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BEHAVIOUR OF BOILER STEEL SA-192 IN OXIDATION AND HOT CORROSION AT DIFFERENT TEMPERATURES

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ABSTARCT:
The major degradation mechanism occur due to oxidation and hot corrosion which is responsible for failure of boiler and gas turbine components. These failures occur because of the usage of wide range of fuels such as coal, oil at increased temperatures. In current investigation oxidation and hot corrosion performances of bare Boiler Steel SA-192 has been evaluated in air and with aggressive environment. For aggressive environment composition of sodium sulphate and vanadium pentaoxide have been mixed in proper ratio (Na_2SO_4+60%V_2O_5) to provide an experimental condition under cyclic conditions at an elevated temperatures of 850^{0}C & 950^{0}C. The kinetics of the corrosion is approximated by weight change measurements made after each cycle for total duration of 50 cycles. Each cycle consists of keeping the samples for 1 hour duration in Kanthol wire tube furnace at 850^{0}C and 950^{0}C followed by 20 minute cooling in ambient air. Weight change data has been taken after each cycle by digital electronic balance machine with an accuracy of 1 milligram. Graphs have been plotted between weight gains per surface area to number of cycles. Boiler Steel SA-192 has shown poor performance in oxidising and in hot corrosion environment as the temperature increased. It suffered from intensive spallation in the form of removal of scales.
Keywords: *Oxidation ,Hot Corrosion, Spallation*

1. INTRODUCTION

Gas turbine, Boiler components and blades and other important engineering systems operating at high temperature. Due to this high temperature they may be fail and it concluded that high-temperature oxidation and hot corrosion are the main failure modes of components in the hot sections of gas turbines, boilers etc [1]. Corrosion is deterioration of material means unwanted wear or scale formation on surface of material. Oxidation is the high-temperature corrosion reaction, which occurs when metals or alloys are heated in oxidizing environments such as with access of air and oxygen. Metals and alloys sometimes experience accelerated oxidation when their surfaces are covered with a thin film of fused salt in an oxidizing gas atmosphere at elevated temperatures. This is known as hot corrosion where a porous no protective oxide scale is formed at the surfaces. [2],[3]. Hot corrosion is basically the result of attack by fuel and/or ash compounds of Na, V, S, and Cl that are present in the coal or in fuel oil used for combustion in the mentioned applications. Residual fuel oil contains sodium, vanadium and sulphur as impurities, which form compounds such as Na_2SO_4 (melting point 884^{0}C), V_2O_5 (melting point 670^{0}C), and complex vanadates by reactions in the combustion systems [1]-[3]. These compounds, known as ash, deposit on the surface of materials and induce accelerated oxidation (hot corrosion) [4]-[6].

2. EXPERIMENTAL

2.1 *Substrate Material :*

The Boiler Steel SA-192 has been selected for study the nominal chemical composition of substrate material is reported in table 2.1.

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Table 2.1 Nominal Composition of Boiler Steel SA-192

Material	P	Mn	C	Si	Fe
Boiler Steel SA-192	0.35	0.5	0.18	0.45	Bal

2.2 ***Substrate preparation and Coating formulation***

The specimens, with dimensions of 20 × 15 × 5 mm^3, were cut from the alloy sheet of Boiler Steel SA-192. The specimens were polished using emery papers of 180, 220, 400, 600 grit sizes. Subsequently the specimens were washed properly, cleaned with acetone and dried in hot air to remove any moisture.

2.3 ***Air and molten salt corrosion test***

Cyclic studies were performed for the steel substrates in molten salt environments (Na_2SO_4–60% V_2O_5) and in air for 50 cycles. . A Salt deposition of uniform thickness with 3–5 mg/cm^2 of (Na_2SO_4–60% V_2O_5) were applied with a camel hair brush on the preheated sample (250°C) after that heat them up to 3-4 hrs for proper adhesion of salt. Each cycle consisted of 1 h of heating at 850°C & 950^0C in a Kanthol wire tube furnace followed by 20 min of cooling at room temperature. The purpose of imposing cyclic conditions was to create an accelerated environment as observed in real cases for hot corrosion testing. The weight change measurements were taken at the end of each cycle using an electronic balance machine with a sensitivity of 1 mg. [7, 8]

2.4 ***Experimental condition:*** Condition which we have taken.

Table 2.2 Experimental conditions

Material	Temperature	Environment	Time
Boiler Steel SA-192	850^0C,950^0C	Air	50 cycle of 1 hrs heating followed by 20 min cooling in ambient air
Boiler Steel SA-192	850^0C,950^0C	Na_2SO_4+60% V_2O_5	

3. RESULTS AND DISCUSSION

Oxidation and Hot Corrosion testing has been done and for each cycle weight change has been measured. This weight change is in milligram and for result we divide it by surface area of used boiler steel for testing. After this plot a graph between Number of cycle and Weight change (mg/cm^2). Following graph has been plotted after complete 50 cycles for each condition.

