The oxidation behaviour of welded 2.25cr-1mo (t22) boiler tube steels under cycli...

Psychology, Behaviorism

Abstract: This research examines the oxidation behaviour of SMAW and TIG weldment in 2. 25 Cr-1Mo (T22) boiler tube steels after exposure to air at 900°C under cyclic conditions. Weight gain/area has been plotted against number of cycles to identify the kinetics of oxidation. Scanning electron microscopy/energy dispersive X-ray spectroscopy (SEM/EDX) and X-ray diffraction (XRD) techniques were used to analyze the oxidation products.

The results reveals that the SMAW welded steel showed more weight gain than that of TIG welded because of the formation of higher extents of cracks and a thicker oxide scale on HAZ and weld region.

Introduction

At moderately high temperature Cr-Mo steels are a broadly used group of engineering materials for applications, for example, steam generation/handling, petroleum processing/refining, thermal reforming/polarization/cracking [1]. The improvement in strength at elevated temperature is preferable to avoiding the increasing of wall thickness when using traditionally Cr-Mo steel for reheater or superheater tubes.

The reheater and superheater tubes may fail well inside their intended design life by a combination of fireside corrosion and creep [2]. In any case, in steam generator systems, a large number of welds were found in tubes to tubes or tubes to sheets forms. Welding subjects the base metal to intense thermal cycling resulting in a significantly altered, inhomogeneous microstructure adjacent to the weld deposit.

This region is known as the heat- affected zone (HAZ) [3]. The heat-affected zone (HAZ) of 2. 25 Cr-1 Mo steel and the weld crown region of 9 Cr-1 Mo steel were found to oxidize at higher rates when exposed to high temperatures, and grow significantly thicker scale than other regions in the weldments of the respective steels. This was considered while using scale thickness measurement as a tool for life assessment of high temperature welded parts.

The difference in the oxidation behavior of the different regions was found to emerge from the difference in the Cr content of the inner layer of the protective oxide [4, 5, 6]. The faster propagation of cracks along the grain boundary of HAZ than that of other regions of the 2. 25Cr-1Mo steel weldments was seen because of the formation of Cr-rich secondary phases and corresponding depletion of free Cr along the grain boundaries, which might be the result in an increase in oxidation [7].

The oxidation behaviour of complex alloys has not been studied widely and isn't surely knew, particularly of welded components moreover. Along these lines, additionally examines are required on oxidation behavior of complex alloys, especially those utilized for high temperature applications [8]. The cyclic conditions have been chosen for testing as these conditions constitute more practical approach towards taking care of the issue of metal corrosion in real industrialenvironment[9, 10].

This paper describes an experimental work carried out at 900°C to assess the oxidation behaviour of welded 2. 25Cr-1Mo (T22) boiler tube steels under cyclic conditions. The oxidation product analyzed by XRD, SEM/EDX and cross-sectional BSEI.

Experimental Procedure

Preparation of weldments and specimen

ASTM SA213 2. 25 Cr-1Mo (T22) steel was acquired from the thermal power plant Bhatinda, Punjab, India in the tube form. Gr. T22 boiler tube steel (10 mm thickness x 26 mm diameter) was cut into approximate length of 150 mm each. Each tube was machined to obtain a single conventional V-groove, with 30° bevel angle, constant root gap and root face of 1 mm.

Preceding welding the tube was altogether cleaned with brush and CH3)2CO in order to expel any oxide layer and soil or oil holding fast to the tube. Tubes were welded together by shielded metal arc welding using basic coated electrode AWS A5. 5 E9018-B3 and tungsten inert gas welding techniques using 99% pure argon gas with filler wire AWS A5. 28 E90S-B3 with constant arc current 95A.

The specimens each measuring approximately 20×15×5 mm3 were cut from the circular weldments. The specimens were polished with (220 grade) silicon carbide paper and emery paper and after that wheel polished before being to oxidize. The chemical compositions of T22 boiler tube steel and electrode/filler wire used in present study are shown in Table 1 [11].

Cyclic oxidation test

Cyclic oxidation studies were conducted in air at 900°C temperature in the a laboratory silicon carbide tube furnace for 50 cycles. Each cycle comprised of

1 hour heating at 900°C took after by 20 min cooling at room temperature. During experimentation, the prepared specimen was kept in an Al2O3boat and the weight of the boat and specimens was measured. Al2O¬3 boats used for the investigations were preheated at a steady temperature of 1200 °C for 6-8 hours, and it was accepted that their weight would stay consistent throughout high temperature cyclic oxidation study.

Then the alumina boat containing the specimen was embedded into the hot zone of the furnace set at a temperature of 900 °C. Weight-change measurements were taken at the end of each cycle using an electronic balance model 06120 (Contech, Mumbai, India) with a sensitivity of 10-3 g. After that the oxide scale was characterized by X-ray diffraction (XRD) and scanning electron microscopy/Energy dispersive X- ray spectroscopy (SEM/EDX). The oxidized specimens were then cut over the cross-section and mounted for the cross-sectional oxide scale thickness measurement.

