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Potentio dynamic corrosion studies of dissimilar metals in sea water environments using Tafel's method

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Abstract

This experiment aims to determine the corrosion characteristics of Maraging steel 250 grade, AISI 4340 aeronautical steel and Inconel 625 which are used in aeronautical applications under normal and heat treated conditions. Potentio dynamic polarization studies in sea water environments of 3.5% NaCl and 5% Nacl are done in order to understand the corrosion behaviour and corrosion rates of each metal under different conditions.

Keywords: Maraging steel, AISI 4340, Inconel 625, Potentiodynamic Corrosion.

Introduction

Maraging steel 250 and AISI 4340 aeronautical steels are widely used in various aerospace applications such as aircraft landing gears, helicopter shaft drives and especially the combination of above are used in specific critical defense applications [1- 3].

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Maraging steel is a best alternative for aerospace application since this steel possesses ultra-high strength combined with good toughness. Readily weldability, high corrosion resistance, good formability, high strength to weight ratio and good dimensional stability are other attributes of this steel which makes it an eligible material for critical aerospace applications [4][5]. Being classified into M200, M250, M300 and M350 grades according to their 0.2% proof stress levels, the 250 grade which has better mechanical properties is used in this study [6]. Transformation from austenite to martensite followed by ageing, the two reactions gives this steel an exceptional strength [7] whereas high strength low alloy steels possess excellent ductility [8]. Even though low alloy steels are less corrosion resistant when matched with Maraging steels and super alloys, its tensile strength is relatively high and therefore finds its applications in many critical conditions.

In the space mission these materials are subjected to heat (in the order of 700° C). These materials tend to corrode faster because of the same especially when in contact with water and/or any other liquids. Moreover, post mission the rocket boosters are designed to fall in sea and is resurrected from it after several days, where it starts to corrode. Therefore, it is utmost important to understand the corrosion behaviour of these metals when they are subjected to such an environment. In this attempt, accelerated corrosion testing is done in order to evaluate the behaviour under two different sea water environments viz; (3.5 % Nacl and 5%Nacl)

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Experimental Procedure

The samples of Maraging steel(250 grade), AISI 4340 low alloy steel and Inconel 625 were cut to required dimensions of 1cm^2 each and were used for testing. Potentio dynamic corrosion analyser (make: CH instruments) was used for conducting the studies. Accuracy was maintained with respect to the area of the sample exposed in the bath confining to 1cm^2. The samples tested under heated condition were heated to a temperature of 800 $^\circ$C. Out of various factors present on determining the corrosion rate, the factor (mil/year) is taken as reference in this study for analysing the same.

Results and Discussions

The potentiodynamic polarization curves of maraging steel, AISI 4340 low alloy steel and Inconel 625 are depicted in Fig 1(a, b, c). Corrosion potential is a static indicator of electrochemical corrosion resistance, which reveals the susceptibility of materials to corrosion. As illustrated in Fig 1. The corrosion rates of the two materials are found to be 10.76 and 84.07 mil/year. It can be inferred that the low alloy steel is highly prone to corrosion than the maraging steel which is highly resistant. It is due to the fact that the low alloy steel, being a medium carbon steel has higher carbon content (0.38%by wt) that the other (0.10%).

