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Analysis of Boiler Tube Failure

R.Karthikeyan [a], C.Karthick Srinivas [b] ,U.Logeshwaran
[a]Assistant Professor, Department of Mechanical Engineering, VelTech, Avadi, Chennai, Tamilnadu, India
[b] Student, Department of Mechanical Engineering, VelTech, Avadi, Chennai ,Tamilnadu, India

Abstract: The Causes and mechanisms of failure area unit mentioned and recommendation for hindrance of reoccurrence of such failure is provided. The tubes had circumferential cracks and blown up parts. All the failures were detected on the fire-side surfaces of the tubes. Presence of sulphur within the oil ash deposits on the fire-side of the tubes seems to be the most reason for failure of boiler tubes. The cracking of the tube at the well-intentioned was thanks to the combined result of S-induced corrosion and attachment stresses. Circumferential fissures initiated by the liquefied ash were increased greatly thanks to attachment stresses and resulted within the cracking of tube Ate the part. it's counseled to avoid high sulphur within the fuel and to take care of an occasional metal temperature within the boiler. Super heater tubes of boiler of thermal powerhouse were found busted. The rupturing and hole formation within the superheated tubes is that the results of long run heating of the tubes. dilution of tube walls occurred thanks to localized deposits and heating issues. For avoiding reoccurrence of such failures it's counseled to hold out regular scrutiny of scale deposition on the steam/water facet surface and mensuration of degradation within the boiler tube thickness. If the number of the deposits has crossed the allowable limit, cleanup of the tubes ought to be distributed right away.

Keywords:- *Corrosion, Fatigue failure, Erosion, Overhea Ting.*

I. INTRODUCTION

Failure analysis and also the principal mechanisms by that boiler tubes fail in commission are examined during this introduction. Deficiencies in style, fabrication, operational conditions, unsuitable materials choice and gone helpful life area unit necessary factors to contemplate not just for boiler tubes, however operational parts generally. so the failure analysis should contemplate them of primary importance once a failure happens in an exceedingly boiler. If known early, potential failures or accidents will usually be prevented, and as a result pricey repair expenses, lost revenue and legal expenses is also avoided. to research a failure, and analyse the conditions that promoted the failure, necessary info on the build and model of thee boiler and also the tube, specification, the service history and physical proof of the failing half area unit necessary parts to see why, how, when, and wherever a failure might have occurred. If these answers area unit provided throughout the course of the Investigation, future failures is also higher understood or presumably prevented. The conditions that promoted the failure area unit essential in distinctive the underlying factors which will have initiated the failure. Provided during this survey may be a step by step approach to failure analysis investigation. The accepted theories and mechanisms, that cause boiler parts to fail, are explored during this investigation.

II. BOILER FAILURE ANALYSIS

Internal pressurised tubes area unit essential part in water tube boiler and steam super heater part. Tubes in such application area unit liable to temperature excursions, as a consequence the fabric might enter the creep regime, and creep deformation and even fracture might occur. Therefore, boiler tubes in power plants have finite life due to prolong exposure to warmth, stress, aggressive setting, corrosive degradation, etc. However, uses of safe boiler tube material in thermal power plants is needed to form positive that these materials area unit safely used below higher temperatures and pressures for long periods of operation[9].

Ray et al. [10] conducted assessment of service exposed to boiler tube of the super heater and reheater fabricated from two.25 Cr-1 Mo steels in an exceedingly one hundred twenty MW boiler of a the localized prolong heating as a consequence thermal powerhouse. The results show that though there was degradation of final lastingness (UTS), and stress rupture of the boiler tubes thanks to increasing temperature and prolonged service exposure, however at the operational condition of 540oC/40 mpa, of these service exposed tubes have a remaining lifetime of quite one hundred,000 hours, providing there are not any defects within the materials thanks to long run service exposure. Husain and Habib [11] investigated the steel tubes failure in an exceedingly super heater boiler at one in every of the Kuwait Electrical and Power plants that suffered localized heating. The tube was fabricated from low steel, Storm Troops 213-T12 and it's been operational for 109,415 hours before failing. The investigation indicated that the failure attributed to the formation of thick scale of magnetic iron-ore at the inner surface of the tube wall. This development prevented the accessibility of warmth to the tube materials and consequently native, prolong heating occurred, within which the temperature raised up to 700oC in an exceedingly frequent manner for long amount of your time. The properties of the tube materials modified from its original style values thanks to the result of the localized prolong heating as a consequence of accelerating of the temperature. Baoyou et al. [12], analyzed a

boiler tube rupture through analysis, scanning microscope, and energy dispersive spectrographic analysis. The result showed that the tube burst thanks to heating and excess temperature caused by obstruction of stream flow.

