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# Power Plant Heat Transfer Components: A Review of Thermal Analysis

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**ABSTRACT:** Heat-transfer parts are very important in power plants. Heat transfer components are made to move heat from one fluid to another. Power plant steam cycles use different parts to transfer heat, such as water wall tubes, super-heater tubes, economizer tubes, air pre-heaters, feed-water heaters, condensers, oil coolers, tube and shell type heat exchangers, flat plate heat exchangers, etc. On these different heat exchangers, analysis is done in different ways, such as thermal analysis, hydraulic analysis, etc., to make sure the boiler tubes are working well, to avoid possible failures, and to find out where scale is forming on the inside of the tubes. The heat source is used to heat and boil the feed water in the heat generator, which is also known as a boiler. This paper makes some methods for analysing water tube boilers official.

**KEYWORDS:** Heat exchangers, heat generators, hydraulic analysis, thermal analysis, water tube boilers.

## I. INTRODUCTION

Heat-transferring parts, which are made to move heat, are very important in a power plant. Water walls are made up of a number of tubes and their fins, which are joined together to make one long wall with a lot of heating surface area. The boilers are made by putting these walls together. At the bottom, these are covered with refractory, which will make up the rest of the furnace. The insides of these walls are always in contact with the flue gas, while the outsides are insulated with materials like glass wool and aluminium sheets. So the different temperatures on the surface.

It is very important to look at different parts of the water wall tube at different times to understand the whole evaporation process. The steam made by the in-bed evaporator is sent to the riser header with the help of water walls. These are the tubes inside the boiler that evaporate water to make steam. They are also called "Steam Generating Tubes." These tubes are also the walls of the boiler, so they are called "Water Walls" or "Water Wall Panels."

A superheater tube is a device that turns saturated steam or "wet steam," which is also called "non-superheated steam," into "dry steam," which is used in steam engines and other processes like reformation. There are three different kinds of superheaters: convection, radiant, and separately fired. A superheater can be anywhere from a few tens to several hundred feet long. In a steam engine, the superheater re-heats the steam made by the boiler, making it more thermally efficient. Superheated steam is the right name for steam that has been heated to a very high temperature. The group of tubes that are already very hot is put at the beginning of the flue gas path or at the end of the boiler. The main benefit of using a superheater is that you use less fuel and water.

Heat exchangers with a shell and tubes are made up of a series of tubes. The fluid that needs to be heated or cooled is in one set of these tubes. The second fluid flows over the tubes that are being heated or cooled so that it can either add heat or take heat away as needed. A group of tubes is called a "tube bundle," and it can include plain, longitudinally finned, and other types of tubes. Most of the time, shell-and-tube heat exchangers are used for high-pressure Applications. The shell and tube exchanger provides ratio of the area of heat transfer to the weight and volume. Shell-and-tube heat exchangers are made up of tubes, a tube sheet, the shell and shell-side nozzles, the tube-side channel and nozzles, channel covers, pass drivers, and baffles.

In this paper, we give a summary of the thermal analysis of the parts of the power plant that move heat.

## **II. PREDICTION OF RISER'S TEMPERATURE IN WATER TUBE BOILERS**

The dynamic thermal model was proposed by author [1]. Model for riser tubes and figured out the temperature of the walls when the heat was evenly distributed. The author has also calculated the riser tube heat transfer coefficient. The fluid dynamic model of a water-tube boiler is made, which shows the relationship between the steam's volume, pressure, flow rate, rate of evaporation, and quality. He made the fluid dynamic model for the natural circulating boiler by using the down comer-riser flow loop equations and the global mass balance and energy balance. Different loads are used to compare the different parameters. This comparison gives a point of reference for how the boiler works, so that changes in operation and safety can be found for the boiler's different load conditions. To make more steam, the firing order is changed and the pressure in the steam header is also raised, which causes the temperature of the tubes to rise. So, being able to predict the temperature of the tubes is important for the boiler to work well and for safety. This method can be used to check the temperature of the tubes online to prevent tube failures and prevent the riser tubes from getting too hot, which will be very helpful for operation engineers.

## **III. ITERATIVE TECHNIQUE AND FINITE ELEMENT SIMULATION FOR SUPPLEMENTAL CONDITION MONITORING OF WATER-TUBE BOILER**

In [2] author has proposed an iterative technique and finite element simulation for condition monitoring of water-tube boiler. The technique of condition monitoring is used to monitor the condition parameters in a system where a momentous change indicates the possibility of failure. Also it can be said that it allows actions to be taken to evade the consequences of failure, before its occurrence. The fundamental principle of condition monitoring is to select a material measurement that indicates the occurrence of deterioration.

The proposed method uses the empirical formula to estimate scale thickness that is developed on the inner surface of the tube over period of time. An iterative procedure is conceded to determine the average temperature in the tube as oxide scale thickness on its inner surface increases. The method uses finite element simulation in order to avoid failure due to increase in temperature in the tube. The finite element simulation is done by using the software ANSYS.

In this paper author gives the variation of scale thickness, temperature increase of tube with respect to time, so that the life of the tubes can be identified.

