

CORROSION STUDIES ON STAINLESS STEEL IN ACIDIC MEDIA

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Key words: corrosion, stainless, acid environment, passivation, uses

Abstract: Stainless steel corrosion in aqueous acid systems is mainly an electrochemical process. The use of new materials to resist corrosion in acidic media is the object of laboratory research in regard to the study of corrosion rates and the influence of different factors that affect the process. This article is dedicated to study the corrosion behavior of the five major groups of stainless steels.

1. INTRODUCTION

Stainless steel corrosion in aqueous acid systems is mainly an electrochemical process. A major part of industrial equipment, related piping, pumps and vents are undergoing corrosion. Apart from the common steel, the stainless steel has the following properties: lower thermal conductivity that makes it more susceptible to major deformations; higher thermal expansion coefficients and as a result steel has higher deformations and higher tension levels; high oxygen affinity therefore a better protection of the welding area is required; higher sensibility to superheating and as a consequence to that the fragility is higher. In the same context steel's chemical reactivity in active environments is lower, these metals showing a high resistance to common chemical reactions. Also we can talk about a very good mechanical resistance and a very good plasticity; the CrO layer formed on the surface of the metal in direct contact with air confers a good chemical resistance for steel.

Stainless steels can be classified into five major groups according to its chromium and nickel content, as shown in figure 1. We can talk about the following types:

- Martensitic stainless steels;
- Ferritic stainless steel;
- Austenitic stainless steel;
- Duplex stainless steel (austenitic/ martensitic structures);
- Precipitation- hardening stainless steel.

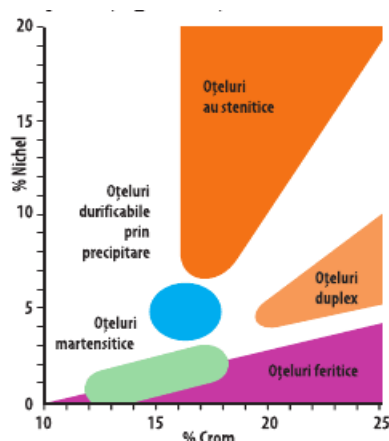


Fig. 1. Stainless steel types according to their Chromium and Nichel content

Table 1. Properties of different types of stainless steel [11]

Steel type	Corrosion resistance	Ductility	High temperature resistance	Low temperature resistance
Austenitic	High	Very high	Very high	Very high
Ferritic	Medium	Medium	High	Low
Martensitic	Medium	Low	Low	Low
Duplex	Very high	Medium	Low	Medium
Precipitation hardening	Medium	Medium	Low	Low

2. EXPERIMENTAL

The corrosion study of URANUS B6 steel in aqueous HCl and H₂SO₄ 0.01M to 5 M concentration solutions has been accomplished through electrochemical measurements. Polarization curves and open circuit measurements (EOC) have been used in order to establish the corrosion potential in time.

The HCl and H₂SO₄ solutions have been prepared from reagents with high purity and distilled water. All measurements have been made a constant temperature of 20 °C ± 0.2°C. The composition of the stainless steel used in this experimental part was 2% Mn; 1% Si; 0.045% P; 0.03% S; 16.5- 18.5% Cr; 3-3.5% Mo; 21.5-23.5% Ni; 2% Cu; 8% Nb (percentage relative to C).

A saturated calomel electrode (ECS) was used as reference and platinum as counter electrode. The working electrode was maintained in a static position and solutions were aerated. Experiments were carried out on a EQ 41 electronic potentiostat. All the potentiodynamic measurements were performed at a scanning rate of 15 mV/min. Cyclic voltammetry measurements have been performed on the samples using A Wenking potentiostat connected to a EMG generator type IR-0452. and the schematic is presented in figure 2. Potential and current intensity were recorded on a X-Y diagram ENDIME type.

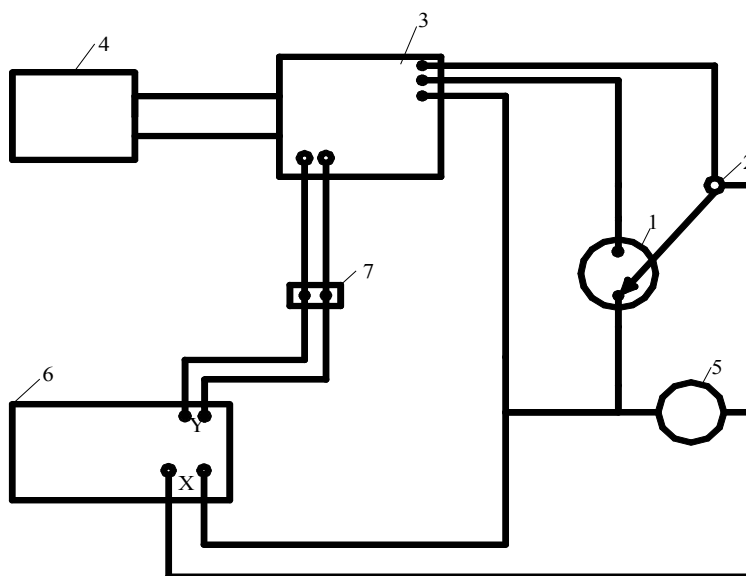


Fig.2. Schematic of the potentiostat system used
 1 – polarisation cell; 2 – reference electrode; 3 – potentiostat; 4- function generator; 5- voltmeter; 6 recorder; 7- resistance element.

