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Research paper on Analysis of Boiler losses to improve Unit heat rate of coal fired thermal power plant.

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Abstract: This paper is concerned with calculating boiler efficiency as one of the most important types of performance measurement in any steam power plant. Thermal power plant converts the chemical energy of the coal into electricity. The heat rate of a conventional coal fired power plant is a measure of how efficiently it converts the chemical energy contained in the fuel into electrical energy Heat rate is expressed as kcal/kwh. The aim of monitoring boiler performance is to control the heat rate of plant. This paper deals with determination of operating efficiency of Boiler and calculates major losses for GSECL 210 MW unit in India.

Keywords: Boiler efficiency, Boiler losses, Unit heat rate

I. INTRODUCTION:

Boilers are considered to be as the key part in any generation station as it is the place where the fuel is used for producing the needed amount of heat. A boiler is an enclosed vessel that provides a means for combustion heat to be transferred to convert water into steam. A boiler is a complex integration of evaporator, reheater, super heater, economizer, air pre heater along with various auxiliaries such as pulveriser,fans, etc,[1]. The purpose of the performance test of boiler is to determine actual performance and efficiency of the boiler and compare it with design values. It is an indicator for tracking day to day and season to season variation in boiler efficiency and energy efficiency improvements to control unit heat rate. [2]

Basically Boiler efficiency can be tested by the following methods:

The direct method:

Where the energy gain of the working fluid (water and steam) is compared with the energy content of the fuel. This is also known as 'input-output method' due to the fact that it needs only the useful output (steam) and the heat input (fuel) for evaluating the efficiency. This can be evaluated using the formula: [2]

$$\text{Boiler Efficiency} = \frac{\text{Heat Input}}{\text{Heat Output}}\times 100$$

$$\text{Boiler Efficiency} = \frac{\text{Steam flow rate}\times(\text{steam enthalpy-feed water enthalpy})}{\text{Fuel firing rate}\times \text{GCV of fuel}}$$

$$\text{Boiler Efficiency} = \frac{\text{Heat in steam output}}{\text{Heat in fuel input}}\times 100$$

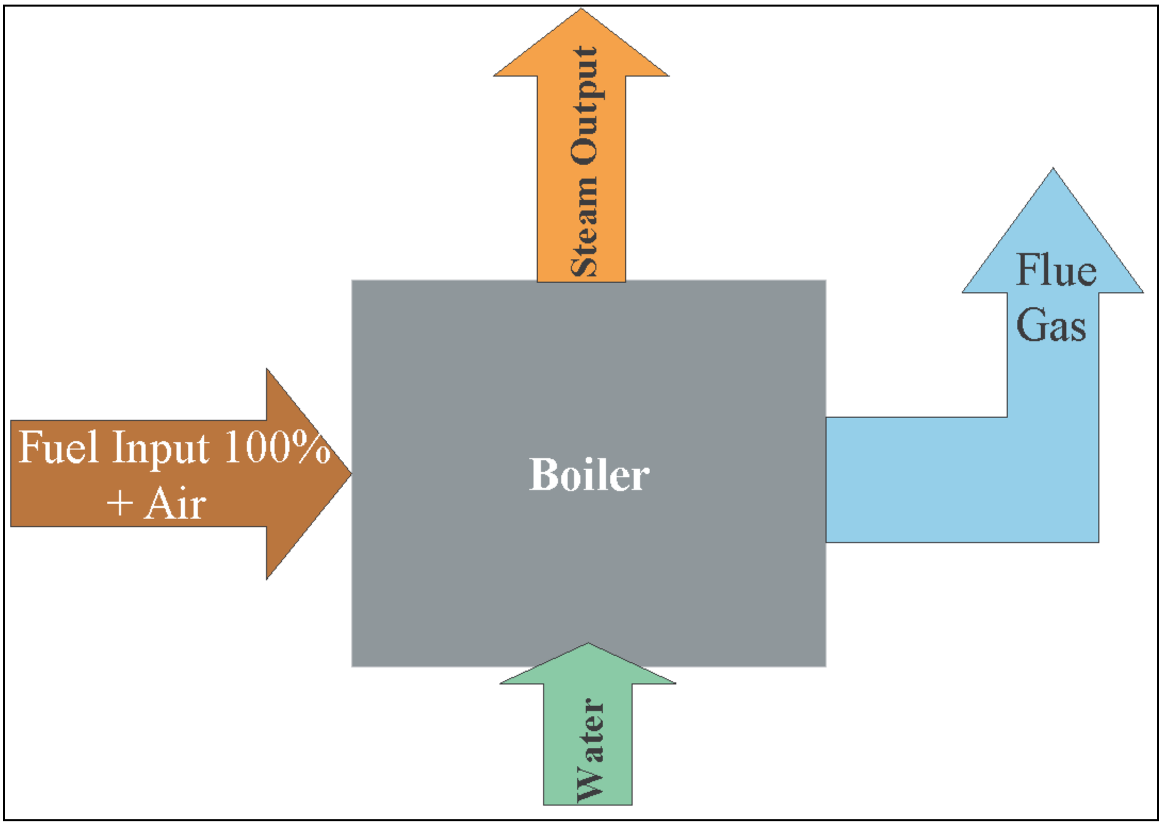


Fig.1 Direct method

The Indirect method:

