International Research Journal in Advanced Engineering and Technology (IRJAET)

ISSN (Print) : 2454-4744 | ISSN (Online) : 2454-4752 (www.irjaet.com)

Vol. 1, Issue 1, pp.13-17, June, 2015

RESEARCH ARTICLE

Counteractive Measures and Malfunction Analysis of Boiler Economizer Tube

V. Ethirajulu *

ARTICLE INFO

Article History:

Received 19th, May, 2015

Received in revised form 23rd, May, 2015

Accepted 9th,June, 2015

Published online 24th, June, 2015

Key words:

Economizer tube

Water tube boiler

Malfunction analysis

ABSTRACT

Frequent shutdown of thermal power plant for maintenance causes interruption of power supply in our day to day life due to malfunction of any part in the power plant. The cause of malfunction may be associated with waterside corrosion, fire side corrosion, overheating, stress rupture, erosion or fatigue. Our study is concerned with a thermal power plant employing water tube boiler. The data collected from the above said thermal power plant the malfunction of economizer tube is the cause of frequent shutdown. The causes of malfunction are investigated using Scanning Electron Microscope, Energy Dispersive X–ray Spectroscopy, X-ray diffraction so as to find out the major causes of malfunction and also provide preventive measure to minimize the malfunction.

1 Introduction

A boiler economizer is a heat exchanger device that captures the "lost or waste heat" from the boiler's hot stack gas. The economizer typically transfers this waste heat to the boiler's feed-water or return water circuit, but it can also be used to heat domestic water or other process fluids. Capturing this normally lost heat reduce s the overall fuel requirements for the boiler. Less fuel equates to money saved as well as fewer emissions -since the boiler now operates at a higher efficiency. This is possible because the boiler feed-water or return water is pre-heated by the economizer therefore the boilers main heating circuit does not need to provide as much heat to produce a given output quantity of steam or hot water. Again fuel savings are the result. Boiler economizers improve a boiler's efficiency by extracting heat from the flue gases discharged. Flue gases from boilers are typically in the range of 230 - 345°C depending upon boiler pressure. Stack Economizers recover some of this heat for pre-heating water. The water is most often used as boiler make-up water or some other need that coincides with boiler operation. Stack Economizers should be considered as an efficiency measure when large amounts of make-up water are used. The Economizer efficiency is based on the existing stack temperature, the volume of make-up water needed, and the hours of operation. Economizers are available in a wide range of sizes, from small coil like units to very large waste heat recovery boilers.

**Corresponding Author:* V.Ethirajulu, Assistant Professor, SRM University, Chennai, India. E-Mail: vethirajulu@gmail.com

2 Literature Survey

AnandaRao and Sankaranarayanan (2012) have done a comprehensive analysis of a boiler bank tube made of SA210GA1 steel malfunction in one of the captive power plant using optical emission spectrometer showed that the main causes of boiler bank tube are by Ash corrosion, Galvanic corrosion and copper deposition. Stereomicroscopic analysis of the deposits on the fireside reveals the presence of oxide scales, which might have also influenced the corrosion behavior of the failed tube. A scanning electron microscope attached with energy dis persive X-ray analysis (EDAX) used to analyze the morphology and chemical composition of the deposition reveals the presence of iron, oxygen and carbon as major elements with a reasonable presence of aluminum, silicon, phosphorus, sulfur, chlorine, and potassium. The chemical and micro analysis Proceedings of the concluded that the boiler bank tube failed due to corrosion both from the fireside as well as from the waterside.

Liu (2012) has found that the malfunction of boiler tubes (economizers, reheat tubes, water-wall tubes and superheaters) is the major cause of outage in the energy industry. The tube material made of ASTM A210 GrA1and the nominal tube thickness was 4.5mm fed with boiler water with the internal temperature of approximately 109°Ċ and operated at the external temperature of approximately 150°Ċ is studied. Samples of the economizers cut from the boiler during the shutdown period for malfunction analysis using ESEM/EDS showed three morphologies of iron oxides – aggregate oxide (Fe3O4), flower oxide (Fe3O4) and spherical oxide (FeO). The ash and corrosion products on both the interior and exterior surfaces of the tube examined closely revealed that the internal surface of tube malfunction due to corrosion product of magnetite and hematite. The diversity of the corrosion products is due to differences in water quality. The EDX analysis indicates the amount of carbon deposit in the Boiler tubes. The external tube malfunction is due to sulphide and nitric compounds. (The X-RAY) method used to analyze the composition of ash particles showed that the average oxide scale thickness at top was 60mm, which was thicker than that at the side concluded the Fe2O3 was absent from both top and flat side scales. Fe3O4 was only present at top scale. His study concluded that this could be due to the erosion by the fly ash particle impingement which produces harder and denser alloy oxide layers on the outer surface of economizer from the point of view of metallurgy.

