International Journal of Theoretical & Applied Sciences, 6(1): 168-171(2014)

ISSN No. (Print): 0975-1718
ISSN No. (Online): 2249-3247

To Investigate the Effect of Impingement Angle on Erosion of Boiler Steels

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(Received 17 December, 2013 Accepted 15 January, 2014)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Erosion is defined as the process of material removal when hard material strikes in a fluid stream. Solid particle erosion is caused when solid erodent strikes with high velocity. One type of solid particle erosion is fly ash erosion which takes place in steam generation boilers which is responsible for boiler tube failure results in untimely shout down and production loss. The same problem was frequently experienced by Steam Generation Plant of National Fertilizer Limited Nangal which gave the reason for this research work. The present research work done on bank tubes and economizer tubes for the investigation of effect of impingement angle on erosion boiler steels. The experiment has been performed on air jet erosion test rig by taking alumina powder of 50 micron size as erodent. Different angles of impingement from 30^o to 90^o are taken into consideration. The air jet velocity was maintained at 35 m/s. Mass loss of each sample was recorded to get exact idea of material loss under prescribed working conditions. SEM images were taken to investigate the erosion mechanisms.

Keywords: Erosion, Solid Particle Erosion, Mass loss, Scanning Electron Microscope.

I. INTRODUCTION

Erosion is defined as the process of material removal when hard material strikes in a fluid stream. Solid particle erosion is caused when solid erodent strikes with high velocity. One type of solid particle erosion is fly ash erosion which takes place in steam generation boilers which is responsible for boiler tube failure results in untimely shout down. This problem was frequently experienced by Steam Generation Plant of National Fertilizer Limited Nangal which gave the reason for this research. The present research work done on bank tubes and economizer tubes for the investigation of reasons of frequent failures. Solid particle erosion is also the problem of power plant industry due to which boiler tube failures take place this was also defined as the main reason diagnosed by Anees U. Malik [1]. When the flue gas passes the boilers tubes they erode the surface of the tubes at different sections mainly at the sides of walls of the tubes by reducing its thickness from Job History Cards NFL N. Nangal [2]. Room temperature is an important problem in several engineering application like rocket motor trail nozzles by Neilson and Gilchrist [3]. The engine of a helicopter operating in dusty terrain by Tilly [4], equipment in oil and mining industries by Finnie I [5] and Forse and Ball [6] are subjected to solid particle erosion at ambient temperature. The present research was done on bank tubes made of SA192 and economizer tubes made of SA210 steels. The investigation was done by taking different angles of impingement from 30^o to 90^o into consideration for mass loss due to erosion at ambient temperature.

II. EXPERIMENTATION

The samples of SA192 and SA210 Gr A1 boiler steel are prepared of 25 mm length 25 mm breadth and 5 mm thickness. Then these samples are finished on metallurgical polishing machine to make the surface smooth so that the erosion impression can be observed easily. The samples are dried with blower to make it moisture free. The weight of the samples is measured with weighing machine before and after the erosion so that the weight loss can be estimated for the prescribed duration of erosion test. The duration of test is continuous three hours without any break during experimentation. Surface finishing of all samples is also measured before and after the erosion test by using Mitutoyo Surface Roughness Tester SJ – 201P, and Ra value is measured in micron meter at ambient temperature. Air Jet Erosion Test Rig TR 471 M10 is used to perform erosion test. The test was performed by taking as 50 micron Alumina powder as erodent. The velocity of air get is set at 35 m/s at a pressure of 0.1 Kg/cm^2. Nozzle having 4 mm diameter is used and feed rate of erodent at 2 gm/min is selected. Each sample is continuously tested for three hours at different impingement angles of 30^o, 45^o, 60^o and 90^o. After each experiment weight loss and surface roughness of each sample is recorded.

Figure 1 shows the Air Jet Erosion Test Rig TR 471. Figure 2 shows the images of surface after erosion test of SA210 Gr A1 boiler steel at various angles of impingement i.e. 30°, 45°, 60° and 90°.

Figure 3 shows the images of surface after erosion test of SA192 boiler steel at various angles of impingement i.e. 30°, 45°, 60° and 90°.

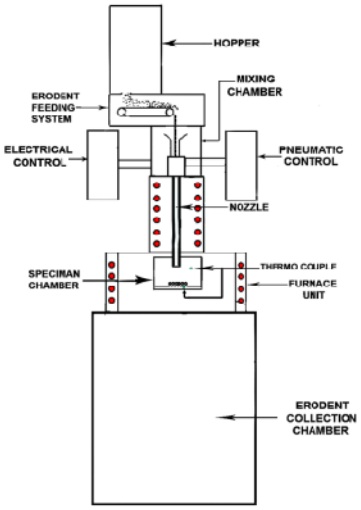


Fig. 1. Air Jet Erosion Test Rig TR 471.

