CORROSION BEHAVIOUR OF SS 316L IN DIFFERENT MEDIUM

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ABSTRACT

Corrosion resistance of SS 316L has been evaluated in presence of Sodium hydroxide, Hank's solution, Seawater and Ringer solution. Potentiodynamic polarization study has been used to investigate the corrosion behaviour of the SS 316L. The order of corrosion resistance of SS 316L in different medium was Ringer solution > seawater > Hank's solution > sodium hydroxide.

Keywords: SS 316L, Seawater, Sodium hydroxide, Hank's solution and Ringer solution.

INTRODUCTION

Corrosion is defined as the destruction of metals and alloys by chemical or electrochemical reaction with its environment. The corrosion occurs because of the normal trend of metals to come back to their thermodynamically stable native state. Corrosion cannot be avoided, but it can be controlled and prevented by using suitable methods like cathodic protection, anodic protection, metallic coating, alloying and using inhibitors, etc. Of these the application of inhibitors reduces the aggressiveness of the corrosive and unsafe aqueous surroundings and preventing the metal and alloy from corrosion by forming a protective layer over the metal surface. The corrosion behavior of stainless steel and other metals in sea water has been studied by many researchers. Austenitic stainless steels have been used successfully in many applications in marine environment. Austenitic AISI 316L is considered to be one of the most resistant of common stainless steels under marine environments, and it has good mechanical properties at elevated temperatures, and easy fabricability, and it is an important structural material for many industrial unit especially the desalination plants. The most common cause of failure of 316L stainless steel in marine environment is pitting and crevice corrosion, which are very dangerous. Types 304 and 316L are the most likely candidates for marine applications due to their excellent corrosion resistance especially for pitting and crevice. Therefore, they are found in excess in work boat propellers, pump components, valves, shaft components, hull fittings, fasteners, and oceanographic instruments.

The present work was undertaken to study the corrosion behaviour of SS 316L metal in different medium such as 5% Sodium hydroxide, Hank's solution, Seawater and Ringer solution by polarization study. Corrosion parameters such as corrosion potential, corrosion current and linear polarization resistance have been derived from these studies.

MATERIAL AND METHODS

Preparation of specimen: The composition of Stainless steel 316 specimen was (wt %): (13.308 Ni, 0.926 Si, 0.042 P, 1.837 Mn, 0.026 S, 17.030 Cr, 0.026 C, 2.260 Mo, 2.130 Ti and the rest Fe) of dimensions 1.0 cm x 4.0 cm x 0.2 cm were polished to a mirror finish and degreased with trichloroethylene.

Preparation of Electrolytes: The electrode was immersed in seawater, Hank´s solution, Ringer´s solution and 5% Sodium hydroxide solution. Seawater is collected from Mahaballipuram seashore, Tamilnadu. The Hank's solution and Ringer's solution that were prepared by mixing the analytical grade reagents and triple distilled water, with pH value of 7.4±0.2. The Hank´s solution has a chemical composition: NaCl - 8 g/l, $CaCl_2$ – 0.14 g/l , KCl – 0.4 g/l, $NaHCO_3$ – 0.35 g/l, Glucose - 1 g/l, NaH_2PO_4 – 0.1 g/l, $MgCl_2.6H_2O$ – 0.1 g/l, $Na_2HPO_4.2H_2O$ 0.06 g/l $MgSO_4.7H_2O$ - 0.06 g/l to distilled water. Ringer´s solution has a chemical composition: NaCl - 9 g/l, $CaCl_2$ – 0.24 g/l, KCl – 0.43 g/l and $NaHCO_3$ - 0.2 g/l.

Potentiodynamic Polarization Study: The polarization tests were carried out using a three-electrode cell assembly at 37 ºC steel specimen with 1 cm^2 surface area to study the corrosion behavior of 316L stainless steel in sea water, Hank's solution, Ringer solution and 5% sodium hydroxide solution. Polarization studies were carried out in a CHI Electrochemical workstation with impedance, Model 660A.

A three electrode cell assembly was used. The working electrode was one of the SS 316L. A saturated calomel electrode (SCE) was the reference electrode and platinum was the counter electrode.

The specimen was immersed into the solution for about 30 min to make its open circuit potential (E_{ocp}) become stabilized and then the potentiodynamic polarization was performed. From the polarization study, corrosion parameter such as corrosion potential (E_{corr}), Corrosion current (I_{corr}) and Tafel slopes (anodic = b_a and cathodic = b_c) were calculated. During the polarization study, the scan rate was 0.01 (V/s), hold time at Ef (s) was zero, and quiet time (s) was 2. All the measurements were repeated at least three times, and a new solution was used if a new polarization test was performed.

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RESULT AND DISCUSSION

Analysis of polarization curve: The potentiodynamic polarization curves of 316L stainless steel immersed in 5% sodium hydroxide solution, Hank's solution, sea water, Ringer solution and are shown in Fig: 1,2,3,4. The corrosion parameters namely corrosion potential (E_{corr}), Tafel slopes (b_c = cathodic b_a = anodic), linear polarization resistance (LPR) and corrosion current (I_{corr}) are given in Table 1. When corrosion resistance of a metal in a medium increases, *LPR* (Linear polar resistance) value increases and corrosion current decreases.

