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THE INFLUENCE OF HEAT TREATMENTS IN CORROSION RESISTANCE OF AUSTENITIC STEELS

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Abstract: *This paper presents the results of laboratory research on the influence of heat treatment on the corrosion resistance of austenitic steels (Cr-Ni, Cr, Mn, Cr-Mn-Ni), research that may extend under certain conditions and ferrites steels and semi-ferrites chrome steels.This type of intercrystalline corrosion was observed in other alloy systems due to media containing chloride ions.The experimental results consist in comparing structural changes and corrosion rate for different types of austenitic steels that were made experimental research.*

Keywords: *Intergranular corrosion, austenitic steels, heat treatment*

1. INTRODUCTION

Intercrystalline corrosion is the type of preferential corrosion of grain boundaries in which destruction is diffuse, intercrystalline. The attack occurs along the crystalline grain boundaries, known as a deterioration of the structure, followed by decreased resistance of the metallic material. This type of corrosion is typical austenitic stainless steel (Cr-Ni, Cr, Mn, Cr-Mn-Ni) but may occur under certain conditions and chromium ferrite steels and semi-ferrites. He has also been observed in other alloy systems occur secondary phase (Zn - Al) particularly in environments containing chloride ions [1].

Stainless steels are generally used in aggressive environments due to their passivation capacity [7, 10,13, 14, 15].

Staineless steels from austenitics classes are caracterized by a high resistance against general corrosion, but their usage resistance is low. Also, these steels are sensitive at inter-crystalline and pitting corrosion (corrosion points) [6].
Sensitivity metallic material intercrystalline corrosion is determined on the one hand the chemical composition and condition of structural, on the other hand the composition, concentration and temperature corrosive environment.

From the wide range of stainless steel, the most commonly used are the type and 20-25Mo 18-8 Mo and the Cr ferrite around 17% due to their good resistance to atmospheric corrosion in industrial environment and in various chemical agents: in nitric acid at any concentration, but not to higher temperatures in the environment of sulfuric acid with a concentration of up to 15% and more than 75% in acetic acid, the alkali metal hydroxides and organic compounds to a temperature of 50° C.

Today the corrosion is a real scourge, therefore the study of corrosion processes could solve a lot of problems that arise in industry. Research experience consist of various studies on the corrosion resistance of austenitic stainless steels (X5CrNi 18-10) before and after different surface treatments (cold plastic deformation).

The intensity of the corrosion process can be expressed as: change in weight, change in mechanical properties, depth of attack. In many cases, such as gas or atmospheric corrosion, corrosion effect is evaluated by comparing experimental evidence or witness specimens photos standards catalogs [6].

Temporal evolution of temperature distribution in a system depends on the appearance of heat flow from warmer regions to colder ones.

2. MATERIALS AND EXPERIMENTAL PROCEDURE

The material used for the experimental determination is an 18-10X5CrNi austenitic stainless steel with the following composition.

Table1. Austenitic stainless steel composition

Element	C	Mn	Si	S	P	Cr	Ni
%	0,05	1,32	0,32	0,006	0,026	18,5	8,88

3. COLD PLASTIC DEFORMATION

Cold forming austenitic stainless steel used in experimental determinations was done by identifying the different degrees of reduction of the material in multiple passes.

In figure 1 can see that stainless steels are susceptible to corrosion (attack) localized in all cases due to defects or tears off the passive layer.

