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AN OXIDATION BEHAVIOUR OF DISSIMILAR WELDMENTS IN THE PRESENCE OF MOLTEN SALTS AT 1123K

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ABSTRACT

In order to investigate the effect of Inconel 718 and ASS 316 dissimilar (thickness of 3mm) weldments made by Gas Tungsten Arc welding in the presence of molten salts at 1123K in the air. To assess the performance of the weldments in the real time environment, at various zones of the welded coupons was subjected to hot corrosion studies. The coupons used for corrosion studies was mirror polished down to 1 m before the corrosion run. Cyclic hot corrosion studies were performed on different zones of the weldments by exposing in the molten salt environment of Na_2SO_4- 48% Nacl mixture at 1123K. Hot corrosion studies were performed on different zones of dissimilar weldments of INCONEL 718 and ASS 316. to estimate the corrosion behavior for 50 cycles (each cycle consists of 1 h heating followed by 20 min of cooling to room temperature) at 1123K. A coating of uniform thickness with 3–5 mg/cm^2 of Na_2SO_4- 48% Nacl was applied using a fine camel hair-brush on the samples. The salt coated samples were first heated and dried at 200°C in the oven. Each cycle consists of 1 hour heating followed by 20 min of cooling in the room temperature. The weight changes are measured for all the regions for each cycle using electronic weighing balance with a sensitivity of 1 mg. The weight gain or loss of the spalled scale was also included at the time of measurement to determine the rate of corrosion. The corroded samples of various regions were characterized for XRD and SEM analysis.

KEYWORDS: Oxidation, Hot Corrosion, Inconel 718, Austenitic Stainless Steel (ASS) 316, Na_2So_4 & Nacl Cyclic Hot Corrosion

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Original Article

1. INTRODUCTION

Inconel 718 and austenitic stainless steel type ASS316 is extensive and widely used in petrochemical, thermal power plants, boiler part pressure vessel etc. because of their improved corrosion resistance at the ordinary temperature conditions. Corrosion is the deterioration of a material by its reaction with the surroundings. It adversely affects those properties that are to be preserved. At higher temperature, this mode of degradation is known as oxidation or dry corrosion. Metals and alloys sometimes experience accelerated Oxidation when their surfaces are covered with a thin film of fused salt in an oxidizing atmosphere at the elevated temperatures. This mode of attack is called 'hot corrosion'. Hot corrosion has been observed in the boilers, internal combustion engines, gas turbines, fluidized bed combustion and industrial waste incinerators since 1940s. However, it became a topic of importance and popular interest in the late 1960s, when the gas turbine engines of military air craft suffered severe corrosion attacks during the Vietnam conflict, while operating over and near sea water.

During operation, blades and vanes of gas turbines are subjected to high thermal stresses and mechanical loads. In addition, they are also attacked chemically by oxidation and/or high-temperature corrosion. In our previous studies, this alloy material is good in microstructure stability to at least 750^0C and exhibited a stress rupture strength of no less than 100mpa at 750^0C [1], in this study high temperature oxidation behaviour of this alloy with and without temperature ranges between 800^0C and 1000^0C was studies to understand the corrosion performance the analysis of temperature of major elements occurring during oxidation in the alloy is presented to determine, their resistance to high temperature oxidation in critical application and to elucidate the corrosion mechanism.

Metal depending on their chemical nature and that of the environment, exhibit different corrosion resistance. Stainless steel is a family of iron based alloy containing at least 15% Cr and other elements such as Ni, C, Si, Mn, P, S and Fe. The high degree of chromium activity is actually the principal basis for utilizing it as an alloying element in the corrosion resisting alloys. There are many types of stainless steels in the literature and these are often the basis of their matrices as ferrites, martnesitic and austenitic stainless steels, not all the stainless steel are equally resistant in most of the environment, but some have been developed through alloy additions to resist the aggression from anions in certain environments among these are the ASS316 austenitic grade with an average of 17.5% Cr and 53. Ni, [2]. Materials degradation as a result of corrosion reaction is an important issue in the energy production and energy assumption devices, especially current collections and metallic components of fuel cells [3]. The corrosion behaviour of stainless steel in the molten alkali corroborate at the elevated temperature was the subject of many investigations. The resulting oxides scales in the weldments have been characterized systematically using surface analysis techniques. Scale thickness on low alloy steel sides was found to be more and was prone to sapling. Weld region has been found to be more proved to degradation than base metal due to inter diffusion of elements across the interface and the formation of inter metallic compound [4]. Advances in gas turbine technologies for power generation and for aero engine applications have led to an increasing demand of welding of dissimilar metals. Fossil-fuel boilers and fired power generating equipment, experience hot corrosion problems in components of steam generation, water walls surrounding the furnace, economizer assemblies and, in the front and rear portions of super heater and re-heater [5]. This alloy exhibits the stress rupture strength no less than 100mpa at 750^0C [6] and a good oxidation and hot corrosion resistance at high temperature. This investigation studies the microstructure evolution during a long term aging at the elevated temperature and to study the corrosion resistance of the super alloy under laboratory simulated pulverize coal fired boiler environment.

2. EXPERIMENTAL PROCEDURE

2.1 Specimen Preparation

The material was available in the form of sheet from which rectangular specimen with the dimensions of 60mmX4mmX2.5mm were cut having the chemical composition (wt%) C-0.03, S-0.02, Si-0.10, Al-051, Ti-0.097, Mo-0.97, Cr 17.5, Ni-53.0, Fe-remaining for INCONEL-718. The material was available in the form of sheet from which rectangular specimens with dimensions 60mmX4mmX3mm were cut having the chemical composition (wt%) C-0.08, S-0.03, P-0.04, Si-1.0, Mn-2.0, Cr-18, Ni-10.0, Fe-remaining for ASS-316.

