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THERMOCHEMICAL TREATMENT ON AISI 8620 STEEL

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Abstract: A thermochemical treatment was performed on an AISI 8620 steel. The purpose of this treatment is to enrich the surface of the steel with carbon by means of the diffusion mechanism, so that the surface layer of the steel contains a higher concentration of carbon than that of its core. As a result, the case-hardened steel acquires a combination of properties: containing higher surface hardness and greater wear resistance, but without losing toughness in the core. The cementitious components added were: 90% charcoal and 10% barium carbonate ($BaCO_3$), the temperature in the furnace was 930°C, with a permanence of 8 hours, then the steel piece was cooled in oil for quenching and subsequently tempered at 230°C for a period of 30 minutes. The total depth is defined as the perpendicular distance from the limit of the surface to the end of the hardened zone. On the other hand, the microstructure obtained on the surface was of a martensite phase and the core was of a pearlite and ferrite phase, thus achieving a high toughness and wear resistant steel.
Keywords: Steel, Carburizing, carbon**.**

INTRODUCTION

Carburizing is a thermochemical treatment that, by means of a diffusion process, enriches the surface of a steel with carbon in order to obtain a layer with a higher carbon concentration than that of the core [1].

Carbon saturation on the surface induces the formation of martensite. This results in a part formed by two microstructural phases that present a combination of properties: the core with a low carbon index, tough and fatigue resistant, and the surface with higher hardness, wear resistance and higher compressive strength [2]. The carburizing depends mainly on the temperature, this must be above the carbon solubility limit [3] being 900°C- 930|C. And the steel must remain a certain time being from 8 to 12 hours. The depth of carbon diffused into the steel, from the surface to the core, will depend on the treatment time. A higher concentration of carbon in the layer will increase the hardness of the layer. With the help of heat treatment, it is possible to prepare parts that will be subjected to frictional wear and stress, and case hardening is an option with which it is possible to obtain mechanical properties that can guarantee the work of the elements that make up a machine or tool, starting from a commercial steel with low carbon content [4].

EXPERIMENTAL DEVELOPMENT

For the development of this study, specimens were machined for tensile testing under the ASTM E8 standard and half-inch-long samples for chemical metallographic and microhardness analysis. See figure.1

Chemical analysis was performed on AISI 8620 steel bar used for the thermochemical treatment study, using a HITACHI PMI-Master Smart optical emission spectrometer. The chemical analysis was performed to corroborate whether it corresponded to AISI 8620 steel for the first sample. And for the second sample it was to see how much carbon diffused into the steel after being heat treated.

The procedure for the thermochemical treatment was by placing the tension specimen and the AISI 8620 steel sample for metallography and a mixture of charcoal (90%) and ($BaCO3$)(10%) in a metal box which was then covered with a lid, sealing the gaps between the box and lid with clay to prevent the entry of oxygen during the treatment. Once the box containing the specimens and the mixture of carbon and $BaCO3$ was prepared, it was introduced into an oven heated to a temperature of 930°C for 8 hours, then the box was removed from the oven, the lid was removed and the specimens were extracted for tension together with the

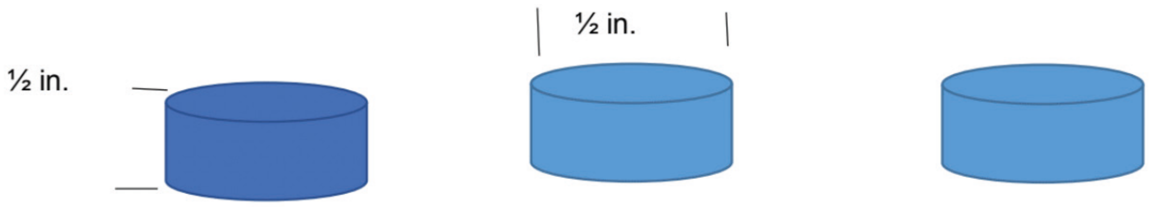


Figure 1. Specimens for Metallography, Chemical Analysis and Hardness.

cores that would be prepared for chemical analysis, hardness and metallography. The specimens are quickly tempered in a container containing quenching oil with a high cooling rate, always maintaining agitation during the cooling of the specimens. Once the specimens have a temperature of 60°C, they are placed in a furnace for tempering at a temperature of 400°C. Figure 2 shows the box used for the thermochemical treatment.