## **IV. THERMAL ANALYSIS OF TUBULAR HEAT EXCHANGER BY USING ANSYS**

In [3] author has discussed the temperature analysis of tubular heat exchanger by using the software called Ansys. The tube and shell type heat exchanger is composed of four tubes that are made up of Aluminium. The author initially analyses these tubes for temperature and velocity of cold and hot water in tube and Shell. These aluminium tubes are then replaced with the copper tubes. After replacement again the analysis is made for temperature and velocity of hot and cold water in tube and shell by using CFD from Ansys software. The exchanger works on the atmospheric pressure. The obtained parameters are compared between tubes of copper and aluminium metals. The analysis shows that the output temperature for both the material is found nearer to the actual value.

## **V. IDENTIFICATION OF LOCAL HEAT FLUX TO MEMBRANE WATER-WALLS IN BOILERS**

In [4] author explored the new technique in order to find the local heat flux to the water walls of boiler. The flux tube welded to the water tube of water walls is used. The water walls are having more than three numbers of holes to insert the thermocouples. Out of these three thermocouples one is placed on the backside of the flux tube which is not facing the furnace of boiler. The readings observed by thermocouples will help to find out the parameters like temperatures of water steam mixture at different locations of flux tube, the absorbed heat flux, the heat transfer coefficient on the inner side of tube. The heat transfer coefficient is obtained by using the Least Square method in order to minimize the obtained temperature differences. The unknown parameters can be finding out by Leven berg-Marquardt method. For experimentation author has used the Ansys Software and found out the temperature of tubes at different locations. This paper is used for the on line assessment of slagging of boiler tubes to improve the thermal efficiency and in turn the performance of the boiler.

## **VI. TUBE TEMPERATURE DISTRIBUTION IN WATER TUBE BOILER – A**

### **PARAMETRIC STUDY BY FINITE ELEMENT METHOD**

Author [5] has formulated the finite element model for the boiler tube and analysed the temperatures at different conditions of the operation of boiler. The 2-D model of the inner side of the tube with the scale deposited on it is designed. The temperature distribution is studied in both the conditions that are scaling inside the tube and tubes without scale.

Temperature distribution –

- i) Due to the variation of mass flow rate inside the boiler-As the mass flow rate decreases, the temperature of flue gas increases and that of tube decreases.
- ii) Due to different thermal conductivity of tube- The tube material is changed from carbon Steel to stainless steel and it is found that when the thermal conductivity decreases, the tube temperature inside the tube will be decreased and temperature of outer surface of tube will be increased.
- iii) At different steam inlet temperature – As the temperature of the inlet steam increases the temperature of the inner side of tube will get increase in both cases, with scale and without scale.
- iv) At different scale thickness – Scale reduces the heat transfer rate and hence the temperature outside the tube increases to maximum and the temperature inside the tube decreases as the scale thickness increase.

For this analysis the MSC Patran -Nastran software is used. This analysis uncovers the disadvantages of scale formation inside the tube.

## **VII. MATHEMATICAL MODELLING AND THERMAL- HYDRAULIC ANALYSIS OF VERTICAL WATER WALL IN AN ULTRA SUPERCRITICAL BOILER**

The Author in [6] has explored the mathematical model of a water wall tube of the ultra-super critical boiler and calculated the metal temperature distribution as well as the mass flux distribution at 35%, 50%, and at 100% BMCR. The water walls are considered as the circuit and it is divided into eight parts on the basis of position as upper, lower, rear, front, etc. The same parameters are obtained at different location of water wall of the boiler at Yuhuan Power plant of China experimentally. Both the obtained results are compared to get the graphs of i) mass flux, ii) outlet fluid temperature in furnace, ii) metal temperature along the height of the water wall at different load and at different location. From the graph it is clear that both the calculated and the experimental data are near about same. From the analysis it is concluded that at higher BMCR load the mass flux distribution is also higher.

## **VIII. FAILURE ANALYSIS ON DEFORMED SUPER HEATER TUBES BY FINITE ELEMENT ANALYSIS**

The author in [7] focuses on the deformed super heater tubes to find out the maximum allowable stresses by the expansion and contraction of the material of coil as well as the location of the maximum stress occurred. The super heater tubes are having welded joints and U- shaped bend. The analysis is carried out on the already deformed tubes by using the MSC Patran Nastran Software. The author has proposed the model of super heater tube and applied the boundary condition to find the numerical results by using finite element analysis. The first boundary condition assumed is that one end near the header will be considered fixed and applied constraints for all six degree of freedom. Second boundary condition is to find the tube deformation at seven different cases considering different constraints by simulation. Assumptions made for the analysis are

- i) The temperature and pressure inside the tube are constant and uniform.
- ii) The metal tube temperature is found out by using the overall heat transfer coefficient. These results give the correlation between the maximum and the allowable stress. The analysis provides guidance to the plant inspector for the inspection of the boiler.

## **X. CONCLUSION**

It's important to analyse the boiler's different parameters to make sure it works well and keeps people safe while it's running. This paper takes a look at the different ways to do thermal analysis of heat-transferring parts in a power plant. The survey results show that there is a lot of room for this kind of analysis, taking into account things



like temperature, pressure, water volume, and so on. This will make it easier to estimate over time and improve the way things are done. It will also help avoid accidents.

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