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"A REVIEW PAPER ON BOILER TUBES FAILURE: CAUSES & REMEDIES"

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Abstract

Failure of tubes in boiler of the power plants may happen due to different reasons. These include failures due to creep, wearing away, overheating and many other reasons. Unscheduled boiler outages in process businesses are a major problem resulting not only in expensive emergency repairs, but also loss of production. This paper draws on the experience of the author's company relating to common failures of pressure parts of boilers. The paper identifies the most common types of pressure part failure and the involved. With the knowledge of the hidden failure some basic causes can be identified. Overheating and wall thinning of the tubes resulted from oxygen escaping to the inner side of these tubes, and presence of deposits and oxides on the external and internal sides which led to failure was studied a lot. Engineering fixes were also given to confine the problem and to prevent it in future. The mechanical properties of boiler tube material have been tested at the section of failure, which gave significant clue for maintenance.measures and were taken in the method of coal firing, quality of water and operation of plant.

Keyword-boiler tube, tube failure, coating, fossil-fired boiler, erosion, corrosion

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1.INTRODUCTION

Unexpected boiler tube failure is the major factorcausing unreliability in utility boilers. Boiler tubefailure is the major cause of unscheduled shutdowns inthe coal fired boiler plants, which is responsible forproduction loss. There are many factors responsible forboiler tube failure like, short time overheating, longtime overheating, creep, thermal fatigue, mechanicaloverload, corrosive fatigue[1,2], Solid particle erosionof metals and alloys at elevated temperature is a loss ofmaterials during repetitive impacts of solid particles,and is one of the primary reasons for the damage ofcomponents used in the energy production andutilization industries such as coal gasifiers, fluidizedbed combustors, steam turbine, gas turbine andcompressor blades[3]. To estimate the remaining life ofpower plant boilers which have been in use from longtime is highly demanded for economy and safetyreasons. In India there is a great demand as some powersector boilers are older than twenty years. In real lifeboth premature retirement and life extension (in relationto design life) can be encountered. The decision forretiring a component is not purely technical but alsoone of economics and safety [4]. The present study isrelated to the boiler tube failure analysis of threeBoilers which are under operation at

NationalFertilizers Limited Naya Nangal. The stem generationplant consists of three boilers, which are in operationsince 1970.Thermal Power Station Power station is located in the Workington area of the capital city along Coventry road. Station 1 commissioned in 1942 had a capacity of 21MW but was decommissioned in 1970. Station

2 had an initial capacity of 75MW when it was commissioned in 1955, but it was de-rated to 20MW due to uneconomical units. This station consists of nine chain-grate boilers and six turbo-alternators. Five boilers and three turbo-alternators have since been decommissioned. With a capacity of 60MW, Station 3 consists of pulverized fuel-fired boilers. The station also has two large turbo-alternator machines producing 30MW each. Currently one of the turbo alternators is not in service as it is awaiting turbovisory equipment for it to return to service. Stations 2 and 3 operate independently but they are linked electrically through four interconnector transformers. Presently, the dependable capacity for Station 2 is 20MW while Station 3 has a dependable capacity of 30MW.The function of the boiler is to convert water into superheated steam, which is then delivered to turbine to generate electricity. At the same time reliability and safety aspect is also to be considered.

2. LITERATURE REVIEW

Adarsh Kumar and at all [1] describe the boiler tube failure is occurring frequently in fertilizer plants, power plants, sugar manufacturing plants, paper manufacturing plants and all industries using boilers. There are many factors responsible for boiler tube failure like, short time

overheating, long time overheating, creep, thermal fatigue, mechanical overload, corrosive fatigue. Caustic Attack, Oxygen Pitting, Hydrogen Damage, Acid Attack, Stress Corrosion Cracking (SCC), Waterside Corrosion Fatigue, Super heater Fireside Ash Corrosion, High temperature Oxidation, Water wall Fireside Corrosion, Fireside Corrosion Fatigue, Graphitization, Dissimilar Metal Weld, Erosion and Mechanical Fatigue. There may be some other reasons depends upon the service conditions but we can diagnose the reason in advance by visual inspection and NDT techniques images were reviewed for detecting internal failure and their propagation. The mechanical properties of boiler tube material have been tested at the section of failure, which gave significant clue for preventive maintenance. which can save the production loss of the industry and increase the safety of workers.