III. MATERAL SELECTION

Inclusion in ASME Code or Code Case or equivalent International code Adequate warmth mechanical strength Average stress to rupture of one hundred Mpa for one hundred,000 hrs. at style temperature of part. Knowledge of weld strength reduction factors High thermal conduction & low thermal growth constant to attenuate thermal stresses. Good Formability & Weld ability Satisfactory corrosion resistance in steam & flue gas Moderate creep- fatigue interaction Industrial availableness / confidence in autochthonal development.

IV. METHODOLOGY

Visual Examination analysis Techniques Fracture Mechanics

V. FAILURE MECHANISMS

There area unit many various varieties of boiler tube failure mechanisms, which might be sorted into six categories: Stress rupture (short-term heating, warmth creep, dissimilar metal welds) Water-side corrosion (caustic corrosion, atomic number 1 injury, pitting, stress corrosion cracking) Fire-side corrosion (low temperature, water wall, ash) Erosion (fly ash, falling scoria, soot blower, coal particle and regularly amendment the load variation) Fatigue (vibration, thermal expansion) Lack of management internal control} (damage throughout chemical cleanup poor water chemistry control, material defects, attachment defect).

A. Short Term Over Heating

Short terms heating in water cooled tubes due to abnormal fluid flow area unit excessive combustion gas temperature. As a result, the tubes area unit subjected to to a fault warmth usually many degrees which ends in speedy failure. Fig 1.

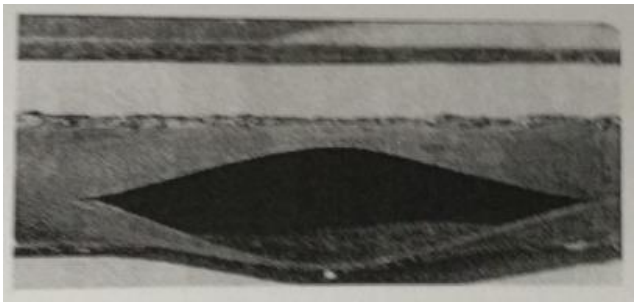

Fig 1:- Short Term Over Heating

- *Corrective Actions*

The deposits are often blown off that is extremely time intense, or The unit are often with chemicals closed.

B. Long Run Over Heating

long run heating happens thanks to choice of incorrect material, scale formation within the tube, Water facet deposits. Fig 2.

Fig 2:- Long Run Over Heating

- *Corrective Actions*

Temporary pad welds mustn't be used due to the uncertainty related to base metal condition. Tube shielding

C. Dissimilar Welded Joints

Dissimilar metal welds causes rupture for Boiler tubes. this sort of failure principally happens thanks to use of dissimilar metal rods for attachment the tube. The prime location of dissimilar metal welds rods failures area unit super heater, Reheater dissimilar weld joints. Fig 3.

Fig 3:- Dissimilar Welded Joints

- *Corrective Actions*

Replacement. Frequent scrutiny.

D. Atomic Number 1 Damage

Atomic number 1 injury in boiler tubes is caused by a corrosive reaction between steam and steel. The atomic number 1 that's free reacts with carbides to decarbine the steel and forms gas gas at the boundaries. Results in wall loss thanks to corrosion and reduces the strength in material attacked by atomic number 1. The injury typically happens in

areas of high heat flux and flow disturbances embrace tubes opposite to burners and tube bends. Fig 4.

Fig 4:- Atomic Number 1 Damage

- *Corrective Action*

Chemical cleanup Replace affected tubes

E. High Temperatures Creep

Warmth creep ends up in stress rupture of boiler tubes. Causes for such failures area unit general blockage, incorrect material, and material transition higher stress thanks to weld attachment. Fig 5.

