

ELECTROCHEMICAL BEHAVIOR OF 430 FERRITIC STAINLESS STEEL

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Abstract: Ferritic stainless steel are less weldable than austenitic stainless steel and have drawn greater attention due to their lower costs and better resistance to stress corrosion cracking than austenitic stainless steels. The most commonly used ferritic stainless steel is perhaps the AISI 430 grade. These are iron-chromium alloys with sufficient chromium plus another ferrite stabilizer. The stabilizer, such as, aluminum, niobium, molybdenum, or titanium, are used to inhibit the formation of austenite on heating. Therefore they are non-hardenable. In ferritic stainless steel, the predominant metallurgical phase is ferrite. These alloys possess good resistance to stress corrosion cracking, pitting corrosion and crevice corrosion (particularly in chloride environments). Various studies have been carried out for determination of corrosive behavior of stainless steel in acid and basic mediums, but its corrosion resistance in salt aqueous solutions at high concentration of salts is a little bit limited.

Keywords: ferrite stainless steel, corrosion, electrochemical behaviour, Tafel curve, SEM.

I. INTRODUCTION

Some of the ferrite stainless steel not only have good corrosion resistance but also have good resistance to high temperature environment [1]. They are used to variety of applications where corrosion resistance, rather than mechanical properties (strength, toughness and ductility), is the primary service requirement. Low chromium (10.5% to 12.5% by weight) grades are used for application such as automotive exhaust system, where resistance to general corrosion is superior to carbon steel [2]. Medium and high chromium grades are used in more aggressive corrosion environments. Super ferritic alloys are used in the chemical processing and a pulp and paper industry, where resistance to corrosion in severe oxidizing media is required. High chromium grades are also used in high efficiency furnaces. The ferritic stainless steel are considered as low-cost materials with good corrosion resistance [1]. Ferritic stainless steels can be welded by SMAW, GTAW, GMAW and SAW processes. The most commonly used ferritic stainless steel is perhaps the AISI 430 grade, which contains 17% Cr and 0.5% - 0.12% Carbon. These are iron-chromium alloys with sufficient chromium plus another ferrite stabilizer. The primary aim of this work is to study the electrochemical behaviour (by weight loss measurement test) of 430 ferritic stainless steels in 1M HCl, 1M H₂SO₄ and 1M HNO₃ and 3.5% NaCl.

II. EXPERIMENTAL RESULTS

A. Weight loss measurement tests

The corrosion behaviour of the alloys was first studied using weight loss measurements in 1M H₂SO₄ acid, 1 M HCl and 3.5% NaCl. The corrosion behaviour of the alloys in acid solutions was studied for 8 days. The results of weight loss tests are shown in table: 1 and the results (Weight loss and corrosion rate) are compared in the Figure no 1.

TABLE 1: The results of weight loss tests

S.No	Corrosive Medium	Time (days)	Weight loss (gm)	Corrosion Rate (mpy)
1	1 M H ₂ SO ₄ acid solution	2	3.01	39.059
		4	2.792	36.256
		6	-0.013	27.62
		8	-0.023	--
2	1M HCl acid solution	2	0.56	7.2668
		4	1.29	16.053
		6	0.691	21.875
		8	0.268	---
3	3.5% NaCl solution	2	0.023	0.3373
		4	0.036	0.467136
		6	-0.024	0.544992
		8	-0.017	---