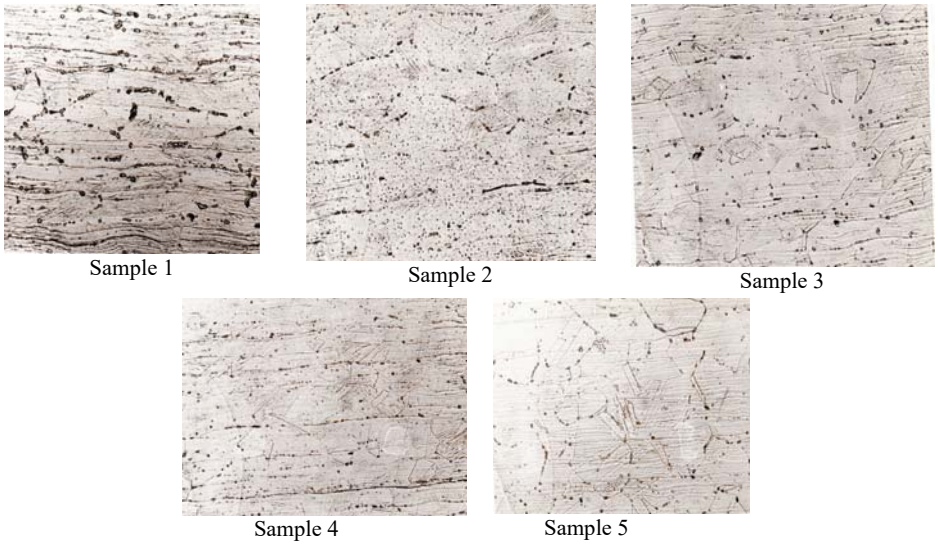


Figure 1. Influence of cold plastic deformation of steel structure (magnification x500)

Passive film rupture causes may come from: peculiarities of the metal structure (edge grain, inclusions, etc.), the geometrical effects of surface or mechanical effects [7]. Plastic deformation of single crystals and polycrystals is made by several mechanisms, which are treated in the literature [5, 6, 7, 8]. In our study we used a cold plastic deformation by slip, obtained by multiple passes yielding dealt with different degrees of reduction.

For steel subjected to experimental research with austenitic structure a structure carbide (sample 1) arranged on grain boundary is inadequate, being susceptible to corrosion and pitting intergranular. Following these findings received from the literature were made tests of corrosion resistance of the material under investigation.

4. EXPERIMENTAL PROCEDURE

The experimental procedure involves performing mechanical measurements and determination of intergranular corrosion and pitting corrosion type specific stainless steels. Before introducing the corrosive environment, the samples were well degreased with organic solvents. For a distribution as uniform corrosion currents and eliminating edge, bordered on each sample to an area of 1 cm^2, and the remaining surface was covered with a varnish used in corrosive environment.

4.1. Determination of intergranular corrosion

Intercrystalline corrosion is the type of preferential grain boundary corrosion in the absence of mechanical stress. Corrosion products remain in this case inside metallic material and weaken cohesion so much so that even very small loss in weight of the piece, apparently insignificant, can significantly reduce the strength, thus conceding song at the slightest request.

Intercrystalline corrosion is found more often in alloys having a solid solution structure, stainless steel by heating in the temperature range between 350°C and 800°C (microstructures of Figure 1), intercrystalline corrosion phenomenon is observed even in environments moderate corrosive.

In some cases, attack intensity is so high that the alloy crumble in separate granules, losing its total strength, and in other cases not crumble total alloy, but destroying the inner material is enough to make you lose strength.

The experiments on the determination of the resistance to intergranular corrosion [2,3] were made using plant in figure 1.

The solution used to obtain corrosive effect was next: 110-160g: $CuS0_4 \cdot 5H_2O$, 100ml H_2S0_4, ρ = 1.835 g / cm^2, 1000ml distilled water, copper scrap materials used X5CrNi 18-10.

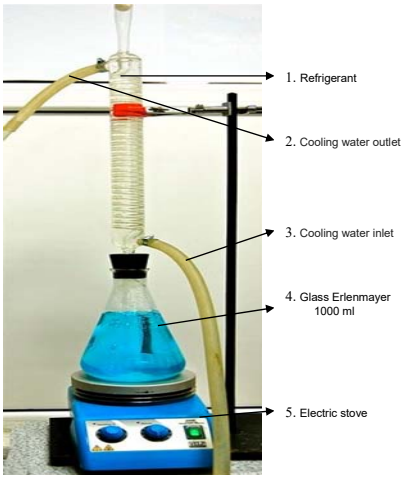


Figure 2. Equipment for testing the stainless steel to intergranular corrosion

In the other part [5] shows that a passive film good elasticity, can offer a significant corrosion resistance alloy wire and plastic deformation. Even if there is a momentary breaking local passive film he recovers quickly without having time to unleash and develop localized corrosion. By other research [6, 7] a passive film formed in an environment not always retains the protective properties to environmental because each metal-environment system creates occurring chemical processes and / or specific physical interfaces [12].