Suhas R Bamrotwar and at all [2] describe cause & effect analysis of boiler tube failures and identifies the zone where the failure are more and also emphasis on the factors which contribute for such type failure mechanism. The data pertaining to boiler tube failures for one of Thermal Power Plant in Maharashtra State of last ten years is referred. Out of total 144 failures, 43 failures are observed in Economizer zone. Economizer is the main part of the boiler in the furnace second pass. It is the medium for transportation of the feed water to boiler drum. It helps to increase the boiler efficiency. Economizer is placed in the flue gas path, to absorb the heat from the flue gas and increase the temperature of the feed water. Factors contributing for Economizer tube failure include stress rupture, fatigue, erosion, water side corrosion, fire side corrosion and lack of material quality.

K.Balamanikandasuthan and at all
[3] describe use of tube shields for the boiler tube protection is studied and an analysis of different alloy materials for tube shielding is done by comparing its thermal property and a suitable material is selected. Out of the four materials Stainless Steel 30 , Stainless Steel 316 Stainless Steel 316L , Stainless Steel 304 chosen to provide as a shielding, SS 316 was found to have a higher heat transfer (Q) value than the other materials. Hence, SS 316 is suggested as a suitable material for shielding. The heat transfer co-efficient and the net heat flux is not much affected by adding the protective shield to the eroded portion of the
pipe bend. In turn it slightly improves the heat transfer rate. Thus, providing SS 316 as a shielding to the reheater bends prevents the reheater tubes from getting eroded and increases the operational life of the tubes, leading to effective functioning of the plant.

Amabogha B. [4] describes Coating technology is one of the more rapidly growing technologies in the field of materials. A combination of the development of materials specifically designed for erosion and corrosion resistance and the appropriate technique for the application of these materials, as a coating would be the optimum solution. From a production point of view, three methods are in current use to deposit coatings, these being chemical vapour deposition (CVD), physical vapour deposition (PVD) and Plasma spraying. The CVD process comes under the category of Diffusion coatings, in which the coating material forms a chemical bond with the substrate. Whereas the PVD and Thermal spraying processes comes under the category of Overlay coatings, in which the desired material is placed over the substrate material. coatings made of Al2O3 containing 13 wt% TiO2 are commonly used to improve the wearcorrosion and erosion resistance of steel.

Piyushkumar B. and at all [5] describes about case study of CFBC boiler whose tube failure frequently due to erosion. It is found out that the causes, as known Lignite contains 2.55% sulphur it breaks bond between refractory and it breaks
so, erosion is mainly found due to refractory failure. When lignite fired in internal circulation within furnace so back flow occurs. And furnace bed temperature not maintained it causes uniform erosion pattern at kick off zone. There are many more solutions available to avoid erosion; anti abrasive coating is one of them. Also in this case it is required to remove excess refractory from kick off zone as shown in fig.2 and at time of erection of panel butt joints of fin are not properly ground flushed shown in fig 3, due to these flow of material gets diverted and tube eroded.

Mohammed Imran [6] describes Oxygen corrosion in boiler feedwater systems can occur during start-up and shutdown and while the boiler system is on standby or in storage, if proper procedures are not followed. Systems must be stored properly to prevent corrosion damage, which can occur in a matter of hours in the absence of proper lay-up procedures. Both the water/steam side and the fireside are subject to downtime corrosion and must be protected. Corrosion also occurs in boiler feedwater and condensate systems. Corrosion products generated both in the preboiler section and the boiler may deposit on critical heat transfer surfaces of the boiler during operation and increase thepotential for localized corrosion or overheating..

3.COAL SAMPLES

Coal samples have been tested in the laboratory, following observations were made:

IM% w/w	1.04
Volatile Matter %w/w	16.02
Ash %w/w	47.95
Fixed Carbon %w/w	34.99
Gross Calorific Value cals/gm	3844
Net Calorific Value cals/gm	3699

Table1.

Case-I: Plant SGP (Mech), Section: Boiler-I Date:15.09.2005
Observations of Import Steam Super Heater Tube Leakage On 15.09.2005 coil no 1 from south side of ISSH

reported leakage [5] on the bottom tube just above theeconomizer of this coil in segment-B. During analysis,it was found that failure occurred because of erosion caused by ash passing between this tube & skin casing.Around one meter length of the tube had severethinning because of this erosion. Also the tube just above this tube in the same coil had severe thinning. Then the coil was plugged with alloy steel taper plugs on both the headers using E-8018 electrodes.

