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Oxidization and Hot Corrosion behavior of Inconel718 and Ass 316 Dissimilar Joints in GTAW Process

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Abstract—*In the present investigation oxidation and hot corrosion studies were made on Inconel 718 Vs Austenitic Stainless Steel (ASS) 316dissimilar sheet metal (thickness of 3mm) weldments made by GTAW process. Theweldments and parent material have been studied in the presence air and molten salt environment (52%Na_2SO_4-48%Nacl)Air and molten salt studies were performed in the laboratory furnace for 20 cycles , each cycle consisting of 1 hour heating at 650^0c followed by 25 minutes cooling . At the end of each cycle the samples are critically examined and the change in weight is recorded. In the case of studies under the molten salt, a uniform layer (3-5mg/cm^2) of the mixture of 52%Na_2SO_4- 48%Naclis coated on the samples with the help of camel hair brush by preheating the sample at 200^0c Chemicalcomposition of oxide scales and scales morphologies were determined by means of X-ray diffraction analysis and SEManalysis. The oxide scales ofNa_2SO_4- Naclcoated weldments and parent material showed complex microstructures and compositions. The high temperature oxidation resistance is not only related to the nature of the passive film but is also strong dependent on the salt environments and the structure of alloy.*

Keywords*: -Oxidation, Hot corrosion, Inconel 718, Austenitic Stainless Steel (ASS) 316, Na_2So_4,Nacl.*

1. INTRODUCTION

Dissimilar metal joints are widely employed in the energy demanding sectorsincluding marine, oil and petroleum, thermal, geothermal and nuclear power plants, where they are prone tohigh temperature corrosion or hot corrosion and high temperature wear.The dissimilar combinations of Inconel 718 and ASS316 can be used in moderately high temperatureand corrosive environments as in the case of oil gasification plants, chemical processing equipment's etc. Inaddition, a combination of moderate oxidation resistance and creep strength extends their application to steamgenerator tubing and other components operating at temperatures up to 650° C in conventional fossil-fuel powerplants [1, 2].

Pulse current gas tungsten arc welding (PCGTAW) is one of the widely used welding techniques,which has been reported to have numerous advantages over the conventional Gas Tungsten Arc welding(GTAW) or Continuous Current GTA welding process. The beneficial effects most often reported in theliterature include claims that the total heat input to the weld is reduced, which results in the reduction of weldbead size, residual stresses by the reduction of heat input, thermal distortion, porosity and micro segregation[3,4].Current pulsing has been used in the past for obtaining grain refinement in weld fusion zone.Significant refinement of the solidification structure and a transition from columnar to equiaxed growth werereported [5, 6]. These researchers reported about current pulsing to obtain grain refinement in weld fusion zonesand improvement in weld mechanical properties.Hot corrosion can be defined as deposit modified, gas induced degradation of materials at hightemperatures. Some of the well-known materials employed in high temperature applications include Ni basedsuperalloys, stainless steel and low alloy steels. The operating environments of these dissimilar metal jointsinvolve high temperatures and the presence of various elements which inherently combine to form the moltensalts such as Na_2SO_4, K_2SO_4, NaCl, KCl, V_2O_5 and thus form the eutectic mixtures during cyclic operations.The combinations of these types of molten salt deposits at high temperatures are vulnerable and will fuse on tothe dissimilar metal system and thereby accelerating the corrosion attack. Hence characterization of theweldments is must both in the ambient as well as in the high temperature conditions, before putting them in use.Devendranath et al. [7] investigated the performance of bimetallic combinations of Inconel 718and ASS 316 inthe aggressive hot corrosion environments.This paper investigates the characterization of these dissimilar weldments exposed in the molten saltenvironment containing K_2SO_4+NaCl. And Pulsed current GTAW uses less welding input energy than continuous current process while obtaining better weld quality and less distortion, residual stress and damages to the HAZ microstructure. The pulsed current GTAW has advantage of reduced heat input, HAZ size, residual stress, distortion, and porosity. Compared to continuous current welding, Metallurgical and mechanical characterization was also investigated inthe study using the Chemical composition of oxide scales and scales morphologies were determined by means of X-ray diffraction analysis and SEManalysis to evaluate the structure – property relationships of the weldments.