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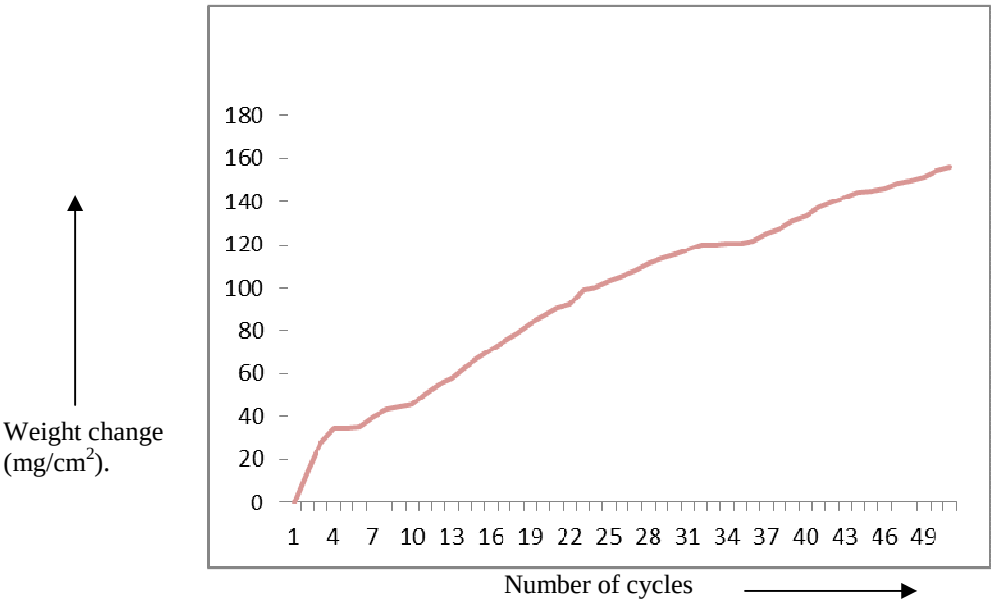

Fig: 3.1 Oxidation performance of Boiler Steel SA-192 at 850^0C.

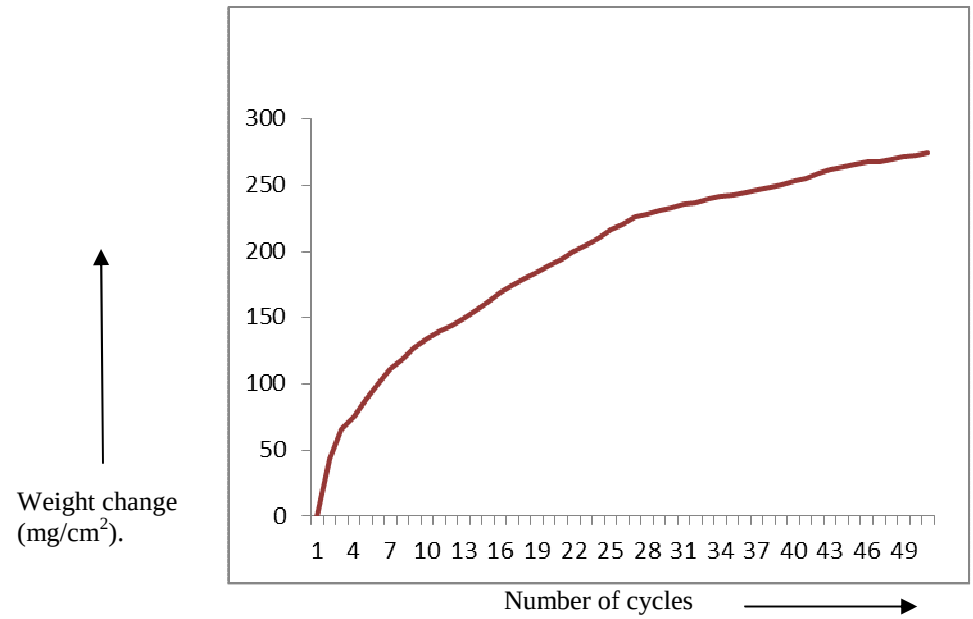

Fig: 3.2 Oxidation performance of Boiler Steel SA-192 at 950^0C.

