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REFURBISHMENT OF ASTM A213 T-11 STEEL BOILER TUBES AFFECTED BY EROSION

Amandeep Singh Sidhu[1] & Er. Sandeep Kumar Sharma[2]

Abstract- Industrial components associated with oil and gas transportation and storage often encounter severe problems of erosion hence short life span. Boiler pipes are one of such components which requires careful attention due to high number of erosion failures in power plants. Aim of the present research is to reimburse ASTM A213 T11 steel boiler tubes affected by erosion using hardfacing technique. Two different kind of electrodes (Mild steel, and Hard alloy V) were chosen to analyze the effects of hardafcing process on ASTM A213 T11 steel. results indicate that hard alloy V electrodes were more effective in preventing erosion as compared to mild steel electrode and hardfacing process has been found efficient for Refurbishment of erosion affected pipes.
Key words: Erosion; Hardfacing process; industrial boiler tubes ; ASTM A213 T11 steel

1. INTRODUCTION

During the production of oil and gas in pipelines erosion is a severe problem[1]. Industrial components often get corroded and eroded when operated in aggressive working environmentsfor a long time and ultimately leads to premature failure of the component[2].Erosion is a serious problem in most of the engineering systems, including steam and jet turbines, oil transporting gas lines[3],valves used for slurry transportation of matter[4], and fluidized bed combustion systems [5]. Some serious problems like Hot corrosion and erosion phenomenaisfound in Indian coal based power plants[6]. ASTM A213 T-11 STEELis widely used in boiler pipes and heat exchangers. Due to the continues exposure with steam, there is always a tendency of the material to get corroded in such environments. Costs of repairing and replacement of damaged tubes in the same installations are extremely high, and can be observed up to 54% of the total cost of production, which is a massive amount, and needs careful consideration[7]. Coatings and surface treatments have been found useful to overcome these problems [8]. In the late 1800 s it has been already known how to improve the penetration resistance of a target by layering it with materials having different properties [9]. These composite hardfacing coatings, commonly known as particle-reinforced metal-matrix composites (PRMMCs), can enhance the material's tribological properties significantly by inserting a metallic alloy as the matrix and the ceramic particles as reinforcements [10]. In order to enhance the corrosion and erosion resistance of materials in harsh environments, some Hardfacing techniques such as plasma transferred arc (PTA), gas tungsten arc welding (GTAW), arc welding hardfacing, thermal spraying and laser cladding gained popularity in industry[11]. For thick coatings on the complex shaped surfaces arc welding hardfacing is best suitable [12]. The process uses welding techniques to deposit a wear resistant material on the surface of the components being treatment [13].

Some major applications of arc welding hardfacing are mining and mineral processing, cement production, pulp and paper manufacturing, agriculture tools and sugar industry to extend the service life of equipment [12]. Researchers are continuously putting their best efforts to optimize the hardfacing process for different components. J.N. Lemke et. al. in 2016 presented a simplified model to correlate the amount of dilution in hardfacing alloys after a casting process considering several reference parameters [14]. Ke Yang et. al. in deposited the Fe-Cr13-C-Nb hardfacing alloy with and without Ti addition on carbon steel substrates by shielded metal arc welding and found significant results [15].H. Hinners in 2017 elaborated a fundamentally new approach to the fabrication of novel WC-based hardmetals in form of hard-facing obtained by PTA (plasma transferred arc) welding [16]. Junfeng Gou et. al. in 2017 studied the work function and dry sliding wear behavior of the hardfacing alloys with different content of nano rare earth oxides (REOs) [17].

2. EXPERIMENTATION

ASTM A213 T-11 steel has been used for present research. general purpose 4.25 Kw capacity welding machine has been used. Total 24 no. of workpieces were prepared from T11 tube, with 130 mm diameter, 08 mm thickness, and lengthwise it was 220 mm the pieces were prepared by cutting the tube into two 65mm wide pieces from right of its half and then it got flattered with the help of press work. After flatting specimens were again cut into 3-3 pieces, which are 220 mm long and 22 mm wide. After reviewing the literature on hardfacing, Current (I), Voltage (V) and Electrode were chosen as input parameters. Mild steel and hard alloy were selected as consumables. Since pipe erosion is the leading problem in boiler industries, erosion has been chosen as the output response. Table 1 shows the design of experiment.