2. EXPERIMENTAL PROCEDURE:

In this chapter experimental procedure used for the study has been summarized. It includes the procedure to obtain the weldments, their characterization, the hot corrosion studies and the analysis of final corrosion products.

2.1 Nominal chemical composition in %wt for Inconel 718

Inconel 718 cold rolled sheets (2.5mm thick) in 980^0c solution treated condition.

Element	Ni	Cr	Fe	Mo	Ti	Al	C	Si	S
Wt.%	53.0	17.5	Bal	3.13	0.97	0.51	0.03	0.10	.002

Nominal chemical composition in %wt for ASS 316commercialsheet of 3mm thickness

Element	Ni	C	Si	Mn	P	S	Cr	Fe
Wt.%	10	0.08	1.0	2.0	0.04	0.03	18	Bal

Welding parameters for GTAW weldments

Welding parameters	Peak current((Ip)	Back ground current(Ib)	Speed	Voltage	Flow rate	Polarity	Pulse frequency	Heat input
Selection	75 A	37 A	149 mm/min	12 V	40 lit/min	DC EN	6 Hz	271 J/min

2.2 Preparation of Sample Materials:

The samples are cut in the Weld Zone (WZ), and Base Metals (BM). The samples were polished with 220 grit silicon carbide papers followed by 1/0, 2/0, 3/0, and 4/0 grade emery papers and finally wheel polished.

3. HOT CORROSION AND OXIDATION STUDIES:

Experimental Setup

Hot corrosion and oxidation studies were conducted at 650^0C for both similar and dissimilar weldments in the laboratory silicon furnace, Digitech, India make. The furnace was calibrated with the variation of $\pm 5^0$C using Platinum-Rhodium thermocouple and temperature indicator of Elecromek (Model-1551 P), India. Al2O3 boat was preheated up to 200^0C for hours with the assumption that its weight would remain constant during the cycle of study. The composite weldment, different regions of weldment and unwelded samples were subjected to mirror polishing following to wheel cloth polishing for 5 minutes before study. After polishing the samples were washed properly and dried in the hot air to remove the moisture. For every experiment the sample was kept in the boat, weight of boat and sample was measured before inserting in to the hot zone of the furnaces at 650^0C. The holding time in the furnace was one hour and after that the boat with sample was taken out and cooled at the ambient temperature for 25 minutes. Weight of the boat along with sample was measured and this constitutes one cycle. All hot corrosion and oxidation carried out for such 25 cycles. The weight change measurements were taken at the end of each cycle using an electronic weighing balance machine (Name of customer: MAARS DIGITECH SCALS) with a sensitivity of 0.1mg.

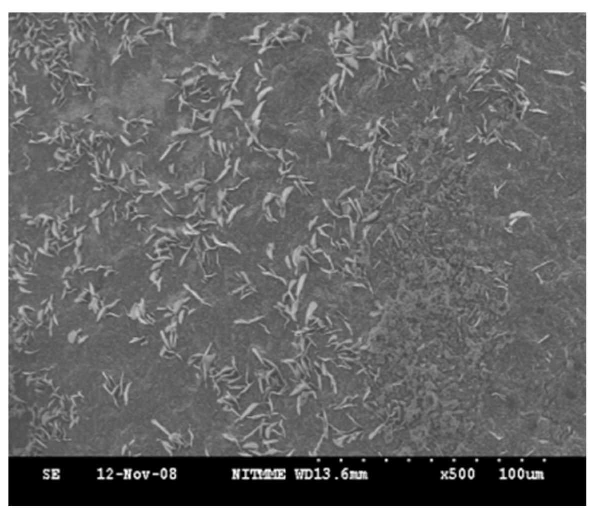
4. RESULTS AND DISCUSSION

The metallographic examinations of base steel as well the weldment have been discussed. The mechanical properties like porosity, micro hardness of weldment have been reported and discussed with respect to the existing literature

