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Energy and Exergy analysis of Thermal power Plant

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Abstract-The energy supply to demand narrowing down day by day around the world, the growing demand of the power made the power plant scientific interest, but the most of power plant designed by the energetic performance criteria based on the first law of thermodynamics. The real energy losses of the power plant cannot be justified by the first law of thermodynamics, because it does not differentiate between quality and quantity of energy. Based on the several activity and power plant experience some key observation has made and is presented in this paper. The aim of the paper is to be find out causes of energy destruction that can be helpful help designer to re-design the system component.

Keywords-Thermal power plant, energy, exergy, efficiency, exergy destruction, irreversibilites

1. Introduction:

Energy consumption is the most important problem in today's era. In the present scenario of energy capacity and consumption determines the level of development of nation .This cause interest in the scientists and researcher to take a close look on energy conservation devices and to develop for better utilisation of available sources.

The first law of thermodynamics deals with the amount of energy of various forms transferred between the system and surrounding and with the change in the energy stored in the system. The first law places no restriction on the direction of the process but satisfying the first law does not ensure that the process can actually occur .This inadequacy of the first law to identify whether a process can take place in remedied by introducing another general principle, the second law of thermodynamics.

The exergy method based on the second law of thermodynamics and concept of irreversible production of entropy. The fundamental of exergy method were laid down by Carnot in 1824 and Clausius in 1865. The exergy concept has gained considerable interest in the thermodynamic analysis of thermal process and plant system since it has been that the first law has been insufficient from an energy performance stand point. Exergy represent that the part of energy, which can be converted into maximum useful work. Unlike energy, exergy is not conserved and gets depleted due to irreversibilites in the process. Efficiency based on exergy measures the departure from ideality, while the efficiency based on energy fails to indicate the same.

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Thus the exergy analysis can clearly identified the location and the sources where design improvement in the energy system can be sought. Exergy analysis is very important for the economic evaluations, through comparisosn, optimization and improvement of the energy system using quality based component design. Exergy of the thermodynamic process shows the efficiency and inefficiency of the process. Exergy provides us with better understanding of process for qualifying energy. Therefore, it would be better to use exergy to locate, qualify and quantify energy destruction.

Keeping in view the facts stated above, it can be expected that performing an analysis based on the same definition of performance criteria will be meaningful for performance comparisons, assessments, and improvement for thermal power plant. Additionally considering both the energetic and exergetic performance criteria together can guide the way of efficient and effective usage of fuel resources by taking into account the quality and quantity of the energy used in the generation of power in thermal power Plant. The purpose of the study is to carry out energetic and exergetic performance analyses at design condition, for the existing coal fired power plant in order to identify the needed improvement. In order to perform this, considering thermodynamic model of power plant on the basis of mass, energy and exergy balance equation.

2. Literature review:

Sarang j gulhane, Prof.Amit Kumar Thakur "Exergy analysis of boiler in cogeneration thermal power plant" [1]

In this paper energy and exergy based analysis performed on the gas fired and coal fired power plants. The thermodynamic simulation results are compared. Lot of precautions already taken to reduce heat losses like insulation of boiler, but still from observation boiler seem most exergy destruction part to which need to improve for 6 MW power plant analysis of exergy indicates that the 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 and 2nd law increases with load we have to work on peak load for reduce irreversibility. The material study and exergy study can be the scope, with the passage of time the technology getting matured and new material like with higher capacity heat transfer rate like heat pipe and thermo syphon is used.

Ibrahim Bin Hussain, Mohd Zamri Bin, Mohd Hariffin Boosorh"Exergy analysis of a 120 MW Thermal Power Plant" [2]

This paper prsents the result of an exergy analysis performed on 120 Mw steam power plant in malasiya. The result of the analysis indicates that the boiler produces the highest exergy destruction of 54 Mw. Compareing the three turbine stages the result of the analsyis indicates that the High pressure(HP) and intermediate pressure(IP) turbine produces higher exergy destruction than the Low pressure(LP) turbine. Comparing the results of analysis on the feed water heaters, the feed water heater 4 produces the highest exergy destruction.

In the analysis of the plant, the cycle was assumed to be operate at steady state with no stray heat transfer from any component to its surroundings and negligible potential and kinetic energy effect. It has been seen that the large exergy losses occurs into combustion reaction and large temperature difference during heat transfer between the combustion gases and steam.

The result of analysis for the main component of plant 80MW. This paper has presented the result of an exergy analysis performed on a 120 MW power plant. The analysis applied on the unit with running load 80 MW.

P.Regulagadda, I. Dincer, G.F. Naterer "Exergy analysis of a Thermal Power Plant with measured boiler and turbine Losses" [3]

In this paper, a thermodynamic analysis of a sub-critical boiler turbine generator is performed for a 31 Mw coal-fired power plant. Both energy and exergy formulation are developed for the system. Finally, it will perform parametric study to determine how the system performance varies with different operating parameters. The performance of the system depends on the surroundings.