It is observed from the Table.1 SS 316L was immersed in 5% NaOH the corrosion current was 8.866×10^{-6} A cm^{-2} and the LPR value was 283 Ω cm^2. Then SS 316L was immersed in Hank's solution the corrosion current was decreased from 8.866 × 10-6 A cm^{-2} to 2.1536×10^{-7} A cm^{-2} and the LPR value was increased from 283 Ω cm^2 to 286384 Ω cm^2. When SS 316L was immersed in seawater the corrosion current was decreased from 2.1536×10^{-7} A cm^{-2} to 4.8102×10^{-8} and the LPR value was increased from 286384 Ω cm^2 to 754744 Ω cm^2. When SS 316L was immersed in Ringer solution the corrosion current was decreased from 4.8102×10^{-8} A cm^{-2} 2.4736×10^{-10} and the LPR value was increased from 754744 Ω cm^2 to 102430666 Ω cm^2. From these data concluded that SS 316L was more corrosion resistance in Ringer solution than that of seawater, Hank's solution and 5% NaOH. These observations suggest that the formation of protective film on the metal surface.

Table.1: Corrosion parameter of SS 316L immersed in different environment obtained by polarization study

System	E_{corr} mV vs SCE	b_a mV / decade	b_c mV /decade	LPR Ω cm^2	I_{corr} A cm^{-2}
NaOH	-347	.001	0.0058	283	8.8660×10^{-6}
Hank's Solution	-144	0.1774	0.7132	286384	2.1536×10^{-7}
Seawater	-430	0.1257	0.2506	754744	4.8102×10^{-8}
Ringer solution	-128	0.4430	0.0672	102430666	2.4736×10^{-10}

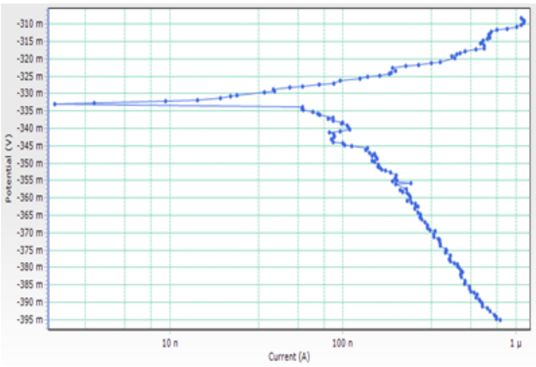

Figure.1 Polarization curve of SS 316L immersed in Sodium hydroxide

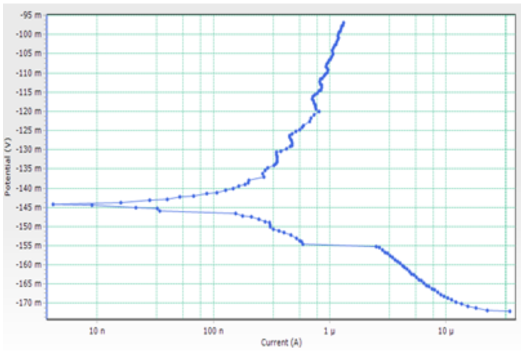

Figure.2 Polarization curve of SS 316L immersed in Hank's solution

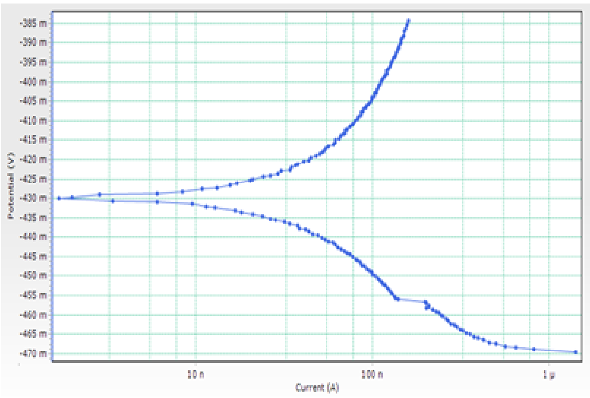

Figure.3 Polarization curve of SS 316L immersed in Seawater

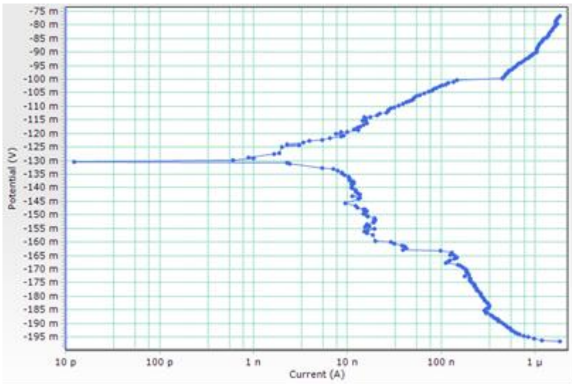

Figure.4 Polarization curve of SS 316L immersed in Ringer solution Conclusion

The corrosion behaviour of SS 316L has been studied in 5% sodium hydroxide solution, Hank's solution, sea water, Ringer solution. Polarization studies have led to the following conclusions. The LPR values are increasing and I_{corr} values are decreasing from 5% sodium hydroxide solution to Ringer solution. The order of corrosion resistance of SS 316L in different environment was:

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Ringer Solution > Seawater > Hank's Solution > Sodium hydroxide

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