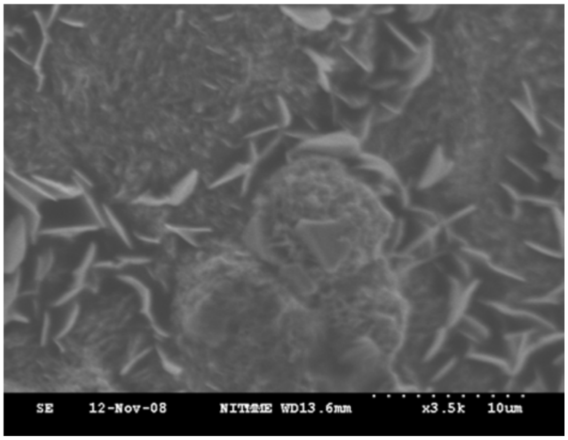
Different Regions of Inconel718, ASS316, GTAWweldment exposed to Molten Salt at 650^0C

Macro morphology of the oxide scale for different regions of GTAW dissimilar weldment after hot corrosion in Na_2SO_4-48%NaCl at 650^0C for 25 cycles is shown in fig. The color of substrate steels turned dull grey from dark brown during first cycle. Whereas in case of weld metal an elephant black color scale appeared on the whole surface from 1^{st} cycle itself and spalling of oxide scale inweldment has appeared around 25^{th} cycle.

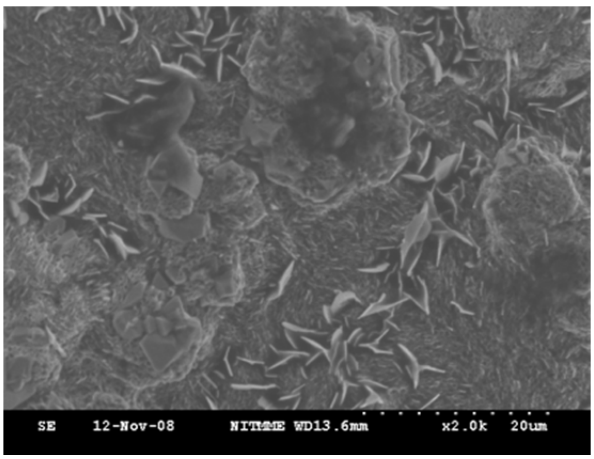
SEM Analysis:



Inconel718



ASS 316



Weldment

Fig. Mass Change plot for different regions of Inconel 718,ASS 316,and GTAW weldment, exposed to Na_2SO_4-48%NaCl at 650^0C for 25 cycles.

5. CONCLUSIONS

GTA weldments were successfully made in the boiler tube steels with minimum carbide formation. Micro hardness measurement across the cross-section of weldments for GTA welded sample showed that the weld region and HAZ have higher hardness as compared to the base metal. This difference in hardness has been attributed to the formation of carbides during weld thermal cycle.TIG weldment showed the lowest weight gain as compared to unwelded base metal in case of molten salt (Na_2SO_4-48%Nacl) environment studies.XRD analysis has indicated the presence of Fe_2O_3 as a predominant phase in the hot corrosion environment. The cracks were observed nearly on the welded steel specimen subjected to cyclic hot corrosion in molten salt environment.The find weight gain in welded sample is 1.747 grams, where as the weight gain in Base metal is 1.980 grams, Hence Corrosion rate is more in the unwelded sample .This may be due to more oxidation of Cr from the base the metal compared to weld metal, because of the weldment contains less quantity of Cr.

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