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STUDIES REGARDING THE PROPERTIES MODIFICATION OF AISI 310S STEEL

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ABSTRACT

The paper presents an analysis of classical heat treatments, which can be applied to AISI310S steel samples. The influence of these heat treatments was highlighted by micro-hardness measurements – Vickers method, and also the structural analysis made on electronic microscope, at different magnitudes. The AISI 310S steel is part of chrome-nickel stainless steels and presents good resistance properties. These properties are due to principal alloying elements (nickel, chrome) and recommend its being used in corrosive medium and high temperatures.

KEYWORDS: steel, properties, stainless, refractory

1. Introduction

The alloying of the steel with various chemical elements can induce a good corrosion resistance in aggressive environments, in water, in atmosphere or at high temperatures oxidation.

Alloying elements help the appearance of a superficial layer, compact and adherent of resistant oxides at the chemical action of the work environment.

The stainless or refractory steels are alloyed with chrome or chrome-nickel in order to enhance their resistance at chemical action of the environment. In combination with elements which present a high tendency to form carbides, like titanium, niobium, molybdenum and tungsten, the chrome-nickel high alloyed steels form the base of austenitic and austenitic-ferrite refractory steels.

The refractory and anticorrosive steels are high alloyed with chrome, with additions of:

- Aluminum and silicon – which increase the oxidation resistance at high temperatures;
- Molybdenum, vanadium and tungsten – which increase the resistance properties;
- Nickel – which increase the tenacity and plastic deformation processing.

The stainless steels present a good chemical stability associated with good mechanical properties, especially long-time resistance.

Oxidation resistance at high temperatures of refractory steels is assured by the forming of a stable layer, compact, protector of oxides: SiO_2, Cr_2O_3 and Al_2O_3. The stainless steels alloyed with nickel can be used in cryogenic environments.

The structure of laminated or forged austenitic steels consists in an austenitic mass with numerous special carbides included. The special carbides, included in base mass, stopped the slippage and harden the plastic deformation at the work temperatures in exploitation. The δ ferrite, which appears in austenite – ferrite steels, is often unstable and is discomposed even at higher annealing temperatures, and also at maintaining work temperatures in exploitation.

To point out the existent structural constituents, a multiple attack is necessary. Through royal water attack are first revealed the outlines of different crystallites. The next electrolytic attack with chromic anhydride 10% in water solution has colored the fine carbides in black, meanwhile the σ phase was removed through dissolution.

2. Experiments

2.1. Determination of alloying elements

The chemical composition is determined through quantitative spectral analysis, using a Foundry Masters optical spectrometer, type 01J0013, calibrated for iron analysis base.

***Table 1.** Chemical composition of analyzed samples (wt.%)*

Fe	C	Si	Mn	P	S	Cr	Mo
52.3	0.122	1.08	1.46	0.0272	0.005	24.1	0.12
Ni	**Al**	**Co**	**Cu**	**Nb**	**Ti**	**V**	**W**
20.1	0.0055	0.2	0.0837	0.0252	0.085	0.0714	0.02

2.2. Industrial applicability

The analyzed steel is part of stainless steels, type 12NiCr120 – refractory and anticorrosive steels category.

The names it has are 1.4845 after EN10095; 310S after AISI; 12NiCr250 after STAS.

Stainless Steel 310, combining excellent high temperature properties with good weldability and ductility, is designed for high temperature service.

SS 310 resists oxidation in continuous service at temperatures up to 1150 °C provided reducing sulfur gases are not present. SS 310 is also used for intermittent service at temperatures up to 1040 °C.

Stainless Steel 310S is used when the application environment involves moist corrodents in a temperature range lower than that which is normally considered "high temperature" service.

The lower carbon content of SS 310S does reduce its high temperature strength compared to 310.

Typical applications: heat exchangers, furnace parts, combustion chambers, welding filler metals, gas turbine parts, jet engine rings, incinerators, recuperates, rolls for roller hearth furnaces.

2.3. Structural modifications induced through heat treatments

Recommendations regarding the heat treatments regime applied to the refractory steels:

The martensitic and ferritic refractory steels will be submitted to some annealing heat treatments, regarding the increase of machine processing.

The annealing temperatures are between 750-850 °C, with maintaining times established according to chemical composition and thickness of the materials. It can be observed that after the recommended annealing, the steel has a plastic component.