Figure 2. Shows the box for treatment and when it is already lined with clay ready for thermochemical treatment.

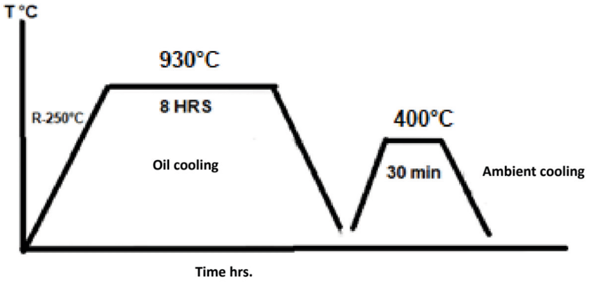


Figure 3 shows the thermal cycle applied in thermochemical cementation.

Figure 4 shows the moment when the case is removed from the furnace and the quenching in mineral oil is performed.

Figure 4. Thermochemical treatment development.

The specimens treated in the thermochemical treatment were analyzed by means of a Vickers hardness tester previously mounted and polished in order to obtain the depth of the cemented layer in AISI 8620 steel and the tensile specimen was tested in a universal machine.

RESULTS AND DISCUSSION

CHEMICAL ANALYSIS

A sample of the AISI 8620 steel bar used for the study was obtained and sent for chemical analysis with the following results.

The chemical analysis based on the AISI 8620 standard is shown.

Measurement Results

SpArcfire

Instrument 78Y0021
Sample MUESTRA 1
Alloy FE_100 Mode Element Concentration 28.03.2023 17:34:45

	C [%]	Si [%]	Mn [%]	P [%]	S [%]	Cr [%]	Mo [%]
1	0.1822	0.2309	0.8608	0.0262	0.0009	0.5753	0.1502
2	0.1765	0.2267	0.8687	0.0256	0.0017	0.5783	0.1495
3	0.1722	0.2224	0.8630	0.0259	0.0005	0.5670	0.1481
4	---	---	---	---	---	---	---
5	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---
Ø	**0.1770**	**0.2267**	**0.8642**	**0.0259**	**0.0011**	**0.5735**	**0.1493**

Source: HITACHI PMI-Master Smart optical emission spectrometer.

Grade	standard	C	Mn	P	S	Si	Ni	Cr	Mo
ASTM A29	8620	0,18-0,23	0,70-0,90	<0,035	<0,040	0,15-0,35	0,40-0,70	0,40-0,60	0,15-0,25

Comparing the chemical analysis of the steel to be studied with the chemical analysis established by the standard for AISI 8620 steel. It is determined that it corresponds to an AISI 8620 steel.

Another sample was sent for chemical analysis, this sample was treated by thermo-chemical treatment, the thermal conditions were: temperature 930°C, permanence 8 hrs, cooling in oil and tempering at 400°C for 30 minutes and cooling to the environment. The result obtained is shown.

PM Smart SNr. 57U0097 Optik Nr. 57U0103
Sample : Muestra 1
Alloy : FE_T_200 Mode : PA 01/11/2023 10:45:23

	Fe	C	Si	Mn	P	S	Cr
1	95,2	2,10	0,258	0,719	0,0123	< 0,0020	0,471
2	95,2	2,10	0,249	0,739	0,0140	< 0,0020	0,474
3	95,2	2,06	0,250	0,755	0,0165	< 0,0020	0,480
Average	**95,2**	**2,09**	**0,252**	**0,738**	**0,0143**	**< 0,0020**	**0,475**

	Mo	Ni	Al	Co	Cu	Mg	Nb
1	0,164	0,901	0,0269	< 0,0040	0,130	0,0025	< 0,0050
2	0,160	0,902	0,0267	< 0,0040	0,130	0,0025	< 0,0050
3	0,161	0,903	0,0256	< 0,0040	0,130	0,0024	< 0,0050
Average	**0,161**	**0,902**	**0,0264**	**< 0,0040**	**0,130**	**0,0024**	**< 0,0050**

