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Failure Study of a Water Boiler Tube in a District Heating System to Generate Power

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ABSTRACT: The failure of the boiler tube remains the principal cause of forced outages of fossil boilers. The breakdown of the tube may be a trivial matter, unless it damages the power plant and compromises human security. The problem of the tube failure is only realised once the cost is assessed because of the failure. The major purpose of our project is to reduce the frequency of tube failures happening in thermal power plant accessories by assessing the reason and providing appropriate remedies for the failure of the tube. Boiler accessories are tube failures due to several factors and main failures are flue gas erosion, long-term overheating and steam erosion. The main reasons for failure are the tube failure. Major causes of failure can be controlled using following remedies, such as optimization of fluid gas speed, the use of greater creeping strength tube material and the provision of tube wall-side coating. The optimization for the flue gas rate is done by means of computing fluid dynamics software (Ansys fluent). The material for the boiler tube is based on the cost, creep resistance and corrosion resistance. The foregoing treatments, if adopted in power plants, can significantly reduce the tube failure.

I. INTRODUCTION

A. General General

In this chapter, we will explore tube failures in boiler accessories owing to different

Grounds and main reasons for failure are the erosion of flue gas, long-term overheating and steam erosion. The main reasons for failure are the tube failure. Major causes of failure can be controlled using following remedies, such as optimization of fluid gas speed, the use of greater creeping strength tube material and the provision of tube wall-side coating.

B. Boiler: A boiler is a container that provides a mechanism of transferring combustion heat into water till heated water or vapour. The hot water or the steam under pressure can then be used to deliver heat to a process. Water is a helpful and affordable medium in order to transport heat to a process that is nearly as explosive as cannon powder. This makes the boiler exceedingly unsafe and must be treated very carefully.

The process of heating a liquid to its gaseous form is known as evaporation. Heat is transmitted from one body to another by methods of

- ✚ the transmission of heat from the hot to the chilled body without a transport agent,
- ✚ the transmission of heat by means of convection mediums such as air or water
- ✚ Leading, physical contact heat transmission, molecule to molecule.

1.1 Boiler Water Tube

A water tube boiler is a type of boiler in which water circulates in externally heated tubes. Fuel is burned within the oven and hot gas is produced to heat water in the tubes producing steam. Additional generator tubes in the oven are separated in smaller boilers, while bigger utility kilns relay to water-filled tubes that create steam through the walls of the oven.

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Then the heated water gets into the steam drum. Here, saturated steam is drawn off the top of drum.

In some services, the steam will reenter the furnace through a super heater to become superheated. Cool water at the bottom of the steam drum returns to the feed water drum via large-bore 'down comer tubes', where it pre-heats the feed water supply. To increase economy of the boiler, exhaust gases are also used to pre-heat the air blown into the furnace and warm the feed water supply. Such water tube boilers in thermal power station are also called steam generating units. Fig 1.1 shows the schematic representation of a simple water tube boiler.

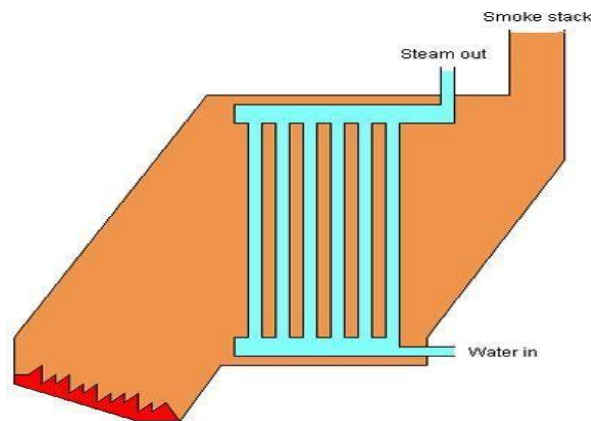


Fig. 1.1 simple water tube boiler

1.2 Boiler Tube

Boiler tubes are set of long goes several folds inside the furnace, sometimes their total length may be several kilometers mainly in the case of power plant boilers, and these tubes transfer heat from flue gas to water or steam. Fig 1.2 shows tubes of a typical water tube boiler in a power plant

Table 1.1 shows the specification of economizer tubes in water tube boiler of Thermal power station.



