

Reheater Failure Analysis Using ANSYS

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Abstract: The concept of thinking is changing very fast in entire world. The life cycle of product is also very short. We approached several engineering and production industries for our project work and the information that collected from them initiated us to do a project in the CAM/CAD area. We selected our project “REHEATER FAILURE ANALYSIS USING ANSYS” in Mettur thermal power station, which contributes a major part of electricity production in Tamilnadu. We have analyzed the failure of Reheater tubes inside the boiler and suggested some recommendations to reduce and prevent the failure. We used one of the recent analysis package ANSYS to analyze the reheater tube failure.

I. INTRODUCTION

In modern power stations, high pressure boiler unit system pattern is adopted. In case of any outages on boiler whole unit will have to be shutdown. The steam Generator in a power plant works in very hostile atmosphere and a major source of unplanned outage causing reduction in availability factor of power plant. Tube failure is the most frequently listed reason for forced outages of boilers. Forced/unplanned outages in a power station amounts to 15% of total outages. In this 60% of outage is resulting out of boiler and outage due to boiler tube leakage are 75% or more of total boiler forced outages. A shut down of 210MW units on account of tube failure will cause a loss of several lakhs of rupees even the shutdown is only for three days. It is also generally noticed that the repair takes longer time due to forced outage of boiler on account of tube failure if not adequately prepared for repair. The actual cost of repairing failed tube is far less than the cost of Generation loss due to outage, the resulting economic loss is still very high. So it is very important to make repairs and return the unit quickly into service. Also it is equally important to identify the cause of failure to take corrective action so that the failure does not occur. The detailed analysis of Reheater tube failure at Mettur Thermal Power Station, using an Effective computer analysis package, ANSYS

II. METTUR THERMAL POWER PLANT

Mettur Thermal Power Station is located at 11°56' North Latitude and 77°48' East Latitude elevation and 213 m above MSL. It has 4 units each having 210 MW capacities, so total capacity of the plant is 840 MW.

III. OPERATION OF THERMAL POWER STATION

Coal is used as fuel for the generation of heat energy. As the water in the boiler evaporated due to the intense heat, it becomes high-pressurized steams. The steams are passing through a conduit (there is a turbine at other end of the tunnel), it forces its way through the turbine, thus rotating the turbine. (As the steams are high-pressurized, the turbine will rotate very fast.) The turbine is connected to a generator via a coupler. As the turbine is rotating (from the force of the steams), electrical energy is being produced. After the steams have passed through the turbine, it enters a condenser, the condenser has got a cooling agent (namely seawater) and the steam will go through the cooling agent via a pipe. The steam thus changes back to its liquid form and returns to the boiler.

IV. PLANT DATA

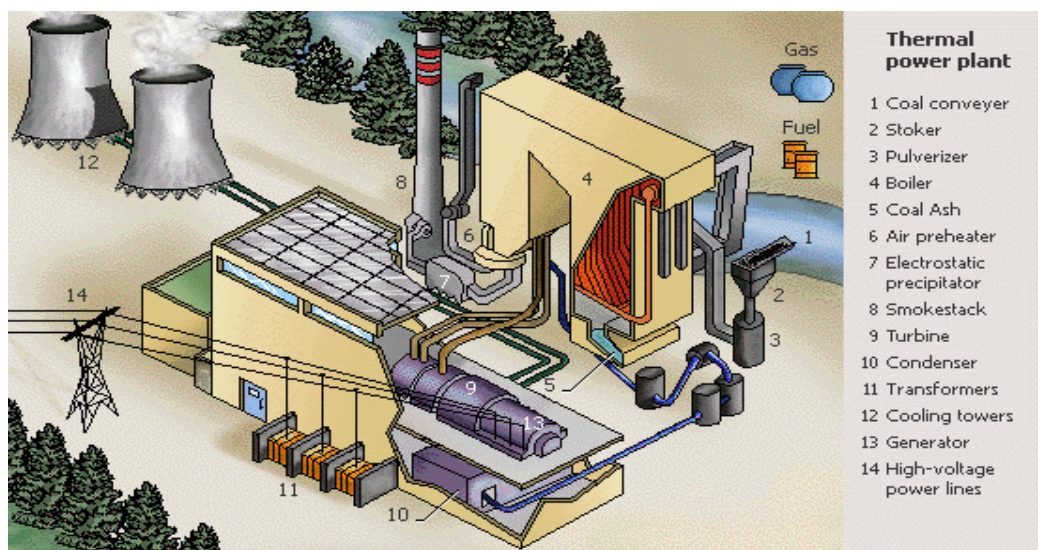
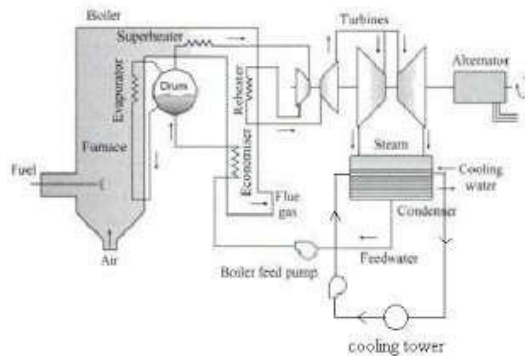
1. Area - Main plant-362 Acres [Total 1733 Acres, Including Railways, Raw water storage, etc.]
2. Installed capacity - 4 units (840 MW)
 - I Stage - 2 x 210 MW (2 units)
 - II Stage - 2 x 210 MW (2 units)