The austenitic refractory steels will be subjected to solution quenching, to increase especially the corrosion resistance.

The samples were heat treated, according to the work specific parameters (see Table 2).

The heating and maintaining of heat treated samples were made in an electric furnace, with resistors and fixed hearth, type UTTIS CE12.

The samples have small dimensions and are obtained through cutting on METACUT 250 machine, using an abrasive disk and cooling with water.

***Table 2.** Mechanical properties and heat treatments*

$R_{p0.2}$ [N/mm^2]	R_m [N/mm^2]	A_5 [%]	HB	Annealing [°C]	Environment	Quenching [°C]	Environment
225	490	20	140-190	850-900	Furnace	1050-1100	Water

***Table 3.** Adopted parameters of applied heat treatments*

	Initial temperature [°C]	Final temperature [°C]	Maintaining time [min]	Cooling environment	Cooling speed
Annealing	20	850	10	Furnace	Slow
Quenching	20	1100	10	Water	Fast

2.4. Structural analysis

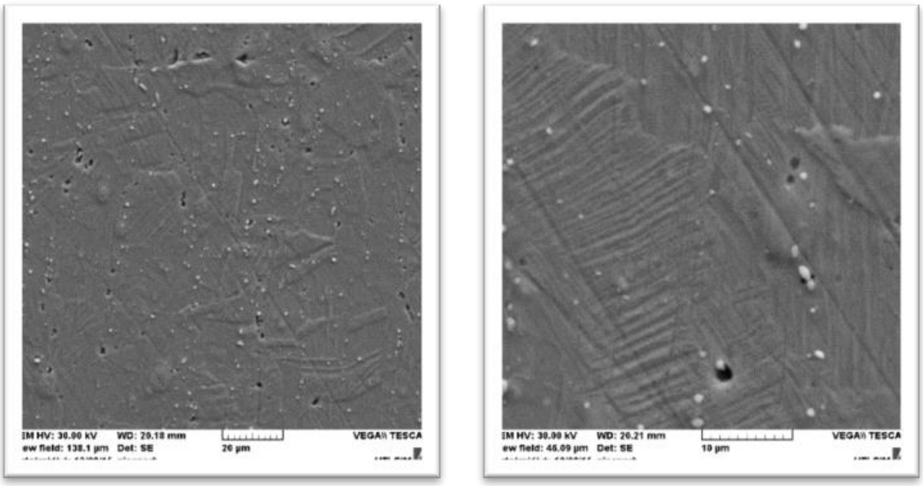
With the help of scanning electronic microscopy, we can obtain images of topography and characteristic composition of sample surface.

The formation of images is realized with the help of a primary electrons fascicle, very thin, which scan the sample surface.

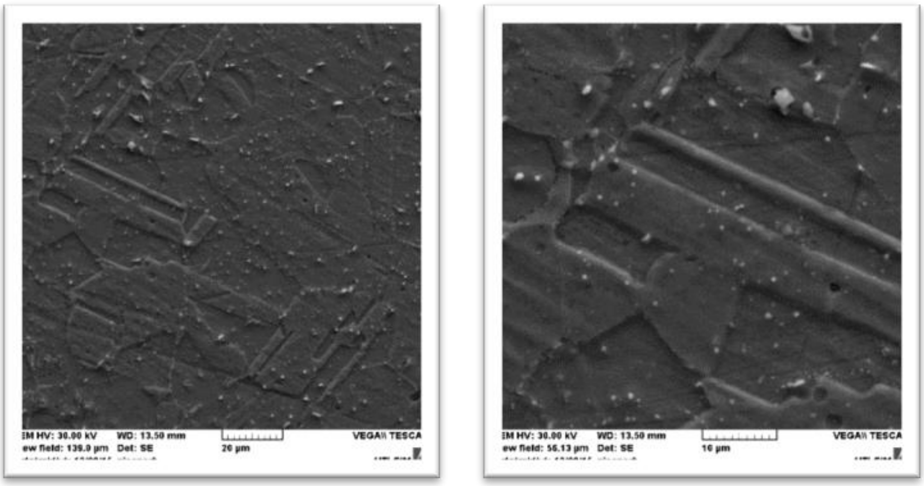
Through the interaction of the primary electrons with the surface, some of them are refreshed, and another part determines the forming of the secondary electrons.