Fig 5:- High Temperatures Creep

- *Corrective Action*

Corrective actions involve the determination of the remaining lifetime of the conduit supported the particular temperature, stress level, and material properties. Corrective actions like a tube defend log, to scale back the speed of wall dilution caused by corrosion or erosion.

F. Caustic Corrosion

The boiler tube failing thanks to caustic corrosion, it arises due Feed water system corrosion deposits, condenser tube outflow, and better concentration of NaOH in Boiler water and temperature increase thanks to internal deposits. Fig 6.

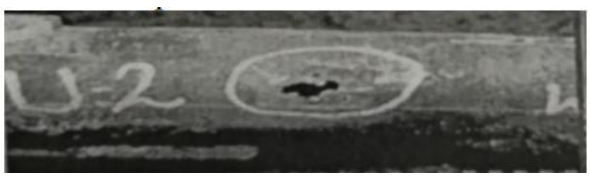

Fig 6:- Caustic Corrosion

- *Corrective Action*

Corrective action involve management of boiler water chemistry, step-down of feed water corrosion product and condenser outflow product into the boiler, and removal of corrosion product deposits by periodic chemical cleanup.

G. Fatigue Failure

Fatigue failure of tubes arises thanks to improper flexibility, attachment weld corrosion, cold bend restriction to the thermal growth, improper heat treatment and contouring of welds. Fig 7.

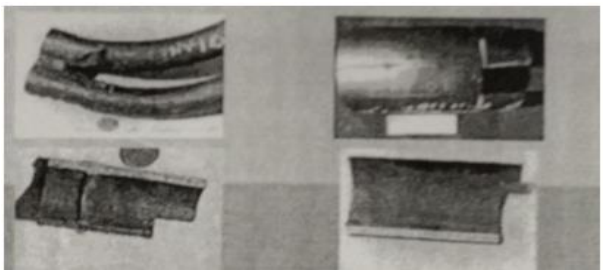

Fig 7:- Fatigue Failure

- *Corrective Action*

Corrective actions involve replacement of the broken conduit once the depth of the cracks approaches the bounds of the fabric to contain the interior pressure.

H. Ash Erosion

Ash has abrasive action it erodes the outer surface of tube in economiser, LTSH, Reheater regions. the main reason for ash erosions area unit, Temperature of flue gas, high ash content in coal high flue gas rate and high impingement angle of ash particle. Fig 8.

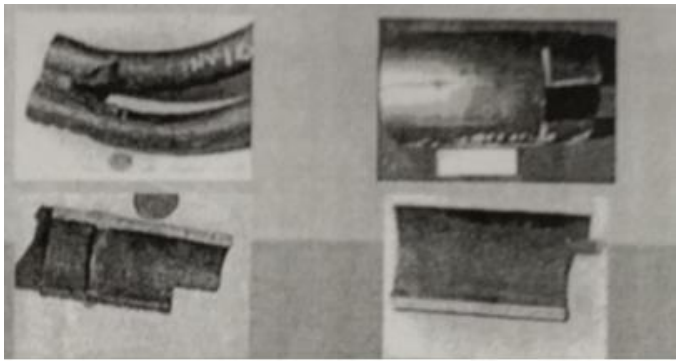

Fig 8:- Ash Erosion

- *Corrective Action*

Corrective actions concerned either reducing the number and rate of ash placing the tube or increasing the number of wear and tear resistance of the tube. Changing

boiler operation conditions like reducing load, equalization air flows and preventing ash accumulations.

I. Pitting

The formation of tiny pits in an exceedingly surface as a consequence of corrosion. Pitting corrosion might takes place within the setting of stagnant ventilated water fashioned throughout ending. Most acquainted kind chemical element attack in boiler and atmospheric phenomenon system Dissolved chemical element is important to corrosion of copper alloy tubes. At higher temperatures chemical element weakness steel.

- *Corrective Actions*

If D.O in feed water is > 10ppb, its supply must be known and in remission is also automatically or with chemicals. Proper operation of deareator L.P.Feed tank.

