International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435 (Online) Volume 15, Issue 08, August 2026)

Enhancement Measures of Sub-Critical Boiler Efficiency of Coal Fired Thermal Power Plant

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***Abstract*— Boilers or steam generators in a coal-fired thermal power plant have to be operated efficiently so as to achieve overall plant efficiency. Typically the sub-critical boilers perform around or less than 60% efficiency. Certain energy enhancement if followed can lead to increase in efficiency which directly involves savings of operating cost. In order to perform this, the analysis of the performance of boilers needs to be analysed and remedial measures to be taken wherever needed. The optimum used of the fuel namely coal is essentially needed to conserve fuel consumption and hence to reduce environmental pollution. This paper analyses the sustainable ways of enhancing the boiler efficiency of the thermal power plant.**

***Keywords*— Boiler, Plant Efficiency, Fuel Cost, combustion, Excess air**

I. Introduction

Boiler is regarded to be the heart of a coal-fired thermal power plant. The boiler efficiency is one of the major factor which affects the performance of thermal power plant. Performance of the boiler decrease due to under performance of any boiler auxiliary systems like air and draft systems, feed water systems etc., Saidur et al. [1] studied energy, exergy analysis, energy losses, and exergy destruction for a boiler to reduce total energy consumption.

Controlling the amount of excess air, reducing the percentage of unburnt carbon and enhancing the plant heat transfer rate increase the boiler efficiency of the thermal power plant.

II. Boiler Operating Techniques Towards Maximum Efficiency

In simple terms, Boiler efficiency is the ratio of energy output to energy input. The energy input is the amount of heat energy released by the burning of coal. The energy output is the amount of steam produced at high temperature and pressure.

As fuel involves a major cost in the boiler operation, reduction in the fuel burnt for the designed production maximizes the boiler efficiency and also cost savings, Patel et al. [2] researched various parameters regarding to the boiler which tends to increase boiler performance. The schematic of the 210MW coal-fired thermal power plant is shown in Figure No.1.

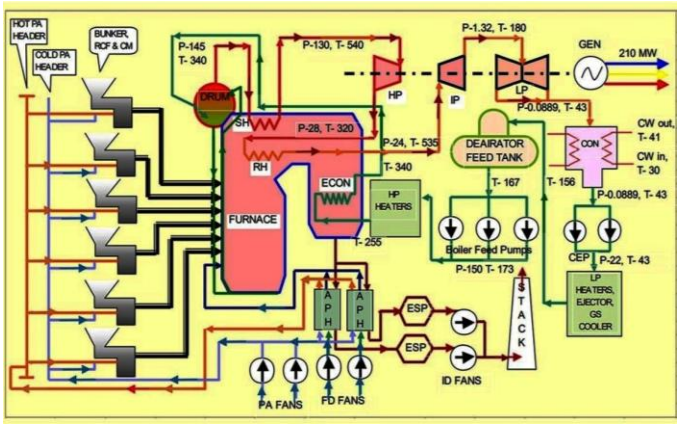

Figure No.1 Schematic of a 210 MW Coal Fired thermal Power plant

A. Optimization of Primary air flow

The optimum primary air flow ranges from 15% to 30% of total air needed for combustion for a coal fired system. Bhatt [3] studied the nature of air suction on efficiency of the combustion, of coal-fired thermal power plants and it is thus concluded that the optimum amount of oxygen is 3% for optimum combustion in the pulverized coal-fired systems.

The primary and secondary air streams should not be made to run with identical momentums. The adjustment of primary air flow level with the variations in boiler load should be ensured. The figure No.2 shows the optimum primary air-fuel ratio with combustion parameters.

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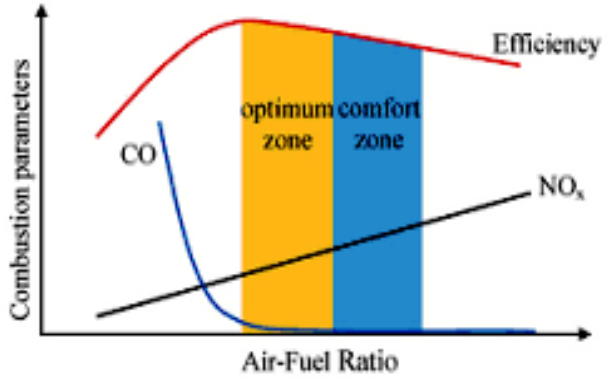

Figure No.2 Optimum Zone of combustion System

A. Stack temperature

The stack temperature denotes the quality of heat that is leaving the atmosphere. The stack losses are the unutilized heat energy escaping through the atmosphere through the chimney. This account for 15% to 25% of the total fuel input which means minimizing this loss increases the boiler efficiency as shown in figure No.3.

The Quantity of the heat energy is dependent on the fuel burnt and directly proportional to the amount of excess air supplied to burners.

The temperature of the flue gases leaving the chimney is critical as excessively low temperatures is not acceptable since corrosion can occur at the acid dew point temperature. Ashokkumar [4] studied and concluded that the flue gas loss in a boiler is more important than any other losses.

B. Excess Air

The total air required for combustion is usually controlled by the furnace draft in proportionate to the fuel flow rate. Excess air is the amount of air blown above the stoichiometric air for a given amount of fuel. The additional air if optimized increases the combustion rate, and reduced carbon loss. The slagging conditions are reduced.

But if the additional air becomes excess, then the power consumption increases and the stack loss increases. Also the tube erosion increases and increased NOx formation occurs and hence emission level increases.

Oman et al. [5] investigated the process on the coal fineness and flue gas soot blowing system.

At the flue gas temperature of 150 ° C, when the air excess coefficient was increased by 10%, the total heat loss was increased by 8% due to the flue gas heat, and when the air excess coefficient was increased by 50%, it was increased by 28%.

C. Feed water system

The main aim of the boiler is to transfer heat energy to water and convert to high pressure and temperature steam by the process of conduction since the water flows through metal tubes.

The water wall tubes will have deposits of scales over the inside surface whereas soot deposits over the outside surface of the tube. Water wall tube deposits reduce the heat transfer, raise the tube temperature leasing to boiler tube failures.

D. Soot Blowing

Soot blowing is done by an automated device that uses steam or compressed air to remove ash deposits from the outer side of the water walls. Excessive soot blowing results in increased operating cost erosion of tubes and failure of the equipment.

III. Conclusion

An efficient operation of boiler will reduce fuel costs and conserve fuel, lower emissions to environment. The downtime will be minimized and hence the overall productivity will be improved. The various boiler operating techniques discussed above if performed at an sequential manner, The losses will be cumulatively reduced and hence the boiler efficiency will be enhanced considerably.

REFERENCES

[1] Saidur R., Saidurn, J.U., et al, Energy, exergy and economic analysis of industrial boilers Energy Policy, 2010.

[2] Chetan T. Patel, et al Efficiency with different GCV of coal and efficiency improvement opportunity in boiler, International Journal of Innovative Research in Science, Engineering and Technology, 2013.

[3] M. S., Bhatt, Effect of air ingress on the energy performance of coal fired thermal power plants'', Energy Conversion and Management, 2006.

[4] A. Ashokkumar, Improvement of Boiler Efficiency in Thermal Power Plants, Middle-East Journal of Scientific Research, 2012.

[5] J. Oman, A. Senegačnik et al, Influence of lignite composition on thermal power plant performance Part 1: Theoretical survey, Energy Conversion & Management, 2000.