Advance Physics Letter

"Thermal Power Plant Analysis of Coal Fired Boiler"

[1]Sachin Yadav, [2]P.S.Yadav

[1,2]Scope college of engineering, Bhopal
Email : [1]mesachin008@gmail.com, [2]pravindra3001@gmail.com

Abstract : The most important part of the industrial economics is Energy consumption, and its play the very wide role in the development of countries. Now a day, however with energy costs rising, a fundamental pre-requisite for the identification and evaluation of energy resource, conservation measures is a parameter for assessing the efficiency of the energy system or process with reference to energy utilization. In the common perception of efficiency there are some deficiencies. The efficiencies of different energy system cannot be compared directly involving different types of energy inputs and outputs. The fact of the matter is that the former involves the conversion of C.E. of fuel to sensible enthalpy of steam to mechanical work while latter's involve work to heat conversion. It is because of both the outputs and inputs are energies of the same quality. We are aided by the thermodynamic concept that every transformation requires an energy exchange. Thermodynamic analysis (first law and second law) can certainly lead to truly achievable energy conservation measure and help not only to reduce energy costs but also reduce the pollution which is an associated evil with higher energy consumption. Analysis of multi component plant (like combine cycle power plant, cogeneration plant) based on this concept indicates the total plant irreversibility distribution amongst the plant components, pinpointing those contributing most to overall plant inefficiency. The complete energy analysis of the plant is carried out based on massive data collection over a period of two months. The main objective of the work is to improving the overall performance of the power plant.

I. INTRODUCTION-

The era after Second World War (1945-1973) was a period of cheap and abundant energy, especially oil. Large oil reserves were discovered in the Middle East during this period. Oil consumption increased from 0.5 Gigaton in 1950 to 3.0 Gigaton in 1970. Now a days energy consumption in the industrial, transport, agricultural and residential sectors increased sharply. In the industrial sector, new energy intensive industries like petrochemicals and fertilizers flourished. Extensive expansion took place in textiles, cement, engineering and other industries. In design and operation of industrial processes and equipment, energy efficiency was not a very important criterion. In the residential sector, use of new gadgets like color TVs, refrigerators, washing machines and air-conditioners increased sharply; again energy efficiency was not an important factor in their design. The transport sector saw the growth of road transport sector resulted in low energy efficiency and high-energy consumption.

The realization that there are finite world's energy resources and fast depleting has simulated interest in the efficient use of existing resources. This renewed interest has led to a greater emphasis on concepts of thermodynamics and kindled efforts to apply these principles to improve industrial process efficiency.

The energy resources in India are limited. While coal resources may last for about 100 years, oil and gas may last only few decades. India has 1% of the total world's energy resources, but is home to 15% of the world's population. Since independence and even today, the energy policy is oriented towards increasing the supply of coal, oil and electricity. Our oil consumption has increased fivefold in the past 25 years after the energy crisis of 1973. About 65% to 70% of the oil is imported. A refrigerator in India consumes about 50% more energy than some international brands. There are no standards for efficiency of equipment like boilers, motors, fans, compressors etc. A concentrated effort is required to improve energy efficiency and reduce dependence on imported oil.

In India the power sector faces peculiar problems. Most electricity boards are making heavy losses with highly subsidized agricultural rates. The electricity boards have no money to invest in new power plants, while foreign investors as well as institutions like the World Bank are reluctant to lend to loss making electricity boards. To a certain extent, energy efficiency improvement can help this matter. The electricity price for industrial consumers is already Rs. 4/kWh in most states and may soon reach Rs. 5.5/kWh.

II. LITERATURE REVIEW-

The work carried out by various investigators on energy analysis the present chapter reviews. The work reviewed is detailed in separate sections giving details of methodologies their relative merits and applications to various industries viz. Steam and Gas Turbine Plant, Co – Generation Plants and chemical and process

Industries. More emphasis is given on the power generation industries as it is the aim of the present study.

III. ENERGY ANALYSIS-

The concept of energy was first introduced by Newton in mechanics when he hypothesized about potential and kinetic energies. Today the concept of energy is so familiar to us that it is intuitively obvious, yet we have difficulty in defining it exactly. Energy cannot be observed directly, it is a scalar quantity but can be recorded and evaluated by indirect measurements. The absolute value of energy of system is difficult to measure, where as its energy change is rather easy to calculate. The sun is the major source of the earth's energy.

