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Exergy Analysis of Furnace in Sub-Critical Boiler in a Coal-Fired Thermal Power Plant

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***Abstract*— The demanding needs for energy in various power sectors raises a call for an efficient utilisation of natural resources like coal in case of coal-fired thermal power plant. The effective utlisation of useful energy lies in evaluating the thermodynamic aspects involve in the process of combustion. The combustion chamber is said to be the thermal core of the coal- fired boiler and hence its working potential needs to be identified. The process of irreversibility needs to be pinpointed and thus the exergy analysis plays an important role in the performance of any thermodynamic system.**

***Keywords*— Exergy, Irreversibility, Work Potential, Furnace, Sub-critical**

I. Introduction

In India the generation of power from the coal fired power plants is around 63 % of total power generation [1]. Around 60% of the coal-fired plants located for power generation are associated with 210 mega watts pulverized systems in our country [2].

The process of combustion of coal involves the exchange of the internal energy when the heat is released during the break down of fuel and formation of various gases. Thus a comprehensive review is needed to be performed for the irreversible systems like the boiler furnace in a thermal power plant in order to evaluate its optimum efficiency.

II. Exergy Analysis Of Furnace

The boilers are the crucial component in the thermal power plant as the quality and quantity of the heat generation plays a vital role in the useful work potential of the system. The evolution of steam generators is progressing with advancement in design to enhance the energy efficiency and to reduce the emissions [3].

However the optimum operation of the furnace includes the analysis of the exergy as the combustion process involves the various irreversibilities. The most significant way to reduce the loss of energy in a combustion process is to lower the irreversible limits of operation which could be possible only by performing an exergy analysis.

The operating condition needs to be evaluated with respect of temperature and pressure changes inside the combustion chamber. Exergy analysis is a tool to identify the insights of the performance of systems in thermal boilers as it quantifies the destruction of energy and also identifies the locations of them [4]. Figure No.1 shows the basic components involved in the exergy analysis in a coal-fired furnace of a boiler.

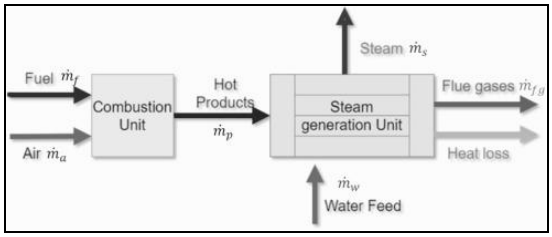


Figure No.1 Basic components in the Exergy Analysis of the furnace

In the combustion Unit, m_f is the mass flow rate of fuel and *ma* is the mass flow rate of air entering the combustion chamber and m_p is the mass flow rate of the products formed during the process of combustion and leaving the combustion chamber and entering into the steam generating unit. m_w is the mass flow rate of the water fed into the steam generation unit and m_s is the proportionate steam formed form the steam generation unit. After useful heat is transferred, m_{fg} is the mass flow rate of the flue gases leaving the steam generating unit.

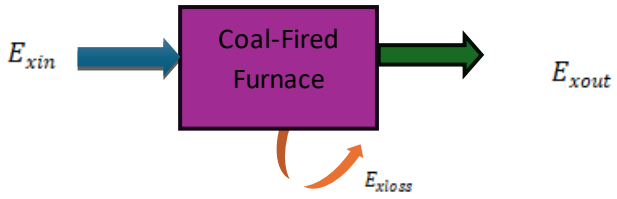


Figure No.2 Exergy analysis in a boiler Furnace

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The exergy flow in a furnace is depicted in figure No.2. Exergy input to the furnace is the chemical energy inside the fuel E_{CEC}, which is the primary input and the physical energy from combustion air E_{PEA} sent along with the physical energy of the coal E_{PEC} and is evaluated using equation 1 below.

$$E_{xin} = E_{CEC} + E_{PEA} + E_{PEF} \qquad \text{Equation (1)}$$

The physical energy of the incoming air is due to the preheated air at a temperature T_a and pressure P_a. The physical energy from coal is due to the coal entering at a particular temperature T_f and Pressure P_f before the process of combustion.

Exergy Output E_{xout} is the amount of exergy transferred to the water-steam mixture through the process of radiation and convection inside the boiler furnace to the water wall tubes. Exergy loss E_{xloss} is the exergy lost by the flue gases leaving the furnace and also includes the heat loss to the ambient. The exergy efficiency for furnace for a the coal fired thermal power plant is given by the following equation

$$\eta = \frac{E_{xin}}{E_{xout}} \qquad \text{Equation (2)}$$

III. Conclusion

The Exergy analysis includes the second law of thermodynamics for finding the irreversibilities and thereby the losses in a system focusing on energy conservation [5].

The application of this in power plant sector has shown a great importance in the work potential savings and hence reduction in operational cost [6].

This type of analysis gives a detailed understanding and perspective of the energy degradation in a thermal power plant and throws a light on the opportunity for identifying the improvement of the system and hence enhance the energy efficiency and thereby cumulative improvements will result in huge reduction in the operating costs of the thermal power plant.

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