Fig. 1.2 Tubes of a water tube boiler

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Tube material	SA210GrA1(C=0.27%)
Tube diameter	44.5 mm
Tube thickness	4.5 mm
Tube length	32 km(approx)
No of bends	14
Tube arrangement	Horizontal
Tube bend diameter	65 mm

Table 1.1 specifications of economizer tube

II. CAUSES OF TUBE FAILURE

This chapter explains about problems in boiler tubes and the factors that cause major damage to the boiler tubes. This helped to identify the major reasons for tube failures and suggest suitable remedies for the failures caused due to the problems.

2.1 Types of failure

Failures in the boiler tubes occur at various places corresponding to the parameter causing the defect. Below listed are such failures which could be seen in boiler tubes

- Fish mouth opening
- Window opening
- Burst open puncture
- Pin hole puncture
- Crack formation

2.2 Areas of failure

Most of the failures in the boiler happen at repeated places. Places at which tube failures seen most are Economizer, Extended steam cooled tubes, Water walls, LTSH, Reheater tubes, Platen super heater and Final super heater. All these places require very good maintenance for longer life and to reduce the failure rate occurring in it.

2.3 Causes of Tube Failure

There are numerous that accounts to the failure of boiler tube in water tube boilers. There are twenty-two primary reasons for tube failures in a boiler. Knowledge and good operating and maintenance practice reduce tube failures. Reducing tube failure in boilers increases the availability of boiler.

A single tube failure in boiler may cause loss of millions of rupees apart from power loss. There are four major groups into which all tube failures can be classified. Tube failures are classified as in-service failures and can be grouped under four major causes:

- Erosion
- Corrosion
- Stress rupture
- Loss of quality

2.3.1 Erosion

There are various reasons behind the erosion of boiler like fly ash, coal particles etc. The factors that which causes erosion in boiler tubes are listed below

- Fly ash
- Falling slag
- Coal particles
- Air erosion

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2.3.1.1 Fly ash

Fly ash travels with the flue gas at the same speed around 11m/s when it continuously travels at this speed it would erode the metal in constant manner and finally it would reaches the critical limit at which the tube could no more with stand the pressure.

The amount of ash in coal and its velocity are major factors in the rate of fly ash erosion. fly ash erosion is experienced in the economizer, primary SH, and inlet section of steam reheater tubes. When non-uniform flue gas flow distribution occurs in these areas, the rate of erosion increases multifold.

Factors influencing fly ash erosion in coal fired boilers are

- The velocity of flue gas
- The temperature of flue gas
- The mineral content in coal
- The change in direction of flue gas
- The arrangement of pressure parts and
- The operation above the maximum conditions design rating or with excess airflow above design rate.

2.3.1.2 Coal particles

Coal particle erosion is to similar to Fly ash particles erosion in which unburnt coal particles flew with the Flue gas erodes the boiler tube material, it may also deposit on the tube surfaces and cause reduced heat transfer and corrosion. The following are the areas in boiler where coal particle erosion is normally experienced Economizer bends and tubes, Screen tubes, Goose neck portion at furnace top, Soot blower opening in the water walls, Wind box opening in the furnace, Bottom hoper tubes. Fig. 2.3 represents the boiler tube erosion due to coal particles.

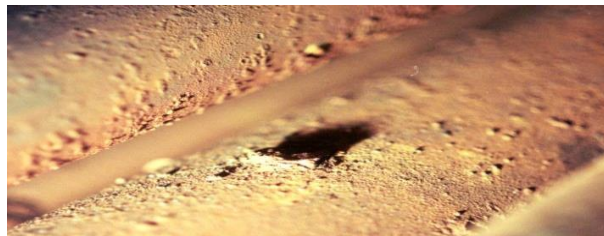


Fig. 2.3 Coal particle erosion

2.3.1.3 Slag formation

Slag is formed by the reaction of deposited ash particles with the boiler tube material, prolonged traveling of ash particles around boiler tube cause deposition of ash and at high temperature these ash deposit and boiler tube particle reacts to form molten metal slag , this falls on the lower tube and erodes those tubes. Fig. 2.4. represents the formation of slag around boiler tubes.



