INVESTIGATION THE CORROSION OF HEAT TRANSFERRING UNIT IN HYDROGEN PEROXIDE & SODIUM CHLORIDE SOLUTION USING WEIGHT LOSS MEASUREMENTS

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Depending on the conditions of their use, most equipment gets deteriorated in time. In this paper the corrosion rate (CR) was calculated by monitoring the weight loss of specimens from the body of heat transferring unit, usually are made of 304L. The hardness and tensile strength have been studied. The obtained results have been compared with the ones in the standard specification for 304L and have evidenced a decrease of the tensile strength and increases of hardness. The corrosion rate was calculated by specimens' weight loss in the corrosive environment at 25 °C to mimic the corrosive environment.

Keywords: Heat transferring unit, austenitic stainless steel, corrosion rate, weight loss

1. Introduction

Due to the increased demands of these materials and their usage, our concerns regarding the effect of natural forces on the materials functionality must be at a high level [1].

Latest studies indicate that the corrosion is caused by the interaction between the materials and the environment surrounding it. Therefore, there are many types of corrosion which refer to the form of corrosion, these multiple types lead to different forms of deterioration in the mechanical properties of the base metal [2].

Corrosion is a process of deterioration, caused by the chemical reactions between a material and the surrounding environment, which can alter the materials properties. This process can lead to the formation of corrosion products, influencing so the materials integrity and performance, or even cause its failure [3].

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So, corrosion is a significant problem in industrial applications such as pipelines, tanks, boilers and heat transferring units (HTU), because it causes a loss in service and materials [4].

HTU are used in power plants, chemical plants, petrochemical and oil refineries [5]. The best way to protect corrosion from happening in HTU is through selecting the best design of the system and the optimum materials [6].

Research aim is to know the reason of the fault in the HTU, and why it failed in terms of studying the working conditions and the corrosive environment. A good understanding of the materials used for HTU, in terms of mechanical properties and corrosion rate, enables us to determine the performances that are affected under high temperature and pressure or not, or if there are other causes. A macroscopic image of a sample taken from the HTU which has been exposed to corrosive processes is presented in Fig. 1.

Fig. 1. Heat transferring unit section exposed to corrosive process

2. Materials and methods

The chemical compositions of the alloy which has been extracted from the HTU are shown in Table 1

Table 1

Chemical composition (wt. %)

HTU specimen	C	Si	Mn	P	S	Cr	Ni	Mo	Cu
304L	0.033	0.52	1.88	0.045	0.0065	17.7	9.16	0.240	0.351

Specimens of 304L with dimensions of 2×2 cm^2, and 5 mm in thickness were used for the weight loss measurement. All samples have been metallographically prepared on SiC paper of different grit (300-1200 grit) followed by cleaning in distilled water, acetone and were dried in air.

In order to evaluate the materials mechanical properties, the tensile and yield strength have been analyzed by using a 300 KN servohydraulic universal testing machine. The samples dimensions used for tensile tests are illustrated in

Fig. 2. Also, the materials hardness was determined on several regions by Rockwell hardness (HRC) testing method.

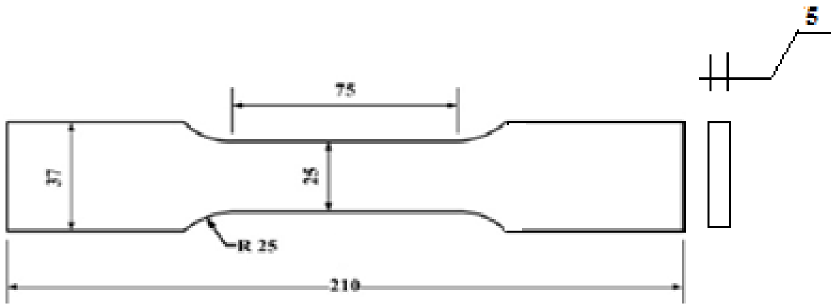

Fig.2. Dimension of the samples used in mechanical testing experiments

Because the HTU are exposed to a very corrosive environment, weight loss experiments have also been achieved. The tests were carried out at 25 ºC in 10%NaCl-10%H_2O_2 media which mimics the environment in the plant during specific times. Using a hand grinding wheel machine, the surface of the specimens was polished. After that, surface preparations were carried out by wet grinding with a series of SiC papers to 1200 grit followed by cleaning in distilled water, with acetone and air drying.