[1] Research Scholar, ME Section, GKU, Talwandi Sabo, Bathinda
[2] Department of Mechanical Engg, GKU, Talwandi Sabo, Bathinda

Table 1- Design of experiments

W/P No.	I (Current)	V (Voltage)	Electrode
1	100-140 A	20 V	Mild Steel
2	100-140 A	20 V	Mild Steel
3	100-140 A	20 V	Mild Steel
4	100-140 A	20 V	Mild Steel
5	140-180 A	20 V	Hardalloy V
6	140-180 A	20 V	Hard alloy V
7	140-180 A	20 V	Hard alloy V
8	140-180 A	20 V	Hard alloy V

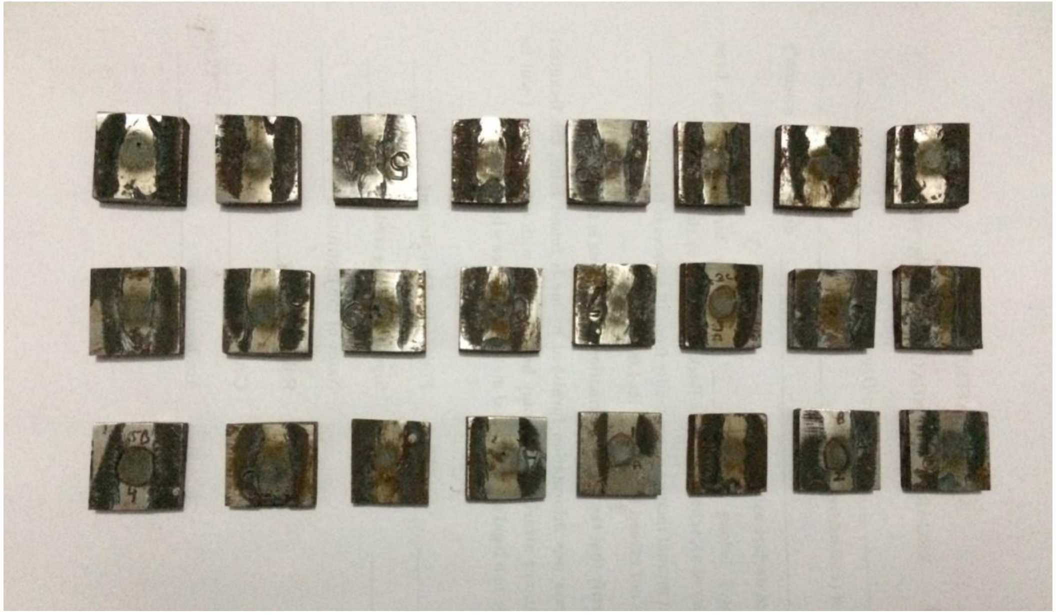

Figure 1- Prepared specimens

3. RESULTS AND DISCUSSIONS

Erosion tests were performed on the prepared specimens in varying environments. First 12 experiments were performed using Mild steel electrode, at 20 V, and 100-140 A current. Figure no. 2 represents the erosion rate in mg/min. for the hardfaced specimens. It has been observed that erosion rate has been very less, i.e. less than 0.0005 in most experiments after hardfacing process. However, in experiment no. 6 the value of erosion rate increased a bit due to erroneous factors.

