A Review: Energy and Exergy Analysis of High Pressure steam Boiler

Vijay. D. Shimpi[1] Mr. Mandhata Yadav[2] Bhailal. V. Bhuva[3] Somchandra. M. Patel[4]
[1,3,4]Student of M.E [2]Professor
[1,2,3,4]Department of Mechanical Engineering
[1,2,3,4]Spit, Piludara, Gujarat, India

Abstract— This paper presents a framework of thermodynamic, energy and exergy, analyses of industrial steam boilers of 690 TPH boiler in 210 MW coal based thermal power plant. Mass, energy, and exergy analysis were used to develop a methodology for evaluating thermodynamic properties, energy and exergy input and output resources in industrial steam boilers. Determined methods make available an analytic procedure for the physical energetic analysis by exergy destruction method and calculate all the losses occurred in the boiler.

Key words: Thermal Power Plant, Energy analysis, Exergy analysis, Irreversibility

I. INTRODUCTION

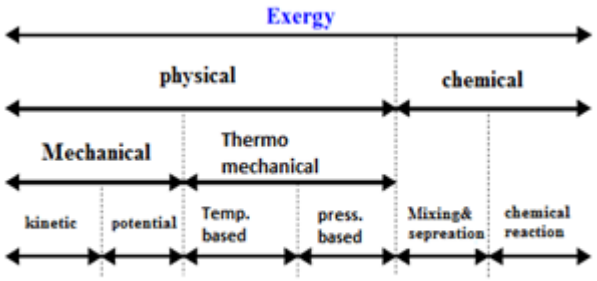
Power generation industry plays the major role in the economic growth of the any Country. Now, 80% of total electricity in the world is approximately produced from fossil fuels (coal, petroleum, fuel-oil, natural gas) fired thermal power Plants [7]. The total power generating capacity of India are 163304.99MW (Feb 2014), out of that coal fired thermal power plants have the generation capacity140723.39MW and natural gas fired thermal power plants have the generation capacity of 20359.85MW and reaming 22580MW include Gas and Diesel plant[CEA-2014].

To assist in improving the efficiency of boiler, their thermodynamic characteristics performances are usually investigated. Boilers are normally examined using energy analysis but better understanding is attained when a more complete thermodynamic view is taken, which uses the second law of thermodynamics in conjunction with energy analysis via exergy methods. Efficiency is one of the most frequently used terms in thermodynamics, and it indicates how well an energy conversion or process is accomplished. Efficiency is also one of the most frequently misused term in thermodynamics and often source of misunderstanding this is because efficiency is often used without being properly defined first (Cengel and Boles, 2006)

In case of coal fired power plant, the first law indicates that the condenser greatly effects the power plant efficiency as large amount of heat is transferred to the cooling water without providing any clue on the real usefulness of this relatively low temperature fluid. Also, energy balances do not provide information about the internal losses such as throttling valve and heat exchanger. Second law or exergy balance, however indicates that there is hardly 1% exergy loss in the condenser and maximum losses in the boiler. The contribution in the boiler exergy loss accounts for irreversibility associated with combustion and finite temperature differences. Hence, analysis of exergy plays a deterministic role in identification of processes and rectifying the components. [4]

The term Exergy was used for the first time by Rant in 1956, and refers to the Greek Words ex (external) and ergos (work). Another term describing the same is Available Exergy or simply Availability. "Energy is maximum useful work obtained from the system at a given state in a specified environment".Exergy is based on second law of thermodynamics which has proved to be very powerful tool in optimization of complex thermodynamic system. For any thermodynamic system energy supplied is equal to work done plus heat rejected ,in this work done term is referred as the Exergy (available energy) and heat rejected is referred as unavailable energy(Energy).

A. *Types Of Exergy:*



The exergy efficiency of the boiler may be defined in two ways. The first one is the physical exergy and the second one is the chemical exergy. In this study the kinetic and potential part of exergy are negligible. The chemical exergy of fuel is computed from the stoichiometric combustion chemical reactions. The chemical exergy is associated with the departure of the chemical composition of a system from its chemical equilibrium which is important in processes involving combustion.[6]