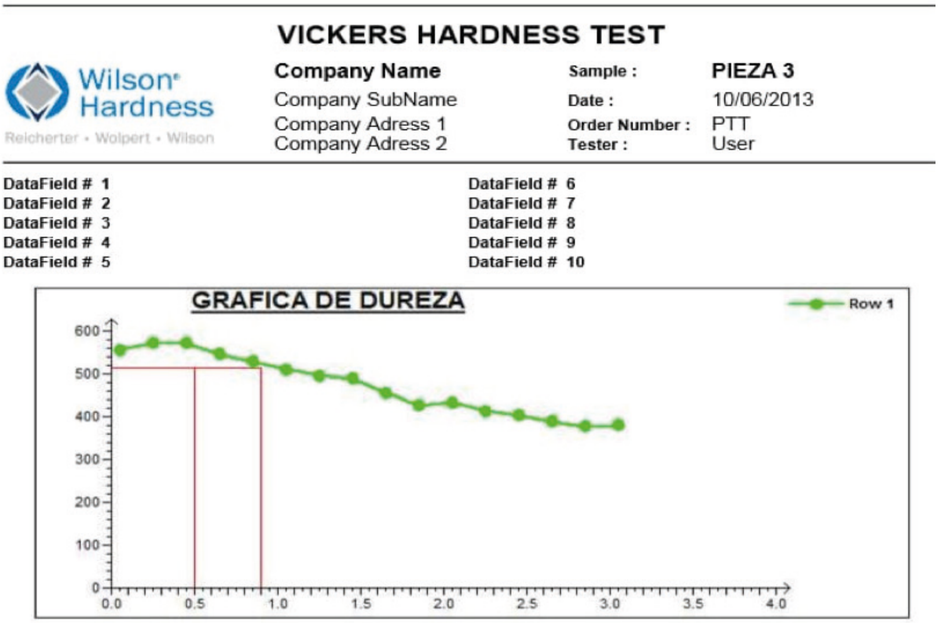
As can be observed, the chemical analysis obtained in the sample that was cemented under the established conditions, the percentage of diffused carbon shows an average of 2.09, which indicates that its increase in the subsurface was 1.92 % of carbon, considering that the initial analysis was 0.17% of C. Therefore, and following the rule that mentions that the higher the carbon, the greater the hardness of the steel, the increase in hardness was achieved, as well as the formation of a martensite structure characteristic of high hardness.

DEPTH OF CEMENTATION OBTAINED IN THE THERMOCHEMICAL TREATMENT.

The results obtained from the depth of cementation contemplate a general study where the depth of cementation and micro hardness is annexed, which is obtained when the value of 50 Hrc found in the mapping according to the SAE J423 standard is registered, the graph and the microstructures in the superficial zone, intermediate zone and core were obtained. The piece was sectioned, then the metallographic assembly was performed (encapsulated in thermosetting phenolic resin, edge retention bakelite) see figure 5 and metallographically prepared (roughing with silicon carbide abrasive paper of different granulometry, ending with polishing with cloth and 1 μm diamond paste).

Figure 5. Shows the specimen that was mounted for mapping to determine the depth of cementation.

The cementation depth result was 1.03 mm according to the study performed



Result

CHD 513 HV 0.5 = 1.03 mm

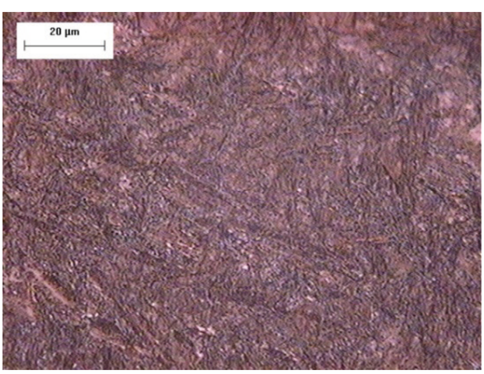
Row 1

Point	Distance	Hardness	Conv Hardness 1	Comment
1	0.0500	556 HV 0.5	52.8 HRC	
2	0.2500	572 HV 0.5	53.7 HRC	
3	0.4500	572 HV 0.5	53.7 HRC	
4	0.6500	546 HV 0.5	52.1 HRC	
5	0.8500	529 HV 0.5	51.1 HRC	
6	1.0500	511 HV 0.5	49.9 HRC	
7	1.2500	497 HV 0.5	48.9 HRC	
8	1.4500	489 HV 0.5	48.4 HRC	
9	1.6500	456 HV 0.5	45.8 HRC	
10	1.8500	426 HV 0.5	43.3 HRC	
11	2.0500	433 HV 0.5	43.9 HRC	
12	2.2500	413 HV 0.5	42.1 HRC	
13	2.4500	403 HV 0.5	41.1 HRC	
14	2.6500	389 HV 0.5	39.7 HRC	
15	2.8500	378 HV 0.5	38.6 HRC	
16	3.0500	381 HV 0.5	38.9 HRC	

