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Studies On Salt Fog Corrosion Behaviour of Ferrous and Non-Ferrous Alloys

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ABSTRACT
The salt spray (or salt fog) test is a standardized and popular test technique for measuring how effectively materials and surface coatings resist corrosion. Coated samples are tested with salt spray, which speeds up corrosion, to see if they are appropriate for use as a protective finish. The presence of rust (iron or even other oxides) is evaluated after a set period of time. The length of the test depends on how well the coating resists corrosion. In the current study, an effort has been made to look at how different ferrous and non-ferrous alloys react to salt fog corrosion over the course of varied exposure intervals. Borated stainless steel, mild steel, aluminum, and aluminum composite material were the materials chosen for this investigation (Made by powder metallurgy), Microstructures were photographed using an optical microscope both before and after the test. Additionally, compared and analyzed are the microstructures of specimens tested with salt-fog spraying during intervals of 5 hours, 10 hours, and 24 hours. Also, the specimens' weight in miles per year is computed, and the rates of corrosion of ferrous and non-ferrous materials are contrasted for various exposure durations.

Keywords: Salt fog; SS304B4; AA6061; Mild steel

1. INTRODUCTION

Borated austenitic stainless steels (BASS), which include boron, have been widely used in the nuclear industry as reactor control materials in the nuclear reactor due to their ability to absorb thermal neutrons [1]. In order to control the nuclear reactor's chain reaction, shielding is largely employed to reduce neutron irradiation [2]. Building fuel storage racks and barrels for the storage of wasted and dense fuel are other uses for this steel [3, 4]. the broad application of boron-containing materials. Boron is either alloyed into these steels or is dispersed throughout the stainless steel matrix. Because to the austenite matrix's limited ability to disperse boron, they produce intermetallic compounds that are abundant in Iron, Chromium, and Nickel (solubility limit is about 100 ppm).

The chemical structure and mechanical characteristics requirements of borated steels are covered by ASTM standard A887, which contains eight boron levels (types) with two classes for each type. For each of the eight kinds, standard A887 establishes two categories, A and B, based on the requirements for mechanical qualities. Borated stainless steel is divided into 304B1 through 304B7 categories. In terms of weight, the typical range of boron content is 0.2 to 2.25%. Material 304B is often used in the construction of radiation shielding for Intermediate Heat Transfer (IHX) purposes in Prototype Fast Breeder Reactor construction.

Due to the formation of intermetallic compounds, borated austenitic stainless steels will have less ductility than type 304 austenitic stainless steel. Since only a small amount of structural support is required, this alloy is generally used as simple strap-on neutron shielding materials. These alloys were frequently bolted or riveted to a structural part in the past to satisfy the demands of the reactor control need. As riveting is a time-consuming, manual process, welding is utilized in the final stages of production [6]. Moreover, a lot of the conceptual designs that are already in use need welded fabrication, and the ASME boilers and pressures vessel code just adopted BASS. The formation of the steel eutectic phase in austenitic stainless steel is caused by the addition of boron content. In the heat-affected zone, the lower boiling austenite phase that forms as a result of welding heat can lead to liquid fracture (HAZ).

Early on, Borated SS buildings were constructed using a riveting technique, but this labor-intensive method could not be mechanized, which increased the cost of construction [7]. There have been several attempts to combine borated stainless steels using an automated technique. According to Robino et al. [8], binary irregular eutectic alloys like Fe-C and Al-Si react similarly to the borated stainless steels. The same author [9] also investigated the weld quality of reposts stainless steels of the functions and resources type and came to the conclusion that it did not differ noticeably from that of normal austenitic stainless steels. Hot cracking is unlikely to occur if boron addition of >06% are made to Iso 304 stainless steel, according to studies by Shinoda et al. [10]. The entire absence of liquid cracks in weldments, as per Arivazhagan et al. [11], was caused by the concentration of the eutectic ferrite phase rising with the heat input. Despite the fact that the eutectoid matrix in borated SS is ductile, the mechanical properties, such as elasticity and impact toughness, were negatively impacted by the dispersed secondary phase's brittleness at both low and high temperatures [12]. The availability of (Cr, Fe)2 B and -Fe's low melting point eutectic liquid, which aids in the healing of fractures, is what causes the higher boron steel's lower susceptibility to solidification cracking, claim Matsumoto et al. [13]. Sadly, there aren't many data on the microstructural and mechanical properties of borated stainless steel that has been filled during welding. The general and localised electrochemical properties of this material has also been studied by several researchers [14, 15]. Some researchers have presented their investigations into the weldability of 304B stainless steel in the literature study, but there haven't been any particular studies on whether we can use an austenitic filler to make multipack welds. The purpose of the current work has been to investigate FSW in order to understand weldability, micro and macroscopic structural changes, and to evaluate the mechanical properties of the welded joints.