B. *Different Between Energy And Exergy:*

- Energy is ability to produce motion
- Energy is always conserved in a process.
- Exergy is always conserved in a reversible process, but is always consumed in an irreversible process.
- Energy is never destroyed during a process, it changes from one form to another.
- Exergy is destroyed by irreversibilities.The destroyed exergy has been called Anergy.
- Exergy can be regarded as property of the system-environment combination because it is measure of the departure of the state of system from that of the environment.
- Energy is find out using first law efficiency.
- Exergy is find out using second law efficiency

C. *Energy Analysis Method:*

A. Exergy destruction method (EDM)
B. Entropy generation method (EGM)
In this paper exergy destruction method is used

1) *Exergy Destruction Method:*

For any thermal system under consideration for the analysis we need some input, which is referred as fuel and out of this is referred as a product. Here exergy input in terms of fuel

exergy (E_F) and this input transfers in process of conversion into the output that is produced of exergy, in this some exergy be destroyed (E_D) and the remaining is loss of exergy (E_L). There is a difference between the terms exergy destruction and exergy loss, exergy destructions is the amount of exergy lost due to irreversible and cannot be used anywhere, while exergy lost is the amount of exergy that is wasted from the system under consideration but can be useful to other system.

II. LITERATURE REVIEW

The literature on various investigations using exergy analysis based on second law analysis high pressure steam boiler

Mehmet Kanoglu et al. In 2007[1] conducted the **"Understanding energy and exergy efficiencies for improved energy management in power plants"** in which various energy and exergy-based efficiencies used in the analysis of power cycles. Vapor and gas power cycles, cogeneration cycles and geothermal power cycles are examined, and consideration is given to different cycle designs. [1]

S.K.Som et al. In 2008 [2] **"Thermodynamic irreversibility and exergy balance in combustion processes."** pointed out that, in almost all situations, the major source of irreversibility is the internal thermal energy exchange associated with high temperature gradients caused by heat release in combustion reactions and the primary way of keeping the exergy destruction in a combustion process within a reasonable limit is to reduce the irreversibility in heat conduction. [2]

R. Saidur in 2010 [3]**, "Energy, exergy and economic analysis of industrial boilers"** Conceptualized about Energy, exergy and economic analysis of industrial boilers, Energy and Exergy efficiencies are found to be 72.46% and 24.89%,combustion chamber is major source of exergy destruction and major losses through flue gases. Variable speed drive (VSD) used in boiler fan motor for energy saving. [3]

P. Regulagadda et al, in 2010 [4]**, "Exergy analysis of a thermal power plant with measured boiler and turbine losses"** conducted thermodynamic analysis of a subcritical boiler–turbine generator for a 32 MW coal-fired power plant and concluded that the boiler and turbine irreversibility yield the highest exergy losses in the power plant compare with highest energy losses in condenser. Plant is designed to operate with an air cooled condenser that shows environmental benefits since the water consumption is reduced and also the water rejection from the power plants is reduced.[4]

Ankit Patel et al, in 2012[5] **Energy And Exergy Analysis Of A Boiler With Different Fuels Like Indian Coal, Imported Coal And L.S.H.S. Oil** Compare different types of coal like Indian coal, Imported coal, Mixture of both(60% imported+40%indian) and L.S.H.S Oil and conclude that first law efficiency is 76.54%, 83.03%, 80.60%, and 88.20% respectively and as well as exergetic efficiency of the Boiler Plant are 37%, 37.7%, 37.8% and 40.1% respectively.[5]

Idehai O. Ohijeagbon et al, in 2012[6]**, "Methodology for the physical and chemical exergetic analysis of steam boilers"**energy and exergy efficiencies obtained for the entire boiler was 69.56% and 38.57% at standard reference state temperature of 25^0C for an evaporation ratio of 12 all the calculation were based on the analytical method.[6]

Sarang j gulhane et al. In 2007[7] **"Exergy Analysis of Boiler In cogeneration Thermal Power Plant"** concluded that boiler has exergy destruction at home load 1.1 mw is around 83.35% and as load increases for highest load 5.6 mw the exergy destruction found to be 76.33%thus efficiency of 1st law and 2nd law increases with load, we have to work on the peak load for reduce the irreversibility. [7]

III. FUTURE SCOPE AND CONCLUSION

From this Review work we conclude that difference between exergy and energy analysis and found that both the result are different. Exergy is based on second law of thermodynamics which has proved to be very powerful tool for effective analysis of boiler system.

But optimum work on reducing exhaust flue gas losses, so that We tried to reduce exhaust flue gas losses by utilizing its waste heat for other useful purpose in power plant.

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