International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 1 Issue 7 ǁ Nov 2013 ǁ PP.34-37

Effect of LVOF Sprayed Coating in Oxidation & Hot Corrosion Performance of Boiler Steel SA-192 at Different Temperatures.

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ABSTRACT : *Oxidation and hot corrosion is the major degradation mechanism of 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. To obviate these problems, in current investigation Al_2O_3+40%TiO_2 powder has been deposited on Boiler Steel SA-192by LVOF (Low velocity oxy fuel process). The oxidation and hot corrosion performances of Al_2O_3+40%TiO_2 coated as well as bare Boiler Steel SA-192 has been evaluated in air and with aggressive environment Na_2SO_4+60%V_2O_5 under cyclic conditions at an elevated temperatures of 850^0C & 950^0C. 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 850^0C and 950^0C 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 it suffered intensive spallation in the form of removal of scales. To improve oxidation and hot corrosion resistance Al_2O_3+40%TiO_2 coating has been successfully deposited on Boiler Steel SA-192 by Low velocity oxy fuel process using CERAJET spray nozzle (A proprietary item of MECPL, Jodhpur). Coating has shown approximately 90% & 92% improvement respectively in the oxidation and hot corrosion resistance of Boiler Steel SA-192have been observed .*
Keywords*- Oxidation, Hot Corrosion, LVOF Coating*

I. INTRODUCTION

Many 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 nonprotective 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 884^0C), V_2O_5 (melting point 670^0C), 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].

II. 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.

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. The coatings were sprayed at M/S Metalizing Equipment Co. Pvt. Ltd., Jodhpur (India) by using two types of thermal spray system for bond coating of Ni-80%Cr (100um thickness). Arc spray has been used and for top coating of Al_2O_3+40%TiO_2 (250um thickness), LVOF (Low velocity oxy fuel) has been used that is new technique which used instead of plasma spray method due to its low cost.

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^{0}C 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
Uncoated Boiler Steel SA-192	850^{0}C,950^{0}C	Air	50 cycle of 1 hrs heating followed by 20 min cooling in ambient air
Uncoated Boiler Steel SA-192	850^{0}C,950^{0}C	Na_2SO_4+60% V_2O_5	
Coated Boiler Steel SA-192	850^{0}C,950^{0}C	Air	
Coated Boiler Steel SA-192	850^{0}C,950^{0}C	Na_2SO_4+60% V_2O_5	

III. RESULTS & 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 superalloy 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.

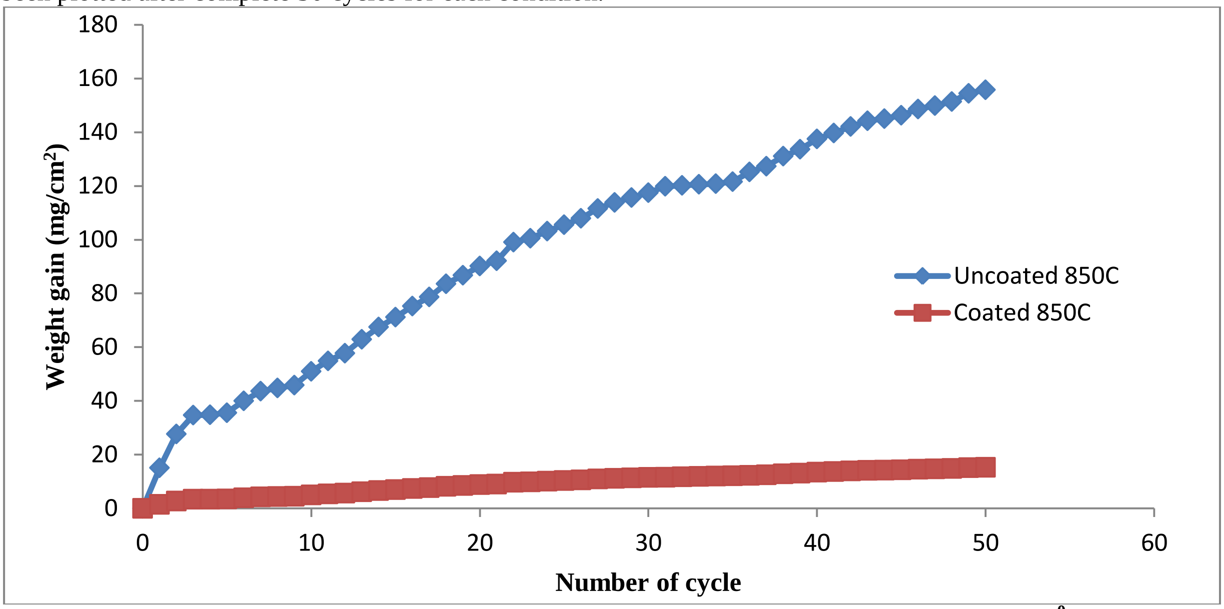

Fig: 3.1 Oxidation performance of Coated and Uncoated Boiler Steel SA-192 at 850^{0}C.