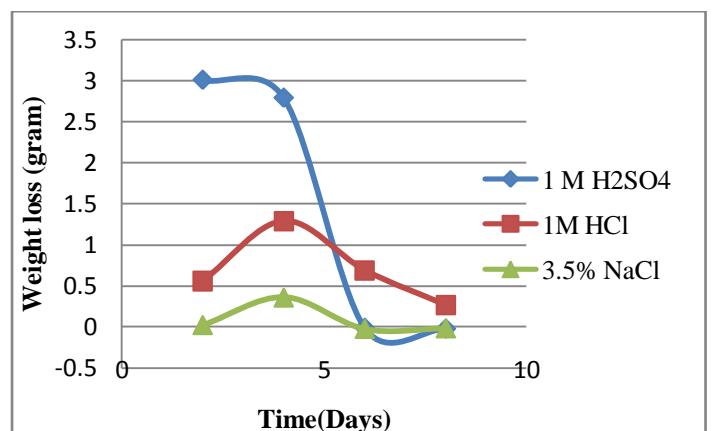


Fig. 1(a) Weight Loss with time for different Corrosive Medium

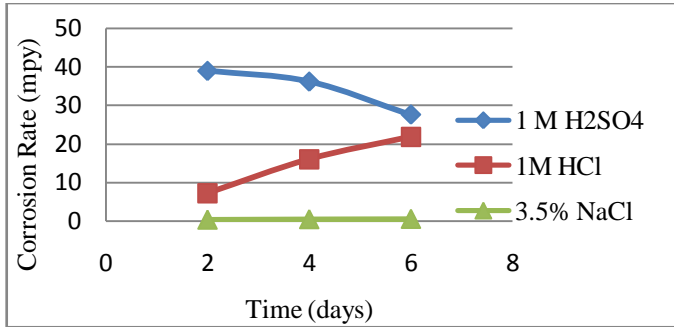


Figure 1 (b): Corrosion Rate with time for different Corrosive Medium.

Potentiodynamic experiments were performed using each of the rectangular specimens in turns, in which 5.419 cm² surface area of the specimen was exposed to the test solution at room temperature. The working electrode specimen of 5.419 cm² exposed area was in contact with the experimental solution for 45 min in ambient temperature. The polarization was performed potentiodynamically by starting at a negative potential or initial potential (-1.2V) and then moving to the positive or final potential (1.2V) direction in steps of 0.2 mV and step time 2 sec, with the scan rate of 0.01 V/sec.

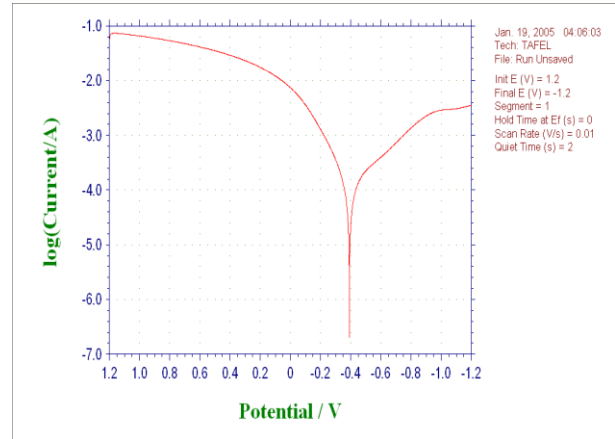


Fig.2(c) Tafel curve in 3.5% NaCl.

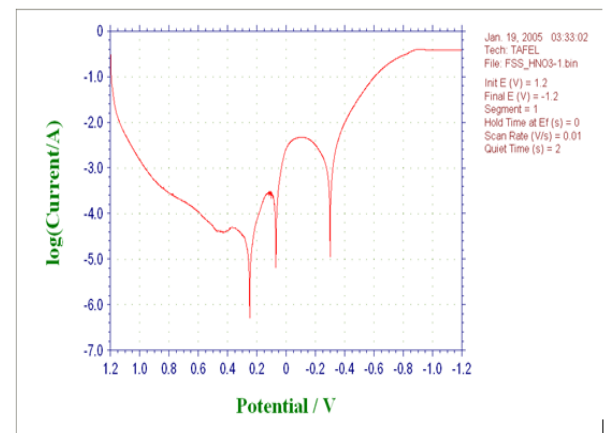


Fig. 2(d)Tafel curve in 1M HNO₃

The surface texture of the specimen studied by the SEM image analyzer after corrosion is taken at different magnification.