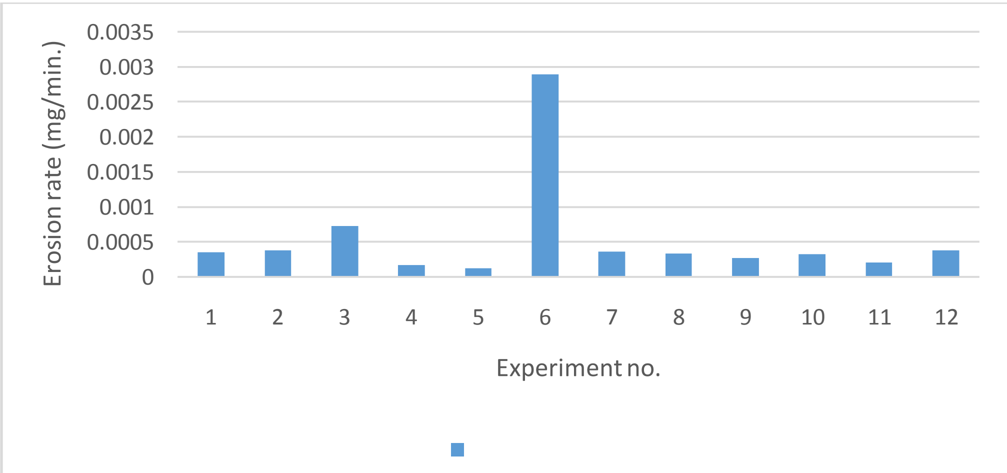

Figure 2. Erosion rate for Mild steel electrode.

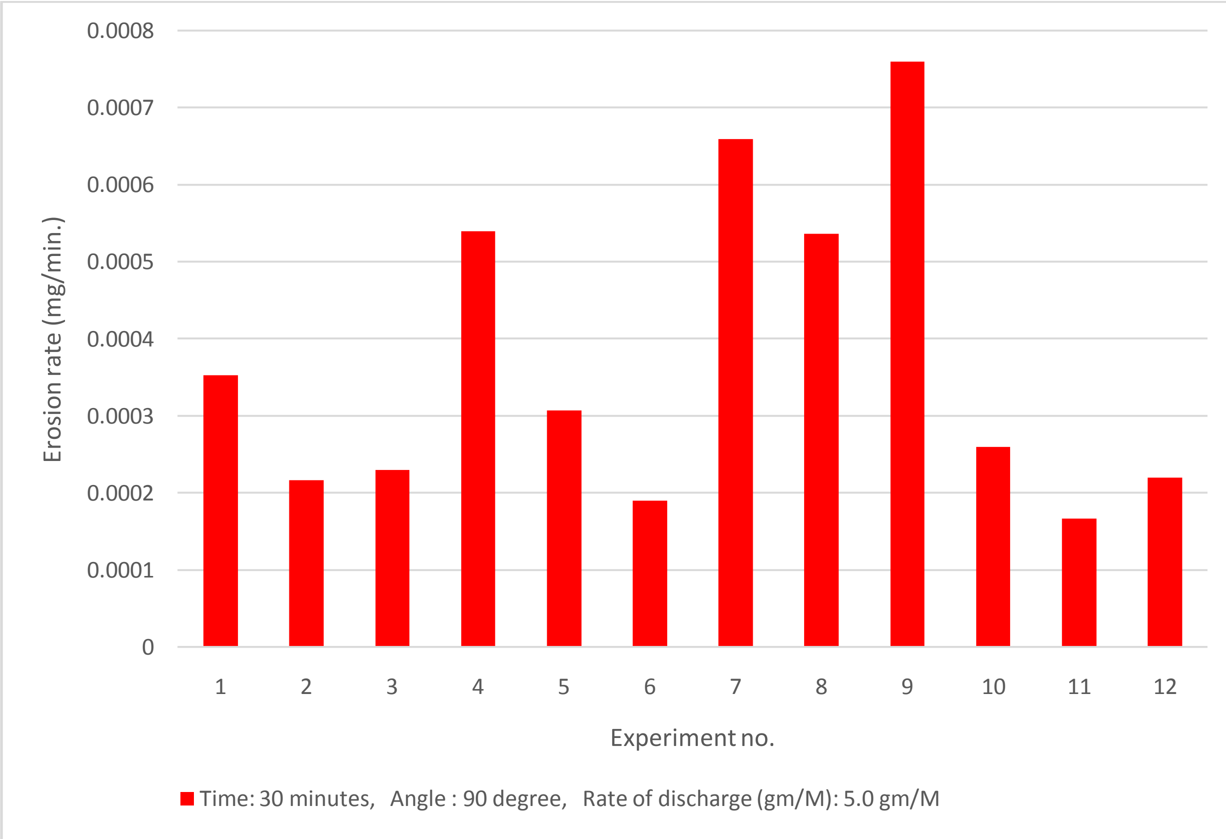

Figure 3. Erosion rate for Hard alloy V electrode.