Fig. 2.4. Slag formed around boiler tubes

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2.3.1.4 Air erosion

Continuous flow of hot air in the flue gas also cause a considerable erosion, but when compared to other factors which is causing the erosion it is bit lower.

2.3.2 Stress rupture

Stress rupture is another important cause to the failure of boiler tubes in water tube boilers. Some reasons for the stress rupture of boilers are given below

- Long term over heating
- Short term over heating
- Dissimilar metal welding

2.3.2.1 Short term over heating

Short term over heating can occur if temperature of pressure part(tube, drum, pipe and header) increases rapidly in short period exceeding limitation of design temperature. It can occur at the pressure part which has high operating temperature such as superheated, reheater, water wall, roof wall, boiler bank, screen tubes and down comers and rarely occurs in low operating temperature of pressure part such as air heater and economizer. When the tube has insufficient cooling from water flow inside and receives excessive heat input from combustion process will lead to short term overheating. Fig. 2.5 shows the boiler tube failed due to short term overheating.



Fig. 2.5 Short term over heating

2.3.2.2 Long term over heating

Long term overheating tube failures are due to metal temperature of the boiler tubes going above the allowable limit. These types of failure are seen in steam cooled tubes like super heaters and re-heaters and in water cooled tubes of water walls. While selecting the tube there is a requirement to select the correct material for withstanding the metal temperature.

Normally the water cooled areas like economizer and water walls are made of carbon steel of boiler quality. Super heaters and re-heaters will have combination of low alloy tubes to stainless steel tubes selected to with stand the metal temperature. Fig. 2.6 shows the failure of boiler tube due to long term overheating.

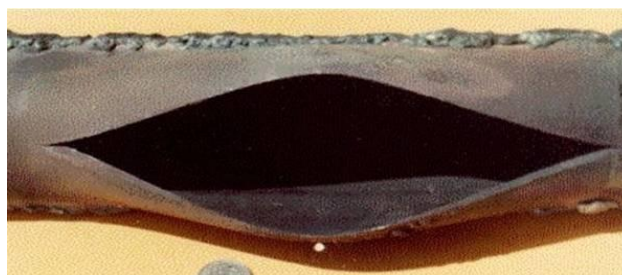


Fig. 2.6 long term overheating

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2.3.2.3 Dissimilar metal welding

In the thermal power station, dissimilar metal welds (DMWs) are used to join ferritic low-alloy steels to austenitic stainless steels. Unfortunately, these welds can fail prematurely from accelerated creep. However, a transition joint where the composition changes from austenitic steel to ferritic steel could replace then one dissimilar weld with two similar welds. Fig. 2.7 shows the failure of dissimilar metal welds in boiler tube of a water tube boiler



Fig. 2.7 Dissimilar metal weld failure

2.3.3 Corrosion

In corrosion boiler tubes materials are taken away by chemicals around it. Some of reasons behind corrosion are listed below

- Caustic corrosion
- Pitting corrosion
- High temperature corrosion
- Low temperature corrosion

2.3.3.1 Caustic corrosion

Caustic corrosion, a specific form of stress corrosion, results in the inter crystalline cracking of steel. Inert crystalline cracking results only when all of the following are present: specific conditions of stress, a mechanism for concentration such as leakage, and free NaOH in the boiler water. Therefore, boiler tubes fail from caustic embrittlement at points where tubes are rolled into sheets, drums or headers. Fig.2.8 shows the boiler tubes attacked by caustic corrosion.



Fig.2.8 Caustic corrosion

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2.3.3.2 Pitting corrosion



Fig.2.9 Pitting corrosion

Pitting corrosion is a form of extremely localized corrosion that leads to the creation of small holes in the metal. The driving power for pitting corrosion is the depassivation of a small area, which becomes cathodic; leading to very localized galvanic corrosion. The corrosion penetrates the mass of the metal, with limited diffusion of ions. Fig. 2.9 shows the pitting corrosion in a tube of water tube boiler.