In weight loss experiment, a solution of 10%NaCl-10%H_2O_2 in distilled water was used, to mimic the environment in the plant during specific times at 25 °C. Whereas, the concentration of solution represents the work's environment. The weight loss was monitored by measuring the initial and final mass with an analytical balance (Sartorius, model TE 153S) with a precision of 0.001g.

3. Results

Fig. 3. Refers to tensile specimen used in research, the Load - Displacement curve of the body of the HTU specimen are shown in Fig. 4 and the bar charts shown in Fig. 5 shows the comparison of the tensile parameters obtained from testing and standard 304L alloy respectively.

Fig. 3. Macroscopic images of the 304L samples used in the mechanical tests

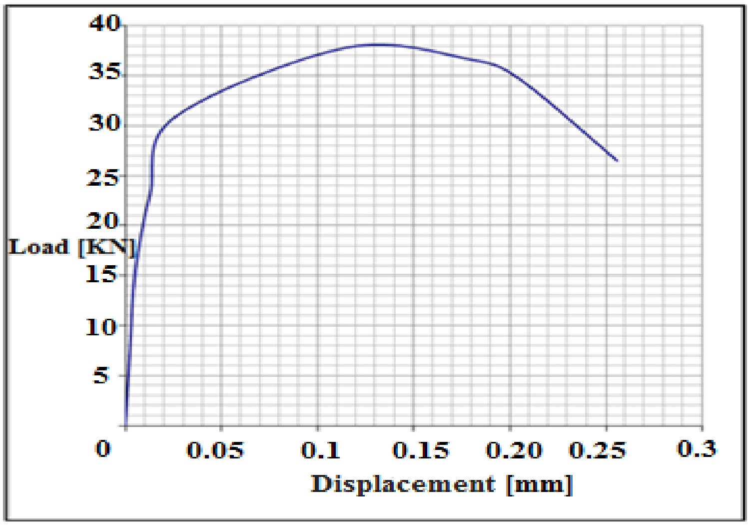

Fig. 4. Load - Displacement curve

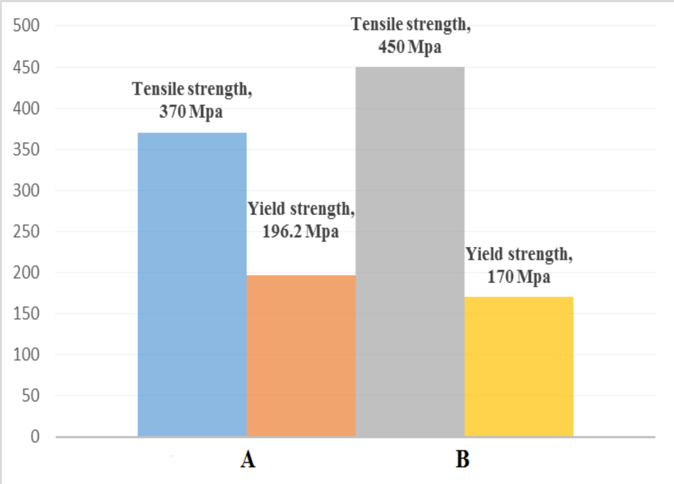

Fig. 5. The tensile strength and yield strength of the tested specimens:
A) body of the HTU specimen and B) standard alloy 304L

The hardness tests have been achieved on different regions, and showed an approximate value of 98.1 HRC for the HTU specimens while the standard alloy 304L have registered a value of 88 HRC.

The weight loss experiments were carried out in order to quantitatively determine the materials deterioration by corrosive process and to establish the corrosion rate. In order to obtain proper results, the materials working conditions (temperature, media etc.) have been simulated.

This method is summarized as follows: initially a control sample, which in this case is a 304 alloy with known dimensions, has been weighed before and after its exposure to the corrosive environment (NaCl-H_2O_2) for a specific period of time. The resulting corrosive products were cleaned from the samples surface, and re-weighed. The difference in weight represents the amount of the corroded material. For the corrosion rate (CR) [7, 8, 9] the following equation has been used:

$$R = \frac{KW}{ATD} \quad \text{(mm /year)} \tag{1}$$

$$WL = m_i - m_f \quad \text{(mg)} \tag{2}$$

Where: R: CR (mm/year);
K: 87.6 (conversion constant);
WL: weight loss (mg);
A: area (cm^2);
T: time (h);
D: density (g/cm^3).