Figure no. 3 shows the graphical representation of the erosion rate data for Hard alloy V hardfaced specimens. Another 12 experiments were performed using Hard alloy V electrode, at 20 V, and 140-180 A current. It can be observed that rate of erosion decreased significantly when hard alloy V electrode is used as compared to the mild steel electrode. Graph indicates that most of the experiments produced erosion rate less than 0.0005 and the maximum erosion rate (below 0.0008) that occurred is at experiment 9.

4. CONCLUSIONS

The aim of the present research is to reduce the problem of erosion in industrial boiler pipes. ASTM A213 T-11 steel is hardfaced using two types of electrodes i.e mild steel and hard alloy V electrode. After the experimental analysis following conclusions can be made.

1. Hardfacing process can be used efficiently to eliminate the erosion wear in industrial boiler pipes. Due its simplicity and ease in operation boiler pipes can be saved from damaging at very less cost.
2. Erosion rate has been decreased significantly when Hard alloy V electrode is used as compared to mild steel electrode. Thus it can be concluded hard alloy V electrode hardfacing is effective in reducing the erosion wear.

5. REFERENCES

[1] McLaury, B., et al. Solid particle erosion in long radius elbows and straight pipes. in SPE annual technical conference and exhibition. 1997. Society of Petroleum Engineers.

[2] Yang, K., Q. Yang, and Y. Bao, Effect of carbonitride precipitates on the solid/liquid erosion behaviour of hardfacing alloy. Applied Surface Science, 2013. 284: p. 540-544.

[3] Martínez, D., et al., Amine type inhibitor effect on corrosion–erosion wear in oil gas pipes. Wear, 2009. 267(1): p. 255-258.

[4] Roco, M. and G. Addie, Erosion wear in slurry pumps and pipes. Powder technology, 1987. 50(1): p. 35-46.

[5] Mishra, S., et al., Characterisation and erosion behaviour of a plasma sprayed Ni 3 Al coating on a Fe-based superalloy. Materials letters, 2005. 59(28): p. 3694-3698.

[6] Chawla, V., et al., Hot corrosion & erosion problems in coal based power plants in India and possible solutions–a review. Journal of minerals and materials characterization and Engineering, 2011. 10(04): p. 367.

[7] Kaur, M., H. Singh, and S. Prakash, Surface engineering analysis of detonation-gun sprayed Cr 3 C 2–NiCr coating under high-temperature oxidation and oxidation–erosion environments. Surface and Coatings Technology, 2011. 206(2): p. 530-541.

[8] Zikin, A., et al., Characterisation of TiC–NiMo reinforced Ni-based hardfacing. Surface and Coatings Technology, 2013. 236: p. 36-44.

[9] Balakrishnan, M., V. Balasubramanian, and G.M. Reddy, Effect of hardfacing consumables on ballistic performance of Q&T steel joints. Defence Technology, 2013. 9(4): p. 249-258.

[10] Liu, J., et al., Microstructure and wear resistance performance of Cu–Ni–Mn alloy based hardfacing coatings reinforced by WC particles. Journal of Alloys and Compounds, 2016. 654: p. 63-70.

[11] Zikin, A., et al., Advanced chromium carbide-based hardfacings. Surface and Coatings Technology, 2012. 206(19-20): p. 4270-4278.

[12] Gou, J., et al., Bending strength and wear behavior of Fe-Cr-C-B hardfacing alloys with and without rare earth oxide nanoparticles. Surface and Coatings Technology, 2017. 311: p. 113-126.

[13] G.P, R., K. M, and S.R. Bakshi, Hardfacing of AISI H13 tool steel with Stellite 21 alloy using cold metal transfer welding process. Surface and Coatings Technology, 2017. 326: p. 63-71.

[14] Lemke, J.N., et al., Interrelation between macroscopic, microscopic and chemical dilution in hardfacing alloys. Materials & Design, 2016. 91: p. 368-377.

[15] Yang, K., et al., Microstructure and wear resistance of Fe-Cr13-C-Nb hardfacing alloy with Ti addition. Wear, 2017. 376-377: p. 1091-1096.

[16] Hinners, H., et al., Novel hardmetals with nano-grain reinforced binder for hard-facings. International Journal of Refractory Metals and Hard Materials, 2017. 67: p. 98-104.

[17] Gou, J., et al., Study of work function and dry sliding wear behavior of Fe-based hardfacing alloys with and without nano rare earth oxides. Journal of Alloys and Compounds, 2017. 713: p. 255-265.