Results and Discussion

Visual examination and weight gain measurement analysis in air

The macrographs after cyclic oxidation for 50 cycles at 900 °C for welded 2. 25Cr-1Mo (T22) steels are as shown in Fig. 1. The colour of oxide scale for all welded steels after few cycles turned blackish gray. For SMAW welded steel the spalling started to appear just after 4th cycle. The new oxide scale seems to have grown in this void and which led to cracks and spalling of the top scale.

Whereas occurrence of large number of cracks have been observed in the oxidized samples. The weld region appeared black colour during 6th cycle of TIG welded steel. Cracks were observed in the oxide scale. The amount of the spalled scale has also been incorporated in weight gain measurements. The width of cracks was comparatively more in case of SMAW welded steel than TIG welded. The weight gain plots of welded steels in air at 900 °C is shown in Fig. 2 and it can be seen in the plots the weight gain for both weldments was almost same in the initial number of cycles upto 5th cycles then after gradually increased.

It can be inferred from the plot that SMAW welded steel showed the maximum weight gain as compared to TIG welded steel. The behaviour for SMAW welded steel was almost parabolic with parabolic rate constants, Kp(10-8 g2 cm-4 s-1) is 36. 447 and the behaviour of TIG welded T22 steel has followed the parabolic law from 12thcycles due to minor spallation. Its parabolic rate constant (Kp) is 20. 371 x 10-8 g2 cm-4 s-1 as shown in Fig.

Oxide scale thicknesses measurements

The thicknesses of the oxide scale on the weldment (i. e. on weld metal and HAZ) were measured from the BSEI along the cross-section of the mounted samples and the images are shown in Fig 4. The normal scale thickness values measured for weld area of SMAW and TIG weldment in steels are 1. 333 mm and 1. 095 mm individually. Though normal scale thickness measured for HAZ region of SMAW and TIG weldment are 1. 386 mm and 0. 940 mm individually. Least scale thickness was shown by TIG weldment. The oxide scale debonding at metal/scale interface is apparent from Fig. 4 (c); (d) for TIG welded steels respectively.

X-ray diffraction analysis (XRD)

The XRD patterns of the oxide specimens after 50 cycles are shown in Fig. 5. These diffractograms has relatively comparable phases of iron oxide (Fe2O3) with Cr2O3 for both the welded steels. The weak peaks of Fe3O4, Cr2O3 along with main oxide Fe2O3 were indicated in the oxide scale of TIG welded steel.

SEM/EDX analysis

The surface SEM/EDX morphology of welded 2. 25Cr-1Mo (T22) boiler steel is shown in Fig. 6. The SEM micrograph for weld region of SMAW welded steel Fig. 6 (a) reveals that the scale has developed cracks, and through these the iron oxide spalled out. The main upper oxide scale is rich in iron 97. 96% with MnO (1. 95%) point 2. The inner oxide scale having Fe2O3 (95. 41%) and MnO (3. 40%) point 1. The oxide scale of HAZ region of this weldment comprises of Mn with main oxide of Fe (96. 78%) at point 2, however at point 1 it was only 95. 57%Fe with manganese and chromium Fig. 6 (b).

The oxide scale of weld region for the TIG welded steel shown in Fig. 6 (c) indicates massive scale having cracks. The inward scale consists of predominately iron oxides with little amount of MnO (1. 20%) and Cr2O3 (2. 60%) point 1. Whereas the upper scale containing MnO (1. 22%) and Cr2O3 (1. 28%) with iron oxide point 2. The EDX analysis of HAZ region of this welded steel shows the oxide of iron (97. 55%) with little amount of Cr2O3 (1. 58%) at point 1 (black portion), while the white portion consists of

Cr_2O_3(2. 47%) with main phase of iron oxide (96. 75%) at point 2 in Fig. 6 (d).

Fig. 2 demonstrates that both the weldments indicated same weight gain during first few number of cycles, however then after progressively expanded and nearly follows the parabolic oxidation rate law. The kinetics of oxidation, according is concerned in weldments. The resistance to oxidation of SMAW welded steel was less when contrasted with TIG welded and this might be because of the development of higher extents of creaks in oxide scale on weldment (i. e. weld metal and heat-affected zone (HAZ) (Fig. 1).

Less oxidation rate (in terms of weight gain) of TIG weldment was because of the formation of lower extents of cracks in the oxide scale. Some spalling of the oxide scale of welded steels as saw during cooling times of the thermal cycles was because of different values of thermal expansion coefficients of the metal and oxides [12, 13].

As far as scale thickness valuations, the weld region of SMAW welded specimen indicates more oxidation than that of TIG welded, and was expected to the non-availability of Cr in oxide scale as affirmed by EDX Fig. 6 (a) and furthermore as discussed about by Raman [6]. The little amount of chromium with main Fe_2O_3 in the oxide scale of TIG weldment (weld and HAZ regions) has contributed for the better oxidation resistance as can be seen in XRD and further confirmed by SEM/EDX analysis as indicated in Fig. 6(c) and (d).

Conclusions

SMAW welded steel showed the more weight gain than that of TIG welded and it was because of the development of higher extent of cracks and a thicker oxide scale on HAZ and weld region.

The weight gain of the T22 welded steels follows the parabolic rate law in air at 900 °C. The susceptibility to oxidation of welded 2. 25Cr-1Mo (T22) steel specimens has been found to be as in the following order TIG; SMAW.

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