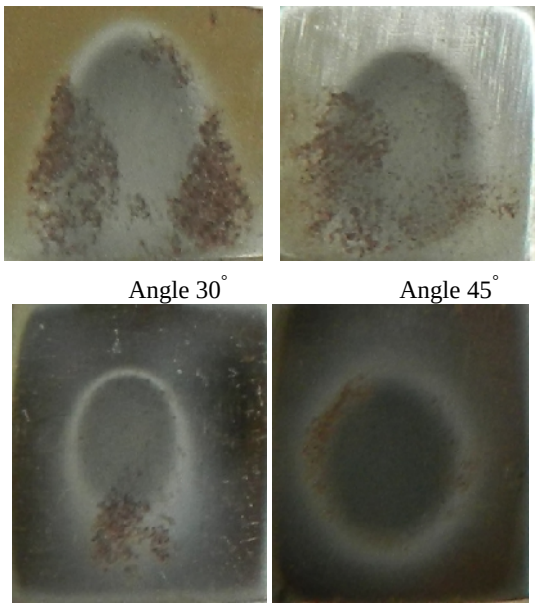


Fig. 2. Erosion Test Images of SA 210 Gr A1Boiler steel at different angles of impingement.

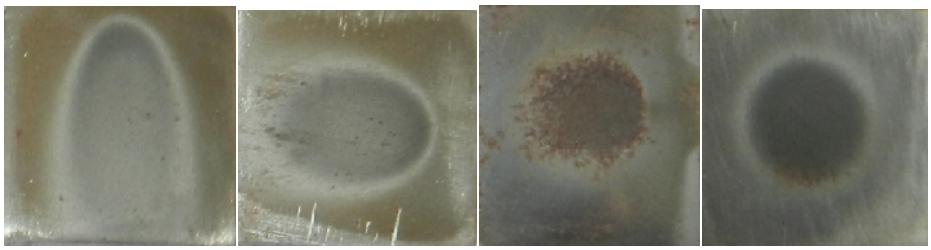


Fig. 3. Erosion Test Images of SA 192 Boiler steel at different angles of impingement.

III. RESULTS

The weight loss of each sample is measured before and after erosion test and it is tabulated in Table1 and also shown in graphical representation in Figure4. The strike of alumina powder as erodent gave impression on the surface which is clearly visible with naked eye. The size of impression is more at small angles and confined to small surface near normal angles. The change in surface finish has also observed and it shows that the solid particle erosion is highly responsible for degradation of surface exposed to direct contact of fly ash in boiler tubes. Initially the surface is deteriorated and then it starts propagating on the whole surface of the boiler tubes, especially at the lower portion of the tubes which comes in initial contact with fly ash. The results are listed below.

Table 1: Mass loss in grams of boiler steels SA 192, SA210 Gr A1 at different angles.

Angle of Air Jet	30^o	45^0	60^o	90^o
SA 192	0.0035	0.0075	0.0023	0.0020
SA 210 Gr A1	0.0043	0.0046	0.0025	0.0015

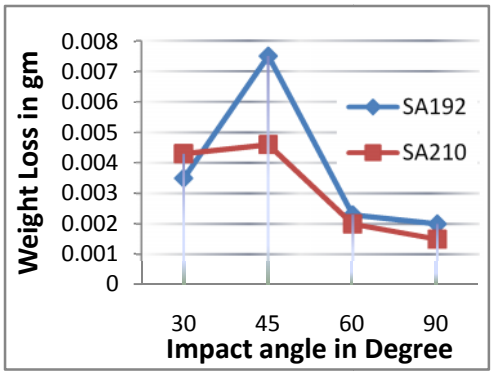
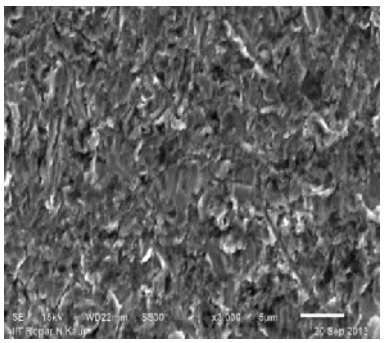


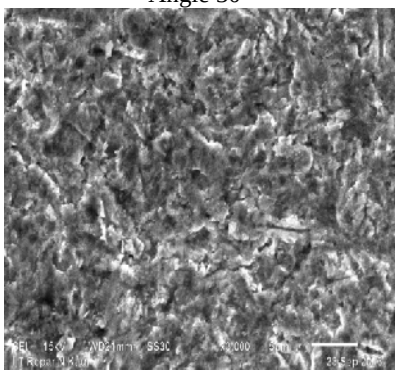
Fig. 4. Graph between angles of impingement and Mass loss in grams.