2.3.3.3 High temperature corrosion

High temperature corrosion is a mechanism of corrosion taking place in boiler tubes coming in contact with hot gas containing certain contaminants. Fuel contains some times vanadium compounds or sulfates which can form compounds during combustion having a low melting point. These liquid melted salts are strongly corrosive for stainless steel and other alloys normally inert against the corrosion and high temperatures. Other High temperature corrossions include high temperature oxidation, sulfidation and carbonization. Fig. 2.10 shows the damaged boiler tube due to high temperature corrosion.

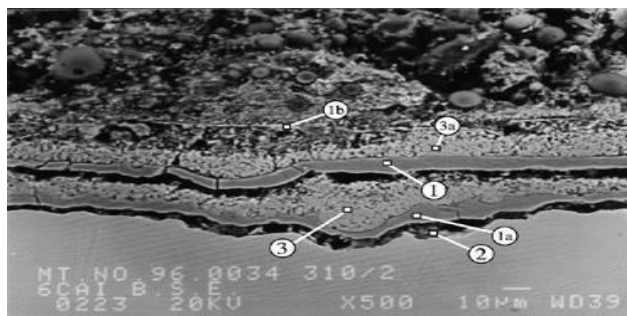


Fig. 2.10 High temperature corrosion

2.3.3.4 Low temperature corrosion

Thermal power station uses coal as a fuel, this fuel contains sulphur to differing percentages. The higher the percentage of sulphur, the higher will be the risk of cold and corrosion in the boiler.

The sulphur in the fuel during combustion gets converted to sulphur dioxide, some portion of the sulphur dioxide gets converted to sulphur trioxide. The presence of moisture in the flue gas due to moisture in the fuel and air, sulphur dioxide, and trioxide, combines with moisture and forms sulphuric acid.

These acids condense from around 115°C to slightly higher than 160°C, depending upon the concentration of

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SO₃ and water- vapour. Condensation of these acids results in metal wastage and boiler tube failure, air preheater corrosion, and flue gas duct corrosion.

III. FAILURE AND REMEDIES

This chapter deals with the detailed analysis of boiler tubes and also tells about the various solutions to reduce most commonly occurring tube failure.

3.1 Remedies of tube failure

From the failure data and analysis using pie chart the three major erosion causing factors are flue gas erosion, long term overheating and steam erosion. Our concentrates on giving remedies to these three problems. The type of failure and chosen remedies are shown in table 3.1

Table 3.1 Remedies for tube failure

S.No	Type of Failure	Remedies
1	Flue gas erosion	Organization of flue gas velocity
2	Long term over heating	Changing the tube metal
3	Steam erosion	Protective coating

3.2 Detail of software for used for Ansys

- Software Name : Ansys
- Geometry : Pro-Engineer
- Meshing : Gambit
- Solution : Ansys

3.3.1 Details needed for software

- Water temperature at inlet of economizer :520k
- Water temperature at outlet of economizer :557k
- Flue gas temperature at inlet of economizer :752k
- Flue gas temperature at outlet of economizer :660k
- Type of flow : counter flow
- Flue gas velocity : 11 m/s

3.3.2 Boundary condition for analysis

1. Water inlet

Table3.2 shows the boundary conditions water inlet of the economizer

Table 3.2 Boundary conditions for water inlet

S.No	Parameters	value
1	Mass flow rate	0.132 m/s
2	Velocity	8 m/s
3	Temperature	520 k

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2. Water outlet

Table 3.3 shows the boundary conditions for water outlet of the economizer

Table 3.3 Boundary conditions for water outlet

S.No	Parameters	Value
1	Outflow	Nil
2	Temperature	552 k

3. Flue gas inlet

Table 3.4 shows the boundary conditions for flue gas inlet

Table 3.4 Boundary conditions for flue gas inlet

S.No	Parameter	value
1	Mass flow rate	0.126 kg/s
2	Velocity	11 m/s
3	Temperature	752 k

