American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-10, pp-385-392
www.ajer.org

Research Paper Open Access

Exergy Analysis of Boiler In cogeneration Thermal Power Plant

Sarang j gulhane, Prof.Amit kumar thakur
**(scholar of mechanical department sagar institute of science and technology Bhopal.)*
** (Associate professor mechanical Engg sagar institute of science and technology Bhopal)*

***Abstract:* –** Effective energy utilization and its management for minimizing irreversibility has made human to look for efficient energy consumption & conversion. Based on several research activity and local power plant experience some key observation has made and is presented in this paper The aim of this paper is to be find out amount and source of irreversibilities gererated in boiler of 35 TPH boiler in 6 MW captive power plant so that any process in the system that having largest energy destruction can be identified that help designer to re design the system components.

***Key Words:* –** *Thermal Power Plant, energy utilization, Irreversibility.*

I. INTRODUCTION

Energy consumption is the most important problem in the today's era. In the present scenario per capita energy consumption determines the level of development of the nation. With the increased awareness that the world's energy resources are limited has caused many countries to reassess their energy policies and take measures for eliminating the waste. It has also ignited the interest in the scientists and researchers to take a close look at the energy conversion devices and to develop new techniques for better utilization of the available resources.

The First Law deals with the amounts of energy of various forms transferred between the system and its surroundings and with the changes in the energy stored in the system. It treats work and heat interactions as equivalent forms of energy in transit and offers no indication about the possibility of a spontaneous process proceeding in a certain direction. The first law places no restriction on the direction of a 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 is remedied by introducing another general principle, the second law of thermodynamics

The exergy method of analysis is based on the Second law of thermodynamics and the concept of irreversible production of entropy. The fundamentals of the exergy method were laid down by Carnot in 1824 and Clausius in 1865. The energy-related engineering systems are designed and their performance is evaluated primarily by using the energy balance deduced from the First law of thermodynamics. Engineers and scientists have been traditionally applying the First law of thermodynamics to calculate the enthalpy balances for more than a century to quantify the loss of efficiency in a process due to the loss of energy. The exergy concept has gained considerable interest in the thermodynamic analysis of thermal processes and plant systems since it has been seen that the First law analysis has been insufficient from an energy performance stand point.

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 plants. Additionally, considering both the energetic and exergetic performance criteria together can guide the ways of efficient and effective usage of fuel resources by taking into account the quality and quantity of the energy used in the generation of electric power in thermal power plants. The purpose of this study presented here is to carry out energetic and exergetic performance analyses, at the design conditions, for the existing coal and gas-fired thermal power plants in order to identify the needed improvement. For performing this aim, we summarized thermodynamic models for the considered power plants on the basis of mass, energy and exergy balance equations. The thermodynamic model simulation results are compared. In the direction of the comprehensive analysis results, the requirements for performance improvement are evaluated.

Energy And exergy analysis of caol fired cogeneration power plant with condensate extraction turbine

(A) Energy analysis of coal fired Cogeneration power plant with condensate extraction turbine.

In general coal based thermal plant works on Rankin cycle. Several advancement has made in recent thermal power plant to increase the energy output per unite mass of fuel burnt like reheating, regeneration etc. The design of any power plant is based on location, avaibility of fuel and it effectiveness. Since thermal power plant works on fossile fuel, it has made great interest to research to look for more efficient utilization of this fuel due to it's stock limitation under earth. Which results into no. of analysis based on energy losses and irreversibility, various attempts where made to over come this loss as and hence reheat cycle, regenerative cycle are the some fruitful outcome that came out for improvement.

II. DESCRIPTION OF COAL FIRED POWER PLANT

Several observed processes are considered for the analysis of a cumulative coal fixed thermal like lowering condenser pressure, superheating the to high temperatures, increasing the boiler pressure, reheat regenerative rankine cycle is used