It is evident that the efficiency rises with an increase in the superheated steam parameters. Increasing the cycle pressure and temperature will result in a higher Power output for the same mass flow rate of steam and fuel input into the boiler. The steam has a higher energy/exergy content resulting into higher work output of the Turbine. Combustion in the boiler is another major source of irreversibility Improvement in fuel consumption can greatly contribute to improving boiler and system performance.

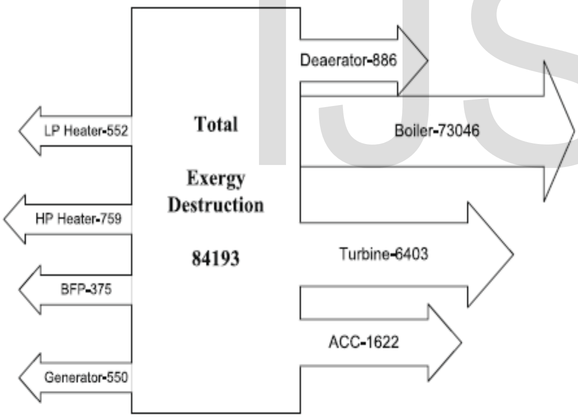

Fig.1

The power plant energy efficiency determined to be 30.12% for the gross generator output. The plant exergy efficiency for the system is 25.38% for the gross generator output. The maximum exergy found to be occurs in boiler.

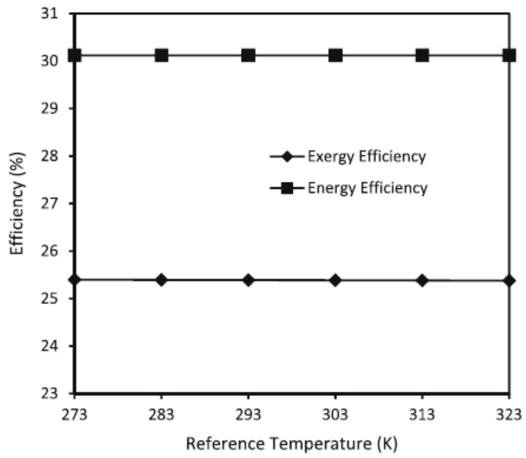

Fig.2

Fig.1 Comparison of exergy destruction of various components

Fig.2 Enegy and Exergy efficiency Vs. Reference temperature

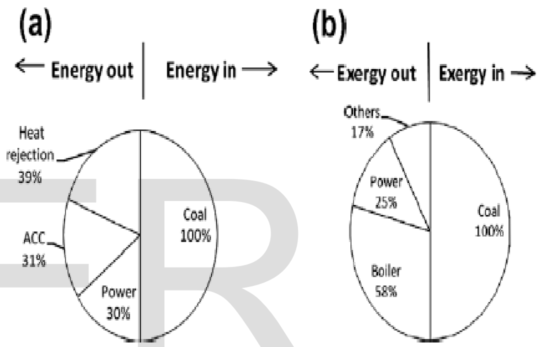

Fig.3

(a) Energy (b) Exergy flows

T.Ganapathy,N.Alagumurthi,R.P.Gakkhar.K.Murugesan"Exergy analysis of operating lignite fired thermal power plant"[4]

The present paper deals with an exergy analysis performed on an operating 50MW unit of lignite fired steam power plant. The comparison between the energy and exergy losses of the individual components of the plant shows that the maximum energy losses of 39% in the condenser, whereas the maximum exergy losses of 42.73% occurs in the combustor. The exergy analysis has been carried out for each component in sub-system to evaluate the exergy losses in each component and then the analysis performed on the overall individual sub-system. Finally the exergy analysis of the overall plant has been carried out and total plant exergy losses have been calculated. The energy and exergy losses for each component in sub-system have been determined using mass, energy and exergy balance equation.

Approximately half of the total energy losses occur in the condenser only and those losses are practicaly useless for generation of electrical power.

Exergy analysis results shows that over 57% exergy losses take place within the boiler system. This may be due to the irreversibility inherent in the combustion process, heat loss, Incomplete combustion and exhaust losses