4. Flue gas outlet

Table 3.5 shows boundary conditions for flue gas outlet

Table 3.5 Boundary conditions for flue gas outlet

S.No	Parameters	Value
1	Outflow	Nil
2	Temperature	660 k

3.4 Erosion rate calculation for tube

1.5

$$E = (0.47 \times Z^{1.5} \times \rho_m \times \rho_p \times V^3 \times \sin^3 \beta) / \sigma_y$$

Where

Z = mass fraction of silica contained in ash

ρ'_m = Density of steel kg/m³

ρ'_p = Density of ash particles kg/m³

β = impingement angle (degrees) σ_y = yield stress of steel (N/m²) V = Flue gas velocity (m/s)

On substituting the values, $E = 0.47 \times 0.016 \times 7830 \times 34.64 \times 1331 \times 0.125 / (250 \times 10^6)$ $E = 0.182$ (mg (steel)/kg (ash))

Similarity for calculating to other velocities Table 3.6 shows the erosion rate for various velocities.

Table 3.6 calculated Erosion rate for various velocities

Flue gas velocity	Erosion rate (mg/kg)
8	0.07
9	0.1
10	0.137
11	0.182
12	0.237
13	0.301

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Table 3.7 shows the outlet temperature for various velocities.

Table 3.7 Outlet temperature for various velocities

S.No	Velocity in (m/s)	Temperature at outlet (k)
1	8	356
2	9	359
3	10	361
4	11	363
5	12	365
6	13	367

By comparing the minimum temperature at outlet from CFD results and Erosion rate the optimum flue gas velocity is 9m/sec.

3.5 Material for boiler tubes

Generally boiler materials need to with stand high temperature and should not corrode easily. The boiler materials should have high creep strength and corrosion resistance. The table 3.8 shows the various materials form boilers tubes which with stand high temperature and have good corrosion properties.

Table 3.8 various materials for boiler tubes

S, No	Material	Maximum withstanding temperature(°C)
1	T91	600
2	S 304 H	645
3	HR 3C	675
4	SANICRO 25	700
5	ALLOY 617	770

3.6 Materials under usage for boiler tubes

Austenitic stainless steel is the material that is currently being used for boiler tubes in thermal power plant. Major reasons for using stainless steel are

- Resistance to corrosion
- Prevention of product contamination
- Resistance to oxidation
- Ease of fabrication
- Excellent formability
- Good strength and toughness at cryogenic temperatures table 3.9 shows the composition of austenitic stainless steel.

Table 3.9 composition of austenitic stainless steel

Material	Type 304	Type 304L
Carbon	0.08 max	0.08 max
Manganese	2.00 max	2.00 max
Phosphorus	2.00 max	2.00 max
Sulfur	0.030 max	0.030 max
Silicon	0.75 max	0.75 max
Chromium	18.00-20.00	18.00-20.00

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Nickel	8.0-12.00	8.0-12.00
Nitrogen	0.10 max	0.10 max
Iron	Balance	Balance

3.6.1 Mechanical properties

Table 3.10 shows Mechanical properties of austenitic steel

Table 3.10 Mechanical properties of austenitic steel

Type	Ultimate tensile strength (MPa)	Yield strength (MPa)	Elongation %	Hardness Rockwell
304L	586	241	55	B80
304	621	290	55	B82

3.6.2 Physical properties

Density : 7.90 g/cm³

3.6.3 Thermal properties

The thermal conductivity, coefficient of thermal expansion of stainless steel are shown in table 3.11 and 3.12 respectively.

Table 3.11 Linear coefficient of thermal expansion of steel

Temperature		Range coefficients	
°F	°C	in/in/°F	cm/cm/°C
68-212	20-100	9.2×10-6	16.6×10-6
18-1600	20-870	11.0×10-6	19.8×10-6

Table 3.12 Thermal conductivity of steel

Temperature range		W/m k
°F	°C	
212	100	16.3
932	500	21.4

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3.6.4 Suggested material –SANICRO 25

Sanicro 25 is a high alloy austenitic stainless steel engineered for the next generation of coal –fired power boilers. It is ideal for reheater and super heater tubes, allowing for material temperatures of up to 700°C (1290°F), significantly greater efficiency and sharply lower CO₂.