Ranjbar (2006) studied the analysis and affecting parameters and corrosion mechanism identified. The chemical analysis and also microstructure analysis used to predict corrosion as well as erosion rate of LPCSH-low pressure convective super heater revealed deposits inside and outside of tubes. The chemical analysis and qualitative analysis of these sediments by XRD (Xray diffraction) examinations showed compounds NaCl, Na2SO4, Fe3O4, Fe2O3 and Fe2Si in the outermost layer and NaCl, Na2SO4, Fe2Si andFe3O4 in the innermost layer. It has been found that accumulation of elements such as sodium in areas like U-bend of the tubes and at water lines leads to continuous oxidization and damage of fresh surface of metal. Analysis of these spots by SEM-EDX confirmed the presence of Sodium, Iron, Calcium, and Silisium as the main constituents in decreasing order due to Oxygen pitting which causes localized type of corrosion, resulting from oxygen attack, and leads to perforations on the internal surface of tubes. Qualitative analysis of these sediments revealed that the most prevailing corrosion mechanisms occurring in reheated tubes are pitting, caustic corrosion and stress corrosion cracking.

Khajaviet al (2006) tested boiler tube malfunction by visual examination, optical microscope, SEM, and XRD revealed the root causes. Since the corrosion resistance of the boiler tube depends on the pH level of the water and amount of contaminants it is studied that a significant factor in waterside corrosion is by the amount of corrosion product deposition on the tube wall and these buildups are most likely to occur where flow is disrupted by bends, welds with backing rings or protrusions at regions of high heat flux; and on horizontal or slanted tubes that are heated from above or below. In this study precipitation of sodium phosphate compounds from boiler water containing disodium phosphate and also operation at low loads are recognized as root mechanisms. The remedies provided included increasing the load and observing the upper and lower limits of Na to PO4 ratio for a given pressure and accurate monitoring of water Liang and Zhao(2012)

Corresponding Author: V.Ethirajulu, Assisatant Professor, SRM University, Chennai, India. E-Mail: vethirajulu@gmail.com

investigated the malfunction causes and to suggest preventive measures, phase compositions and macrostructure of the tube metal surface by X-Ray Diffraction and Scanning Electron Microscope equipped with energy dispersive X-Ray spectroscopy micro-analysis. The water inlet and outlet temperature is 83.8°C and 118°C, the flue gas inlet and outlet temperature is 1520C and 115°C. The spiral finned economizer tube bundles under investigation is built with ND steel, a low alloy which has the composition of Cr-0.8%, Cu-0.36%, Sb-0.06% for resisting acid dew point corrosion, after 3 months, the local spiral finned tube is found eroded seriously.

After visual inspection of the spiral finned tube, three samples are prepared for micro structural analysis. The samples which are i) the surface of the fin (A), ii) the surface of the spiral finned tube at the windward side (B) and iii) taken from the section of spiral finned tube are analyzed by the scanning electron microscope equipped with energy dispersive X-Ray spectroscopy micro-analysis both in secondary electrons and back scattering mode. Three samples of the outer and inner deposit were analyzed by X-Ray Diffraction. The X-Ray Diffraction of ash deposits on spiral finned tube's leeward side shows that main components of ash deposits are $FeSO_4$, $CaSO_4$ and SiO_2 .SEM morphology of fin shows that the uneven surface of the fin is corroded severely so that one could see obvious cracks is principally owing to comprehensive multiphase erosion. It has been studied that the causes are interaction of the fly ash wearing, the flue gas washing, the sulfuric acid dew point corrosion and the splashing dilute H_2SO_3, H_2SO_4 and HNO_3 corrosion.

3 Problem Definition

In large coal fired power stations, pulverized coal is burnt in the burners of boilers. To improve the overall thermal efficiency of the boiler plant, heat exchangers are used to extract residual heat energy from the flue gas and to transfer it to the feed water flowing through the tubes by the process of conduction and convection. Economizer is the main part of the boiler in the furnace second pass. It has been found that regular replacement of economizer tubes is one of the reasons for shutdown of Thermal power plant. That is the reason for study about causes of malfunction of the Economizer tube.