Cause

Fig. 1. Import Steam Super Heater Tubes of Boiler SGP NFL Naya Nangal.

Superheater Fireside Ash Corrosion resulted in external tube wall loss and increasing tube strain. Tubes commonly have a pock-marked appearance when scale and corrosion products are removed. Fireside ash corrosion is a function of the ash characteristics of the fuel and boiler design. It usually is associated with coal firing, but also can occur for certain types of oil firing. Ash characteristics are considered in the boiler design when establishing the size, geometry and materials used in the boiler. Combustion gas and metal temperatures in the convection passes are importantconsiderations. Damage occurs when certain coal ash constituents remain in a molten state on the superheater tube surfaces. This molten ash can be highly corrosive

Case-II: Plant SGP (Mech), Section: Boiler-I Date:10.11.2005

Failure Observation of Economizer

On 10.11.2005 water leakage was detected in theeconomizer tubes in the south east side of the coils [5]. The boiler was shut down for maintenance. After opening the manhole & entering the economizer top following observations were recorded: 25th coil, 2nd loop top SN between segment C&D is having 3mm diameter hole and also eroded 3 inch in length. Due to the impingement of the above leaky coil on coil No 24.first loop bottom length all around & 4 inch in length was found heavy reduction in thickness. NDT testing of surrounding tubes was done and reduction in thickness was observe

Cause

Aggressive localized corrosion and loss of tube wall, most prevalent near economizer feed water inlet on operating boilers. Flooded or non-drainable surfaces are most susceptible during outage periods. Oxygen pitting occurs with the presence of excessive oxygen in boiler water. Non-drainable locations of boiler circuits, such as super heater

Fig. 2. Economizer Tubes of Boiler-I SGP NFL Naya Nangal.

loops, sagging horizontal

superheater and reheater tubes, and supply lines, are especially susceptible. More generalized oxidation of tubes during idle periods is sometimes referred to as out-of-service corrosion. Wetted surfaces are subjectto oxidation as the water reacts with the iron to form iron oxide. When corrosive ash is present, moisture on tube surfaces from condensation or water washing can react with elements in the ash to form acids that lead to a much more aggressive attack on metal surfaces

Case-III: Plant SGP (Mech), Section: Boiler-I Date:22.07.2008

Failure Observation of Bank tubes

Bank tubes of Boiler-I were observed to be leakage near stem drum. 3 no (2 side wall and 1 bank tube) leaked [5] in succession one after the other. When pressure testing was carried out initially side wall tube 4th in North cluster on west side of drum was found leaking. In pressure testing side wall tube 5th in the same cluster was found leaking. When again pressure testing was done 18-1 bank tube was found leaking. All these were plugged in both steam drum and the mud drum of the boiler no I and DPT of the root of each tube was done. Adjoining tubes in the same areas were also scanned for pinhole by grinding, DPT and then welding. Welding electrode used was 7018 2.5 mm, plug size 41.0×44.0×60.0mm

Cause.

Fireside ash corrosion is a function of the ashcharacteristics of the fuel and boiler design. It usually is associated with coal firing, but also can occur for certain types of oil firing. Ash characteristics are considered in the boiler design when establishing the size, geometry and materials used in the boiler.Combustion gas and metal temperatures in the convection passes are important considerations. Damage occurs when certain coal ash constituents remain in a molten state on the water tubes and super heater tube surfaces. This molten ash can be highly corrosive

Case-IV: Plant SGP (Mech), Section: Boiler-IIDate: 3.10.2005

Failure Observation of Bank tubes leakages

Leakage was observed in boiler no 2 in bank tube south side and steam leakage was observed in the north side near ISSH. Manhole cover of ISSH and economizer were opened and

observations are 8th row (W-E) and tube No 4(N-S) in the north cluster were completely open [5]. Skin casing was cut and removed and observed that leakage was at the outlet of the steam drum. This leakage had also damaged the 7th tube in the same cluster due to impingement of water.After scanning the tube it was decided to plug the tubes ends.

Cause.