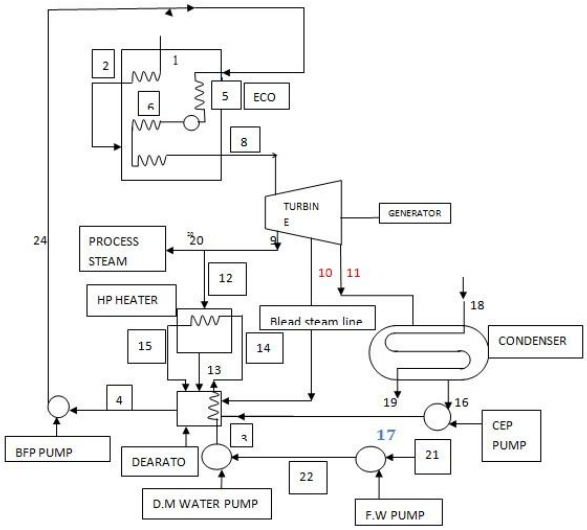


Fig.1 describs the detail part of cogeneration coal based with condensate extraction turbine consists of Boiler (B), Condensate extraction turbine with there stages (T) Pump (P), Decretory (D), a generator (S) , condense (c) high pressure feed water heater (HPH). The thermodynamic model of power plant are based on fundamental mass and energy balances. Using the energy and mass balance equation for each component in the power plant model, it is possible to compute energy and energy contents in terms of turbine power outputs, pump power consumptions boiler flow. for minimized the loss of dry flue gas.

Exergy analysis :-

useful work potential of a system is the amount of energy we extract as useful work. The useful work potential of a system at the specified state is called exergy. Exergy is a property and is associated with the state of the system and the environment. A system that is in equilibrium with its surroundings has zero exergy and is said to be at the dead state

It means available energy at a specified condition

Exergy analysis of boiler can be calculated by following formula which can be taken from research paper.

(1)Exergy analysis of fuel
(2)Exergy analysis of water
(3) Exergy analysis of Air
(4)Exergy analysis of flue gas
(5)Exergy analysis of economizer
(6)Exergy analysis of steam drum
(7)exrgy analysis of super heater

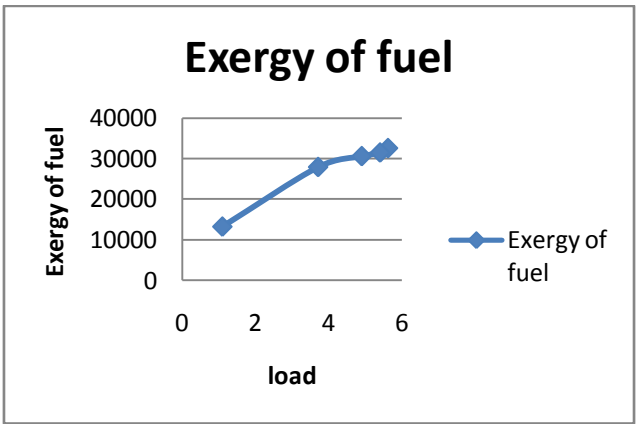
(1) Exergy analysis of fuel:-

Ultimate analysis of coal

COAL CONSITUTENT	UNIT	COAL SAMPLE
C	%	45
H	%	13
N	%	1.69
O	%	4.5
S	%	0.5
ASH	%	29.31
MOISTURE	%	9.82
VOLATILE MATTER	%	20.16
FIXED CARBON	%	34.71
CALORIFIC VALUE	KCAL/KG	4187

Exergy of fuel can be calculated by the equation proposes by shieh And fan for calculating the exergy of fuel
Exergy of fuel can be calculated by using a shieh and fan formula
f=34183016(C)+21.95(N)+11659.9(H)+18242.90(S)+13265.90(O)----------(1)
Accourding to the T.J kotas say that the ratio of exergy of fuel to caloric value of the fuel lies betn the 1.15 to 1.30 Accourding to the our ultimate analysis we get exergy of the fuel is =17683.84 kj/kg and calorific value is 17585.4 kj/kg thus ratio we get is 1.01 that is nearer to T.J kotas ratio.

Load in MW	Exergy of fuel in KW
5.6	32596.79
5.4	31480.92
4.9	30598.77
3.7	27927.78
1.1	13303.81



III. RESULTS AND DISCUSSION

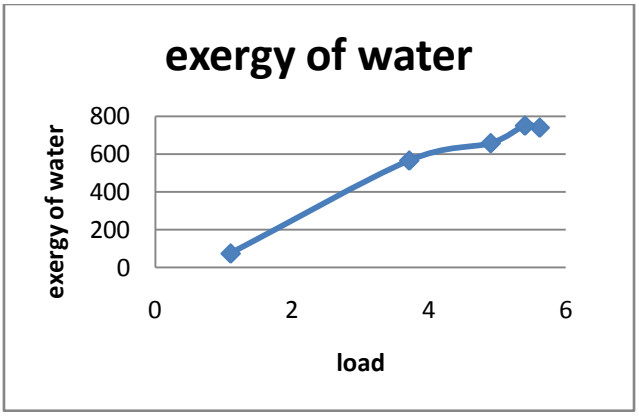
From the above graph it shows as load increases the exergy of fuel is also increases So always run the plant in pick load
(2)The exergy of feed water
Before entering the water into the economizer ,the water is allowed to get heated in the deratator thus the temp of feed water is increased to higher temp
The temp water at economizer i/L from above table
Exergy of feed water can be calculated by

$$€\hat{w}=(c_{pw})\,(T_4-T_a)\text{- }T_a \text{Ln }\left(\frac{T_4}{T_a}\right)$$