3.1 Economizer specification

Design Pressure: 74 bar
Tube side Diameter of Tubes: 38.1 mm
Tube Wall Thickness: 3.2 mm
Number of Elements: 200
Material: SAE210 Gr. A1
Heating Surface: 1529 m2

Table 1 Chemical composition of SAE210GA1

Grade	C	Si	Mn	P	S
SAE 210 GA1	≤0.27	≥0.10	≤0.93	≤0.035	≥0.035

Table 2 Mechanical Properties of SAE210GA1

Grade	Tensile(MPa)	Yield strength	Elongation%
SAE 210 GA1	≥415	≥255	≥30

Figure1 Failed tube

4 Results and Discussion

4.1 Malfunction analysis methods

- Scanning electron microscope(SEM)
- X-ray Diffraction method(XRD)
- Energy Dispersive X-ray Spectroscopy (EDAX)

4.2 Scanning Electron Microscope (SEM)

Visual examination using a scanning electron microscope (Fig 2) has shown that morphology of SAE210GA1 seamless medium carbon steel indicated a uniform distribution of crystal without any deposits, and with uniform orientation.

Corresponding Author: V.Ethirajulu, Assisatant Professor, SRM University, Chennai, India. E-Mail: vethirajulu@gmail.com

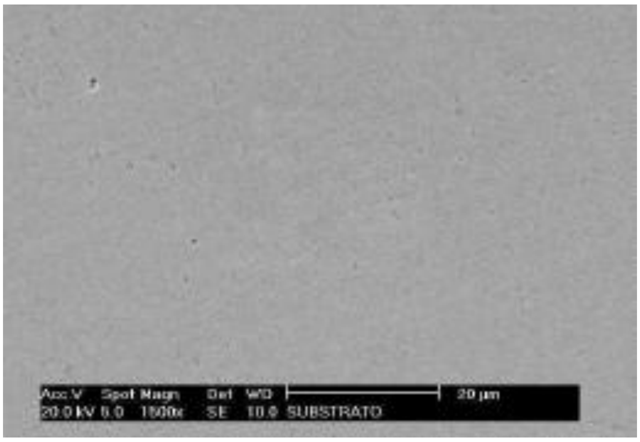

Figure 2 Before erosion

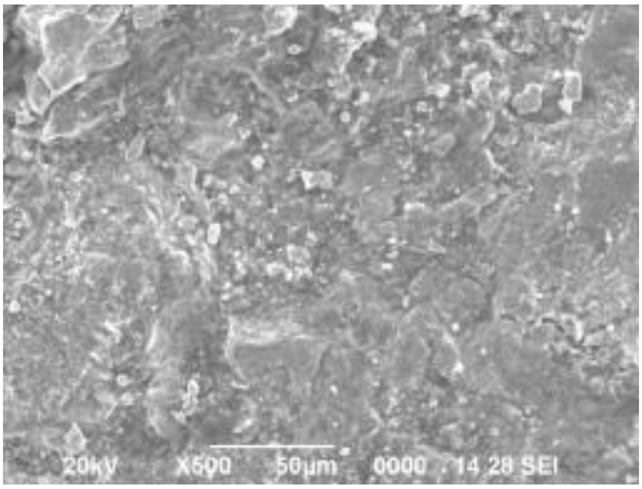

Figure 3 After erosion

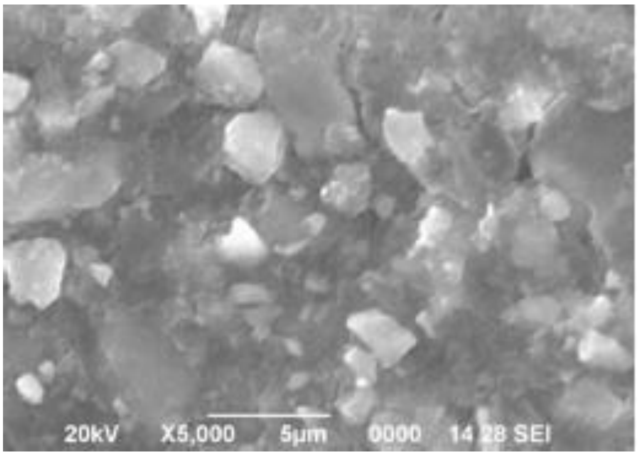

Figure 4 Uneven surface

Visual examination of eroded tube showed a "rocklike" crystal structure, changes in orientation and deposit formation. Rock like crystal structure is due to agglomeration. The figure (5.3) showed the uneven surface of eroded tube.

