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Performance Enhancement Techniques for Boilers

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ABSTRACT

The major part of power generation in the country is from coal based power plants. The most important factor in deciding the overall performance of energy conversion in a coal fired power plant is the boiler efficiency. Analysis on performance of operating boilers in a certain 210 MW plants was made to check their performance levels. Boilers at these power plants have been found to be operating on the lower performance levels than desired. This is primarily due to improper maintenance of certain important operating parameters at the specified values. Boiler performance could be enhanced resulting in considerable savings in fuel and power, and reduction in emissions by monitoring, controlling and maintaining the operating parameters properly which is discussed in this paper.

Keywords: Efficiency, Power Plant, Boilers, Cost savings

I. INTRODUCTION

Coal fired thermal power plants utilize only 30 – 40 % of energy value in the fuel and the remaining 60 – 70 % of energy is lost mainly during generation followed by transmission and distribution. One of the major equipment in a power plant is the boiler, in which about 10 – 15 % heat loss takes place. This paper deals with major energy saving opportunities in boiler system based on the energy conservation studies carried out in some utility boilers of 210 MW power plants.

II. REQUIRED OPERATING PARAMETERS

The design details/ parameters of the boiler, where energy conservation study was carried out, are given in Table 1. During the study, important operating parameters of the boilers were measured using the state of the art portable instruments and some were collected from the plant records.

Table 1 Design parameters of boilers

Description Design	Details / Parameters
Type Radiant	Natural circulation, reheat type, single drum
Fuel	Pulverised coal
Steam generation	690 t/h
Steam pressure	156 ata
Steam temperature	540 ^{0}C
Feed water temperature at economiser inlet	243 ^{0}C
Reheater inlet pressure/ Temperature	38.6 ata / 342 ^{0}C
Reheater outlet pressure	37.3 ata

III. PERFORMANCE IDENTIFICATION

The observations of the boiler performance based on the parameters collected are described below.

Flue Gas Compositions

For efficient operation of any boiler, it is required to maintain optimum o_2, i.e. the excess air supplied for complete combustion should be about 15- 20 % higher than the stoichiometric air requirements for the coal fired boilers. However the actual excess air supplied to the boilers was lower in boiler 2, boiler 4 and boiler 5 as shown in Table 2.

Low excess air in boiler 2, boiler 4 and boiler 5 has increased the formation of carbon monoxide considerably, whereas the residual quantity of carbon monoxide in flue gas should be kept below 100 ppm. Although excess air percentages were lesser than 20% at air heater inlet, it was higher by about 12-35 % at air heater outlet as shown in Table 2. This is higher than the design level of 6.85 % in air heaters of all boilers.

Table 2 Combustion Products in Flue Gas

Boiler	Air heater Inlet		Air heater outlet		Air In leakage %
	Excess %	Co, ppm	Excess %	Co, ppm	
Boiler1	18.9	16.9	33.05	9.3	11.9
Boiler2	9.4	225	47.15	248	34.5
Boiler3	15.8	17	42.86	6.2	17.1
Boiler4	1.5	3987	30.14	4025	28.2
Boiler5	3.5	2553	28.45	2484	24.1

Flue Gas and Combustion Air Temperatures at Air Heater Outlet

Table 3 Flue gas and air temperatures at air heater exit

Boiler	Flue gas exit temp, ^{0}C	Air temp, ^{0}C
Boiler 1	143.3	272
Boiler 2	138.5	270
Boiler 3	144.5	276
Boiler 4	132	260.7
Boiler 5	128.5	279.8

It is seen from Table 3, that the flue gas temperature was marginally higher at air heater exit as compared to design of 140^0 C in boiler 1 and boiler 3.

The combustion air temperature leaving air heater was found to be 60-70^0 C lower than the design level 330^0 C in all the boilers. These factors lowered the boiler efficiency, significantly.

Boiler Load

The variations in power generation load % at different plants are given in Table 4.

