"Review Paper on Energy Analysis of a Boiler at Thermal Power Station"

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ABSTRACT

Overreliance on energy from coal is unsustainable because of their regional depletion and associated environmental impacts. Effective utilization of available energy and its management for minimizing irreversibility has made power plant engineers to look for efficient energy consumption & conversion. This study deals with the energy and energy analysis of a 10 & 20 MW coal fired boiler in design and off design condition at constant pressure mode of operation. Locations and magnitude of energy destruction is evaluated in the boiler and found that the major energy destruction occurs at combustor followed by heat exchanger. The analyses have been performed by component wise modeling and simulation of the boiler and its heating surfaces.

KEYWORDS

Thermal Power Plant, Boiler, Boiler efficiency, Direct Method, Indirect Method, Coal

INTRODUCTION

About 70% of energy generation capacity is from fossil fuels in India. Coal consumption is 40% of India's total energy consumption which followed by crude oil and natural gas at 24% and 6% respectively. India is dependent on fossil fuel import to fulfill its energy demands. The energy imports are expected to exceed 53% of the India's total energy consumption. In 2009-10, 159.26 million tones of the crude oil is imported which amounts to 80% of its domestic crude oil consumption. The percentage of oil imports are 31% of the country's total imports. The demand of electricity has been hindered by domestic coal shortages. Cause of this, India's coal imports is increased by 18% for electricity generation in 2010.India has one of the world's fastest growing energy markets due to rapid economic expansion. It is expected to be the second largest contributor to the increase in global energy demand by 2035. Energy demand of India is increasing and limited domestic fossil fuel reserves. The country has ambitious plans to expand its renewable energy resources and plans to install the nuclear power industries. India has the world's fifth largest wind power market and plans to add about 20GW of solar power capacity. India increases the contribution of nuclear power to overall electricity generation capacity from 4.2% to 9%. The country has five nuclear reactors under construction. Now, India became third highest in the world who is generating the electricity by nuclear and plans to construct 18 additional nuclear reactors by 2025, then India will become second highest in the world.

As per the study carried out by Moni Kuntal Bora & S. Nakkeeran, coal fired Boiler is one of the most important components for any Thermal Power Plant. The prominent Performance parameter of a boiler is ―Boiler Efficiency‖. Boiler Efficiency affects the overall performance of the electricity generation process and as well as plant economy. Boiler efficiency is affected by many factors. It reduces with time, due to various heat losses such as loss due to unburnt carbon in waste, loss due to dry flue gas, loss due to moisture in fuel, loss due to radiation, loss due to blow down, and loss due to burning hydrogen, etc.. Boiler efficiency tests help us to calculate deviations of boiler efficiency from the design value and identify areas for improvement. The current paper puts forward an effective methodology for the efficiency estimation of a coal fired boiler, comparison with its design value and enlists some of the factors that affect the performance of a boiler. This study will help to increase overall boiler efficiency and as a result, annual monetary savings of the thermal power plant. [1]

Basically Boiler efficiency can be tested by the following methods:

A. Direct Method or Input Output Method.
B. Indirect Method or Heat Loss Method.

A. Direct Method or Input Output Method:

Direct method compares the energy gain of the working fluid (water and steam) to 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 (i.e. fuel) for evaluating the efficiency.

$$\text{Boiler efficiency, } \eta = \frac{\text{Heat output}}{\text{Heat input}} \times 100\%$$

Where,

Ƞ = boiler efficiency in %.
SFR = steam flow rate in kg/hr.
SE = steam enthalpy in kCal/kg.
FEW = feed water enthalpy in kCal/kg.
FFR = fuel firing rate in kg/hr.
GVC = gross calorific value of coal in kCal/kg.

B. Indirect Method or Heat Loss Method:

In the heat loss method the efficiency is the difference between the losses and the energy input. In indirect method the efficiency can be measured easily by measuring all the losses occurring in the boilers using the principles to be described. The weaknesses of the direct method can be overwhelmed by this method, which calculates the various heat losses associated with boiler. The efficiency can
be arrived at, by subtracting the heat loss percentages from 100. An important advantage of this method is that the errors in measurement do not make significant change in efficiency. The indirect method does not account for Standby losses, Blow down loss, energy loss in Soot blowing, and energy loss running the auxiliary equipment such as burners, fans, and pumps. Valid losses incorporate with to coal fired boiler:

1. Heat loss due to dry flue gas as sensible heat (L1).
2. Heat loss due to moisture in the coal (L2).
3. Heat loss due to moisture from burning of hydrogen in coal (L3).
4. Heat loss due to moisture in air (L4).
5. Heat loss due to formation of carbon Monoxide-partial combustion (L5).
6. Unburnt losses in fly ash as carbon (L6).
7. Unburnt losses in bottom ash as carbon (L7).
8. Loss due to surface radiation and convection (L8).

$$\text{Total loss in \%} = \sum_{i=1}^{8} Li$$

Boiler efficiency by indirect method:

$$\text{Boiler efficiency, } \eta = 100 - (\text{Total loss in \%})$$

According to Lalatendu Pattanayak and Saiprem Kumar Ayyagari, an energy and exergy analysis of design and off design condition of a 500MW coal fired thermal power plant has been carried out based on mass, energy and exergy balance equation. The power plant boiler was simulated with data like pressure, temperature and mass flow in water steam side and the flue gas temperatures, flow etc is derived from the model simulation. The thermodynamic states of the plant components are shown in Table III. Exergy destruction, exergy and energy efficiency of the boiler components are presented in Table IV. It has been found that maximum exergy destruction occurs due to combustion process. Also there is significant exergy destruction occurs in the boiler pressure parts. It has also been found that exergy efficiency is lower than energy efficiency. The performance can be improved maintaining an optimum excess air level and also with change in ambient temperature.[2]

According to Pankaj Sindhu and Somvir Arya, Overall Plant efficiency at lower loads decreases so we should run the Plant at higher load. Load of Plant depends upon the requirements for consumption of energy. As the energy consumption decreases Plant have to start to run at lower load, because energy can not be stored. For avoiding such kind of the problem we have to take help of Hydraulic Plants for accompanying the fluctuations of energy requirement. This will be cheaper.[3]

According to Acharya Chirag, Prof Nirvesh Mehta, Prof Jaspal Dabhi, 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.[4]

CONCLUSION

In this paper, a review on energy analysis of the thermal power station has been carried out using the methods of thermodynamic analysis by considering the ratio of energy generated per annum to the amount of the fuel consumed and the other involves products of the plants thermal efficiency and the efficiencies of the boiler, turbines and generator. Based on these parameters, three categories of recommendations are incorporated which are short term, medium term and long term. The short term, medium term and long term categories of recommendations suggests the overall working performance of the plant. Lesser consumption of input will not only reduce the cost of electricity generation there by enhancing the competitiveness but also make available the scarce inputs to generate more and more electricity.

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