4.3 Energy Dispersive X-Ray Spectroscope

Since the sample piece during scanning electron microscope examination showed deposits, further study using Energy dispersive x-ray spectroscopy has been necessitated .to find out the composition of deposits

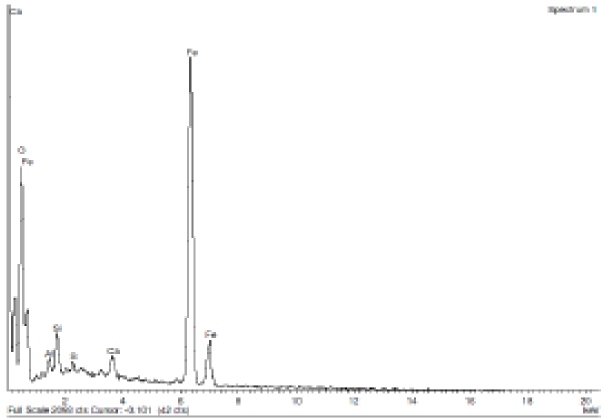

Figure 5 EDAX Graph Showed Chemical Composition of Deposits

Table 3 Composition of deposition

Element	Element %	Atomic %
O	40.76	68.42
Al	1.48	1.48
Si	3.66	3.50
S	0.78	0.66
Ca	1.68	1.12
Fe	51.63	24.82

The agglomeration of the above individual element is the reason for "rock morphology" and change in orientation of the crystal.

4.4 X-Ray diffraction

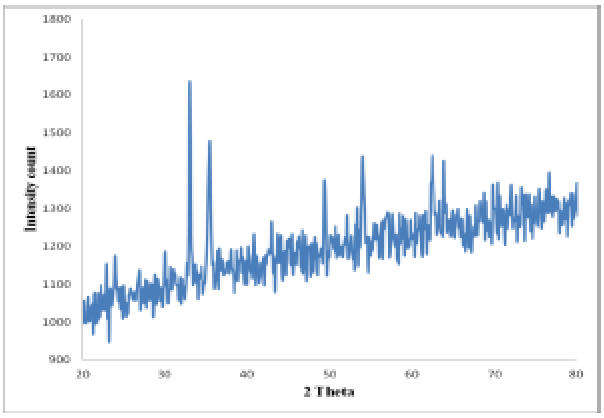

Figure 6 X-ray diffraction graph indicating the structural changes of eroded tube

Corresponding Author: V.Ethirajulu, Assisatant Professor, SRM University, Chennai, India. E-Mail: vethirajulu@gmail.com

The X-ray diffraction to indicate the uneven surface of eroded tube and also graph showed the structural changes.

5 Conclusion

Based on the type and sign of malfunction supported by morphological and compositional evidences derived from SEM, EDAX analysis one can be sure that the malfunction of economizer tube is due to “Fly Ash Erosion” rather than any other malfunction causes listed above. This type of malfunction occurs mainly due to the accumulation of ash deposits on the fireside. In high ash coal fired boilers, fly ash erosion is a major concern and the tube malfunctions due to fly ash erosion are almost 45% of the total tube malfunctions. Fly ash erosion is also experienced in the primary super heater.

References

[1] M.Ananda Rao and T.S.N. Sankara Narayanan, (2012) “Malfunction investigation of a boiler bank tube from a 77×2 MW coal based thermal power plant in the northwest region of India,Engineering Malfunction Analysis 26 (325–331) .

[2] Liu, (2013) “Malfunction analysis on the economizers of a biomass fuel boiler”,Engineering Malfunction Analysis 31(2013)101-117,February.

[3] Khalil Ranjbar, (2006) “Malfunction analysis of boiler cold and hot reheater tubes”,Engineering Malfunction Analysis 14 (2007) 620–625.

[4] M.R. Khajavi, A.R. Abdolmaleki ,N. Adibi, S,(2005) “Malfunction analysis of bank front boiler”, Engineering Malfunction Analysis 14 (2007) 731–738.

[5] ZhiYuan Liang, QinXin Zhao.(2013) Malfunction analysis of spiral finned tube on the economizer”, Engineering Malfunction Analysis, volume28.

[6] J. Ahmad J. Purbolaksono L.C. Beng A.Z. Rashid A. Khinani A.A. Ali and S.K. Dhua, (2009) “Malfunction investigation on rear water wall tube of boiler,”Engineering Malfunction Analysis 16 (2009) 2325–2332.

Corresponding Author: V.Ethirajulu, Assisatant Professor, SRM University, Chennai, India. E-Mail: vethirajulu@gmail.com

[7] S.K. Dhua,(2010) “Metallurgical investigation of failed boiler water-wall tubes received from a thermal power station”,Engineering Malfunction Analysis 17 (2010) 1572–1579

[8] T.A. Daniel Sagayaraj, Suresh S,(2009), “Experimental studies on the erosion rate of different heat treated carbon steel economiser tubes of power boilers by fly ash particles”, Volume 16, Number 5

[9] HockChye Qua, ChwinChieh Khaw, (2011) “Fast identification of O2 corrosion in economiser tubes”,Engineering Malfunction Analysis 18 (2011) 2201–2210.

[10] Farhad Daneshvar-Fatah, Amir Mostafaei, (2012)“Caustic corrosion in a boiler waterside tube Root cause and mechanism”, Engineering Malfunction Analysis 28 (2013) 69–77.