Derived corrosion of stainless steels that are austenitic was studied by Apblett et al. [17][19-21], who also made connections between carbide shape and corrosion susceptibility as well as inter granular corrosion theories. Although rust in the Strauss solution progresses through transpassivity, the formation of a biochemical layer that results in intergranular corrosion seems to have no bearing on corrosion sensitivity. All intergranular corrosion theories are supported by the revelation that the Mending effect is connected to the emergence of discontinuous carbides. Nevertheless, a study will be conducted to look more closely at the connection between the shape of the carbide and intergranular corrosion resistance. In this study, the behaviour of salt fog corrosion on ferrous and non-ferrous metals under various exposure conditions is compared**.**

2. EXPERIMENTAL PROCEDURE

2.1 SALT FOG TEST

It consists of a glass chamber with dimensions 2.4×1.65×2.8 m^3. Internally it consists of two inlet valves which is provide on one side of glass chamber. The air from air compressor enters from one valve and the salt water from the other valve. The two valves are perpendicular to each other. The air enters from the vertical valve, whereas the salt water from the horizontal. The 80 kg/cm air pressure enters the chamber from vertical valve and the continuous droplet of salt water enters from horizontal valve. When both the salt water and air pressure are coincided such that the high air pressure makes salt water as a fog throughout the salt chamber, the salt fog spreads entire the chamber. After sometime the fog in chamber is displaced as water. The water is collected at the bottom of chamber and flows through outlet provided at bottom of chamber. There are two rigid supports on both the sides of chamber. A plastic circular rod can easily placed on these supports. The metals borated stainless steel, aluminium mild steel, powdered metallurgy are hanged in the chamber to determine the corrosion rate. The small holes of 2 mm diameter are made with drilling machine on these metals. A silicon wire is tied separately to all the metals and these metals are tied to the plastic rod which is placed on the supports, such that the metals are hanging in the salt chamber as shown in Fig.1. This test is done about 5hrs, 10hrs, and 24hrs. One mild steel specimen is tested about 5hrs, second mild steel specimen is tested about 10 hrs and finally third mild steel specimen, aluminium, borated stainless steel and powdered metallurgy are tested about 24hrs.

Fig.1 Prepared specimens hanged in the chamber before and after fog

The chemical composition of borated stainless steel, AA6061 and mild steel were given in Table 1. The corrosion rate is determined by observing the microstructure and noting down the weights before and after exposure to salt chamber and Microstructure investigations: Microstructures of the specimens are captured by using optical microscopy at various magnifications like 20x, 100x, 200x, 500x. A chemical etching procedure is used to make the specimen more visible during the microstructures test. The solution used comprises 5g cupric salt, 100ml hydrochloric acid, and 100ml ethanol.

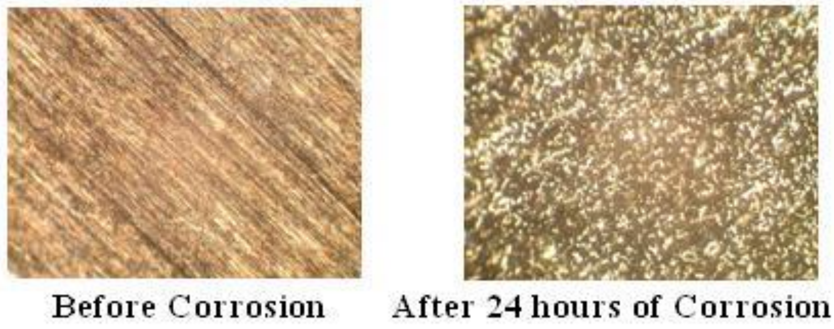
Table 1. Chemical composition of Borated Stainless Steel, AA6061 and Mild steel

304B4	**% Composition**	**AA6061**	**% Composition**	**Mild steel**	**% Composition**
Cr	18.1	Al	Balance	C	0.25-0.290
Ni	12.5	Mg	0.8-1.2	Cu	0.2
Mn	1.3	Si	0.4-0.8	Fe	98
B	1.15	Fe	0.7	Mn	1.03
Si	0.57	Cu	0.15-0.40	P	0.04
P	0.02	Zn	0.25	Si	0.28
C	0.02	Ti	0.15	S	0.05
		Mn	0.15		
		Cr	0.04-0.35		