The image is realized with these electrons, either secondary, or refreshed, which creates a contrast dependent by the incident angle of fascicle and the sample composition.

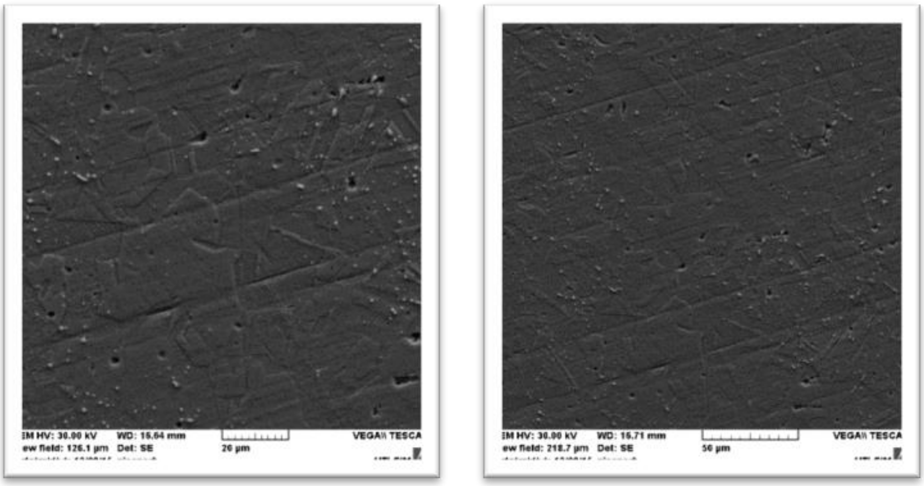
Regarding the microscopic examination, the samples were cut with a machine with abrasive disk and water cooling, then polished on abrasive papers, polished on felt soaked with aluminum oxide and attacked with chemical reactive.



a. AISI 310 steel structures in initial state



b. AISI 310 steel structure after annealing heat treatment



c. AISI 310 steel structure after quenching heat treatment

2.5. Hardness measurements

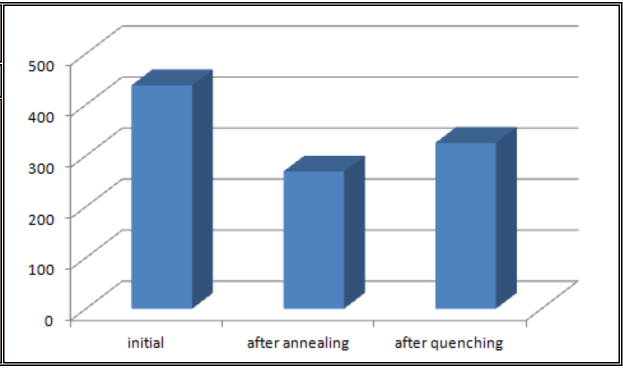
The hardness determination provides indications regarding the mechanical resistance of the alloy, imposing or not the utility of applying the heat treatments.

Vickers microhardness method consists in pressing a pyramidal penetrator, with low speed and a certain force (in this case – 50 grams), on the sample material, for 15 seconds.

The analyzed samples were prepared through polishing on abrasive paper, to remove the oxide traces or other substances resulted from the polishing process.

Table 4. *Measured values of hardness for the samples, after each heat treatment*

Nr.	The initial state		After annealing		After quenching	
	HV	**HV$_{med}$**	**HV**	**HV$_{med}$**	**HV**	**HV$_{med}$**
1.	472	**438**	268	**269**	369	**325**
2.	425		287		313	
3.	416		251		292	



3. Conclusions

The quantitative determinations of alloying elements, made through the quantitative spectral analysis, have demonstrated that the analyzed samples fit in the imposed limits by standard for AISI 310 steel.

The diversity of industrial application where AISI 310 alloy is used imposes the study of some heat treatments of improving the machine processing and also establishing final properties necessary in exploitation.

That is why the recommended parameters were established according to specialty references and experiments were made at medium values of intervals.

The microstructure of AISI 310 was analyzed with the help of a Vega Tescan electronic microscope, with different magnitudes.

From the SEM images analysis specific structures of alloy in initial exploitation state can be highlighted, and also after the 2 applied heat treatments.

The evaluation efficiency of applied heat treatments was made with the help of hardness measurements, through Vickers microhardness method, using a loading force of 50 grams.

The obtained values fit in specific limits of the material and applied heat processing.

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