- Very high creep strength
- High oxidation resistance
- High structural stability
- Good fabric ability

Sanicro 25 is supplied as cold pilgered solution annealed and white – pickled or bright annealed seamless tubes, in common reheater and super heater boiler tube dimensions. The material datasheet 555 is valid for outside diameter 25 mm to 114.3 mm and wall thickness 3 mm to 14 mm.

- Very high elevated temperature strength
- Precipitation strengthening
- Nb or NbCr nitrides, Cu- rich precipitates
- Solid solution strengthening: addition of C, N, Co and W
- High corrosion resistance at high temperature
- High structural stability & good fabricability

3.6.5 Composition of sanicro 25

Table 3.13 shows the composition of sanicro 25 alloy

Table 3.13 composition of sanicro 25

Material	Percentage
Cmax	0.1
Si	0.2
Mn	0.5
Pmax	0.030
Smax	0.015
C	22.2
Ni	25
N	0.23
W	3.6
Co	1.5
Cu	3.0
Nb	0.5

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3.6.6 Mechanical properties

Table 3.14 shows the mechanical properties of sanicro 25 alloy

Table 3.14 mechanical properties of sanicro 25

Temperature °C	Proof strength MPa	Tensile strength MPa
600	205	500
700	195	455

3.6.7 Physical properties

Density: 8.1 g/cm³

3.6.8 Thermal properties

Tables 3.15 and 3.16 below shows the thermal characteristics of material sanicro 25

Table 3.15 thermal expansion

Temperature	per°C
30-500	16.5
30-600	16.5
30-700	17
30-800	17
30-900	17.5

Table 3.16 thermal conductivity

Temperature	W/(m°C)
500	20
600	22
700	23
800	25
900	27

3.6.9 Comparison between austenitic stainless steel & sanicro 25

Table 3.17 compares austenitic stainless steel & sanicro 25

Table 3.17 Steel vs Sanicro 25

Property	Sa 210 gr Al	Sanicro 25
Density	7850 kg/m ³	8100 kg/ m ³
Coefficient of thermal expansion	18.8	19
Yield strength	260n/mm ²	140n/mm ²
Tensile strength	420 n/mm ²	340n/mm ²
Thermal conductivity	21.4	22.5
Creep strength(at 600°C)	120 n/mm ²	230n/mm ²

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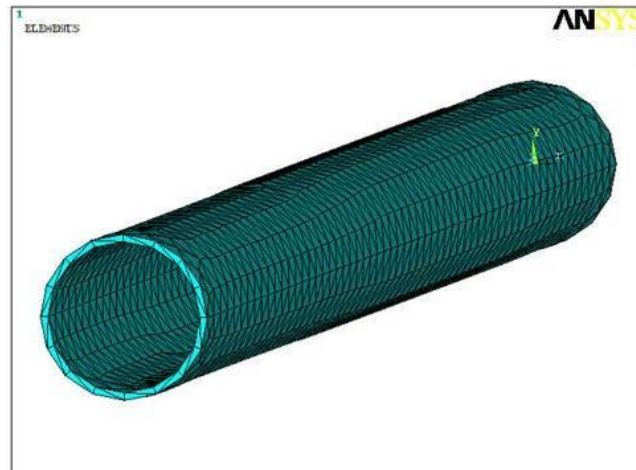