Figure 3 show the microstructures of metallic materials at corrosive degrees of reduction of 0%, 12%, 19%, 24%, 26% and 37% at a magnification of 200.

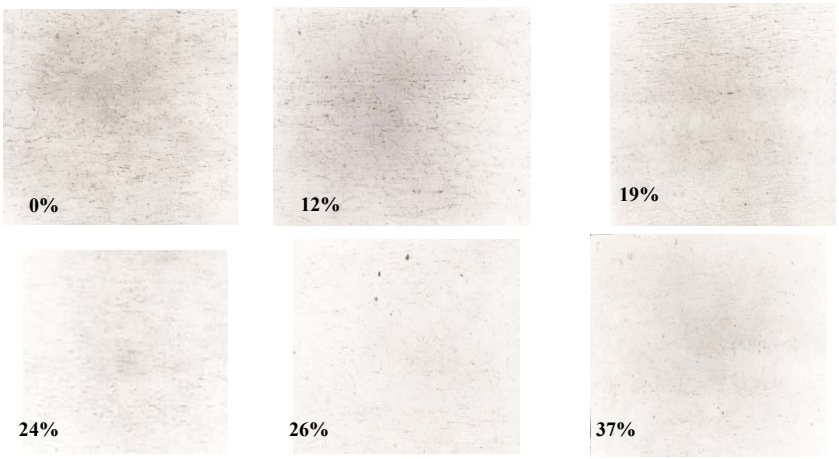


Figure 3. Steel X5CrNi 18-10 structure after trying to intergranular corrosion (magnification x200) (for different degrees of reduction 0%, 12%,19%, 24%,26% and 37%)

4.2. Pitting corrosion

Principle of the method [2,3] consists in maintaining the samples in a weak oxidant solution at boiling temperature for 24 hours, bending the curve 90^0 and examination the curvature area.

Note the first macroscopic then microscopic fissures, after a preliminary training and electrolytic etching with 10% oxalic acid .

This type of corrosion is focused on surfaces small 0,1-2mm, destroying heavy material in depth.

Frequently, such a showing corrode stainless steels aspect in solutions of salts (chlorides) [13] (Figure 4) and other metals covered with protective oxide film acting cathode metal destruction focuses on unprotected portions, the pores (Figure 5).
Loss of visual examination table with corroded surfaces may be an appropriate method for assessing the resistance to pitting corrosion of alloys in laboratory testing .

In Figure 5 is shown a section through a portion appeared as a result of a material defect that leads to a pit followed by a generalization - pitting corrosion.

In any case, mass loss only provide information on the total metal loss due to corrosion in points, but does not provide data on pitting density and penetration depth.

The depth of the corrosion can be determined by vertical sectioning point corrosion especially the setting sectioned surface and polishing the surface. A better way consists in sectioning point a little further corrosion and polishing until you reach the point of corrosion in the section.

The depth of the corrosion spot on the polished surface is measured using a calibrated ocular microscope.

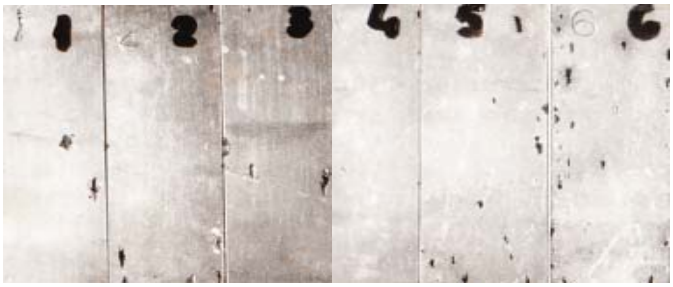


Figure 4. Corrosion test - appearance of pitting

The depth of penetration into the metal can be expressed in terms of index point corrosion (pitting factor). This is the ratio between the largest and the mean depth of penetration in metal, determined by mass loss.

