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Analysis of Boiler Super Heater Tubes from High Flue Gas Temperature

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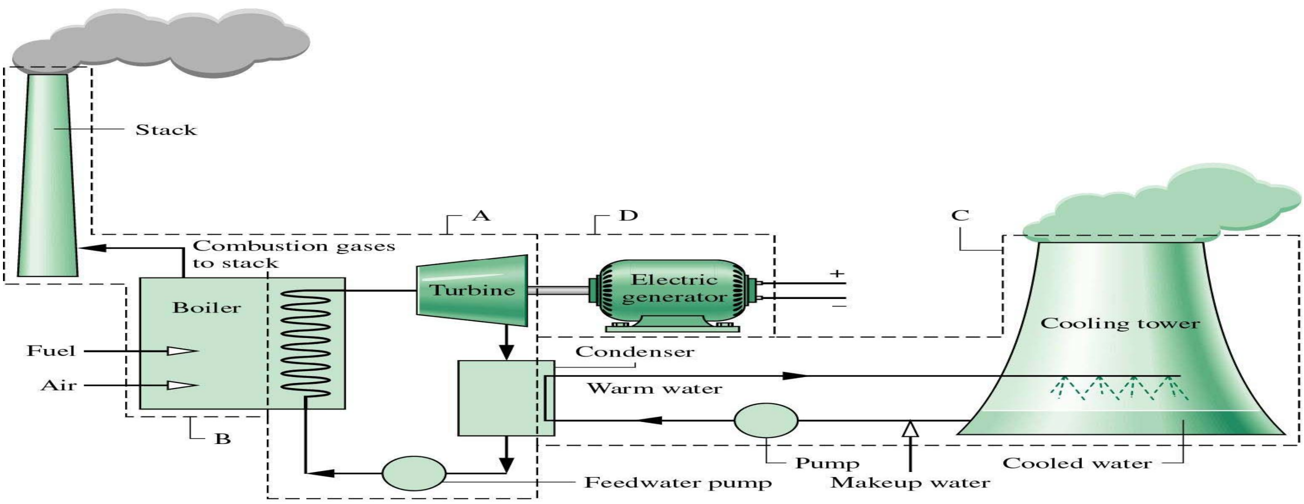
I. INTRODUCTION OF THERMAL POWER PLANT

In Thermal Power Station fuels burn & use the resultant to make the steam, which derives the turbo generator. The Fuel i.e. coal is burnt in pulverized from. The pressure energy of the steam produced is converted into mechanical energy with the help of turbine. The mechanical energy is fed to the generator where the magnet rotates inside a set of stator winding & thus electricity is produced. In India 65% of total power is generated by thermal power stations. To understand the working of the Thermal Power Station plant, we can divide the whole process into following parts. Refer Schematic Diagram of Thermal Power Plant (Fig. No. 1.1)

In coal fired plant coal is transported through Railway wagons and it’s kept reserved on a buffer stock. From the station it is unloaded with the help of wagon tippler. After unloading, the coal is sent to crusher house with the help of conveyor belts. The coal which is now reduced to very small pieces is sent to the coal bunkers with the help of conveyor belt. The raw coal is fed to coal mills through raw coal feeders. Raw coal feeders basically regulate raw coal to coal pipes. The primary air is heated utilizing the heat of the fuel gases & then mixed with the cold air as per requirement. Normally the temperature is maintained from 60 to 70 degrees. The coal is now burnt in the furnace using oil in the beginning showered through the nozzles at different elevations in the furnace. Air for combustion, is heated by the flue gases and the heat produced due to combustion is utilized for the conversion of water into steam. This water is stored in the boiler drum. There are two sets of pipes attached to the drum, one called riser & other known as down corner through which the water comes to the ring header & steam moves up due to the density difference of water & steam. Steam is super heated using super heaters & meanwhile the flue gases are let to the atmosphere through chimney.

The super heated steam is sent to the turbine through pipelines and the three turbines in the units are run using this steam at different temperature & pressures. After passing through high pressure turbine the steam is sent to the reheated for rising the temperature of the steam. The reheated steam is sent to the intermediate pressure turbine through reheated line. Here it loses most of its temperature and pressure and finally sent to low pressure turbine. The uses of three different turbines help in increasing the efficiency of the plant. The turbine in turn connected to a generator to produce electricity. Then this electricity is stepped upto 220 KV with the help of step up transformer & supplied to various sub-station grids. Meanwhile, the steam through low pressure (L.P.) turbine is condensed and the condensed water is stored in hot well.