VI. SURVEY OF BOILER TUBE FAILURES

The plant is of 210 MW generation capability with the prime fuel used as fine coal. Major four area unitas of boiler are known i.e. Water wall, Economizer, low worker SH, and Final SH and also the tube failure occurred in several zones with the loss in generation on account of tube failures were studied. supported the info, it absolutely was found around half-hour of failures occurred in economiser zone.

VII. FORMALIZED BOILER TUBE FAILURE

A. Prevention Programe

Each boiler tube failure are reportable and documented by accountable personal in an exceedingly comprehensive format describing: Specific boiler and tube location Failure mechanism Root-cause and verification basis Type of repair and name of repair Type and extend of prepare-inspection and name inspector Future preventive and management action taken or counseled

B. Live Of Water tube Corrosion

It's counsel, to manage the ingress of cooling water from the condenser tube outflow which can cut back the phenomena of salt concentration on the interior surface boiler tubes.

C. Scale Formation

Any scale in an exceedingly boiler is undesirable. the simplest thanks to subsume scale isn't to let it kind within the initial place. Scale formation is prevented by External pretreatment of boiler makeup water (using water softeners, de-alkalizes, demineralizers, and reverse osmosis) to get rid of hardness/ scale forming minerals before they enter the boiler system. Internal treatment exploitation chemical kindulation into the boiler feed water for example phosphate treatment to stay the common scale forming materials in dissolved form. Adopting correct boiler blow down practices to limit the concentration of scale forming material by dominant cycles of concentration. a section of water is intentionally drained off to stop the fabric engineered up. A cycle of concentration within the magnitude relation of the makeup rate to the blow down rate. The boiler feed water is that the add of atmospheric phenomenon come + makeup water. The atmospheric phenomenon water turn out as a results of condensation of gaseous stream is extremely pure and freed from hardness inflicting salts. The makeup water on the opposite hands has impurities, that should to be treated to get rid of the hardness solve. so the upper conjure water, the shall be the impurities and better are scale forming tendencies.

D. Measures of Hearth Corrosion

- Short-Term Overheating: Identification

Short term heating of times are often known by metallographic examination. Such analysis needs sectioning of the tube for microscopic examination. Most different identification techniques area unit less effective. many factors usually gift in failure caused by short heating area unit uniform tube growth, absence of serious internal deposits, absence of enormous amounts of thermally fashioned magnetic iron-ore, and violent rupture. short heating might turn out bulging. In terribly speedy heating, a thick walled longitudinal metal strength is markedly reduced. In fact, if temperatures rise to terribly high level, failure can occur quickly. If failure happens chop-chop, bulging is also absent and also the rupture are often violent, generally bending the tube virtually double and inflicting secondary metal tearing. within the case of thick-walled ruptures, the tube circumference at the rupture is usually nearly specifically adequate the tube circumference removed from the rupture. Tube circumferences are often roughly measured with a bit of string. Rupture edges is also blunt and retain most of their original wall thickness or bit by bit taper to knifelike or chisel like edges. In some cases, the tube diameter is also uniformly enlarged with no rupture occurring.

- *Elimination*

The answer of short heating, that is commonly caused by transient upset condition, is to eliminate the upset. If restricted fluid flow thanks to tube plug gage is suspected, drums, headers, U-bends, long horizontal runs, and different areas wherever detritus might accumulate ought to be inspected and clean. this is often very true if a failure happens shortly when a boiler cleanup. The drum water level, firing procedures and blow down and start-up procedures ought to be fastidiously monitored. Suspension ought to be aroused if a short failure happens right away when another failure. A failure might disturb circulation, dislodge deposits, and dislodge corrosion product. This, in turn, might have an effect on heat transfer. LONG- TERM heating

- *Identification*

A thick, brittle magnetic iron-ore layer close to the failure indicates semipermanent heating. At greatly elevated

temperature (short-term overheating) reduction in metal strength is such failure happens before important quantity of oxides will develop. Bulging and plastics deformations area unit nearly always gift if the tube is pressurised. Tubes busted as a results of semipermanent heating typically show bulging and plastics deformation at the failure website. The rupture is nearly forever longitudinal, with a fish-mouth form. Rupture is also knifelike or thick counting on the time, temperature, and stress levels concerned. Multiple bulges might occur. Water-side deposits can typically gift and can usually be arduous and stratified. Deposits can typically be "baked" onto the wall and can become arduous brittle. Deposits tend to point out multiple layers of various colours and textures, the innermost layer being hardest and most far sighted. Visual scrutiny in adequate for chemical reaction, spalling, and bulging. thermocouple junction mensuration throughout service ofttimes provides sensible info. the simplest thanks to ascertain that semipermanent heating has occurred is by metallographic scrutiny of a failing tube.