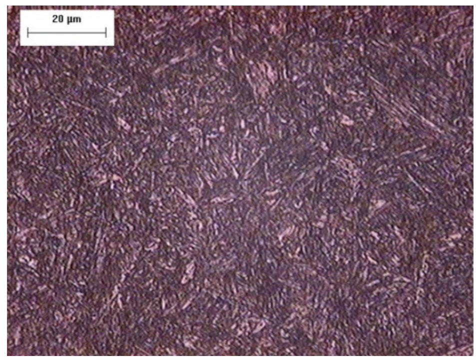
The conditions of the thermochemical treatment were: Temperature 930°C, time 8 hrs. Tempering 400°C, time 30 minutes, which is considered an acceptable cementation depth, since with this result a high wear resistance and deformation resistance can be predicted, guaranteeing a good performance if a part is manufactured and put in a machine under severe stress conditions.

MICROSTRUCTURAL ANALYSIS OF THERMOCHEMICALLY TREATED STEEL

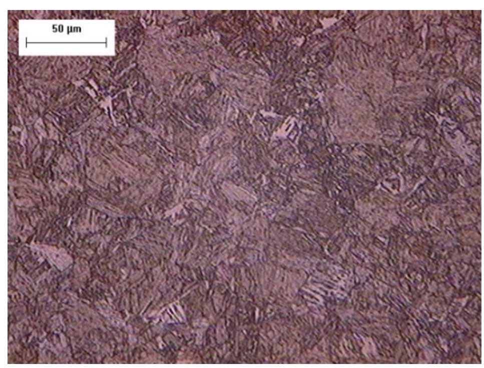
The microstructural analysis of the surface zone, transition zone and core of the sample subjected to thermochemical treatment is shown.



Photomicrograph 1.- Piece 1, ***Surface***, the microstructure consists of a matrix of tempered martensite, 500x, chemical attack: Nital 5%.



Photomicrograph 2.- Piece 1, ***interface,*** the microstructure consists of a matrix of tempered martensite, 500x, chemical attack: Nital 5%.



Photomicrograph 3.- Piece 1, ***Core,*** the microstructure consists of a matrix of mixed phases (ferrite-perlite-martensite), 200x, chemical attack: 5% Nital.

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TEST RESULTS OF HARDNESS AND TENSILE TEST OBTAINED ON THE ORIGINAL SAMPLE AND SAMPLE SUBJECTED TO THERMOCHEMICAL TREATMENT

The hardness values obtained for AISI 8620 steel before and after heat treatment are shown below.

AISI 8620 steel treatment	Hardness (HRc)	Maximum stress (psi)
Sample, untreated steel	23	74,216
Sample, steel with thermochemical treatment. temp.930°C, time 8 hrs. Tempering 400°C	53	117,609

Based on the results obtained in the hardness and tension tests, it is observed that the sample that was cemented by thermochemical treatment has the highest hardness and tensile strength, with a value of 117,609 psi, compared to the original sample that presented a value of 74,216 psi, which reflects a very acceptable value for the thermal conditions established.

CONCLUSIONS

The study of this project was to have managed to obtain a carburized layer as indicated in the previous research. And indeed, with the analysis of the results obtained, a surface layer was obtained with a higher percentage of carbon than what the steel originally had, being 2.09% This can be verified with the metallographic results, hardness tests. For all these reasons it can be concluded:

- The value obtained for the cementation depth was very acceptable, reaching a maximum of 1.03 mm.
- The metallographic analysis clearly shows a superficial cementation layer, which proves that the process was successful, forming the three important phases which are martensite, pearlite and ferrite. This gives the steel high toughness and wear resistance.
- If we make a comparative analysis with other conventional steels in the industry, carbon and barium carbonate carburizing has a higher tensile strength than some of those steels.
- Using this project as a reference ensures that a low carbon steel such as AISI 8620 steel can be satisfactorily case hardened.

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