The condensed water is extracted from the hot well through condensate extraction pumps and sent to the boiler drum with the help of Boiler feed pumps before passing through low pressure heater and de-aerator. While loss in water is made up from condensate storage tank the water used in condenser is sent to cooling tower for cooling. After cooling this water is again sent to condenser with the help of circulating water pump.



(Fig. 1.1)Schematic Diagram of Thermal Power Plant

II. INTRODUCTION OF SUPER HEATER

Super heater is a component of a boiler unit that superheats steam, that is, heats steam above its saturation temperature. This consists of parallel-mounted steel tubes, with internal diameters of 20 to 60 mm, connected directly to a boiler drum or to input, output, and intermediate headers. Depending on the direction in which the steam moves relative to the flue gases, superheaters are said to have parallel flow (uniflow), counterflow, or mixed flow. They are classified as radiant, screen (semi radiant), or convection according to the location of the superheater in the boiler and the type of heat exchange that results.

Radiant superheaters are placed on the crown or walls of a furnace chamber, often between the tubes of waterwalls. The superheaters and waterwalls take up heat radiated by the burning fuel. Screen superheaters, which are separate flat screens of tubes connected in parallel, are mounted in the outlet from the furnace ahead of the convective part of the boiler and heat is transferred by both radiation and convection. Convection superheaters are placed in the flue of a boiler unit, usually after the screens or beyond the furnace. They consist of multirow banks of coils.

Superheaters composed entirely of convection stages are usually installed in average- or low-pressure boiler units having superheated steam no hotter than 510°C. High-pressure boiler units with considerable steam superheating use composite superheaters, which include convection, screen, and sometimes radiant sections.

III. INTRODUCTION OF COMPUTATIONAL FLUID DYNAMICS (CFD)

IV.

CFD is predicting what will happen, quantitatively, when fluids flow, often with the complications of simultaneous flow of heat, mass transfer (example. perspiration, dissolution),Phase change (example. Melting, freezing, boiling),Chemical reaction (example. Combustion, rusting), Mechanical movement (example. Of pistons, fans, rudders), and Stresses in displacement of immersed or surrounding solids.

Knowing how fluids will flow, and what will be their quantitative effects on the solids with which they are in contact, assists:-

- building-services engineers and architects to provide comfortable and safe human environments;
- power-plant designers to attain maximum efficiency, and reduce release of pollutants;
- chemical engineers to maximize the yields from their reactors and processing equipment;
- land-, air- and marine-vehicle designers to achieve maximum performance, at least cost;
- Risk-and-hazard analysts, and safety engineers, to predict how much damage to structures, equipment, human beings, animals and vegetation will be caused by fires, explosions and blast waves.

CFD-based flow simulations enable:-

- metropolitan authorities to determine where pollutant-emitting industrial plant may be safely located, and under what conditions motor-vehicle access must be restricted so as to preserve air quality;
- meteorologists and oceanographers to foretell winds and water currents; - hydrologists and others concerned with ground-water to forecast the effects of changes to ground-surface cover, of the creation of dams and aqua ducts on the quantity and quality of water supplies;
- petroleum engineers to design optimum oil-recovery strategies, and the equipment for putting them into practice;

CFD-based predictions are never 100%-reliable, because:

- the input data may involve too much guess-work or imprecision;
- the available computer power may be too small for high numerical accuracy (this is often the case);
- the scientific knowledge base may be inadequate .

The reliability is greater:
- For laminar flows rather than turbulent ones
- For single-phase flows rather than multi-phase flows;
- For chemically-inert rather than chemically-reactive materials;
- For single chemical reactions rather than multiple ones;
- For simple fluids rather than those of complex composition.

Therefore, coal-fired furnaces represent an extreme of uncertainty; but CFD is nevertheless used increasingly in their design because the uncertainties resulting from its non-use is even greater.