Fig. 3.2 Meshing diagram of tube

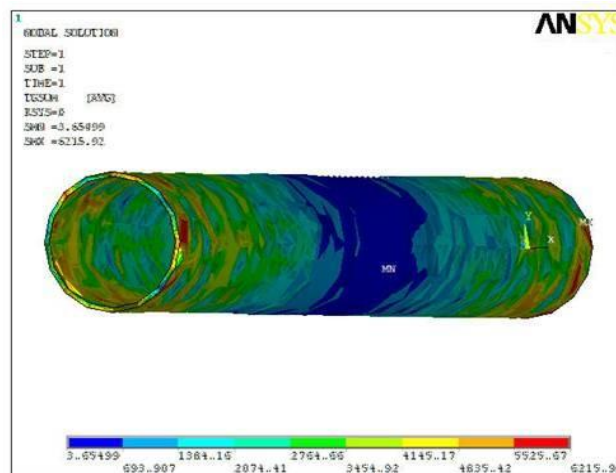


Fig. 3.3 Temperature Distribution of Sanicro25

3.8 Coating for boiler tubes

Boiler operating with low NO_x burner's present unusually harsh environment for power plant material. In particular, a change from normally oxidizing condition in a standard boiler to reducing condition in a low NO_x boiler causes usually protective oxides to give way to severe wastage by sulfidation corrosion and erosion.

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3.9 Coating materials

There are various materials used for coating the boiler tube for protection against various causes that account for the tube failures like Erosion, corrosion etc., the materials used in boiler tube coating are

- M-Cr-Al-y alloy
- Type 310 stainless steel
- Pure chromium
- Molybdenum
- High silicon alloy
- Ni/Cr alloys
- Molybdenum
- Fe-Al

3.9.1 M-Cr-Al-y alloy

The M of stands for either Ni or Co or a combination of both (when applied to steels it can also be Fe) depending on the type of super alloy.co based appear to have superior resistance to corrosion.

Al content is typically around 10-12 wt%. Since oxidation life is essentially controlled by the availability of al it would be tempting to increase the aluminum content. However these results in significant reduction of ductility also typically contain 1 wt% yttrium which enhances adherence of the oxide layer.

3.9.2 Type 310 stainless steel

Type 310 alloys is essentially the stainless steel with more corrosion and temperature resistance it could withstand the temperature up to 1100c and it also resists the chemical corrosion by means of formation of thin chromium oxide layer over it and it also saves the boiler tube by means of self sacrificing.

It contains iron as its main content and other major contributors are Nickel and chromium both its contributes about 15-22% each and other minor contributors are carbon (1.5%), Manganese(2.0%), phosphorous(0.04%) and sulphur(0.03%). This alloy has the density of 8000kg/m³ melting point of 1500c specific heat capacity of 500J/kgc thermal conductivity of 14.2W/m and coefficient of expansion of 15.9/c.

3.9.3 Pure chromium

Pure chromium can be deposited on the boiler tube by means of Electro deposition method as this method could evenly deposit the chromium over its surface this coating could only be done on the shop could not be done inside the boiler this is the main disadvantage of this coating.

This pure chromium coating protects the boiler tube corrosion by forming thin oxide layer over itself on initial operation of boiler after coating surface chromium reacts with oxygen and forms thin protective coating of chromium oxide over its surface to resist the chemical corrosion it also resists the erosion by self sacrificing it distributes the heat evenly over the boiler tube and thus it reduces the fatigue.

3.9.4 Ni/Cr Alloys

Chromium is a corrosion resistant alloy that binds the continuous skeleton of erosion resistant chromium carbide constituents. Due ability to dissipate the impact force of particles by plastic deformation result of Ni-Cr coatings are

- High hardness (to prevent erosion because of ash silica).
- Hot corrosion resistance (that will react with the environment to produce a slow growing protective oxide scale which should not allow the corrosive pieces to diffuse into the coating)
- Low porosity (less area for erodent particle to impact and abrade).
- Small grain size (Small grains tend to be stronger).
- Uniform coating structure (homogeneous distribution of hard constituents & ductile behaviour)
- Absence of cracks (ductile structure, thermal stability, Uniform coating structure (homogenous distribution of hard constituents & ductile behaviour)

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- Smooth surface

3.9.5 Iron aluminide

Iron-aluminium based alloys have been considered as coating for the protection of water wall boiler tubes found in coal-fired furnaces. These iron-aluminium based alloys are potentially good candidates for boiler tube coatings because they have excellent corrosion resistance in a wide range of high temperature gaseous environments including highly sulfidizing environments.