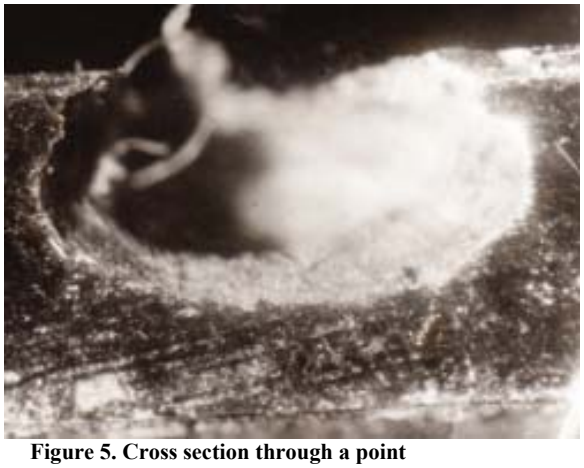


Figure 5. Cross section through a point

In the stainless steel, pitting are either grains boundaries or at some sulphide inclusions. These effects are caused by defects in crystalline and metallurgical structure and composition affects the thickness of the sample.

Table 2. Experimental results

Sample marking	Initial weight [g]	Final weight [g]	Mass loss [g/cm^2]	Corrosion rate [g/cm^2·h]	Number of points /cm^2
1	16,09	15,22	0,87	5,14	1,41
2	17,74	16,89	0,85	4,91	1,08
3	19,52	18,62	0,90	5,21	0,60
4	20,31	19,46	0,85	4,96	0,42
5	22,51	21,58	0,93	5,40	1,85
6	25,04	24,10	0,94	5,27	2,25

Based on experimental results are presented in table 2 traces corresponding graphs (fig 6, 7).

Based on the results plotted corrosion rate (g/h) versus time. It compares steels on structural changes and general corrosion rate.

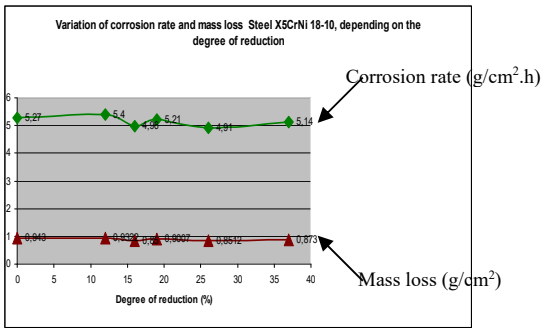


Figure 6. Variation of corrosion rate and loss for X5CrNi 18-10 sample

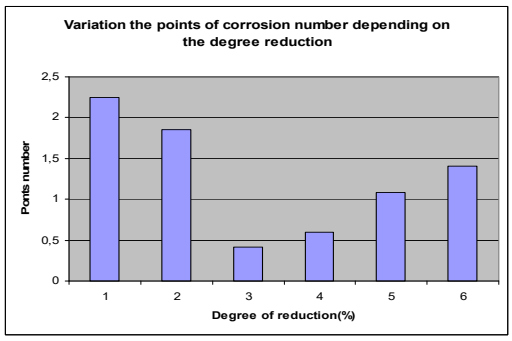


Figure 7. Variation the points of corrosion number mass depending on the degree reduction

We compare the microstructures of steels for different degrees of structural changes and reducing the corrosion rate variation (fig. 6, fig. 7).

An index of pitting corrosion of 1 represents a general. The more higher, the penetration depth is greater. Corrosion index does not apply in those cases where pitting or general corrosion are very small, as are obtained if the values zero or infinite fraction the numerator or denominator tend to zero.

5. CONCLUSIONS

Destruction cause corrosion in many cases not so a metal mass variation, such as stainless steels, especially as change their properties, leading to a sharp contraction mechanical strength. Depending on the nature of steel, aggressive environment and working conditions depending on the corrosion rate may remain constant, increase or decrease over time. I said that the notion of stainless is not absolute notion as a metal or an alloy even "stainless" can be very resistant to certain conditions, but others may become unstable, heavily corroded.

This explains the large number and variety of test and measurement methods of corrosion resistance, taking into account the changes caused by corrosion on the physical and chemical properties of metals and alloys.

Based on theoretical studies showed that plastic deformation stainless steels produce significant changes in their structure and properties that influence corrosion resistance.

First plastic deformation may lead in some circumstances to break the passive film (non passive mechanics), which can cause local or generalized corrosion. To remedy this phenomenon may use a chemical reactivation using appropriate technologies. Secondly, after plastic deformation occurring structural transformations (formation of martensite, ferrite precipitation of CrN and Cr_2N). These changes affect substantial corrosion resistance.

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