- *Elimination*

Eliminating semipermanent heating needs removal of a chronic system defect. Headers, U-bends, long horizontal runs, and also the hottest areas ought to be inspected for proof of obstruction, scales, deposits, and different foreign material. Excess deposits ought to be removed by chemical or mechanical cleanup and prevented from revenant. Firing procedures, BTU worth of fuels, and in-service chamber temperature close to hot areas ought to be checked. Attemperation procedures ought to even be reviewed. If needed, changes in scientific discipline, tube shielding, and also the even handed use of refractories ought to be thought-about. The supply of serious deposits should be known and eliminated. Common causes of deposits embrace improper water treatment, system contamination, improper boiler operation and/or excessive heat input. every potential cause should be self-addressed methodically.

E. Erosion Identification

Fly-ash erosion of times causes swimmingly polished surfaces. In different cases irregular flow marks and shaping area unit made by eddies around scoria encrustations, hangers, brackets, etc. In extreme cases, dilution will cause rupture. Attack is also localized or general. Discrimination between fly-ash erosion and different types of fire-side erosion needs a lot of info. Effects of rate and ash content on the lifetime of a tube. will increase within the variety and rate of the impacting ash particles may result in reduced service life. Deep grooves delve the recent facet of a water wall tube. shaping was caused by channeling of chamber gases containing entrained ash. Locations within the boiler within which attack happens, positions of deflecting baffles, quantity of entrained ash, and native gas rate area unit necessary clues to attack. Fire-side chemical compound and deposit layers arte typically abundant agent on wasted regions, permitting discrimination from coal-ash or oil-ash corrosion, within which deposits and corrosion-product accumulations area unit intensive. No chemical attack is gift as may well be expected in cold-end corrosion. once ruptures occur, they're typically thin-edged. shut scrutiny of the rupture website usually reveals dilution of the external surface and no heating or corrosion. Metallographic examination might reveal microscopic plastic deformation on diluted surfaces caused by impingement of high-speed particles.

- *Alimentation*

Decreasing fly-ash erosion needs a system operations approach. This includes ensuring all baffles; collectors, refractories, and also the like area unit operating properly. In extreme cases, design of boiler parts perhaps needed. of course, reducing the number and rate of ash will limit injury. In extreme cases, fuels less vulnerable to turn out erosive ash might ought to be used. High load and excess air increase flue-gas rate, and thus, increase attack. Slagging promotes fly-ash erosion by channeling gases and increasing eddying. applicable fuel additives and soot processing will cut back slagging. Baffles are accustomed distribute flue gases, and consequently, fly ash, a lot of equally. However, wherever gas flow is horizontal through tube banks, problematic is usually absent. scoria fences are accustomed forestall larger scoria items from coming into horizontal tube banks. Shielding and metal spray coatings area unit beneficially employed in sure erosion-prone locations.

VIII. CONCLUSION

Supported the survey of boiler tube failures were occurred in economizer thanks to ash content is a lot of (40 percent) to avoid that use an honest quality of coal as a result of it's low ash content and providing shrouding and shielding to avoid the break downs. Chromium and metal additions to steel improve its resistance to cracking and decarburization by forming carbides that area unit a lot of thermodynamically stable than iron carbides five. Therefore, steel tubes employed in boilers ought to get replaced by steels containing metallic element and Mo. style of Cr-Mo steel can depend on the condition of the realm wherever these tubes are used. Overheating of the tubes ought to be avoided by effective cleanup of the steam-side surface of the tubes and removing all the tenacious deposits. During fabrication and assembly of the pipes with the welded joints, care ought to be taken to avoid generation of stresses at the weld parts.

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