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Boiler Efficiency Improvement in Thermal Power Plant by Using Audit Tool

Rahul Trele
M. Tech. Research Scholar
Takshshila Institute of Engineering & Technology
Jabalpur (M.P.) [INDIA]
Email: rahultrele7@gmail.com

Pramod Dubey
Assistant Professor
Department of Electrical & Electronics Engineering
Takshshila Institute of Engineering & Technology
Jabalpur (M.P.) [INDIA]
Email: pramoddubey@takshshila.org

ABSTRACT

The problem of savings of energy gets more and more importance in economy of the industries in India. Transition to the world prices for energy resources is accompanied by catastrophic growth of cost of energy consumption. Thus extremely important there is a detailed analysis of all power expenses and ways of savings of energy. By its production, transformation, transportation, distribution and consumption the new direction of power – energy saving is engaged in questions of effective use of energy.

Keywords:— *Generator, Turbine, Boiler, Condenser, Cooling Tower, Furnace, Coal, Oil, Water, Grinder, Chimney, Fans, Super heater, Air pre-heater, Economizer, Ash Handling Plant.*

I. INTRODUCTION

The key object is to adopt energy management in every field in order to reduce the wastage of energy sources and cost effectiveness without affecting productivity and growth. Energy audits help to recognize the pattern of energy, form of energy consumption and amount of energy consumption so that identify the possible Area of energy conservation. The load distribution or consumption patterns in the power plant and the operation of energy intensive equipments or systems were studied during the energy audit in order to identify potential areas where energy saving is practically possible. The rate of exploitation of the energy resources has been expanding over time and may result in reduction of panic reserves. Efficiency of all resources is crucial both in an environmental and economic sense. Using energy inadequately creates waste in all the world's economies. It has environmental impacts with regional, local and global implications. Today, provided continues with the enlarged use of renewable resources and also restricted use of non-renewable resources. The instrument of achievement of efficiency of use of energy is power management. This term the complex of the information and analytical, organizational and technical and standard and legal actions directed on effective production and rational consumption of fuel and energy resources unites. For the solution of practical questions of effective use of energy the knowledge of the main terms and the concepts connected with production, transformation, transportation and energy consumption, and also directly concerning energy saving is necessary. Energy saving – the organizational, scientific, practical and information activities directed on effective use of energy resources and realized with application of technical, economic and legal methods. Energy saving includes a wide set of the interconnected actions and methods for ensuring effective use of energy.

Renewable Power

The Government has been promoting private investment for the setting up of projects for power generation from renewable energy sources and to the special tariffs being provided at the State level.

Table 1: Share of Different Renewable Sources in India

Resource	Potential (MW)	Up to 9th Plan	Up to 10th Plan	Up to 11th Plan	Target Up to 30.09.10	Cumulative Achievement	12th Plan Projection (2017)
Wind Power	48,500	1667	5,427	9,000	4,714	12,809	27,300
Small Hydro Power	15,000	1,438	538	1,400	759	2,823	5,000
Bio Power	23,700	390	795	1,780	1,079	2,505	5,100
Solar power	20-30 MW/sq km	2	1	50	8	18	4,000
Total	**4,000**	**13,497**	**6,761**	**12,230**	**6,560**	**18,155**	**41,400**

(Source: Ministry of New and Renewable Energy, Government of India)

These include capital subsidies, accelerated depreciation and customs duties. The capital subsidy being provided depends on region and the renewable resources. The capital subsidies vary from 10% to 90% of project cost. The higher level of capital subsidies are given for projects in the North -Eastern Region or Special category States. Generation Based incentives have been introduced recently for Wind Power to attract private investment by Independent Power Producers. There are not availing Accelerated Depreciation benefit and feed in tariffs for solar power.

Objective

The objective of the thesis is to increase the efficiency of thermal power plant by comparing the different types of losses on two different loads.

Methodology Used

Energy audit of thermal power plant is carried out on 80% and 100% MCR load. The measured values and calculated values are compared. To compare loads options, a simple approach is to increase the efficiency of plant by check and repair periodically of the equipments of plant and replacement of less efficient or damage equipments with more efficient or new equipments.