In Fig. 6 is presented a macroscopic image of a specimen used in the weight loss experiments. All measurements have been repeated three time, and the values are presented in Table 2. Also Fig. 7 represents the variation of the weight lost within time.

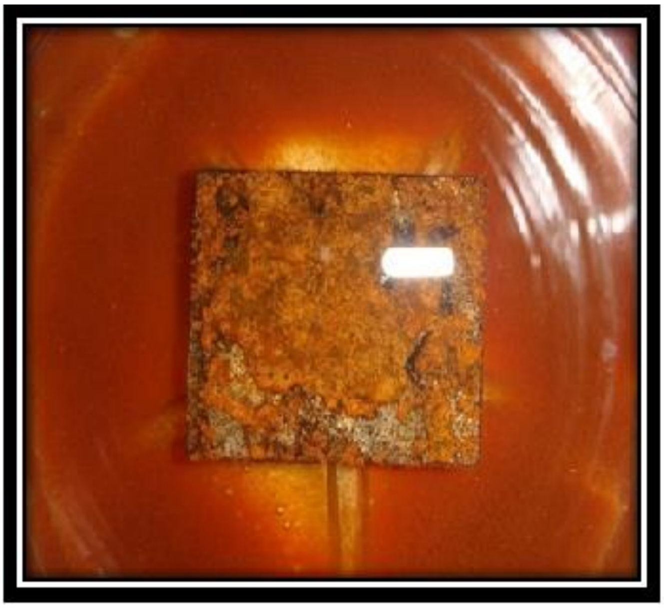

Fig. 6. Macroscopic image of the tested specimen in the corrosive environment during the weight loss analysis

Table 2

Variation of the weight lost within time of the investigated samples

No.	Solution	Time	Initial mass	Final mass	Weight loss	Density	Area	CR
		[h]	**[g]**	**[g]**	**[mg]**	**[g/cm^3]**	**[cm^2]**	**[mm/s]**
1	10%NACl, 10%H_2O_2	288	52.986	52.922	64	8	40.54	0.180
2			52.922	52.854	68		40.54	0.191
3			52.854	52.813	41		40.54	0.115

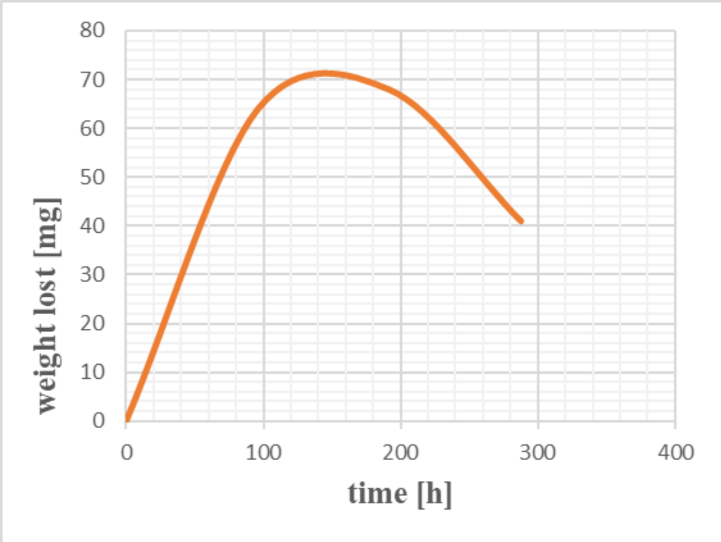

Fig. 7. Time - weight curve for the body of the HTU specimen

4. Discussion and conclusion

The mechanical tests have evidenced that the body of the HTU specimen, presents lower tensile when compared to a standard 304L alloy.

Furthermore, by making a comparison between the body of the HTU specimen and a standard alloy 304L alloy, a variation in hardness was noted: the body of the HTU specimen has a higher hardness.

The weight loss tests have indicated that the interaction that occurs in the corrosive media, at room temperature, leads to materials deterioration. The corrosion rate increases in the first 96 hours, and it starts to decrease during the following hours. This process leads to the formation of a protective layer on the materials surface, inhibiting so the corrosive process.

A higher content in chromium, leads to an increase of the crystals, and the material becomes brittle at higher temperatures [10]. It can be assumed that this material is not proper for usage in NaCl and H_2O_2 based media.

So, as a final conclusion it can be said that 304L is not a proper material for HTU fabrication and should be replaced by 321H austenitic stainless steel that will improve its usage in this application.

R E F E R E N C E S

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