

Performance of Furnace in a Sub-Critical Boiler of Coal-fired Power Plant

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Abstract— The Furnace of the boiler in a thermal power plant have a substantial impact on the overall efficiency of the plant. The furnace comprises on four main components in a sub-critical operating unit: Boiler Drum, Superheater, Economiser and Re-heater. The efficiency of the furnace plays an important role in the boiler performance due to its continuous variation of operating parameters. Performance of furnace is very important in the optimisation of combustion process, energy balance and minimizing harmful emissions

Keywords— Furnace, Pressure, Heat Exchanger, Turbulence, Time, Temperature

I. INTRODUCTION

Furnace is the utmost energy consumption equipment in a boiler of a thermal power plant since by burning the coal in a pulverised form, the useful thermal energy is generated. The heat recovery zone in the furnace is the most important zone in transferring heat by conduction, convection and radiation.

The process of combustion is very critical and if efficiently burnt, the useful energy will be generated with respect to the burning of fuel. This efficiency evaluation is termed and combustion efficiency and it depends upon the type of fuel burnt, the amount of air for mixing fuel, the percentage of excess air blown, and other combustion characteristics.

II. FURNACE OF COAL-FIRED BOILER

In coal-fired boiler, the coal is pulverised to a fine powder and is blown by the use of primary air into the furnace by a set of nozzles.

The nozzles are place at four corners of the furnace so as to create a turbulence of the coal-air mixture inside the furnace as shown in Figure 1 below:

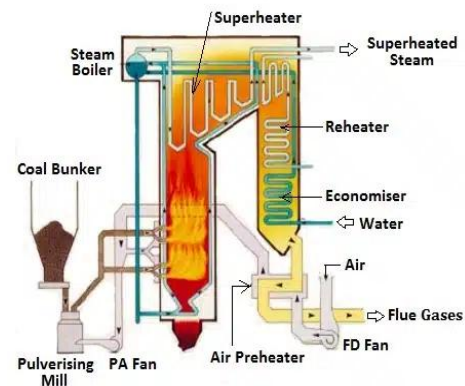


Figure No.1. Furnace of a coal-fired Sub-critical boiler

III. FURNACE EFFICIENCY

The furnace efficiency is defined as the useful heat output to the heat input and is calculated as below:

$$\text{Furnace Efficiency } \eta = \frac{\text{Heat Output}}{\text{Heat Input}}$$

However, there are some losses associated with the furnace which includes the sensible heat loss in flue gas, heat loss due to various openings in furnace, heat loss due to moisture in flue gas, heat loss through furnace skin, and other unaccounted losses. The efficient combustion of coal in furnace and thereby effective heat transfer to the water to get converted to steam is very essential for economical running of thermal power plant.

The pulverised fuel firing is mostly used for generating steam which is in practice from early 1920s. In this system, the coal is pulverised to a fine powder with the help of grinding mills and forced in to the furnace with the help of primary air.

The pulverised coal is transported to a closed chamber which operates under high pressure and inside the chamber, the conversion of chemical energy of coal is converted to thermal energy [1-3]. The air for combustion will be supplied by nozzles to burners by forced draft fan. Thus the mixture of the coal-air will be burnt inside the chamber. The heat formed from the flue gases converts the water to steam at the specified pressure and temperature.

The hot flue gases formed inside the furnace passes through the boiler, air preheater, economiser, super heater and flows to the chimney through an induced draught fan via electrostatic precipitator. The heat from the hot flue gases are transferred to the mentioned heat exchangers and the useful heat is thus extracted from the flue gases. The impact on Boiler efficiency with respect to furnace efficiency for a coal-fired boiler is shown in Figure No.2. below.

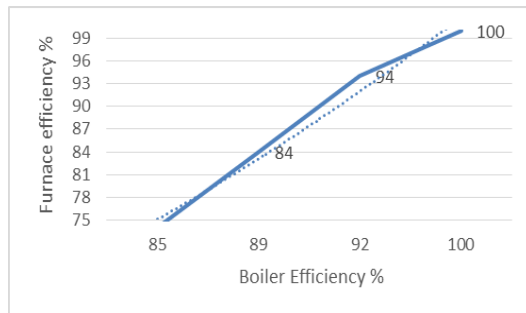


Figure No.2. Boiler Efficiency Vs Furnace Efficiency of a Sub-critical boiler

The reduction in the boiler efficiency and evaporation ratio with respect to time is often said due to heat transfer fouling, poor combustion, Operation and maintenance [4,5]. The absorption of heat by the various heat exchangers in the passage of the flue gases by the three modes of heat transfer : conduction, convection and radiation is crucial as the combustion takes place from 1300 to 1700 deg C.

The boiler efficiency loss at the exit is due to rise in flue gas temperature as it is controlled by the heat absorption process in the primary and secondary air pre-heaters[6,7]. The amount of heat energy in kJ produced by complete combustion of 1 Kg of coal is known as the Calorific value of fuel [8]. The efficiency of the pulverised coal firing depends upon the size of the coal powder fed inside the furnace.

IV. TANGENTIAL FUEL FIRING

The tangential fuel firing is based on the concept of a flame produced by firing fuel-air mixture through four fire guns from four corner of the furnace as shown in Figure No.3. The pulverised coal is entrained by the primary air and fired in suspension. As the four guns blows the coal – air mixture, a fire ball is created which controls the furnace exit gas temperature.

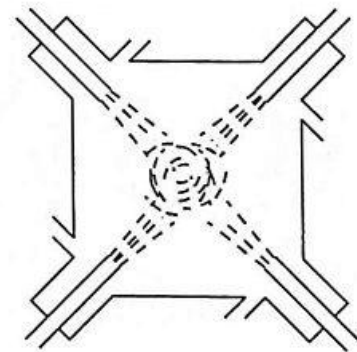


Figure No.3. Tangential fuel firing in a coal-fired boiler

This firing action provides a swirling action to the coal which increases the retention time of the coal staying inside the furnace to ensure complete combustion. The burners play a vital role in the efficiency as it directly affects the heat flow. The role of the primary air is to carry the pulverised coal to the furnace while the secondary air is injected tangentially to ensure complete combustion

V. FLAME STABILITY

The stability of the flame is a crucial impact on the performance of the furnace under all operating conditions. The number of primary air nozzles has to be increased in proportion to the coal flow and hence the stability of flame is enhanced. The secondary air may be sent at a higher velocity but less volume around the primary air which entrains the hot gases in the furnace promoting efficient heat transfer. The distance between the nozzles for the primary and secondary air may be increased for proper ignition.

VI. THERMAL ENERGY UTILISATION

The thermal energy generated is absorbed by the liquid water and thus converted to steam. Steam has high latent heat and thereby cost effective means of heat transfer.



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Due to the ability to store and transport large amount of heat energy in a finite volume, steam has been used widely [9]. As steam forms, it moves up due to density difference and hence no external source needed to pump it and it can be controlled easily [10-12]

VII. CONCLUSION

The performance of furnace is mainly affected by the combustion of coal which is directly proportional to the proper coal-air mix to ensure complete combustion. The amount of Excess air delivered takes away the useful heat which ultimately reduces the efficiency.

The heat losses of the furnace have to be minimised in order to achieve the higher furnace efficiency. Regular soot blowing and optimum blow down maintains the heat transfer rate and furnace efficiency is increased considerably

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