Where
(Cp)w=specific heat of water =4.187 kj/kg
T4= temp of feed water

Ta= temp of ambient temp
While putting the above value , get following result

Load in MW	Exergy of water in KW
5.6	738.78
5.4	749.3812
4.9	656.7425
3.7	565.1152
1.1	74.30



From the above graph it shows as load increases the exergy of water is also increases So always run the plant in pick load

(3)The exergy of Air

The exergy of air can be calculated by following
€a=(c_{pa}) $(T_2 - T_a)$- T_aLn $(\frac{T_2}{T_a})$
Where,
T2= temp of air after air pre heater
Ta= temp of ambient temp.

Load in MW	Exergy of Air in KW
5.6	115.075
5.4	127.077
4.9	139.212
3.7	159.925
1.1	32.77

The exergy of air is depend upon the combustion air temp as well as flue gas temp Due to that it is fund that exergy at full load i.e 5.6 MW is less as compared to the 3.7 MW s proper maintain the combustion air temp as well as flue gas temp

(4)The exergy of economizer :-
The water entering the economizer from deratator is already at higher temp is then heated almost saturated temp at that pressure but leaving the economizer remain in liquid without change in phase

€a=(c_{pw}) $(T_5 - T_4)$- T_4Ln $(\frac{T_5}{T_4})$

T5 & T4 are the temp of the ecomonizer inlet and outlet.

Load in MW	Exergy of Air in KW
5.6	927.45
5.4	940.758
4.9	893.339
3.7	725.191
1.1	211.862

It is also shows load increase exergy also increase

(5)The exergy of drum can be calculated

$€_{drum} = (h_6 - h_5)- T_6\ (s_{6-s_5})$

T6 = temp of drum

Load in MW	Exergy of drum
5.6	5123.369
5.4	5196.87
4.9	4741.2
3.7	3989.80
1.1	1408.98

As it also shows that load increase exergy of drum is also increase but in some case exergy is reduced due to steam flow is reduced as it depends upon the extraction steam or process steam

(7) The exergy of super heater

Super heater is place at end of boiler mounting and water ckt after super heater

Super heated steam is produced .the super heater for a given boiler is made up of three different component of super heater ,primary super heater is rise the temp by extracting the heat from flue gas is called as convective super heater, and second dary super heater is exposed to the flame to which heat is done by radiation thus caused radiating super heater ,temp rang for the turbine inlet is fix if the steam temp is rises above the rang it is found that attemptator or spary control valve is open ,after that steam goes to the bed super heater

Exergy rise in the drum=$(h_8 - h_6)$-$T_8(S_8 - S_6)$

As per the above diagram and reading table is found that

Load in MW	Exergy of super heater
5.6	2399.177
5.4	2103.43
4.9	2224.76
3.7	1456.16
1.1	669.21

It is also shows that load increase exergy rise of super heater also increase ,it is depend upon the temp of drum as well as temp of super heater temp.

(7)The exergy of flue gas

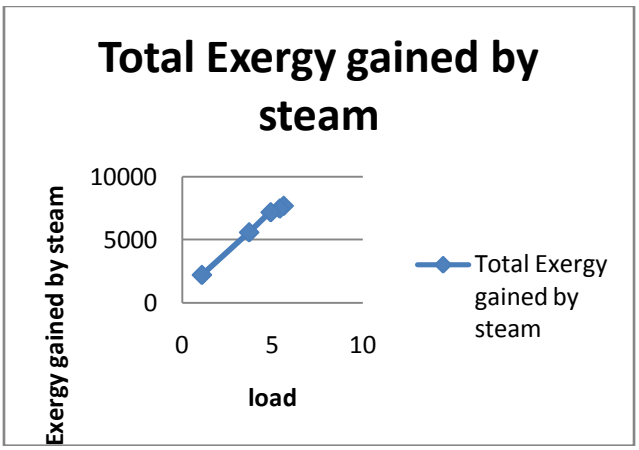
$€a=(c_{pg})\ (T_g - T_a)- T_a \text{Ln}\ (\frac{T_g}{T_a})$

