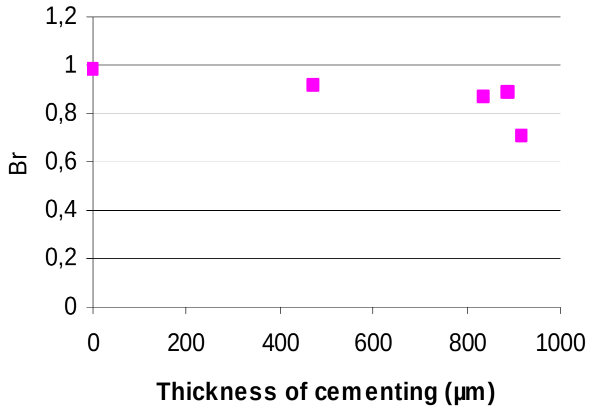
Non cemented 12H

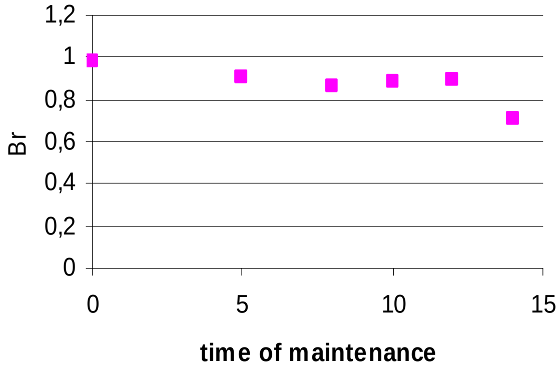
5- Spectral Density BN of 16NC6

The same result is observed by the hysteresis loop as the eddy current evaluation(figure 6).The analyse of the Br according to the time of the cementation give the same evolution that the hardness profile (figure 7).



	Hc	Br
Ref	35,5	0,98
5	35,3	0,91
8	35,4	0,865
10	35,8	0,885
12	35,9	0,89
14	35,8	0,705

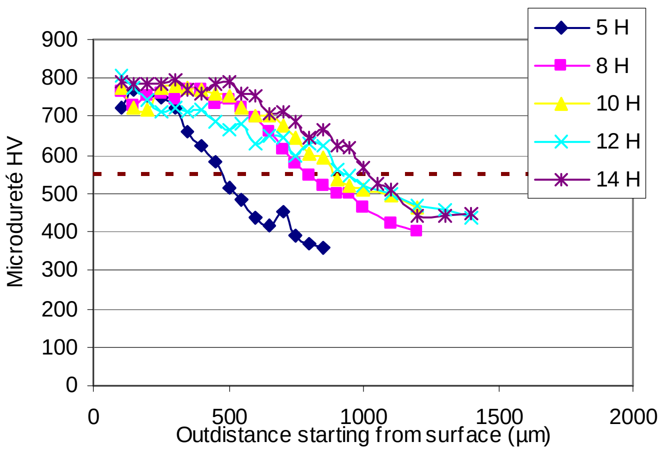




6- Hysteresis loop of the steel parts 16NC6

We studied in this work the possibility of characterizing cementation steels by using the eddy currents, the hysteresis loop, and the noise of Barkhausen. These methods can present by their simplicity and their sensitivity a solution for the characterization of this kind of treatment, considering complexity, the slowness and destructibility of the traditional means used for this purpose, in fact the determination of the profile of micro hardness.

Micro hardnesses profile results



7- Filiation of micro hardness of steels 16NC6 cemented

The most significant remark in the case of ferromagnetic materials is the relationship between the electric and magnetic parameters given by the impedance, and micro hardness profile measures. The micro hardness profile has the same evolution of the impedance variation, Br with the exposure time figure 7**.**

CONCLUSION

The diagram of impedance, remanence Br show the variation in the cementation layer.
The aim of this work is to found similitude between the variation of impedance at specific frequency and the micro hardness profil.
The evolution of the impedance and Br for the xNC6 according to the time of cementation is the same as the micro hardness profile, and it possible to determine carbon rate from micro hardness profile curve.
This result is important in the way that we can use the NDT method as E.T ,hysteresis loop to found the carbon rate in the specimen.

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