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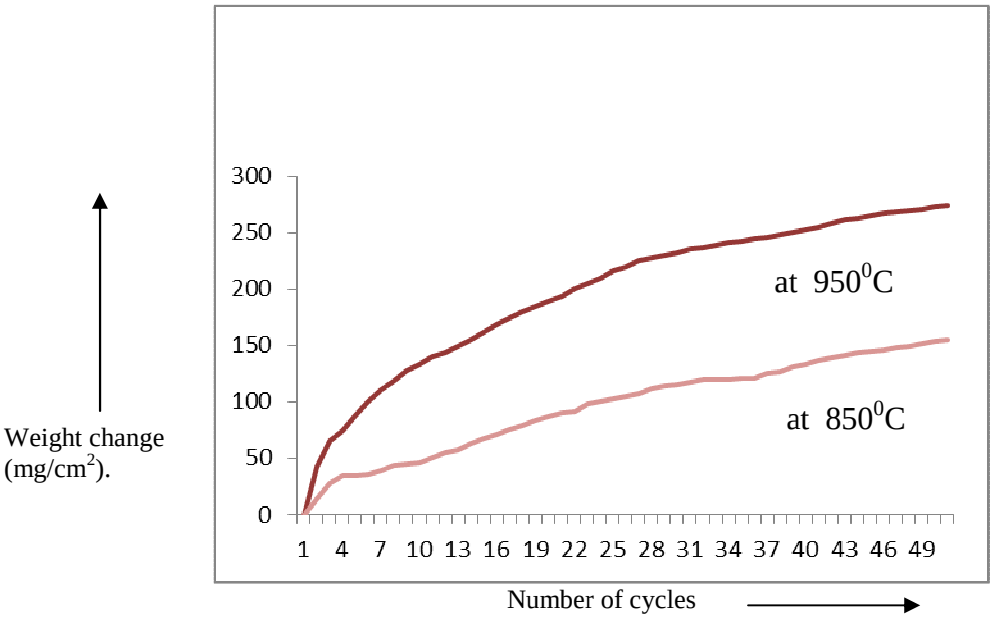

Fig: 3.3 Comparison of Oxidation of Boiler Steel SA-192 at 850^{0}C & 950^{0}C.

3.1 In case of Oxidation

Boiler Steel SA-192 Weight gain at 850^{0}C is 155.67 mg/cm^2 and at 950^{0}C is 274.29 mg/cm^2 up to 50 cycles. It shows that approximate 1.7 times more weight gain due to increase in temperature up to 50 cycles for oxidation.

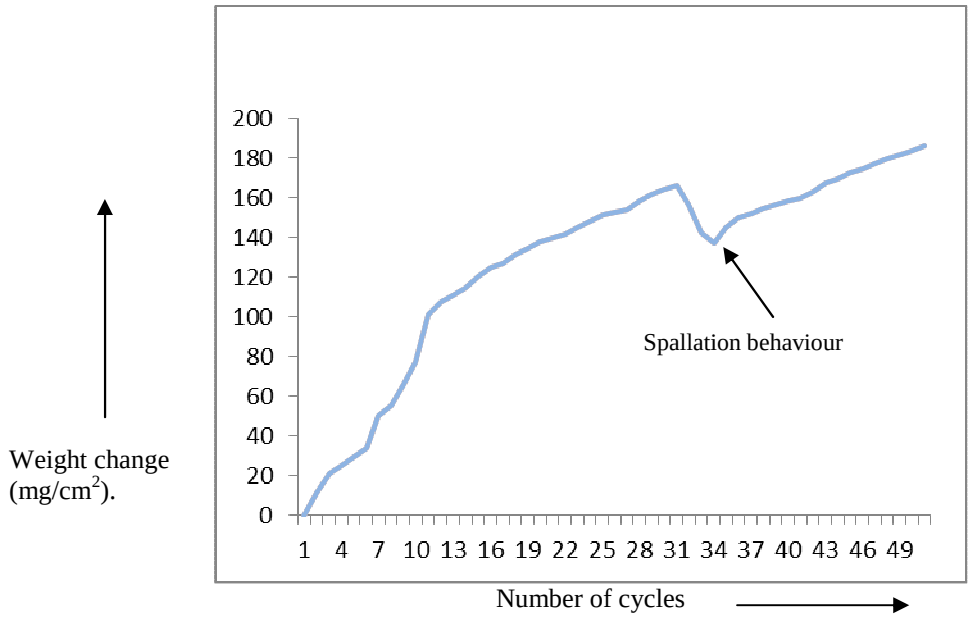

Fig: 3.4 Hot Corrosion performance of Boiler Steel SA-192 at 850^{0}C.