Table 4 Steam and power generation details

Boiler	Variation in power generation load %
Design	Base(210 MW)
Boiler 1	0.38
Boiler 2	-1.33
Boiler 3	-1.86
Boiler 4	-0.71
Boiler 5	-4.81

IV.EFFICIENCY EVALUATION

The boiler efficiency may be computed either by direct method from the heat input and output or by the losses (Indirect) method. The reliability and accuracy of the fuel flow and steam flow measurements are very critical for the direct method, which may be misleading some times. Hence, indirect method is always chosen to compute the actual efficiency, which also helps in identifying and quantifying heat losses. The heat losses from the boiler include,

- Dry flue gas loss, which depends on excess air, flue gas composition and the corresponding gas temperature at air heater outlet
- Heat loss due to the presence of CO in flue gas
- Losses due to combustion of hydrogen and moisture, which depends on H_2 in fuel, and moisture in fuel and combustion air
- Un burnt carbon losses in bottom ash and fly ash
- Sensible heat loss in ash
- Structural heat losses
- Unaccounted heat losses

Based on the parameters collected, various losses in the boiler systems were calculated using the indirect method as per ASME PTC 4 and are presented in Table 5.

Table 5 Efficiency of Boilers

Boiler	Efficiency %	Variation as compared to design, %
Design	88.23	Base
Boiler 1	87.97	-0.29
Boiler 2	**88.05**	-0.20
Boiler 3	86.84	-1.58

Boiler 4	87.72	-0.58
Boiler 5	86.69	-1.75

The major losses in the boiler are due to dry flue gas losses, heat loss due to hydrogen and moisture in the fuel. As described in section III, these losses could be reduced by optimizing the excess air, by reducing the flue gas exit temperature, and by reducing air ingress in duct system, which would increase the boiler efficiency.

The efficiency of the forced draft (FD) fans has been evaluated for the above boilers and is shown in the Table 6.

Table 6 steam and power generation details

Fan	Flow t/h	Head mmWc	Power consumption, kW	Efficiency, %
Fan 1A	212	265	292	59.
Fan 1B	287	265	287	81.4
Fan 2A	380	192	336	65.7
Fan 2B	251	251	323	59.1
Fan 3A	220	187	173	71.9
Fan 3B	222	181	170	71.7
Fan 4A	304	190	292	59.9
Fan 4B	253	200	336	45.6
Fan 5A	229	201	234	70
Fan 5B	277	197	225	73.3

As shown in Table 6, the efficiency of fan 1A, fan 2B, fan 4A, fan 4B were less. This was mainly due to throttling. The following observations have been observed:

- The difference in flow of both the fans was high in all boilers except boiler 3
- The difference in head of both the fans was high in boiler 2
- Power consumption was high in boiler 2 and boiler 4

V. SUGGESTED TECHNIQUES

Reducing Air In-Leakage, Optimizing Excess Air and Reducing Flue Gas Temperature

The efficiency of boilers was reworked considering the levels of excess air, air in-Leakage and flue gas exit temperature at air heater outlet and is presented in Table 7

Table 7 Efficiency and monetary savings

Boiler	Efficiency, %	Monetary savings, lakhs/ annum
Boiler 1	89.27	296
Boiler 2	89.1	289
Boiler 3	87.59	243
Boiler 4	89.33	454
Boiler 5	88.41	455

Table 7 shows that efficiency of boilers could be improved by 0.75 - 1.72 % by optimizing the above parameters, which offers a monetary saving of Rupees 243 – Rupees 455 lakh/ annum/boiler. The efficiency of the boiler system was reworked by optimizing the following measures:

- Reducing air in-Leakages in all the boilers by
  - ➢ Closing ash hopper seals and doors
  - ➢ Repairing/ Replacing the defective expansion joints and defective boiler roof seals
  - ➢ Closing the duct openings
  - ➢ Reducing the damper passing of attemperating air damper and air heater by pass
  - ➢ Replacing the worn out shaft seals on exhauster, etc.
- Increasing the combustion air temperature and reducing the flue gas temperature at air heater outlet
  - ➢ By optimum soot blowing in the boiler and air heater zones
  - ➢ By improving seals in air heater

- Optimum excess air for complete combustion in boiler 4 and boiler 5
  - By supplying about 15 – 20 % excess air at boiler furnace

It has to be noted that this savings due to reduced auxiliary power consumption of draft fans due to reduced flue gas quantities by arresting the air in – leakages in boiler system

Alternative Energy Saving Measures

By adopting other energy conserving measures in boiler and boiler auxiliaries such as draft systems, blow down systems, insulation etc. it is possible to enhance the efficiency of the steam generator further. However, these measures are not discussed in this paper.

VI.CONCLUSION

Although, power plant personnel have sufficient awareness on all energy conservation for the boiler systems, only a few plants which implement these measures, but result in substantial cost and energy savings. Proactive approach in monitoring the performance of the boiler system and implementing the energy conservation measures thus identified would result in substantial cost savings.

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