V. BOILERS

A boiler may be defined as a closed vessel in which steam is produced from water by combustion of fuel.
Boilers at MTPS are

- Water tube type
- Vertical 2 pass system
- High pressure
- Natural circulation
- Tangential firing type
- Balanced draught

- RH type
- Tilting furnace type
- Drum pressure: 147ks.



VI. SUPER HEATER

The function of a super heater is to increase the temperature of the steam above its saturation point. The super heater is very important accessory of a boiler and can be used both on fire tube and water tube boilers.

Super Heater specification at MTPS

Inlet Temperature	320°C
Outlet Temperature	540°C
Pressure	132Ksc
Flow	660T/hr

VII. REHEATER

Reheater is used to raise the temperature of the steam, which is exhausted from HP turbine after doing a work.

Reheater specification at MTPS

Inlet Temperature	320°C
Outlet Temperature	540°C
Pressure	25Ksc
Flow	580T/hr.

The Reheater is composed of two stages, the front pendant and the rear pendant sections. The Reheater coils in between the platen and final SH.

The steam after doing the work in high pressure turbine comes to the front pendant and it passes through the series of tube assemblies and goes to rear pendant.

The steam while passing through the tube picks up the heat from the fuel gas which is passing across the tubes, thus raising the temperature of steams to super heated range. This super heated steam enters the intermediate turbines from the rear pendant.

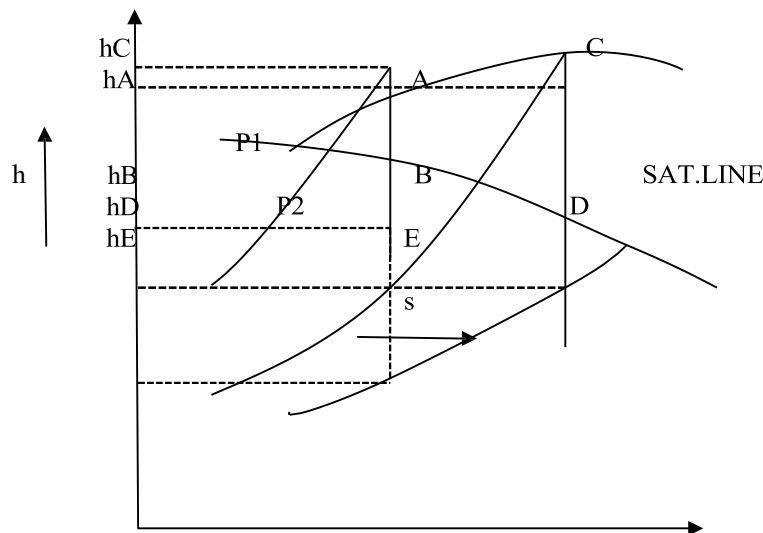
Reheating of the steam is an important method to improve the efficiency of the turbine.

The efficiency of the Rankine cycle can be improved by increasing the pressure and temperature of the steam entering into the turbine. The increase in initial steam pressure will increase the expansion ratio and steam will become quite wet at the end of the expansion.

It is not desirable that the steam may become wet at the end of expansion. The wet steam causes erosion of the turbine blades and increase internal losses. This will ultimately reduce the blade efficiency of the turbine.

The above mentioned difficulty may be overcome by reheating of the steam. In this system the steam is removed from the turbine then it becomes wet. It is then reheated at constant pressure by the flue gases, until it is again in super heated stage. It is then returned to the next stage in the turbine.

VIII. REHEAT CYCLE



After expansion, the steam becomes wet which is reheated at constant pressure gradually up to the same temperature as that at "A" shown by the point "C" where it is again in super heated state. The steam again expands isentropically while flowing through the next stage of turbine.

$$\text{Efficiency} = \frac{\text{Work done}}{\text{Total heat supplied}} = \frac{(h_A - h_B) + (h_C - h_D)}{h_A + ((h_C - h_B) - h_D)}$$

The reheater is used in MTPS is connected in between front and rear pendants. There are 59 tubes assemblies in front pendant and 89 tube assemblies in rear pendant. The tubes are made up of SA 213T91 grade steel having "Cr" content of 2.25% and "Mo" 1%.