2.2 Welding Parameters for GTAW Weldments

Welding parameter is the peak current (I_p)-75A, Background current (I_b)-37A, speed -149mm/min, voltage-12V, flow rate 40lit/min, polarity DCEN, pulse frequency 6Hz, heat input 271j/min. Welding cut pieces were the solution treated in a silicon furnace, digitech India made at a temperature of 1123K $\pm$ 10K for 1 hour these specimens were then water quenched and sensitized by reheating at 723Kfor 20min, all heat treatments were carried out in the air. The samples are cut in the weld zone (WZ) and base metals (BM). The samples were polished with 220 grit silicon carbide paper followed by 1/0, 2/0, 3/0 and 4/0 grade emery papers and finally wheel were polished.

2.3 Experimental Details

The composite weldments, different regions of weldment and unwelded samples were uniformly coated with a thin film of sodium-containing salts, e. g. Na_2SO_4 and Nacl, oxidized at 1123K for 48 hours duration. The temperature of the reaction chamber was controlled within $\pm 5^0$C. The mass gains of the specimens were then monitored continuously recorded for 40 cycles. Each cycle consisting of 1 hour heating at 1123K followed by 25mins cooling. At the end of the each cycle the samples are critically examined and the change in the weight is recorded and the sections of the oxidized specimen were examined using a scanning electron microscope with as x- ray diffraction analysis.

3. RESULTS AND DISCUSSIONS

The mechanical properties like porosity, micro hardness of weldment have been reported and discussed with respect to the existing literature. Different Regions of Inconel718, ASS316, GTAW weldment exposed to the Molten Salt at 1123K Macro morphology of the oxide scale for different regions of GTAW dissimilar weldment after hot corrosion in Na_2SO_4-48%NaCl at 1123K for 50 cycles is shown in the fig 1. The colour of substrate steels turned into a dull gray from dark brown during the first cycle. Whereas in case of weld metal an elephant, black colour scale appeared on the whole surface from 1st cycle itself and spelling of oxide scale in the weldment has appeared around 50th cycle. At 1123K, the coated alloy showed initial increase, followed by a decrease in the mass loss up to 48h. Then further increase in the time, resulting an increased in the mass.

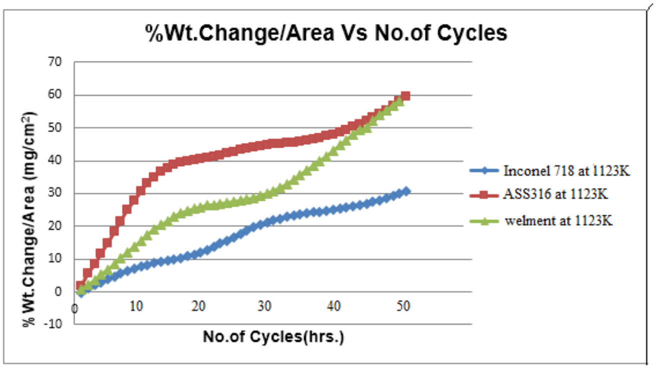

Figure 1: The Change in the Mass Time (Oxidation Kinetic) Curves of Stainless Steel ASS316 and Inconel 718, and Weldment Coated with Na_2SO_4-48%NaCl at 1123K for 50 Cycles

3.1 SEM Analysis

Figures 2 (a), (b) and (c) shows the SEM of Na_2SO_4-48%NaCl coated alloy. The layer of scales is thick. Compact and adhered at 1123K, the spotted area indicated pitting corrosion and at 1123K, stress cracking corrosion and badly deterioration were observed.

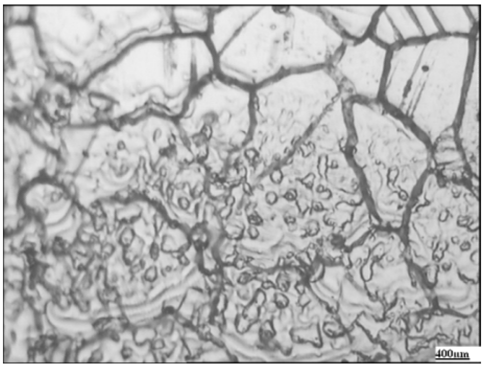

Figure 2(a): Inconel 718

Figure 2(b): ASS316

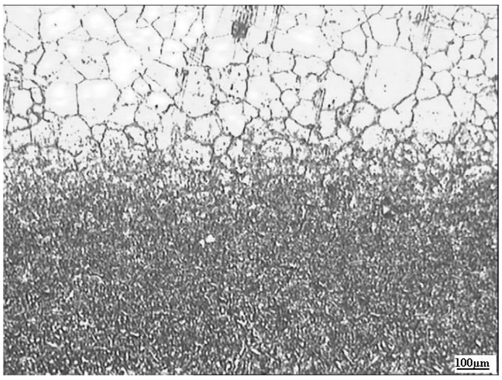

Figure 2(c): Weldment

4. CONCLUSIONS

From the results and observations of this study it can be concluded that

- Weldment should be the lowest weight gain as compared to unwelded base material in the case of molten (Na_2SO_4-48%NaCl) environment study.
- The corrosion rate is more in the welded samples. This may be due to more oxidation of cr from the box the metal compared to weld metal because of the weldment contains less quantity of cr.
- The high temperature oxidation resistance is not only related to the nature of the passive film, but is also strongly dependent on the salt environment and the structure of the alloy.

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