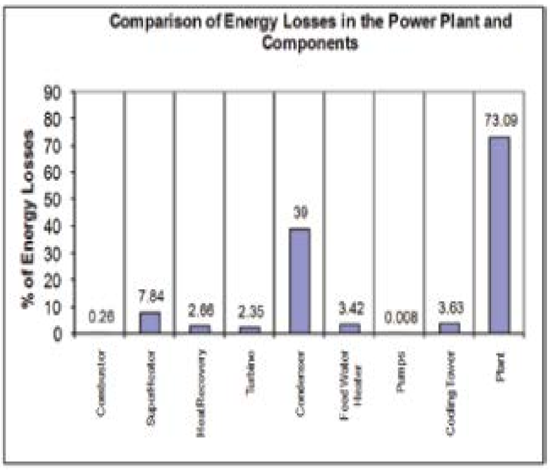

Fig.4 comparison of energy losses in the Plant and components

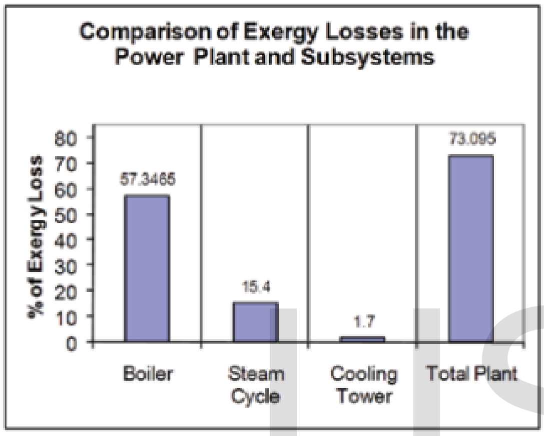

Fig.5 Exergy losses in plant and subsystem

Isam H. Aljundi "Energy and Exergy analysis of a steam power plant in Jordan" [5]

In this study, the energy and exergy analysis of Al-Hussein power plant in Jordan is presented. The performance of the plant was estimated by a component wise modelling and a detailed break-up of energy and exergy losses for the considered plant has been presented. Energy losses mainly occurred in the condenser where 134MW is lost to the environment while only 13 MW was lost from the boiler system. The percentage ratio of the exergy destruction to the total exergy destruction was found to be maximum in the boiler system (77%) followed by the turbine (13%), and then the forced draft fan condenser (9%). In addition, the calculated thermal efficiency based on the lower heating value of fuel was 26% while the exergy efficiency of the power cycle was 25%. For a moderate change in the reference environment state temperature, no drastic change was noticed in the performance of major components and the main conclusion remained the same; the boiler is the major source of irreversibilities in the power plant.
Exergy is a measure of the maximum capacity of a system to perform useful work as it proceeds to a specified final state in equilibrium with its surroundings. Exergy is generally not conserved as energy but destructed in the system. Exergy destruction is the measure of irreversibility that is the source of performance loss. Therefore, an exergy analysis assessing the magnitude of exergy destruction identifies the location, the magnitude and the source of thermodynamic inefficiencies in a thermal system.
The plant was analysed and noted the environmental reference temperature and pressure are 298.15 K and 101.3 kpa respectively.

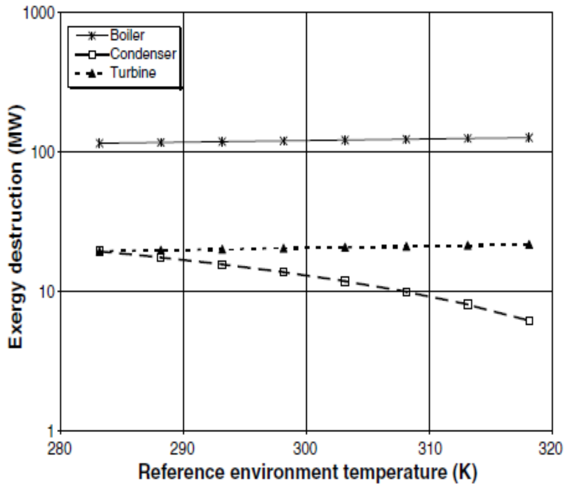

Fig.6 Effect of reference environment temperature on exergy destruction rate in major plant components

The calculated exergy efficiency of the power cycle is 25%, which is low. This indicates that tremendous opportunities are available for improvement. However, part of this irreversibility cannot be avoided due to physical, technological, and economic constraints.
In this study, an energy and exergy analysis as well as the effect of varying the reference environment temperature on the exergy analysis of an actual power plant has been presented. In the considered power cycle, the maximum energy loss was found in the condenser where 66% of the input energy was lost to the environment. Next to it was the energy loss in the boiler system where it was found to be about 6% and less than 2% for all other components. In addition, the calculated thermal efficiency of the cycle was 26%.
In terms of exergy destruction, The major loss was found in the boiler system where 77% of the fuel exergy input to the cycle was destroyed. Next to it was the turbine where 20.4MW of exergy was destroyed which represents 13% of the fuel exergy input to the cycle. The Percentage exergy destruction in the condenser was 9% while all heaters and pumps destroyed less than 2%.

3. Conclusion

After understanding all this above literatures, we can conclude that now only electric power generation is not only requirement but economic power generation is necessity. Exergy analysis is depends on 2nd law of thermodynamics, allows us to locate and quantify the irreversibilites in the production process and to identify which part of the system and what reasons they affect the overall inefficiency. The exergy analysis combines the 1st and 2nd law of thermodynamic and from a prospective of quantity and quality to revel the law of conservation.
It was concluded that to improve efficiency, we should look for a way to reduce irreversibility in boiler, because this component had a high contribution to exergy destruction. This kind of improvement in power plant gives Higher efficiency and economic power generation.

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