Failure of the first tube was contributed to theleakage travel between tube outer diameter and tube sheet internal diameter. The small pinhole in the weld joint is responsible for the leakage of the other tubes.The photographs of the damaged tube are given below. Stress corrosion cracking failures were observed as in a thick wall, brittle-type crack at location of higher external stresses, such as near joints

Fig. 4. Plugging of Bank Tubes of Boiler-II SGP NFL Naya Nangal.

was observed.These failures are associated with austenitic super heater materials and can lead to either transgranular or intergranular crack propagation in the tube wall. It occurs where a combination of high-tensile stresses and a corrosive fluid are present. The damage results from cracks that propagate from the ID. The source of corrosive fluid may be carryover into the superheater from the steam drum or from contamination during boiler acid cleaning if the superheater is not properly protected.Combustion gas and metal temperatures in the convection passes are important considerations.Damage occurs when certain coal ash constituents remain in a molten state on the superheater tube surfaces. This molten ash can be highly corrosive and eroded the surface of boiler tubes. The Combined effect leads to the breakdown of the protective magnetite on the ID surface of the boiler tube. The loss of this protective scale exposes tube to corrosion.

4.REMEDIES

1.The techniques and control of de-aeration should be improved in order to make that all sources of contamination are eliminated.

2.In the time of occurring sudden rupture of the tube in the furnace, boiler must be shut down immediately to minimize or avoid (a) erosion of adjacent tubes of furnace side wall by escaping steam; (b) overheating of the other tubes because of a loss of boiler circulation, and (c) damage to other components in the system resulting from loss of working fluid.

3.Periodic removal of deposits from internal surfaces in the furnaces is part of the normal maintenance of this equipment. Removal of deposits can minimize unscheduled outages caused by.tube rupture due to overheating. Chemical cleaning with a suitable inhibited acid (citric acid, hexa amen and PO4) offers several advantages: less down time; lower cost; ability to clean otherwise in accessible areas such as sharpbends, and ability to clean internal surfaces without dismantling the unit

4. Oxygen must be removed from feed water by using hydrazine in water treatment process

5. It is important to keep fire-side surfaces free of deposits particularly in regions ofhigh heat flux, because of the effect on tube wall temperature.

6. Firing of boiler can be controlled using low excess O2. In this way, 1% excess O2 to maintain a safety cushion in the operation is achieved. The metals in the fuel yield relatively large amounts of high melting point compounds (1930oC). These high melting point compounds do not slag or foul the furnace and do not corrode the metal surface.

7.Fuel treatment using chemical treatment is recommended to neutralize the deleterious effect of V, Na and S. This treatment can be done by three ways: (a) adding MgO or Mg(OH)2 to the fuel, these chemicals form high melting point compounds that are friable and easily removed. (b) organic compounds of Fe and Mn are used to increase combustion reduction rates and minimize the presence of atomic O2. (c) Using combination of MgO or Mg(OH)2 and other metal oxides, these chemical formulations are also used to treat residual fuel oils.

8.Distillate fuel should be used to avoid ash and dirty particles, which might cause corrosion and erosion

5.CONCLUSION

From above research papers we can concludethat,

1) The main causes of boiler tube failure are short time overheating, long time overheating, creep, thermal fatigue, mechanical overload, corrosive fatigue , Waterside Corrosion Fatigue, Super heater Fireside Ash Corrosion, Water wall Fireside Corrosion, Fireside Corrosion Fatigue, Graphitization, Dissimilar Metal Weld, Erosion and Mechanical Fatigue.

2)The Major four areas of boiler are identified i.e. Water wall, Economiser, Reheater, and Final superheater and the tube failure occurred in different zones with the loss in generation on account of tube failures were studied. Based on the data, it was found around 30% of failures occurred in Economiser zone.

3)Providing SS 316 as a shielding to the reheater bends prevents the reheater tubes from getting eroded and increases the operational life of the tubes, leading to effective functioning of the plant.

4) Coatings made of Al2O3 containing 13 wt% TiO2 are commonly used to improve the wear-corrosion and erosion resistance of steel. Presence of sulfur in the oil ash deposited on the fireside surfaces of the tube appears to be the main cause of the failure of the boiler tubes.

5. Because of sudden rupture that cause due to overheating, the steam would escape at high velocity through such rupture. Therefore, a loss of circulation boiler tubes would cause rapid overheating in the adjacent tubes.

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