Working of a Boiler

In thermal power stations water tube type boiler is used. The economizer heat energy developed due to combustion of coal in furnace. This heat is utilized for the evaporation of water in the boiler. This steam is a mixture of water and steam which enters in boiler drum without help of pump. The final steam that comes out of boiler is called saturated steam. Then, saturated steam is passed through number of super heaters. Temperature of this steam is 540° C (Pressure being 138 Kg/).In the boiler furnace, coal burn, then to the second pass to the exit of boiler. Economizer and super heaters are placed in second pass one above the other. In the combustion, the temperature of the flue gases zone is 1200°-1400°C and after furnace C. The temperature of flue gas slowly decreases to 400°C second pass. Its temperature drops down to 140°.

Combustion of Pulverized Coal

Combustion system can be categorized into either of the following two categories:

1. Current commercial technologies the most common are pulverized coal combustion, cyclone firing, and stoker firing. In this type of system, the coal is prepared by grinding to a very fine uniformity for combustion. Typically, 70% of the coal is ground to pass

through a mesh screen. During coal combusts, ash is formed in the combustion chamber. The main advantage of pc combustion is the very fine nature of the fly ash produced. PC combustion results in roughly 65%-85% fly ash and the remainder is coarser bottom ash.

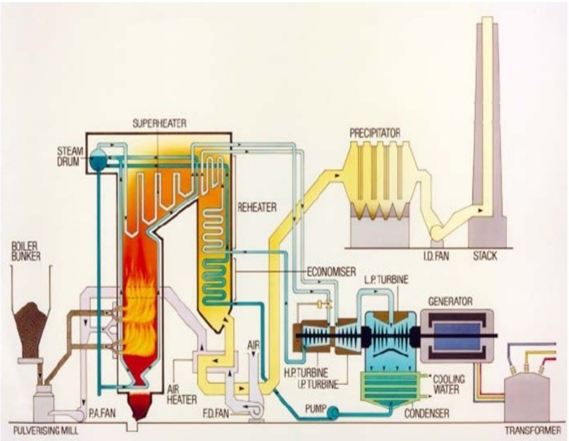

Figure 1 : Complete Diagram of Pulverize Coal

2. Emerging technology is being developed to efficiency environmental compliance and improves cost. Advanced clean coal technologies, including atmospheric fluidized combustors (AFBCs), circulating fluidized bed combustors (PFBCs), gasification systems and produce ash characteristics that differ significantly from conventional coal firing technologies. The literature supplied by the power station.

Testing Procedure

The tests can be carried out at the 100% MCR load.

Boiler Efficiency Test

Due to poor combustion, poor operation, heat transfer fouling and maintenance, the performance of boiler is reduced with time. There are two other causes which also lead to poor performance of boiler i.e. Deterioration of fuel quality and water quality. Efficiency testing helps to observe, how far the boiler floats away from the best efficiency.

Indirect method:

The indirect method is also called the heat loss method. The efficiency can be calculated by subtracting the heat loss fractions from 100 as follows:

Efficiency of boiler (n) = 100 - (i + ii + iii + iv + v + vi + vii)

Whereby the principle losses that occur in a boiler are loss of heat due to:

1. Dry flue gas
2. Evaporation of water formed due to H_2 in fuel
3. Evaporation of moisture in fuel
4. Moisture present in combustion air
5. Un-burnt fuel in fly ash
6. Un-burnt fuel in bottom ash
7. Radiation and other unaccounted losses

Coal

Analysis of coal is very important part during boiler efficiency test. This analysis helps find out the quality of coal. Quality of coal is calculated by the percentages of different constituents which help in categorizing it as a high grade or lower grade coal. There are two types of tests involved in the analysis of coal:

i. Proximate analysis of coal

It includes the determination of carbon moisture, ash and volatile matter and fixed carbon. This gives quick and valuable information.

ii. Ultimate analysis of coal

It includes the estimation of ash, carbon, hydrogen, oxygen and nitrogen. It is essential for calculation heat balance in any process. Proximate analysis of coal is done in thermal power plant but ultimate analysis of coal is not performed, it is also done on annual basis.

Signification of Proximate Analysis

The main purpose of coal sample analysis is to determine the rank of the coal along with its intrinsic characteristics.

Moisture

Moisture is a main property of coal. All types of coal are mined wet. Groundwater and other extraneous moisture are known as adventitious moisture. Moisture may take place in four possible forms within coal:

a) Surface moisture

Water held on the surface of coal particles.

b) Hydroscopic moisture

Water held by capillary action within the micro fractures of the coal.

c) Decomposition moisture

Water held within the coal's decomposed organic compounds.

d) Mineral moisture

Water comprises part of the crystal structure of hydrous silicates such as clays.

ii) Ash

After coal is burnt, ash content of coal is the non-combustible remains left. During combustion, it represents the bulk mineral matter after carbon, oxygen, sulfur and water (including from clays) have been driven off.

iii) Fixed carbon

The fixed carbon content of the coal is the carbon found in the material. These are left after volatile materials are driven off. The total sum of percentages of moisture and ash subtracted from 100 gives the percentage of fixed carbon.