Load in MW	Exergy of flue gas
5.6	194.14
5.4	200.228
4.9	263.251
3.7	220.324
1.1	163.797

AS load increase exergy of flue gas increase ,but it is again depend upon the temp of flue gas and boiler load if at particular load temp is less and boiler load is less then also exergy of flue gas is less.
Total exergy gain by the steam;

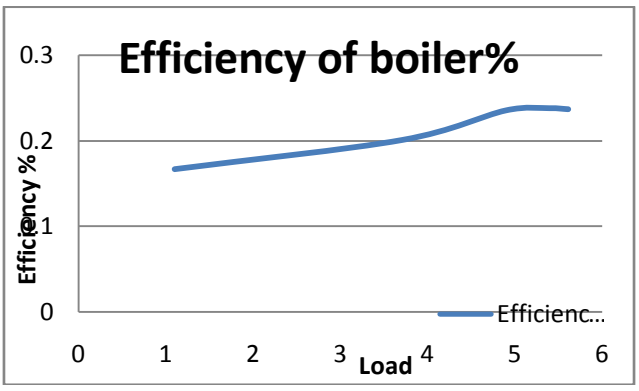
AS load increase exergy of flue gas increase ,but it is again depend upon the temp of flue gas and boiler load if at particular load temp is less and boiler load is less then also exergy of flue gas is less.
Total exergy gain by the steam;

Load in MW	Total exergy gain by steam
5.6	7711.21
5.4	7491.68
4.9	7203.08
3.7	5606.04
1.1	2215.74



AS load increase total exergy of drum gain by the steam increase ,it is sum of exergy rise in ecomonizer and super heater
Efficiency of boiler = Total energy leaving the boiler to total energy entering the boiler

Load in MW	Efficiency of boiler as per 2 law
5.6	23.67
5.4	23.79
4.9	23.54
3.7	20.07
1.1	16.65



Result and discussion:-

Lot of precaution already taken for reducing the heat loss like insulation of boiler ,but still form observation boiler seem most exergy destruction part to which need to improve for 6 mw power plant analysis of exergy indicate 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 1 st law and 2 law increases with load ,we have to work on the peak load for reduce the irreversibility
The material capability study and exergy study on various component of boiler can b e the scop of the study, with the passage of time the technology getting matured and new material wi th higher capacity heat transfer rate like heat pipe and thermo sypon is used ,the data designer of the boiler can redesign the boiler with efficient auxiliary devices

IV. ACKNOWLEDGEMENTS

The author wish to thank Raymond India Limited, Yavatmal, for granting the permission to carry out work and their kind support during work.