These coatings are advantageous over commercial alloys such as stainless steels and ni-based super alloys, because they are significantly less expensive than the commercial alloy, they do not experience micro segregation as seen in the ni-based super alloys and they do not form a brittle interface at the fusion zone as seen in some stainless steel weld overlays.

Studies have shown that increasing the aluminium content of Fe-Al based alloy increases the corrosion resistance of the alloy in high temperature environments containing oxygen and sulphur 2,4,5,8.

3.10 methods of coating

The various methods employed in coating are:

- Electrodeposited inter metallic coatings
- Weld overlay coatings
- Thermal sprays coatings

3.10.1 Electro deposited inter metallic coatings

Fig. 3.4 shows a boiler tube sample coated by electrodeposited inter metallic coatings



Fig. 3.4 Electro deposited inter metallic coatings

One way to protect boiler tubes against corrosion is to apply a thin layer of pure chromium in an oxidizing environment the chromium layer forms a protective oxide layer which prevents deterioration of the underlying steel tube. This work led to the eventual development of a new type of coating intermetallic Aluminize which can be applied by a low electro deposition process.

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3.10.2 Weld overlay coatings

Fig 3.5 shows the boiler surface coating with weld overlay coating .



Fig. 3.5 weld overlay coating

The advantage of welded coatings is that they can be applied to the surface of the boiler tubes in the boiler as well as in a shop, without the usual penalties. However, selection proper weld alloy and control of the weld overlay process conditions are critical to producing coatings with desired properties.

3.10.3 Thermal spray coatings

Fig 3.6 shows the thermal spray coating equipment

In the application of thermal spray coating, a metal powder is heated to a high temperature and propelled toward the boiler tube surface with a high velocity gas or plasma jet. Once at a surface, the particles form a coating. Thermal spray coating have a advantage of being applied in- situ in the boiler and as a consequence, they are easily repaired after exposure.

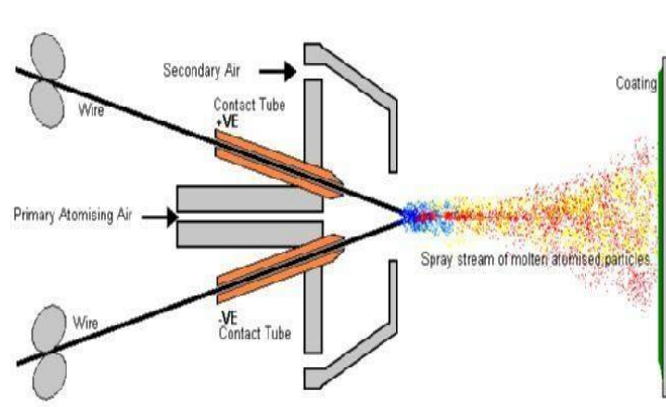


Fig. 3.6 thermal spray coating

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IV. CONCLUSION

Our project will discuss on three major remedies which reduce the tube failure in Birsinghpur Pali thermal power station. From the failure data we come to conclude that the three major reasons for the tube failure is fly ash erosion, long term overheating and steam erosion. Based on the results we obtained, we suggest optimum flue gas velocity is 9m/sec which would considerably reduced tube failure due to flue gas erosion. The usage of sanicro 25 as tube material for boiler tubes provides extended tube life due to its better creep strength and this reduces the failure rate due to long term over heating in boiler tubes. The loss power production and the cost of repair for boiler tubes can be reduced. Failure due to steam erosion is reduced if coatings such as electro deposited inter metallic coating, weld overlay coating and thermal spray coating are applied on the boiler tube surface. The above remedies if implemented in power plants not only reduced tube failure, but also reduce the repair cost of tubes, increase the availability of boiler, less interruption in power generation. The general suggestion to reduced tube failure is to use low as coal which will reduced erosion rate and also reduced the major tube failure problems. The future presents several challenges, with expected tightening electricity market likely to increase the cost of boiler tube failure coming at a time when number of failures is expected to rise.

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