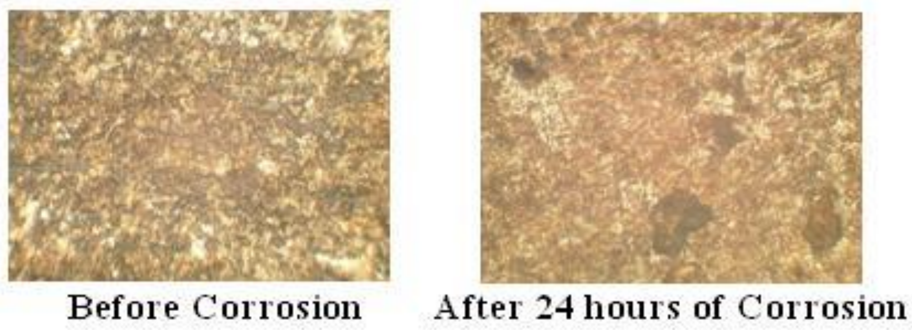
3. RESULTS & DISCUSSION

Table 2 lists the corrosion rates of the various materials, and Figure 2 displays the matching microstructures. It demonstrates that the borated stainless steels have very excellent corrosion resistance and very little weight loss. The powered metallurgy material was discovered to follow the same pattern. The maximum rate of mild steel corrosion was discovered after 24 hours, and it was discovered that the rate rises as the length of time grows. Also, it has been shown that aluminum has a far higher 24-hour corrosion resistance rating than mild steels.

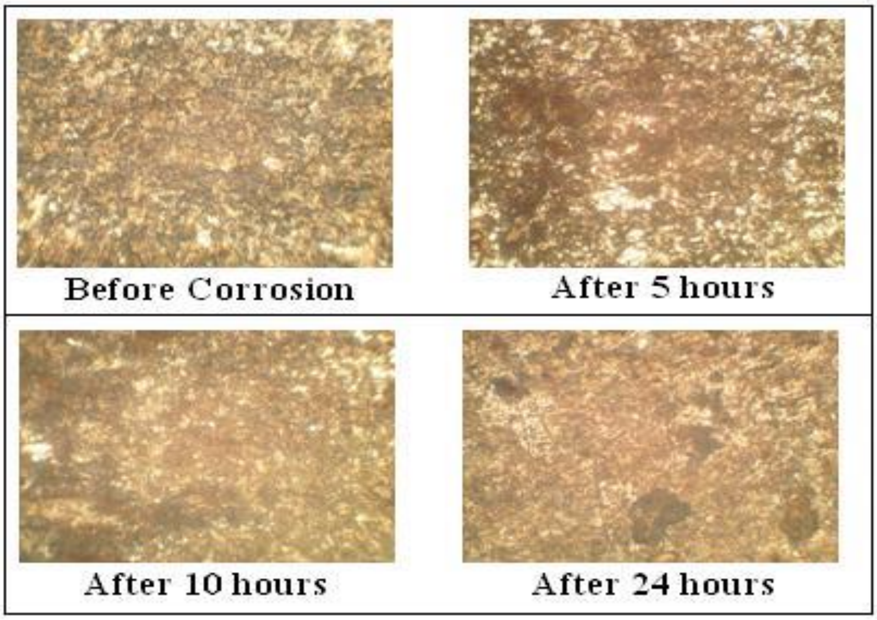
(a) Borated Stainless Steel



(b) AA6061



(c) Mild Steel Specimen -1



(d) Mild Steel

Fig.2 Microstructures of various specimens before and after corrosion taken at 100x magnifications

Table 2. Weight loss of various specimens before and after corrosion

S.No.	Specimen name	Weight of specimen in grams before corrosion	Time period in Hours	Weight of specimen in grams after corrosion	Weight loss	Miles per year
1	Borated stainless steel	24.631	24	24.631	No change	-----
2	Aluminium	20.386	24	20.378	0.008	3.534
3	Mild Steel	92.226	5	91.960	0.266	41.351
4	Mild Steel	88.984	10	88.693	0.291	22.61
5	Mild Steel	92.393	24	91.740	0.653	21.148
6	Powdered Metallurgy	28.626	24	26.621	0.005	0.429

4. CONCLUSIONS

The salt fog corrosion behaviours of various materials have been investigated successfully at different spraying times. It has observed that, borated stainless steels and powder metallurgy material exhibited excellent corrosion resistance for all the different time period. As a result, no variation in microstructures and weight loss was noticed. The microstructure of AA6061 after 24 hours of salt fog corrosion test reveals that the more continuous ditches which appear in boundaries. Mild steel specimen for 24 hours' time period of exposure suffered serious attack and subsequently significant weight loss is noticed.

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