The main causes of reheater tubes are corrosion, erosion and weld defects.

IX. PROBLEM DESCRIPTION

The MTPS was designed to generate 700 TPH/unit of super heated steam with rated steam parameters of 137kg/sq.cm pressure and 540°C. MTPS units have already clocked more than 1, 00,000hrs Operation. After about 90,000 hrs tube failure in RH were reported in 1999.

Since then already 15 times boiler had to face forced S/D due to RH tube failure. Since the situation was becoming critical, M/S TNEB wanted some proactive action for checking the condition/replacement of deteriorated RH coils so that forced outage during operation is avoided/minimized. So M/S TNEB wanted to find the actual causes of the tube failure for taking corrective actions to avoid failure.

Taking all into account this problem can be analyzed using Effective analysis package ANSYS.

ANALYSIS TO BE MAEDED ARE

- Thermal analysis
- Static structural analysis
- Failure analysis.

Thermal and heat transfer problems including conduction, convection, radiation and structural problem for stress strain calculations, can be done very effectively by using ANSYS software. Computational Fluid dynamics can also do by using the ANSYS software.

Process parameters involved in the typical problem, is only heat transfer from flue gas to steam, so we go for ANSYS thermal analysis.

X. SOLUTION METHODOLOGY

In order to find the actual cause of failure a sample of the removed reheater tube is taken iron plant. By visual inspection, it was found that the tube failure near to rear pendant, causing the pressure leakage in the steam line, followed by turbine trip. For finding the reasons for failure a detailed study was made on the punctured tube.



XI. RESULT OF INSPECTION

By visual inspection, the tube was found to have scale formation, both inside and outside of tube.

So it was concluded that the main reason for failure was formation of scale both inside and outside the tube.

For finding the chemical composition of scale material, scales from both sides was collected and given to the chemical lab at MTPS, mettur.

- Scale formation is the major cause for the failure of reheater, formation of scale will be



XII. ANALYSIS USING ANSYS

Following conditions were considered for analysis.

REHEATER TUBE

Material	- SA213T22
Composition	- Cr-2.25%, Mo-1%
Dimensions	
Location 'A'	- 47.63 x 5mm
Location 'B'	- 54 x 3.6 mm
Location 'C'	- 54 x 3.4 mm
Designed working	
Temperature	- 580°C
Thermal conductivity	- 35W/mk
SCALE:	

➤ Material	- Zirconium
Scale thickness:	
Location 'A'	- 0.50 to 0.65 mm
Location 'B'	- 0.50 to 0.72 mm

Location 'C'	-	0.50 to 0.85 mm
Thermal conductivity	-	1.8 W/mk
➤ Material	-	Ferric oxide
Scale thickness:		
Location 'A'	-	0.50 to 0.65 mm
Location 'B'	-	0.50 to 0.72 mm
Location 'C'	-	0.50 to 0.85 mm
Thermal conductivity	-	5 W/mk

XIII. RECOMMENDATIONS

Prevention of high temperature creep failure involves, keeping the tube metal stress and temperature within the capabilities of the tube material. Failure due to overheating caused by internal flow restrictions or tube heat transfer reduction can be eliminated by removal of scale debris or deposits that have accumulated inside the tube. High pressure fluid flushing or hydrochloric acid cleaning (chemical cleaning) may be necessary to restore the tube heat transfer characteristics. Failure due to over stressing caused by wall training can be controlled by applying ultrasonic wall thickness measurement with residual life estimates such residual life estimate techniques have been successfully used to determine which tubes are beyond critical wall thickness and should be immediately replaced to prevent furnace failure within the next operating period.

Heavy scaling on stream side surface of the tube wall act as thermal barrier for effective heat transfer continues operation with hot reheat steam temperature at 545°C will result in excessive metal temperature. Hence it is recommended to operate the unit at reduced steam temperature till replacement is carried out.

Considering the accessibility for modification, it is recommended to replace the outlet section in total with higher chromium contained steel (upgrading material) to ensure trouble free service.

XIV. CONCLUSION

The re-heater tube is analyzed at different location and its performance was carried out by varying the parameters such as scale thickness and temperature. The material such as ferric oxide and zirconium is considered for analysis in ANSYS. From the analysis it is conclude that the root cause of failure is due to scale formulation. The suitable material suggested is zirconium, in order to minimize the reheater tube failure.

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