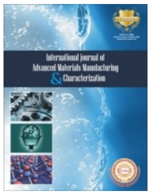

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Evaluation Of Corrosion, Hardness For Stainless Steel – 304 In Varied Corrosive Environments

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Abstract

Austenitic stainless steels are materials commonly used in off shore applications owing to their superior quality in terms of corrosion resistance. However it is also cited that there have been evidences in the past with respect to pitting and crevice corrosion under conditions that were not expected. The current work focusses on evaluation of immersion corrosion studies on stainless steels in varied corrosion environments like water, sea water and dilute hydrochloric acids. The immersion duration was for a period of 7 days for all the three diluents. Hardness studies have also been reported in the paper. The result shows that there is a decrease in the corrosion resistance of stainless steel samples with respect to acid corrosion as compared to fresh water and sea water corrosion tests. Hardness of the samples have also shown a reduction in the values for acid corrosion when compared to the counterparts.

KEY WORDS: Corrosion, Acid corrosion studies, SS304, hardness, immersion corrosion tests.

Introduction

The stainless steels possess an especially useful characteristic in resisting corrosion in that they perform best under those oxidizing conditions which are most harmful to ordinary steel and to many of the non-ferrous metals and alloys. It is also highly significant that the stainless steels demonstrate practically complete resistance to the corrosive effects of the most commonly encountered environment-the atmosphere. Not only do they resist structural damage in atmospheric exposure, but in addition, and in line with their descriptive name, they retain their original bright appearance for long periods. Cold forming operations and cold rolling generally do not decrease the corrosion resistance. The alloys are, of course, not impervious to corrosion in all environments. With respect to certain media, corrosion of different types may occur. The extent can often be minimized by proper composition selection and careful conditioning [1]. The behavior of stainless steels in natural seawater is of great interest since they are widely used in marine structures. Stainless steels such as 316L, 304..., present poor corrosion resistance in seawater. Their durability is altered by the corrosive nature of the marine environment. It is well-known that exposure of stainless steels, as well as any kind of material in natural seawater induces the development of a microbial film, the biofilm. Another theory that proves the sea water corrosion is by pitting corrosion failure [2]. Corrosion occurs in many forms in structures made of these steels during service in various media. Some of these forms are intergranular [3,4], pitting, sulfide stress cracking, chloride stress cracking [5-8] and stress corrosion cracking [9,10]. Weld decay is also common in sensitized stainless steel structures [11, 12]. The consequences of these forms of corrosion are obvious; varying from enormous material losses to unreliability of operating equipment which may lead to catastrophic consequences involving both men and money [13].

2.0 EXPERIMENTAL PROCEDURE

2.1 Hardness (Rockwell B Scale)

Stainless steel (SS304) pieces were ground on a belt and emery to obtain a flat surface. A load of 100 kg was applied. The load was applied for 15 seconds and then released. The readings obtained gives the hardness of the sample on the Rockwell 'B' scale.

2.2 Immersion Corrosion Test

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The corrosion behaviour of the cast samples were studied by static immersion corrosion test to measure the weight loss. Cylindrical specimens of the composites and the pure metal were weighed before and after immersion in 3.5% sodium chloride solution. The immersion corrosion test was conducted as per standards ASTM D-6943-10 on the samples and weight loss for thirty five days were estimated. After the time duration of thirty five days the samples were cleaned with distilled water, rinsed with acetone, dried and weighed. Stainless steel samples were also immersed in dilute hydrochloric acid, sea water and checked for corrosion resistance.

Corrosion rates were computed using the equation

Corrosion rate = 534W/DAT mills per year.

Where W is the weight loss in mg, D is the density of the specimen in gm/cm3, A is the area of the specimen in sq-inch and T is the exposure time in hours. [14].

3.0 RESULTS AND DISCUSSIONS

Sl. No.	Sample Designation	Corrosion Medium	Hardness before corrosion	Hardnessafter corrosion	Corrosion rate (Mills/year)
1	SS-304 - A	3.5% NaCl	98.3	98.2	5.2x10-3
2.	SS-304 – B	Sea Water	98.3	98.2	4.9x10-3
3.	SS 304 - C	Dilute HCl	98.3	98.1	3.1 x10-3

Table 1: Hardness and corrosion readings for SS-304

3.1 Hardness

SS-304 samples were subjected to hardness measurements before immersion corrosion. It is observed that there is no change in the hardness values of the specimen when subjected to change in the environment conditions (sea water, acid corrosion). This clearly showsthat corrosion has no profound effect on hardness. This also indicates that the passive film formed during corrosion has practically no effect on the hardness.

3.2 Corrosion Kinetics

Stainless steel samples were immersed in sea water for a period of thirty five days. The table shows three samples of SS-304 and the corrosion life in mills per year. It is observed that the corrosion resistance of stainless steels is reduced owing to sea water corrosion. The reason for the corrosion is attributed as follows. Since stainless steel contains at least 10.5% chromium, the oxidation of the iron is changed to produce a complex oxide that resists further oxidation and forms a passive layer on the surface. This is a very thin layer (microns in thickness) but very tenacious and will reform if it is removed by scratching or machining. This is in accordance with other researchers [2]. However, a close observation of the table also shows that the corrosion resistance with acid environment is significantly reduced when compared to medium like sea water and 3.5% NaCl. It could be observed that the stainless steel specimen failed in the test media and with greater intensity in the acid chloride. The combined chloride and sulphate ions would undoubtedly cause more deleterious corrosion reactions. Their ability to penetrate the stainless steel formed film on the surface of the metal to initiate, perpetrate and sustain corrosion reactions would be more drastic. The consequence of this was that of severe active corrosion reactions of anodic dissolution of this tested alloy. In the presence of these reacting species, Cl at high concentrations, the ability of the stainless steel to repair its film was drastically reduced and the protection was hence lost [15].

4.0 CONCLUSIONS

- Decrease in weight was observed when subjected to immersion corrosion tests in sea water.

- Significant decrease in corrosion resistance was observed when samples were exposed to acid environment.
- Viability of this material in high acid environments is restricted.
- No appreciable change in hardness was observed after subjecting the samples to corrosion.

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