V. ANALYSIS OF SUPERHEATER TUBES

Based on the analysis of Ajay N. Ingale & Vivek C. Pathede (2012) &Prashant Kumkale (2014) they found tube leakage through CFD Modeling considering two temperature plots, one for steam flowing inside the SH tube and other for temperature of flue gases flowing over the SH Tube. Based on the temperature plots they found that the SH tube bend to be exposed to the high temperature region & velocity is high at SH tube bend and pressure drop more at the tube bend. It will lead to failure of the Tube.

Some of the cases may damage the straight portion tubes also in super heater section but it will be decided based on the CFD analysis. The Two dimensional super heater assemblies modeling is done through auto CAD software and the same is transformed to CFD analysis platform (Fig.4.1).

Refer below some of the damaged Straight portion tubes due to high flue gas temperature (Fig.4.2).

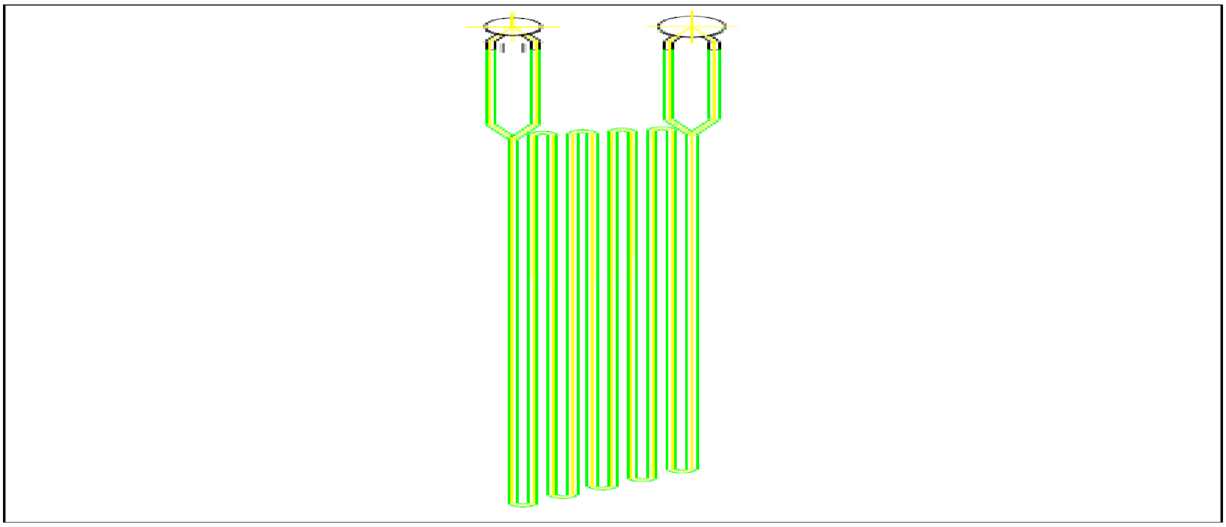


Fig.4.1 Two Dimensional Auto CAD Super Heater Drawing.

Fig. 4.2 Some of the Damaged Super Heater Tubes.

VI. TECHNICAL SPECIFICATION OF SUPER HEATER TUBE, FLUE GAS FLOW & STEAM

Sl.No.	Description	Unit	Values
FLUE GAS PARAMETERS			
1	Flow	Nm^3/hr.	176042
2	Specific Heat	Kcal/Nm^3 deg.c	0.31
3	Velocity	m/s	6
4	Temperature	Deg.C.	1200
TUBE PARAMETERS			
5	Tube Size	mm	Dia 42 x 3.5
6	Material		SA 335 Gr.P11
STEAM PARAMETERS			
7	Flow	Kg/Hr	60,000
8	Temperature	Deg.C	400
9	Pressure	kg/Cm^2	80
10	Velocity	m/s	25

VII. CONCLUSION:

The Purpose of this CFD analysis is to find out the Super Heater Tube Portion which would be affected by High Flue Gas Temperature. The identified Super Heater Tube Portion is to be shielded with SS Plates. The Shield Plate will safe guard the Super Heater Tube where the weak portion has been found out. Providing SS plate transfers the heat in a safe manner to the Super Heater Tube. Due to this the Super Heater Tube Leakage will be avoided and there is no maintenance of Super Heater Tubes. It improves the Power Production without any plant shutdown and subsequently will improve the Power Plant Income.

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