Energy Performance Assessment of Steam Generator System

Ritesh Pednekar[1], Sneha Sawant[2], Shilratna pawar[3], Dadaso Pawar[4], Hemant Chavan[5]
[1, 2, 3, 4, 5] Department of Mechanical Engineering
[1, 2, 3, 4, 5] Finolex Academy of Management and Tecnology

Abstract- *Energy analysis is technique developed to reduce unnecessary consumption of energy which is help to improve efficiency of boiler. Boiler is the heart of any developing industries to process and production. In these paper we shall discuss the two methods of measuring boiler efficiency i.e. Direct and Indirect method. Both gives different result of calculation. Direct losses does not consider different losses of boiler like dry flue gas, unburnt losses in fly ash. Whereas indirect heat loss method consider all heat losses of a system, so in present work we using indirect heat loss method is carried out for a CETHAR FLUIDIX boiler of Finolex Industry, Ratnagiri. All necessary Data for Calculation is taken from Finolex Industry*

Keywords- Boiler, Indirect heat loss method, efficiency calculations.

I. INTRODUCTION

A boiler or steam generator is a device made up of closed container or vessel constructed by steel used to create steam by applying heat energy to water until the water converted into steam at required pressure. Most of the industry used coal as fuel as GCV of fuel is high, efficiency of boiler will be high. The boiler efficiency is the percentage of the energy released in the burning of fuel in a boiler which actually goes into the production of steam.

The efficiency of a steam generator can be find out by two methods i.e. Direct heat loss and Indirect heat loss method . In Indirect heat loss method we consider different losses like, Dry Flue gas, heat loss due to hydrogen in fuel, losses due to moisture contain in fuel, heat loss due to unburnt fuel in fly ash. Whereas in direct heat loss method we only consider heat input and heat output. So for the improvement of the plant and improvement of the boiler efficiency we goes through the indirect heat loss method. The efficiency of boiler is depend on weather also and different parameter like temperature of flue gas, chemical composition of fuel, fuel consumption so it helps to increase efficiency of boiler.

II. LITERATURE REVIEW

Chetan T. Patel, et al.[1] studied two types of coal Indian Lignite with GCV 4300 kcal/kg and Semi Bitumious with GCV 5800 kcal/kg and find out effect on boiler efficiency. The comparison between two coal is given in table No.1.For that they used two methods Direct method and Indirect method. Its conclude that coal with higher GCV give maximum efficiency.

Table 1.

	Indian Lignite coal	Semi bituminous coal
Theoretical air requirement (kg/kg of coal)	7.5313	7.533
% Excess air required for complete combustion of coal		
Method 1	63.04%	63.04 %
Method 2	10.25%	63.34 %
Method 3	11.30%	64.85 %
Actual Air Requirement (kg/kg of coal)	8.303	12.302
Mass Of Dry Flue Gas Exhausted From Stack	8.845	13.243
Heat Loss In Dry Flue Gas	8.245%	6.112 %
Heat Loss Due To H2 In Fuel	4.814%	5.146 %
Heat Loss Due To Moisture In Fuel	2.625%	1.477 %
Heat Loss Due To Moisture In Air	0.3248%	0.3567%
Heat Loss Due To CO Formation (Incomplete Combustion)	1.727%	2.041%
Heat Loss Due To Un-burnt Fuel In Fly Ash	0.2321%	0.3442 %
Heat Loss Due To Un-burnt Fuel In Bottom Ash	0.8863%	0.6571 %

Heat Loss Due To Radiation And Convection (kcal/m^2)	6078.301	6078.3
Surface Loss	3.626%	3.655 %
Boiler Efficiency	**77.51**	**80.20 %**

A.G.Vinchukar, et al. [2] studied the energy management system of thermal power plant and compare the design values and operating values of boiler system. They explain the role of energy management team and action plan for that team Overall purpose of these team is technology innovation, maintaince management , energy audit of the plant. They maximize profitability of the plant by reducing cost of power generation. And also they do the cost analysis of the plant and gives idea for reduce the overall cost of the plant.

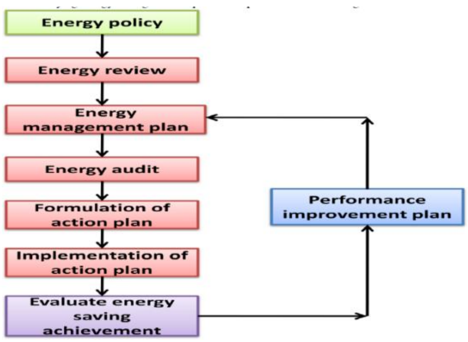

Figure 1.