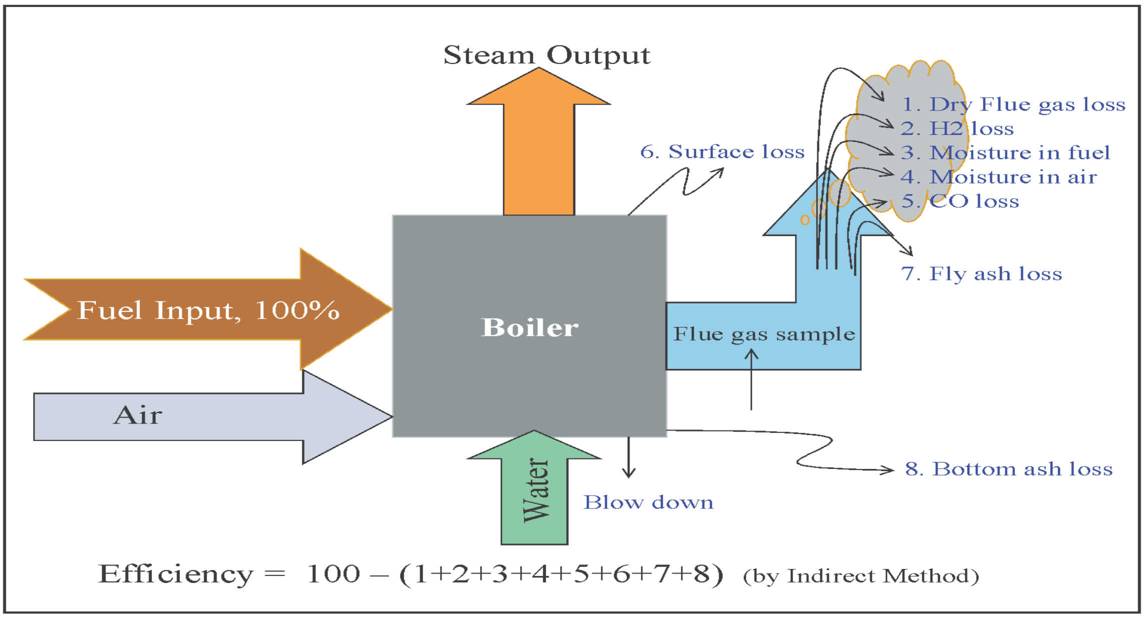
Where the efficiency is the difference between the losses and the energy input.

The efficiency can be measured easily by measuring all the losses occurring in the boilers using the principles to be described. The efficiency can be arrived at, by subtracting the various heat losses from 100. An important advantage of this method is that the errors in measurement do not make significant change in efficiency. [2]

Efficiency=100- (L1+L2+L3+L4+L5+L6+L7+L8)

Where,

L1-Loss due to dry flue gas (sensible heat)
L2- Loss due to hydrogen in fuel (H_2)
L3- Loss due to moisture in fuel (H_2O)
L4- Loss due to moisture in air (H_2O)
L5- Loss due to carbon monoxide (CO)
L6- Loss due to surface radiation, convection and unaccounted
L7- Loss due to Unburnt in fly ash (Carbon)
L8- Loss due to Unburnt in bottom ash (Carbon)



Measurements required for performance Assessment Testing

The following parameters need to be measured, as applicable for the computation of boiler efficiency and performance. [2, 3]

a) Flue gas analysis

- Percentage of CO_2 or O_2 in flue gas
- Percentage of CO in flue gas
- Flue gas temperature

b) Flow measurement

1. Steam
2. Fuel
3. Feed water
4. Condensate water
5. Combustion Air

c) Temperature measurement

- Steam
- Feed water
- Condensate return
- Flue gas

d) Pressure measurement

- Steam
- Flue gas
- Combustion Air

e) Ultimate analysis for H_2, O_2, C, S, moisture and ash content

Boiler Efficiency by indirect method:

Calculation procedure and formula [2]:

$$\text{Theoretical Air required} = \frac{\left[(11.6C) + 34.8\left(H2 - \frac{O2}{8}\right) + 4.35S\right]}{100} \text{ Kg/kg of fuel}$$

$$\%\text{Excess Air supplied(EA)} = \frac{O2\%}{21 - O2\%} \times 100$$

$$L1 = \frac{m \times Cp \times (Tf - Ta)}{\text{GCV of fuel}} \times 100$$

$$L2 = \frac{9 \times H2 \times \{584 + Cp\,(Tf - Ta)\}}{\text{GCV of fuel}} \times 100$$

$$L3 = \frac{M \times \{584 + Cp\,(Tf - Ta)\}}{\text{GCV of fuel}} \times 100$$

$$L4 = \frac{AAS \times humidity \ \ factor \ \times Cp \times (Tf - Ta)}{GCV \ \ of \ fuel} \times 100$$

$$L5 = \frac{\%CO \times C}{\%CO \times \%CO2} \times \frac{5654}{GCV \ \ of \ fuel} \times 100$$

$$L6 = \text{For power station } 0.4 \text{ to } 1\ \%$$

$$L7 = \frac{Total \ \ fly \ ash \ collected \ \ per \ kg \ of \ fuel \times GCV \ \ of \ fly \ ash}{GCV \ \ of \ fuel} \times 100$$

$$L8 = \frac{Total \ \ bottom \ \ ash \ collected \ \ per \ \ kg \ of \ fuel \times GCV \ \ of \ bottom \ \ ash}{GCV \ \ of \ fuel} \times 100$$

$$\text{Unit heat rate, kcal/kwh} = \frac{Turbine \ \ heat \ \ rate, kcal/kwh}{Boiler \ \ efficiency}$$

II. EXPERIMENTATION:

Following data are measured from 210 MW coal fired thermal power plant.

Actual Boiler data:

Sr. No.	Parameters	Unit	Actual value
1	CO2 (by volume in dry flue gas at air heater outlet)	%	14.25
2	CO (by volume in dry flue gas at air heater outlet)	%	10
3	O2 (by volume in dry flue gas at air heater outlet)	%	4.25
4	N2 (by volume in dry flue gas at air heater outlet)	%	81.5
5	C(Total carbon/kg of fuel)	%	30.72
6	S (Total sulphur /kg of fuel)	%	1.17
7	T (gas outlet temp at air heater outlet)	C	193.5
8	t (air temp from FD discharge/ref air temp)	C	36
9	M (moisture/kg of fuel)	%	13.33
10	H (hydrogen/kg of fuel)	%	4.66
11	GCV on volume basis	KJ/kg	14,139
12	h (moisture content/kg dry air)	Kg/kg	0.013
13	A (ash content kg/kg fuel)	Kg/kg	33.25
14	Bottom ash percentage of total ash	%	10
15	Fly ash percentage of total ash	%	90
16	Carbon in fly ash	%	0.6

17	Carbon in bottom ash	%	1.29

III. RESULT AND DISCUSSION:

Following losses are found in boiler efficiency calculation by indirect method

Sr.N0	Losses (%)	Design value (%)	Actual value (%)
1	Dry flue gas	4.663	6.166
2	Wet flue gas	6.103	10.603
3	Moisture in combustion air	0.051	0.146
4	Un burnt gas	0	0.004
5	Combustible loss	0.228	0.532
6	Radiation	0.22	0.22
7	Manufacturing margin and unaccounted loss	1.5	1.5
8	Total loss	12.76	19.17
9	Gross boiler efficiency	**87.24**	**80.83**

Turbine heat rate = 2653 kcal/kwh
Unit heat rate=2653/0.8724
=3041 kcal/kwh (At design boiler efficiency)
Unit heat rate=2653/0.8083
= 3282 kcal/kwh (Actual operating condition)

IV. ANALYSIS:

The above calculation shows the various losses in boiler. The major heat losses in boiler occur due to dry heat gas loss (6.166), wet flue gas loss (10.603), and combustible loss (0.532). To find causes of above losses in boiler and recommendation to reduce the causes of degradation of boiler performance are given by fault tree analysis (FTA). The heat rate fault tree is used to identify areas in the plant where heat rate degradation may be occurring without conducting expensive tests. The fault tree is structured to provide a process by which decisions can be determined that narrow down the causes of the problem based on available information.[3,4,5]

Table 1: Causes of boiler losses and corrective action required

CAUSES OF LOSSES	CORRECTIVE ACTION
Dry Gas losses	
Boiler casing Air in leakage	O2 reading should be taken at several stages
Air preheater air leakage	Monitoring of inlet and outlet temperature of gases.
Incorrect fuel to air ratio	Proper O2 monitoring system

Fouled heat transfer surface	Proper soot blowing system
Wet gas losses	
Excessive soot blowing	Optimize soot blowing system
Change in coal quality	Periodic checking of coal quality
High moisture in coal	Provide proper primary air Proper coal storage
Incomplete combustion	
Incorrect Air-fuel ratio	Proper O2 monitoring system
Burner damper setting	Adjust damper properly
Decrease in mill fineness	Proper classifier setting Set proper mill journal and spring setting

V. CONCLUSION:

Thermal power plant heat rate is directly affected by boiler efficiency. From calculation it is found that 1% decrease in boiler efficiency increases the heat rate by 1%. Heat rate is increases as boiler efficiency decreases so to achieve desired heat rate boiler performance required to be improved. Boiler efficiency is approved by reducing various losses and controlling stack temperature.

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