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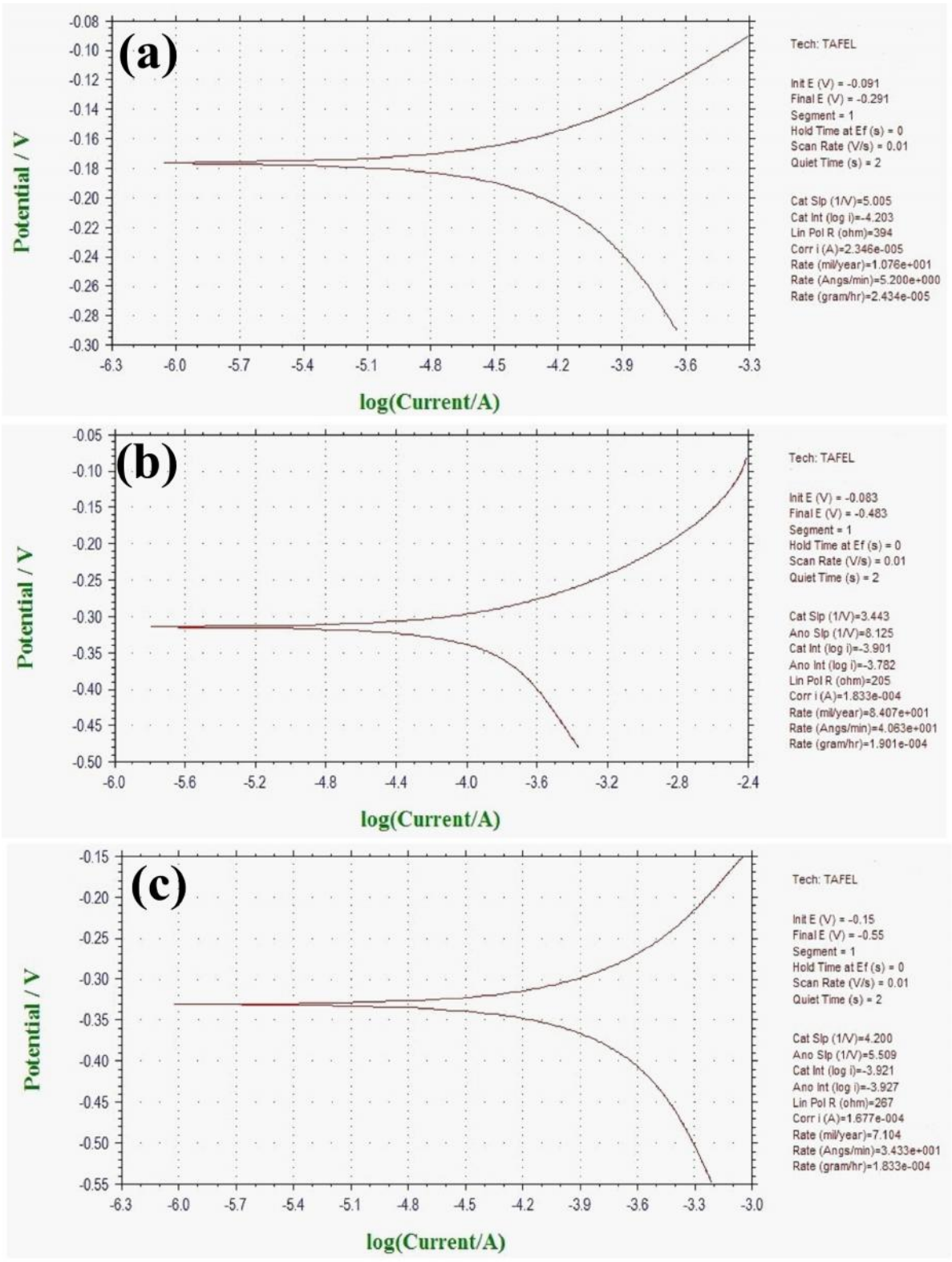

Fig 1 (a) Polarization curve of Maraging steel (250 grade) (b) AISI 4340 (c) Inconel 625

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The polarization curves of the three heat treated materials under (3.5% NaCl) sea water environments are given in the Fig 2. It is seen that corrosion rates of the heat treated materials are proportionately higher when compared to normally tested samples (without heat treatment). The corrosion rates of the heat treated maraging steel, low alloy steel and super alloy are 16.69, 115.1 and 20.52 mil/year respectively.