Formulas to calculate the different losses.

a) Wet Stack Losses

The wet products of combustion are deriving from the moisture (both inherent and surface) and hydrogen in fuel. The mainly controllable factor to control these losses is by reduction in exiting gas temperature.

$$WSL = \left[\frac{M + 9H}{100}\right][1.88(T - 25) + 2442 + 4.2(25 - T)]$$

% WSL = (WSL/GCV) x 100

b) Dry Stack Losses

The components of fuel that burn to form dry product of combustion are sulphur and carbon. The carbon has greater significance therefore sulphur has low (0.42%) in India which is ignored. The major parameters of exiting gas temperature at air pre-heater outlet (APH) are proper index for quantifying the dry stack loss.

$$DSL = \left[\frac{100}{12(CO_2 + CO)}\left(\frac{C}{100} + \frac{S}{100} - C\ in\ A\right)\right]30.6(T - t)$$

c) Moisture in Combustion Air loss

The air is used for combustion. This air has small amount of moisture, which gives rise to heat loss. This is generally small and calculated as:

$$MCA = \left[\frac{3.034(N_2)}{[(C]_2 + CO)}\left[\left(\frac{C}{100}\right)\left(\frac{S}{267}\right) - C\ in\ A\right]\right]1.88(T - t)h$$

% MCA = (MCA/GCV) x 100

d) Sensible Heat Loss of Water Vapor

These losses refer to the losses sensible heat of water vapor. Latent heat of vapor is equal to the difference between gas calorific value and net calorific value. This loss is calculated as:

SHLWV = (WSL) – (GCV-NCV)

% SHLWV = (SHLWV/GCV) x 100

e) Radiation Loss

Radian losses are heat losses from boiler enclosure through insulation. Least conductive insulation can minimize the losses.

RL = % RL = (RL/GCV) x 100

Calculations and Results

210MW at 100% MCR Boiler Efficiency Calculations

1. Boiler Parameters:

Condition at Air Pre-Heater

CO_2 at Air heater outlet (%)	14.42
O_2 at Air heater outlet (%)	4.80
CO in flue gas (%)	0.00
A/H gas outlet temperature °C	137.00

2. Un-burnt Carbon in Ash

Bottom Ash	4.05
Fly ash %	1.38
Dry bulb temperature at F.D. inlet °C	33.08
Wet bulb temperature °C	31.03
Kg moisture/ Kg dry air	0.00
Steam flow	634.00
Boiler evaporation rate Kg/s	184.40

III. ANALYSIS OF COAL

Proximate Analysis of Coal

Ash (%)	31.44
Moisture (%)	14.26
Sulphur (%)	0.30
Gross Calorific Value (GCV)	025.64(kJ/kg)

IV. ULTIMATE ANALYSIS OF COAL

Hydrogen (%)	41.24 2.08
Nitrogen (%)	1.81
Oxygen (%)	10.78
Sulphur (%)	0.30
Net Calorific Value	14220.09 (kJ/kg)

Boiler Efficiency Calculations

	Loss In KJ/Kg	%
Wet Stack Loss	868.64	6.10
Dry Stack Loss	729.55	5.13
Moisture in combustion Air Loss	61.44	0.40
Sensible Heat of Water Vapor	63.9	0.43
Un-burnt Gas Loss	0.00	0.00
Radiation And Unaccountable Loss	251.68	1.58
Total (%) Loss		13.64
Boiler Efficiency		83.50

V. CONCLUSIONS

S. No.	Results	Conclusions
1	Wet stack loss (6.10%) and dry stack loss (5.13%) are occurred due to moisture in coal.	The moisture of coal should be reduced before use. The moisture can be removed by primary air. The dry coal increases the boiler efficiency.
2	6% of radiation losses are increased in the furnace.	The radiation loss occurs due to poor insulation. So, insulation should be good in quality e.g. Rock wool insulation.
3	Un-burnt carbon in bottom ash and respectively.	There should be proper crushing of coal. The classifiers in mills should be cleaned and checked periodically.

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