Before each experiment, the electrode was briefly ground with #600 emery paper, followed by #2000 emery paper. After surface finishing, it was rinsed, washed with deionized water, alcohol and finally rinsed with triply distilled water and ultra-sounded. Three to four polarization curves were recorded then the samples were maintained in the hydrogen release domain. Through this treatment the electrode's surface becomes more homogenous from an electrochemical standpoint.

3. RESULTS AND DISCUSSION

Using the above mentioned open circuit potential measurement for the steel electrodes immersed in the two acidic media: HCl and H₂SO₄ the potential versus time curves (EOC) have been traced and are presented in figures 3 and 4.

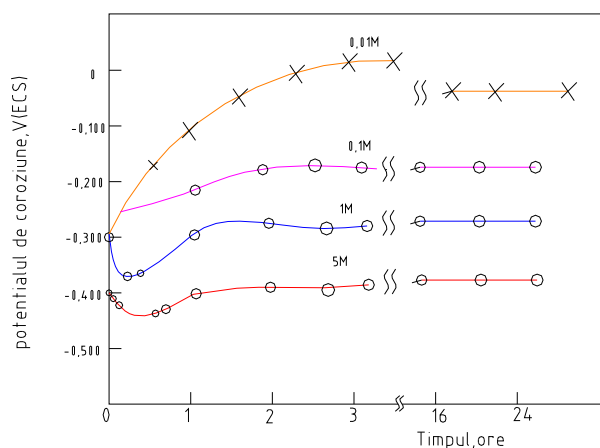


Fig. 3. EOC curves for the steel system UB 6 in HCl; $t=20\pm 0,2^{\circ}\text{C}$

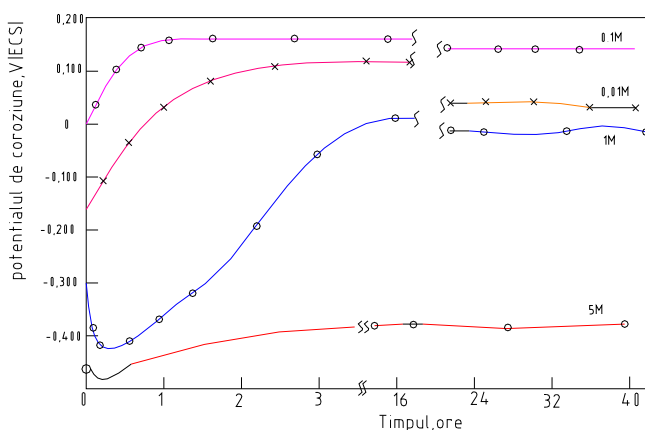


Fig. 4. EOC curves for the steel system UB 6 in H₂SO₄; $t=20\pm 0,2^{\circ}\text{C}$

From figures 3 and 4 one can notice that the variation of potential versus time is 20-30 mV/s. In the case of H₂SO₄ solutions, for all the concentrations is noted a shift towards anodic potentials that could be attributed to the passivation process. For the 0.01 M concentration the shift is more rapid and it can be explained by a faster passivation process.

From figure 5 diagramme we deduct that increasing the pH the passivation tendency of steel is increasing, together with the increase in the corrosion tendency. In the case of steel corrosion processes with passivation phenomena the best approach is the cyclic voltammetry study.

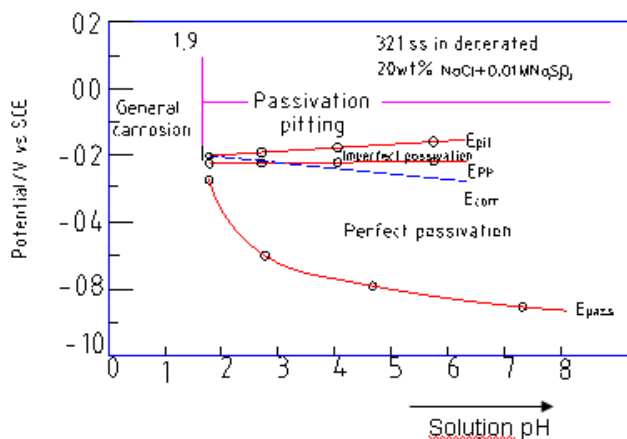


Fig.5. Pourbaix diagram for stainless steel in chlorides media

4. CONCLUSIONS

A laboratory investigation was performed to investigate the behavior of stainless steel in different corrosion acidic media. The conclusion of this investigation is that the H_2SO_4 solutions will passivate steel and makes them more corrosion resistant and usable in industrial environments. Corrosion potentials will shift in time towards positive values. Voltammetric measurements stressed the existence of passivation processes and the lack of pitting corrosion.

The HCl solutions will provide a much smaller passivation range and for concentrations higher than 1M the electrochemical processes determining corrosion will appear at the electrode.

In the case of stainless steels the passivation process (the formation of a protector layer of oxide) can be spontaneous or can develop in time as a consequence of a thermal treatment.

Corrosion process can destroy the metal and will provoke not only a mass change like in the case of stainless steels but also the change in their properties which will reduce the mechanical resistance of the steel.

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