IV. SURFACE CHARACTERIZATION

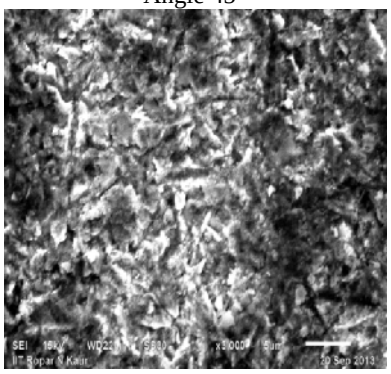
After each erosion test the surface characterization is done initially with visual inspection and then with SEM and at Micro level. It has been observed that the material removal is governed by the synergistic effect of erosion. The detailed examination of the eroded target material is done by using scanning electron microscope. At low temperature, high impact velocity and feed rates, there is no oxidation appeared. The erosion is of ductile behavior. During SEM analysis the mode of material removal appeared as ploughing and cutting. Undercuts are appeared at normal angel. Maximum material removal is observed at 45^o for both the materials.



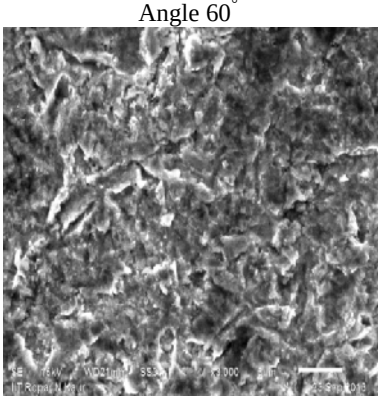
Angle 30°



Angle 45°

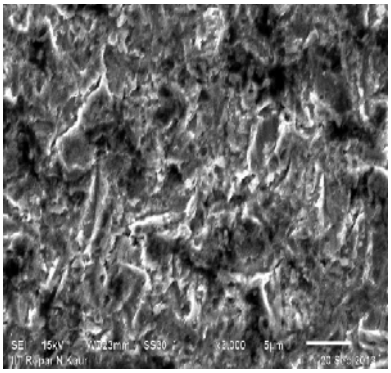


Angle 60°

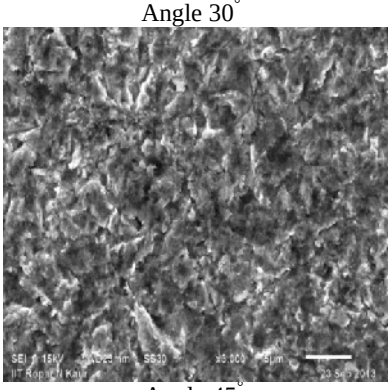


Angle 90°

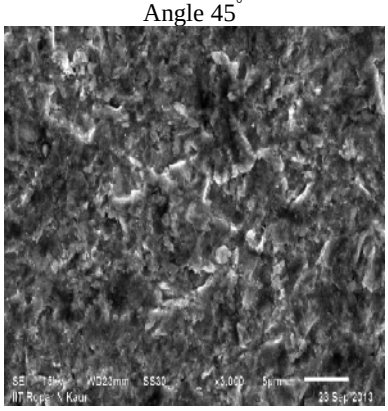
Fig. 5. SEM Images of erosion test at different angles of SA 192 Boiler steel.



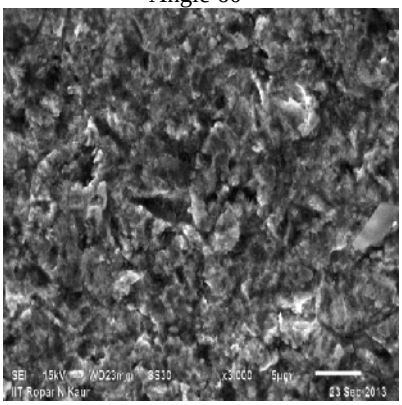
Angle 30°



Angle 45°



Angle 60°



Angle 90°

Fig. 6. SEM Images of erosion test at different angles of SA 210 Boiler steel.

V. CONCLUSION

Solid particle erosion is caused when solid erodent strikes with high velocity. One type of solid particle erosion is fly ash erosion which takes place in steam generation boilers which is responsible for boiler tube failure results in untimely shout down and production loss. The main problem is the continuous material degradation directly exposed to the solid particle which reduces the thickness of various components results in premature failure of the equipments. The present research concentrated on solid particle erosion of the boiler steel of SA 192 and SA 210 Gr A1grade with alumina powder as the erodent, research gave significant clue that the maximum material is removed at the small angles i.e. between 30 degree to 45 degree. This effect was observed less near normal angles. The material removal mechanism is ploughing for small slopes of impingement of air jet containing erodent and under cuts is observed at normal angles. The future scope of this experimentation may be the analysis at elevated temperature.

ACKNOWLEDGEMENTS

The authors are grateful to Punjab Technical University Jalandhar for supporting and motivation to perform the experimental research in this filed.

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