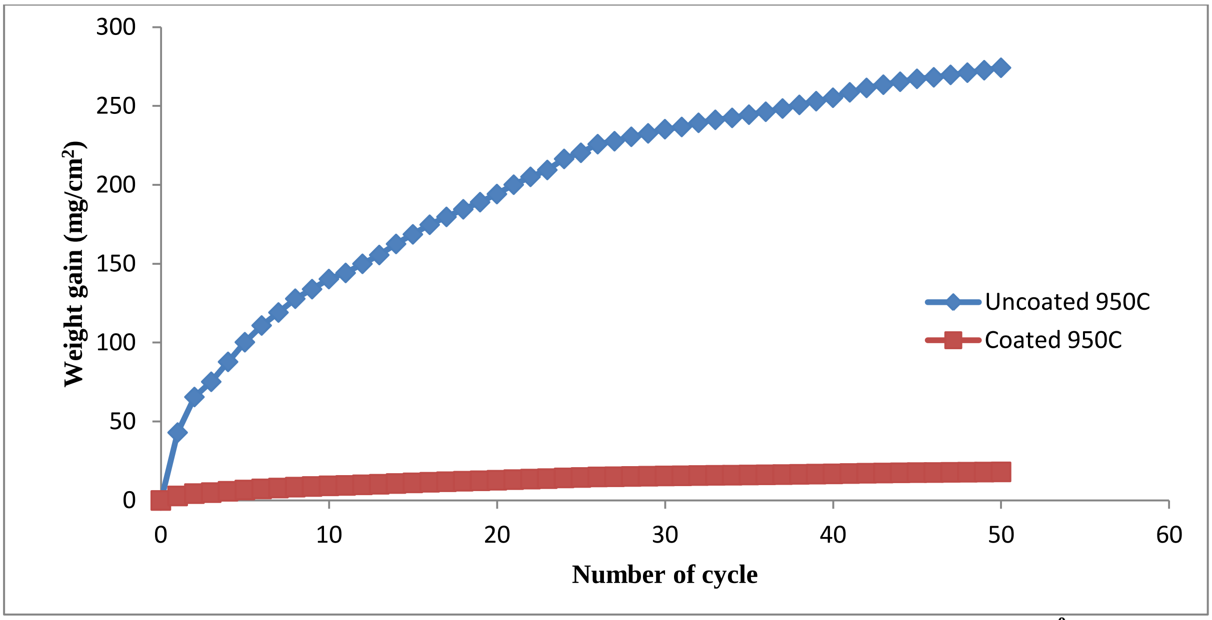

Fig: 3.2 Oxidation performance of Coated and Uncoated Boiler Steel SA-192 at 950^{0}C.

3.1 In case of Oxidation

Uncoated Boiler Steel SA-192 Weight gain at 850^{0}C is 155.67 mg/cm^{2} and Coated Boiler Steel SA-192 is 15.27 mg/cm^{2} up to 50 cycles. Uncoated Boiler Steel SA-192 Weight gain at 950^{0}C is 274.29 mg/cm^{2} and Coated Boiler Steel SA-192 is 18.104 mg/cm^{2} up to 50 cycles.