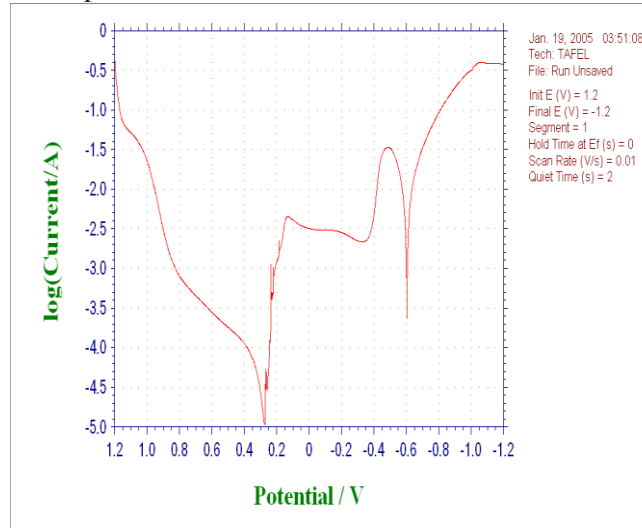


Fig.2(a) Tafel curve in 1 M H₂SO₄ acid

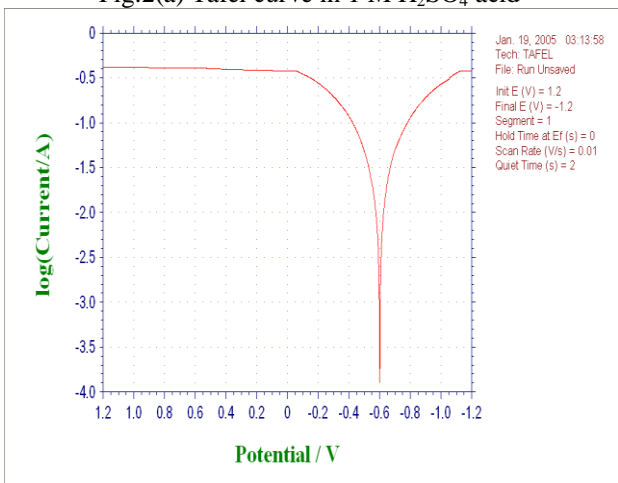


Fig.2(b) Tafel curve in 1M HCl acid

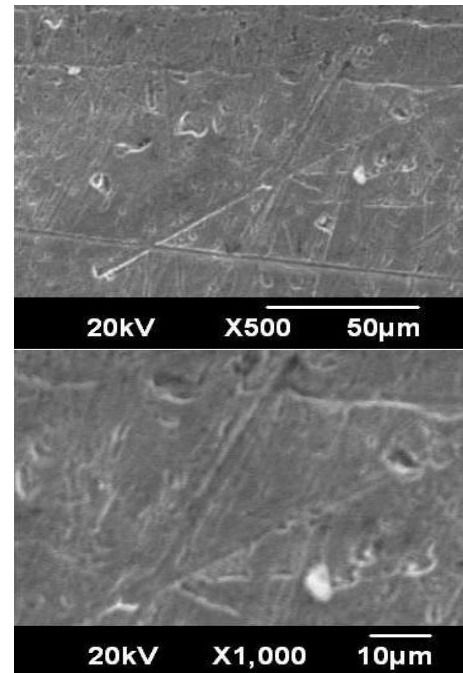


Fig.3(a) SEM of exposed sample in 1M H₂SO₄ solution

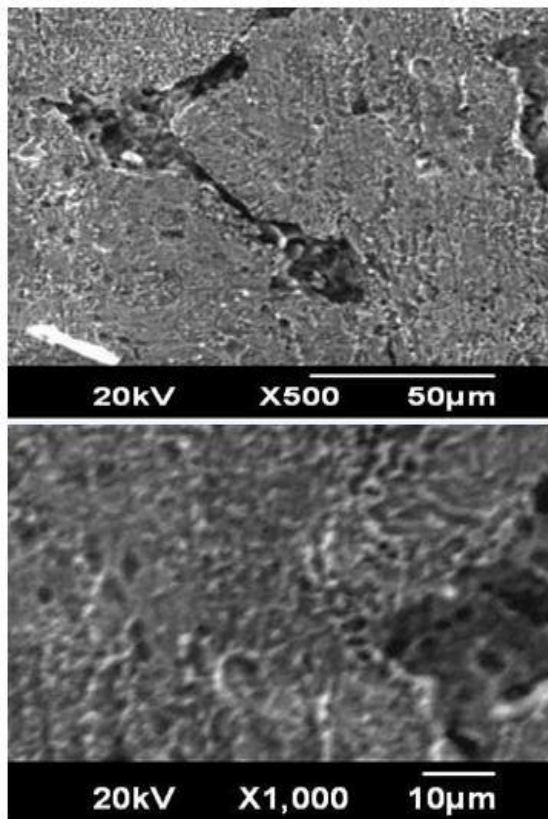


Fig.3(b) SEM of exposed sample in 1M HCl solution

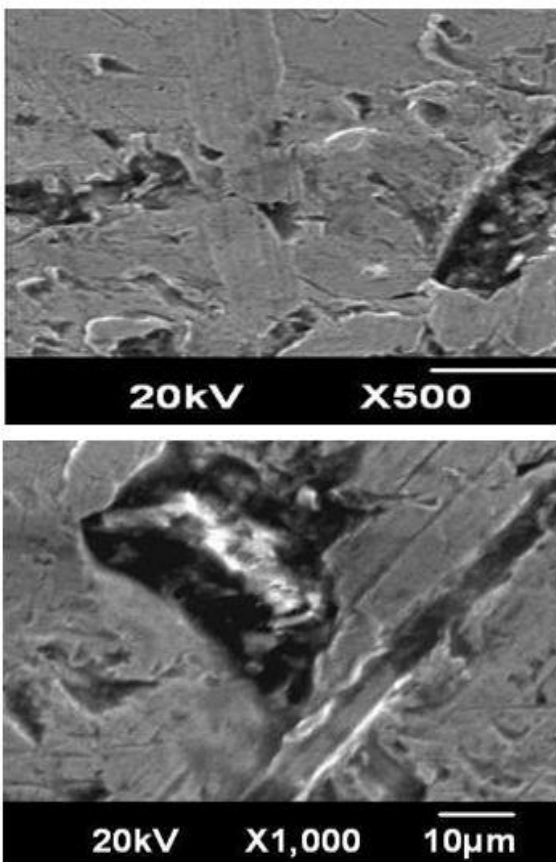


Fig. 3(c)SEM of exposed sample in 3.5% NaCl solution

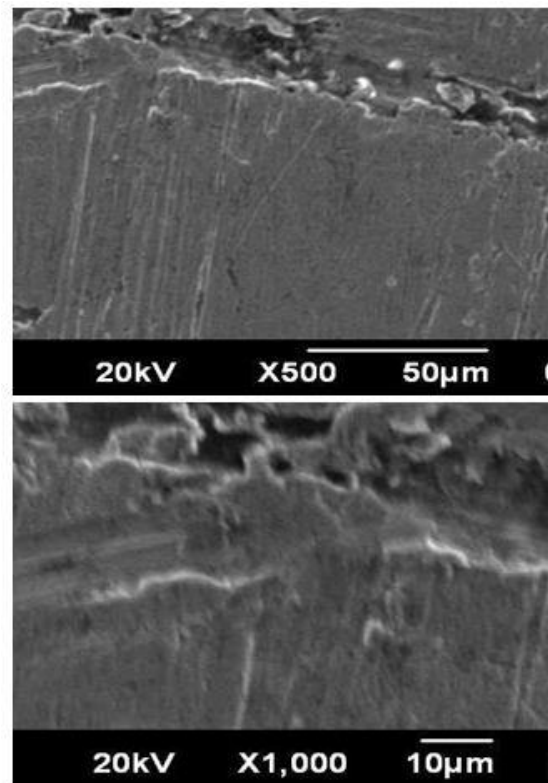


Fig. 3(d) SEM of exposed sample in 1M HNO₃ solution

III. CONCLUSIONS

An electrochemical study and weight loss tests carried out to assess the corrosion behaviour of 430 ferritic stainless steel in 1M H₂SO₄, 1M HNO₃, 1M HCl acid and 3.5 % NaCl were undertaken. The samples were analyzed after corrosion using the scanning electron microscopy. The study thoroughly considered the problems, hypothesis, and the aim and objectives. Based on the results obtained from the present study, the following conclusions could be drawn:

- The alloy shows different corrosion behaviour with considerable difference in their corrosion resistance in all the solutions. This was confirmed by the different patterns in cumulative weight loss of the alloy, as well as the polarization curves from the electrochemical techniques. The alloy shows different active to passive transition behavior in polarization.
- The passivity of alloy seems to remain unstable with passivity breakdown and pitting in concentrations of all the solutions.
- Alloy 430 has more corrosive resistant in 1M H₂SO₄ as compared to 3.5% NaCl in acidic chloride environments.
- In the polarization lead to the conclusion that the 430 SS corroded in the order of 1M HCl > 3.5 % NaCl > 1M HNO₃ > 1M H₂SO₄
- The corrosion rates calculated from weight loss tests did not really show good agreement with those calculated from electrochemical measurement results. There was a poor correlation in the

corrosion rates obtained from the two techniques for the alloys in all the solutions.

- Thus the aims of this investigation which were to study and compare the electrochemical behavior of 430 ferritic stainless steels in HCl, H₂SO₄, HNO₃ and 3.5% NaCl to investigate the types and stability of various passive films formed in different media were achieved. Likewise it can be concluded that the hypothesis of the investigation is true.

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