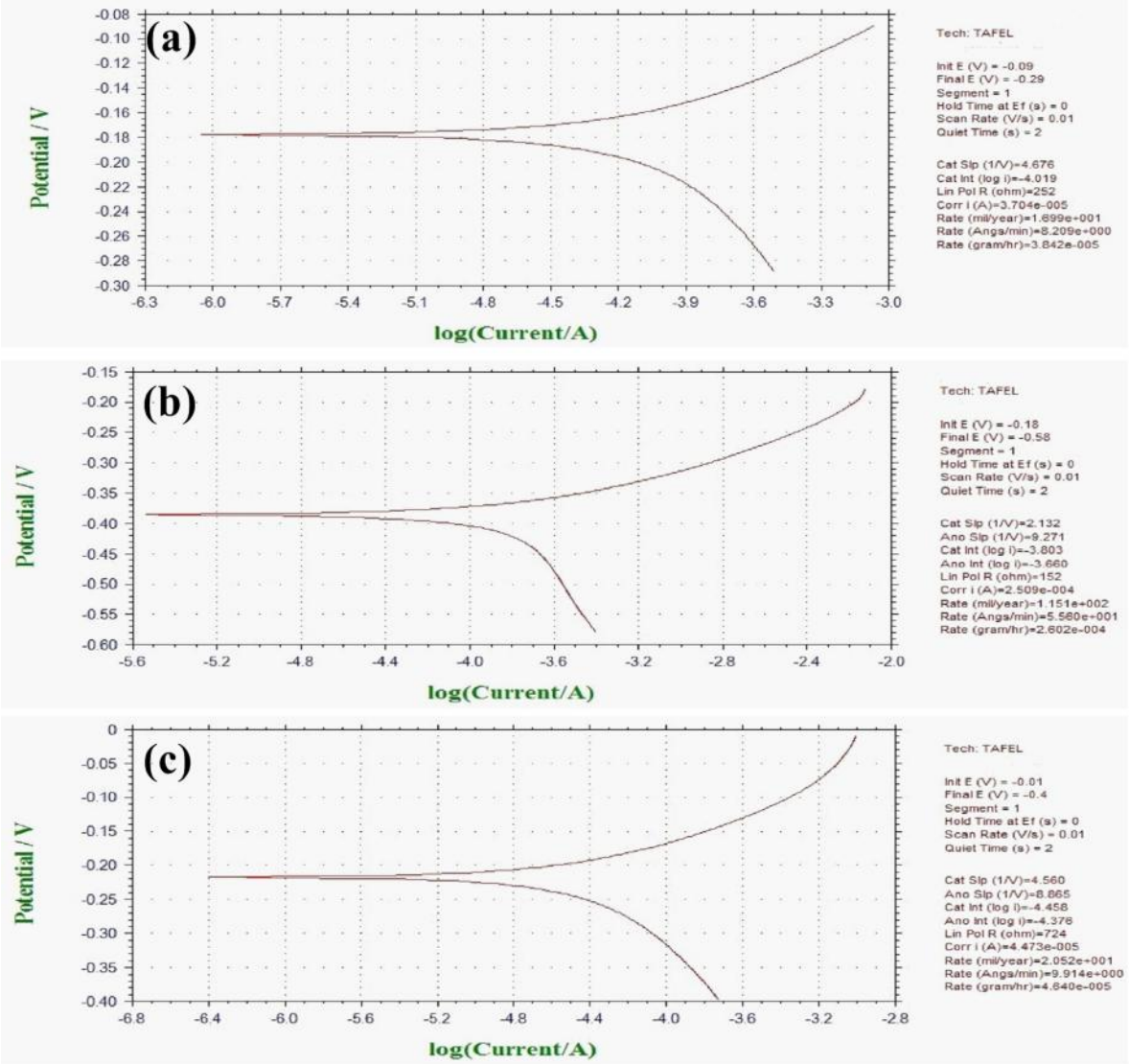

Fig 2 Polarization curves of the samples tested in 3.5% Nacl solution

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The polarization curves of the three heat treated materials under (3.5% NaCl) sea water environments are given in the Fig 3. The corrosion rates under 5% NaCl environment are 18.86, 135.4 and 26.47 mil/year respectively. These values show pronounced difference in corrosion rates as compared to the samples tested under 3.5% NaCl and normal conditions.