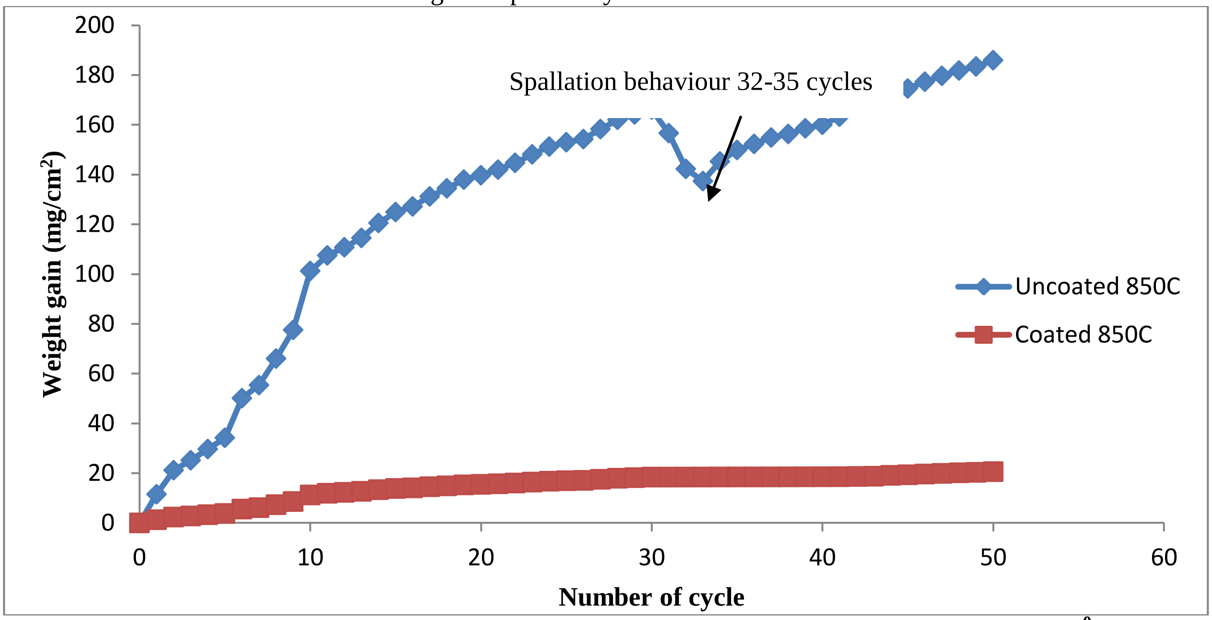

Fig: 3.3 Hot Corrosion performance of Coated and Uncoated Boiler Steel SA-192 at 850^{0}C.

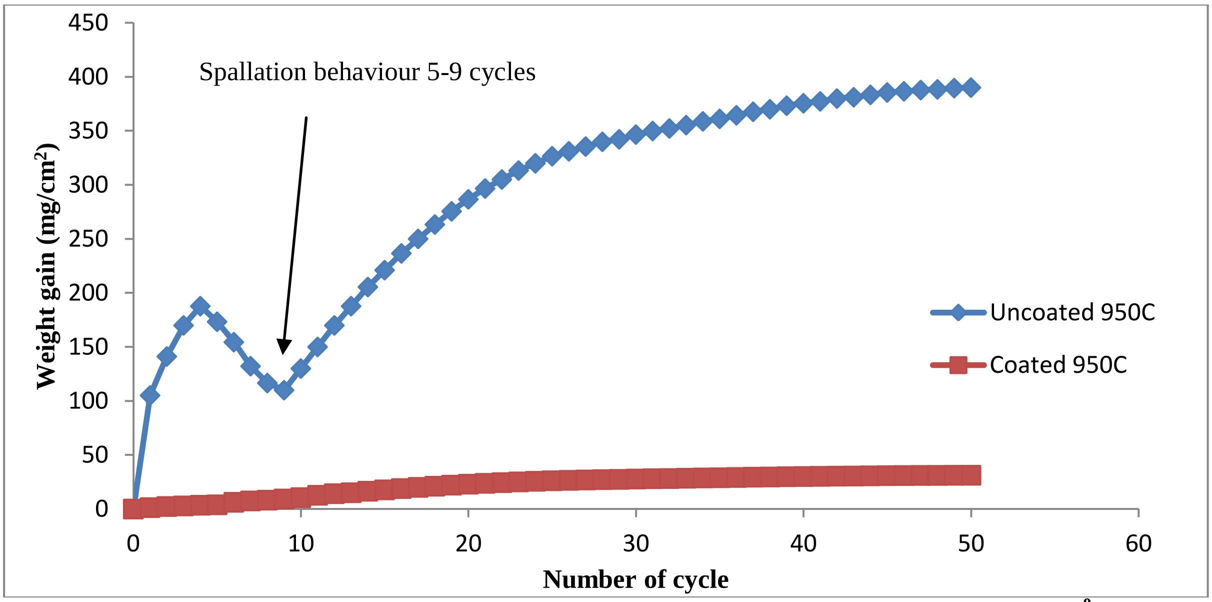

Fig: 3.4 Hot Corrosion performance of Coated and Uncoated Boiler Steel SA-192 at 950^{0}C.

3.2 In case Hot Corrosion

Uncoated Boiler Steel SA-192 Weight gain at 850^{0}C is 185.96 mg/cm^2 and Coated Boiler Steel SA-192 is 20.59 mg/cm^2 up to 50 cycles. Uncoated Boiler Steel SA-192 weight gains at 950^{0}C is 390.10 mg/cm^2 and Coated Boiler Steel SA-192 is 31.28 mg/cm^2 up to 50 cycles.

IV. CONCLUSION

In the present investigation, oxidation and hot corrosion tests of Boiler Steel SA-192 have been carried out at the temperatures of 850^{0}C & 950^{0}C. Further to improve the oxidation and hot corrosion resistance Boiler Steel SA-192**,** LVOF sprayed Al_2O_3+40%TiO_2 coating has been deposited. Following conclusions are drawn:

- When we increase the temperature then corrosion rate also increase.
- Boiler Steel SA-192 shows poor performance for oxidising 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.
- Coating has shown approximately 90% & 92% improvement in the oxidation and hot corrosion resistance of Boiler Steel SA-192 superalloy have been observed by applying coating on it.

V. Acknowledgement

The authors are very much thankful to Mr. K Ramesh, General Manager (Commercial), and Mr. I S N Murthy, Mishra Dhatu Nigam Limited, Hyderabad (India), for providing the Boiler Steel. For coating process I want to thanks Mr. Rohit Upadhyay “General manager” of Metallizing Equipment Co. Pvt. Ltd. Jodhpur.

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