REFERENCES

[1] A. Yunus and A. Michael, "Thermodynamics an Engineering Approach," Tata McGraw Hill, New Delhi, 2007.
[2] T. J. Kotas, "Exergy Criteria of Performance for Thermal Plant: Second of Two Papers on Exergy Techniques in Thermal Plant Analysis," International Journal of Heat and Fluid Flow, Vol. 2, No. 4, 1980, pp. 147-163.
[3] yongping yang “comprehensive exergy based evaluation and parametric study of a coal fired ultra super critical power plant
[4] P Regulagadda “energy analysis of a thermal power plant with measured boiler and turbine losses” applied thermal engineering vol 30-[2010]970-976
[5] T. Ganapathy, N. Alagumurthi, R. P. Gakkhar and K. Murugesan, "Exergy Analysis of Operating Lignite Fired Thermal Power Plant," Journal of Engineering Science and Technology Review, Vol. 2, No. 1, 2009, pp. 123-130.
[6] Seluk Atas “comparative energetic and exergetic performance analysis for coal fired thermal power plant in turkey” vol 48(2009)2179-2186
[7] S. C. Kamate and P. B. Gangavati, "Exergy Analysis of Cogeneration Power Plants in Sugar Industries," Applied Thermal Engineering, Vol. 29, No. 5-6, 2009, pp. 1187-1194.
[8] Arif hepbasil “Thermodynamic analysis of a building using exergy analysis method”
[9] A. Datta, S. Sengupta and S. Duttagupta, "Exergy Analysis of a Coal-Based 210 mw Thermal Power Plant," International Journal of Energy Research, Vol. 31, No. 1, 2007, pp. 14-28.
[10] M.K Gupta “exergy analysis and investigation for various feed water heater of direct steam generation solar thermal power plant
[11] I. H. Aljundi, "Energy and Exergy Analysis of a Steam Power Plant in Jordan," Applied Thrmal Engineering, Vol. 29, No. 2-3, 2009, pp. 324-328.
[12] Ankit patel “energy and exergy analysis of boiler with different fuels like Indian coal ,imported coal and L.H.H.S oil vol 8 oct 2012
[13] R saidur “energy and exergy economic analysis of industrial boiler” Vol 38(2010)2188-2197
[14] I. Dincer and M. A. Rosen, "Effect of Varying Dead-State Properties on Energy and Exergy Analyses of Thermal Systems,"
[15] International Journal of Thermal Sciences, Vol. 43, No. 3, 2004, pp. 121-133..
[16] R Jyothu naik “exergy analysis of 120MWcoal based thermal power plant ’’vol 2 4 apil 2013 issn 2278-0181
[17] M. A. Rosen, "Energy- and Exergy-Based Comparison of Coal-Fired and Nuclear Steam Power Plants," Exergy, Vol. 1, No. 3, 2001,
[18] pp. 180-192.
[19] M.k pal “energy and exergy analysis of boiler and turbine of a coal fired thermal power plant ’’vol 2 Issue 6 jun 2013
[20] I. Dincer and M. A. Rosen, "Effect of Varying Dead-State Properties on Energy and Exergy Analyses of Thermal Systems,"
[21] International Journal of Thermal Sciences, Vol. 43, No. 3, 2004, pp. 121-133.
[22] Alpesh mehata “thermodynamic analysis of gandhinagar thermal power station’’vol 3 oct –dec 2010
[23] H. Erdem, A. V. Akkaya., A. Dagdas, S. H. Sevilgen, B. Sahin, I. Tek, C. Gungor and S. Atas, "Comparative Energetic and Exergctic Performance Analyses for Coal-Fired Thermal Power Plants in Turkey." International Journal of Thermal Sciences, Vol. 48, No. 11, 2009,
[24] pp. 2179-2186.
[25] Amir vosough “improvement power plant efficiency with condenser pressure vol 2 No 3 june 2011
[26] i . H. Aljundi, "Energy and Exergy Analysis of a Steam Power Plant in Jordan," Applied Thrmal Engineering, Vol. 29, No. 2-3, 2009, pp. 324-328.

[27] A. Vidal, R. Best, R. Rivero and J. Cervantes. "Analysis of a Combined Power and Refrigeration Cycle by the Exergy Method," Energy, Vol. 31, No. 15, 2006, pp. 3401-3414,
[28] N. Arai, H. Taniguchi. K. Mouri and T. Nakahara. "Exergy Analysis on Combustion and Energy Conversion Processes," Energy, Vol. 30, No. 2-4. 2005. pp. 111-117.
[29] Nestor Garcia herando "energy and exergy analysis of an absorption power cycle"vol 55(2013)69-77
[30] Dincer and M. A. Rosen, "Exergy Analysis of Waste Emissions," International Journal of Energy Reserch, Vol. 23. No. 13, 1999. pp. 1153-1163.
[31] A. Khaliq and S. C. Kaushik, "Thermodynamic Performance Evaluation of Combustion Gas Turbine Cogeneration System w ith Reheat." Applied Thermal Engineering, Vol. 24. No. 13. 2004, pp. 1785-1795.
[32] G. M. Chen, S. K. Tyagi, Q. Wang and S. C. Kaushik. A New Thcrmoeconomic Approach and Parametric Study of an Irreversible Regenerative Brayton Refrigeration Cycle," International Journal of Refrigeration, Vol. 29. No. 7, 2006. pp. 1167-1174.
[33] S. C. Kaushik, S. K. Tyagi and M. K. Singhal. "Parametric Study of an Irreversible Regenerative Brayton Cycle with Isothermal Heat Addition," Energy- Conversion & Management, Vol. 44. No. 12. 2003, pp. 2013-2025.
[34] S M. Zubair and M A. Habib. "Second-Law-Based Thermodynamic Analysis of Regenerative-Reheat Rankine-Cycle Power Plants." Energy. Vol. 17, No. 3, 1992, pp. 295-301.
[35] M. Yilmaz, O. N. Sara and S. Karsli, "Performance Evaluation Criteria for Heat Exchangers Based on Second Law Analysis," Exergy, Vol. 1, No. 4, 2001, pp. 278-294.
[36] P. K. Nag. "Power Plant Engineering."