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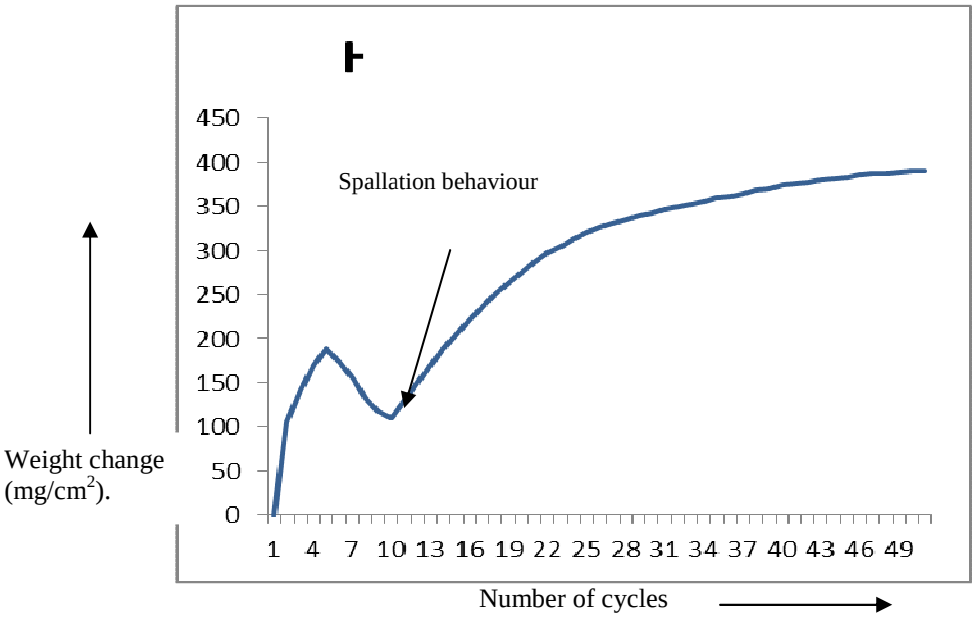

Fig: 3.5 Hot Corrosion performance of Boiler Steel SA-192 at 950^{0}C.

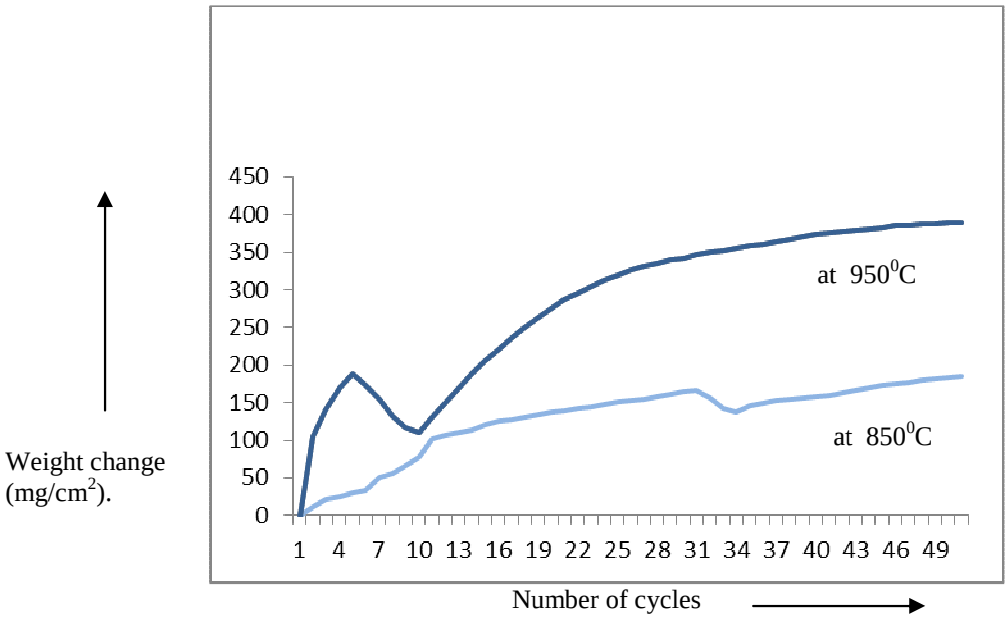

Fig: 3.6 Comparison of Hot Corrosion of Boiler Steel SA-192 at 850^{0}C & 950^{0}C.

3.2 In case Hot Corrosion

Boiler Steel SA-192 Weight gain at 850^{0}C is 185.96 mg/cm^2 and at 950^{0}C is 390.10 mg/cm^2 up to 50 cycles. It shows that approximate 2.1 times more weight gain due to increase in temperature up to 50 cycles for hot corrosion.

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4. CONCLUSION

In the present investigation, oxidation and hot corrosion tests of Boiler Steel SA-192 have been carried out at the temperatures of 850^0C & 950^0C. Following conclusions are drawn:

- When we increase the temperature then corrosion rate also increase.
- Boiler Steel SA-192 shows poor performance for oxidizing environment because there is higher weight gain up to 50 cycles.
- Boiler Steel SA-192 shows very poor performance for corrosive environment because there is spallation behaviour appears in cycles up to 50 cycles.
- At higher temperature is shows more weight gain per surface area.
- Hot corrosion shows badly effect on boiler steel with 2.1 times as we temperature increase and oxidation effect is less as compare to salt environment which is approximately 1.7 times increase the corrosion rate.

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