Parameters	Unit	Design	Actual
Fixed carbon	%	38.96	35.06
Volatile Matter	%	14.8	19.88
Moisture	%	10	8.49
Ash	%	45	36.57
GCV	Kcal/kg	4000	3886

Figure 2.

Anjali T. H., Dr. G. Kalivarathan [3] analyzed the efficiency of component of thermal power plant i.e. boiler, turbine and condenser by using first and second law of thermodynamics. They used two methods for analysis

1. Energy analysis which is dependent on first law of thermodynamics.
2. Energy analysis which is dependent on second law of thermodynamics.

b. Heat input data

Quantity of Bagasse consumed (Input): 38.5 TPH

GCV of Bagasse (GCV)

= 4600 *x* (1– w) – (1200 *x* s)

Where,

w = moisture in bagasse
s = bagasse pol in %

GCV = 4600 x (1– w) – (1200 x s)

= 2276 kcal/kg

Therefore, Boiler efficiency (η)

$$= \frac{Q \times (hg-hf)}{q \times GCV \text{ of Fuel}} \times 100$$

Where,

Q = Quantity of steam generated per hour (kg/hr)
q= Quantity of fuel used per hour (kg/hr)
GCV = Gross calorific value of the fuel (kCal/kg)
hg = Enthalpy of steam (kCal/kg)
hf = Enthalpy of feed water (kCal/kg)

Boiler efficiency

= 104.5 TPH x (829.88 kCal/kg – 178.62 kCal/kg) x 100
38.5 TPH x 2276 kCal/kg

= 77.66 %

Evaporation Ratio

= 104.5 Tonne of steam / 38.5 Tonne of bagasse.
= 2.71

Indirect Method:

Step -1. Find Theoretical Air Requirement

a) Theoretical air required for combustion

= [(11.6 x C) + {34.8 x (H2 – O2 / 8)} + (4.35 x S)] /100 kg/kg of fuel.
= [(11.6 x 23.17) + {34.8 x (4.10 – 21.33 /8)} + (4.35 x 0)] /100
= 3.185 kg/kg of bagasse.

Step -2. To Find Excess Air Supplied On The Basis Of % O_2

b) % Excess air supplied (EA)

= O_2% x 100 / (21- O_2%). [From flue gas analysis]
= 4.90 x 100 / (21- 4.90)
= 30.43 %

Using both methods they found out that efficiencies of boiler both methods and gave suggestions for improvement of plant efficiency.

1. Percentage Heat loss due to evaporation of water formed due to H2 in fuel (L2)

= {9 x H2 x [584+ Cp (Tf –Ta)] / GCV of fuel} x 100
= {9 x 0.041 x [584+0.45 (140 – 40)] / 2276} x 100
= 10.198 %

2. Heat loss due to moisture present in fuel (L3)

= {M x [584 + CP (Tf –Ta)] / GCV of fuel} x 100
= {0.50 x [584 + 0.45(140 – 40)] / 2276} x 100
= 13.818 %

3. Heat loss due to radiation (L4)

= 1.00 % (Here Radiation loss is always taken as a constant value)

4. Heat loss due to unburned carbon in ash (L5)

= {[Quantity of ash in fuel x GCV of ash] / GCV of fuel} x 100
= {[0.013 x 800] / 2276} x 100
= 0.46 %

NOTE: Here L6 and L7 Heat losses are neglected. So, values of that were not considered in boiler efficiency

Boiler efficiency by indirect method.

= 100 – (L1+ L2+ L3+ L4+ L5)
= 100 – (4.42 + 10.198+ 13.818+ 1.00+ 0.46)
= 100 – 29.896
= 70.104 %

Computation of steam to fuel ratio (evaporation ratio)

= [(GCV of bagasse x Boiler efficiency) / (H steam – Hfeed water)]
= [(2276 x 0.701) / (829.88 – 178.62)]
= 2.45 kg of steam / kg of bagasse.

III. CONCLUSION

The energy balance sheet shows that theoretical losses in various components of boiler. It provides information for selection of the component which has maximum losses so, that optimization techniques could be used to make it more efficient . Conclusion derived from the data related to the boiler, heat loss due to hydrogen in fuel are around 5-8 % and heat loss due to moisture content in the fuel are around 4-7% and will affect the efficiency. The heat loss due to dry flue gases are around 4-6% that because of marginally high excess air i.e. ranging from 40-70%.