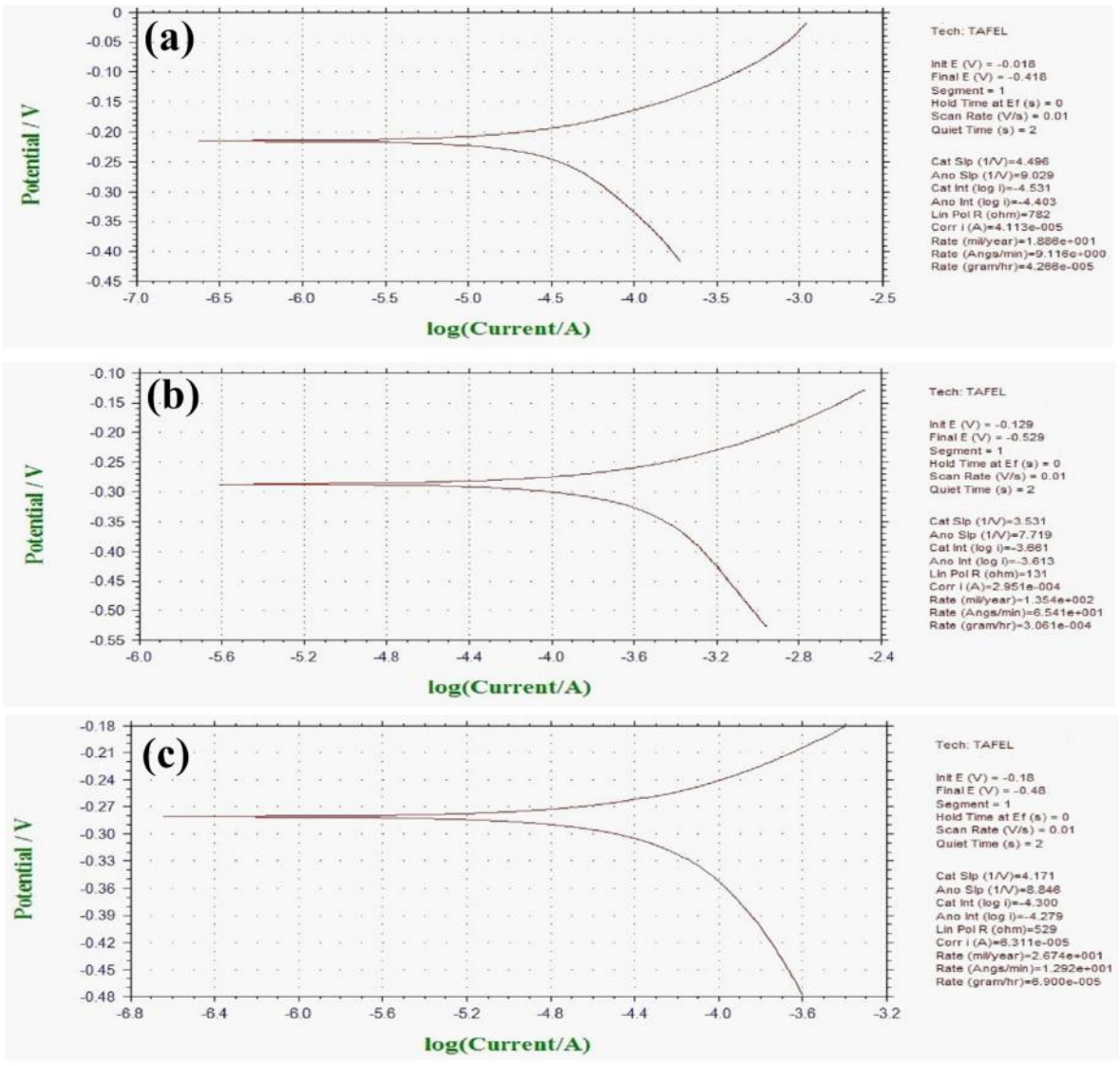

Fig 3 Polarization curves of the samples tested in 3.5% Nacl solution

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Conclusions

Experimental results infer that the Low alloy steel and Inconel 625 samples show pronounced corrosion effects under normal and heat treated conditions in both environments than compared to Maraging steel.

1. The corrosion rates of the metals tested under normal 3.5%naCl conditions can be arranged in the order Inconel 625 < Maraging steel < AISI 4340.
2. The corrosion rates of metals tested under heat treated conditions under 3.5% NaCl environments can be arranged in the order Maraging steel < Inconel 625 < AISI 4340.
3. The corrosion rates of metals tested under heat treated conditions under 5% NaCl environments can be arranged in the order Maraging steel < Inconel 625 < AISI 4340
4. The corrosion rates of the maraging steel can be arranged in the order Non heat treated < Heat treated + 3.5%Nacl < Heat treated + 5%Nacl.
5. The corrosion rates of the AISI 4340 steels can be arranged in the order Non heat treated < Heat treated + 3.5%Nacl < Heat treated + 5%Nacl.
6. The corrosion rates of the Inconel 625 metal can be arranged in the order Non heat treated < Heat treated + 3.5%Nacl < Heat treated + 5%Nacl.

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