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Assessment of Corrosion behaviour of Aerospace materials in Marine environments by Tafel's Potentiodynamic Polarization Studies

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Abstract: The aim of the experiment is to analyse and estimate the corrosion characteristics of Martensitic aged (Maraging 250), EN 24 an aeronautical (high strength low alloy) steel and Alloy 625 (nickel based super alloy) under 3.5% NaCl (normal sea water) and 5% NaCl (severe) marine environments and under heat treated conditions in 3.5% NaCl. Potentio dynamic polarization studies in above mediums are done to understand the corrosion rates of each metal under different conditions using Tafel's polarization. It is deduced that the corrosion rates of the metals tested under severe medium and heat treated conditions showed pronounced corrosion rates than the normal. The variations in corrosion rates are directly proportional to the increase in the alloying content of the materials and severity of testing environments.
Keywords: Martensitic steel; EN 24; Alloy 625; Tafel polarization.

1. Introduction

Maraging steel 250 and EN 24 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]. Maraging steel is a best alternative for aerospace application since this steel possesses ultra-high strength combined with good toughness. Ready 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 (300°-400°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 land in middle of sea which will be extracted from it after several days, where it starts to corrode. Therefore, it becomes essential to understand the corrosion behaviour of these metals when they are subjected to such environments. In this attempt, accelerated corrosion testing is done in order to evaluate the behaviour under two different sea water environments of 3.5 % NaCl and 5%NaCl. As these materials get heated (emanated from engines), testing is also done in heat treated condition at 400°C.

2. Experimental Procedure

The samples of Maraging steel(250 grade), EN 24 low alloy steel and Alloy 625 were cut to required dimensions of 1cm x 1cm 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 400 °C.

3. Results and Discussions

The potentiodynamic polarization curves of maraging steel, low alloy steel and Alloy 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%).

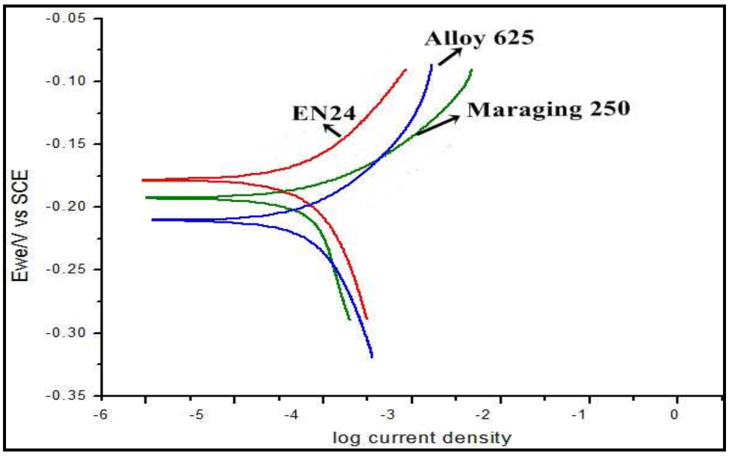

Fig 1 (a) Polarization curve of Maraging steel **(b)** EN 24 (c) Alloy 625 in 3.5% NaCl

The polarization curves of the three materials under (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.

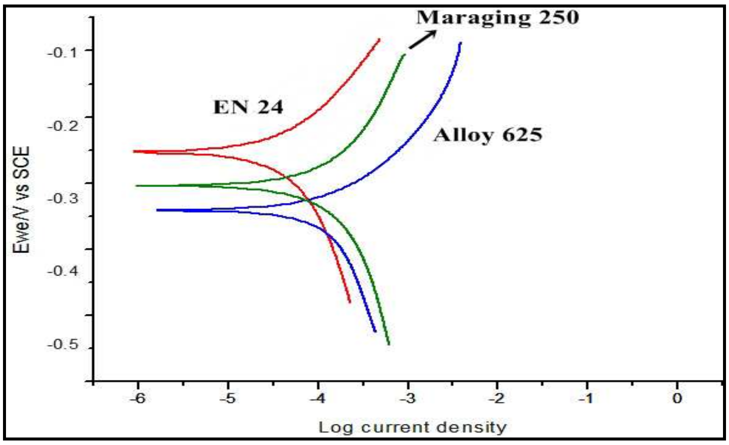

Fig 2 Polarization curves of the samples tested in severe 5% NaCl solution environment

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 3.5% 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 and 5% NaCl and normal conditions.

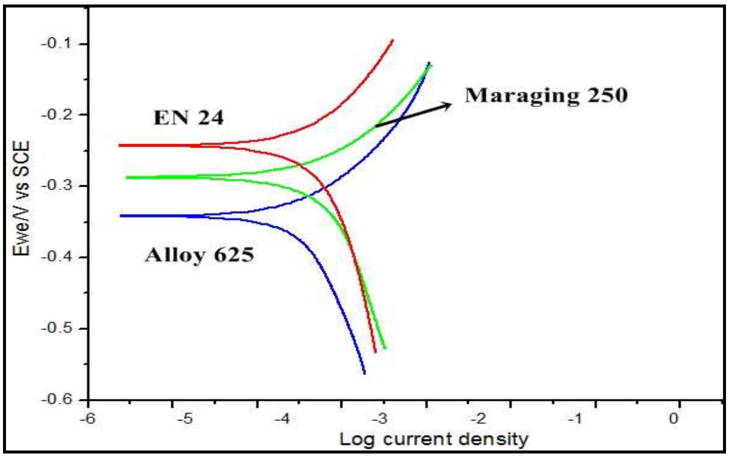

Fig 3 Polarization curves of the samples tested in 3.5% NaCl solution under heat treated state

4. Conclusions

Experimental results infer that the Low alloy steel and Alloy 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 Alloy 625 < Maraging steel < EN 24.
2. The corrosion rates of metals tested under heat treated conditions under 5% NaCl environments can be arranged in the order Alloy 625 < Maraging steel < EN 24.
3. The corrosion rates of metals tested under heat treated conditions under 5% NaCl environments can be arranged in the order Alloy 625 < Maraging steel < EN 24
4. The corrosion rates of the maraging steel can be arranged in the order Non heat treated in 3.5% < Non heat treated in 5%NaCl < Heat treated 3.5 %NaCl.
5. The corrosion rates of the EN 24 steels can be arranged in the order Non heat treated at 3.5% < Non heat treated in 5%NaCl < Heat treated 3.5 %NaCl.
6. The corrosion rates of the Alloy 625 metal can be arranged in the order Non heat treated at 3.5% < Non heat treated in 5%NaCl < Heat treated 3.5 %NaCl.

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