One of earliest procedure in the evaluation of power cycle using energy analysis was due to J. K. Salibury Significant features of his method, generally known as heat deviation method, were to use the analytic description of the turbine cycle in order to reduce the required input data and computational time. In this method he introduced a single variable as a criterion of thermodynamic index of performance of feed water heating system under a given set of boundary conditions. The work of Salisbury formed the basis of a plant monitoring system that has since been widely used for simple system.

Energy balances treat all forms of energy as equivalent, without differentiating between the different grads of energy crossing the system boundary. Thus heat transfer to the environment from a pipe carrying high temperature steam will be treated in the same way as low grade thermal energy rejected in the condenser of a steam plant. Results from energy balance on cryogenic systems can be baffling since here the loss of thermal energy is desirable while gaining thermal energy as a result of a heat transfer from the environment is to be avoided. In general energy balances provide no information, about internal losses. An energy balance for an adiabatic system such as throttling valve, a heat exchanger or a combustion chamber, could lead one to believe that these processes are free of losses of any kind.

Hadi Rostamzadeh [2017] has been investigated that one can obtain a higher PESR by increasing of the generator pressure and ejector mass entrainment ratio or by decreasing of the evaporator pressure and condenser temperature. It is also found that increasing of the generator pressure and ejector mass entrainment ratio or Decreasing of the evaporator pressure and condenser temperature will increase the thermal efficiency.

Yang Cao [2017]has been investigated that The maximum energy losses destructions are found in the CO2 capture units. ROC of 0.75, RSC of 0.06 and TRR of 850 oC are recommended as the optimum operation parameters based on the sensitivity analyses.

Ningning Si [2017] analyzed the performance of a 1000 MW double reheat ultra-supercritical power plant.Results show that the highest energy loss in furnace is as high as 86%, which caused by the combustion of fuel and heat exchange of water wall. The VHP and the two LPs suffer the highest energy losses, namely 1.87%, 2.03% and 2.14% respectively. The regenerative heating system has an energy loss rate of 2.2%. The condenser suffers a heat loss of 998 MW, but its energy is as low as 20.48 MW.

Shihe Chen[2017] The energy-loss of large independent disturbance was calculated based on global variable condition calculation method. Through calculating the energy-loss caused by the classified disturbance factors, the relative errors between the theoretical value and operation value were -3.00% for100%THA (turbine heat acceptance), -9.75 for 75%THA and 16.47% for 50%THA

Meryem Terhan [2017] In this study, energy analyses of natural gas fired boilers in a district heating system are performed. In the boilers, energy or heat losses are exanimate, and the biggest of these is identified as the heat loss of flue gases the ratio of flue gas energy losses in the boilers are 16.80% and 6.13%, respectively. The energy efficiencies of the boilers are found to be 82.3% and 32.77%. The location, where the maximum of the irreversibility in the boilers is noticed as combustion chamber and adiabatic combustion temperature is calculated as 1847 °C

Harun Geokgedik [2016] The total energy efficiency of the system is found to be 9.61%. Its efficiency can be increased up to 15.41% by making improvements in the overall components. Although the heat exchangers had lower energy and modified energy efficiencies, their energy improvement potentials were high. Finally, the main reasons for low efficiencies in the plant, the old technology is believed to be one.

Rauf Terzi [2016] In accordance with the analyses, much energy loses have been found in reactor pressure vessel units. In addition, condenser, turbines and steam Generators also contribute at the energy loss. While the thermodynamic efficiency of the NPP is found as 31%, the irreversibility of pressure vessel and steam generator have been Calculated as 49.5% and 14%. There exist also irreversibility within the amount of 6.5% in turbines, condensers and heaters.

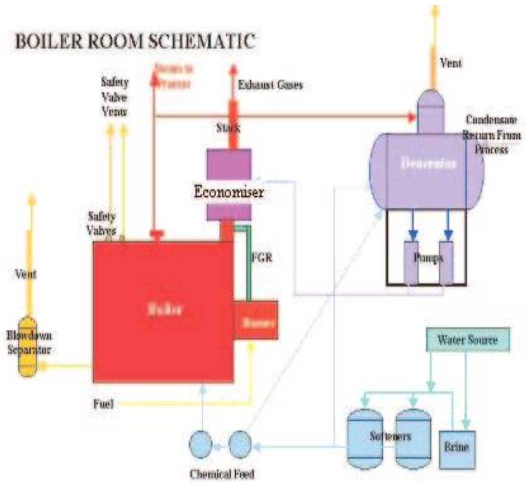
Hui Hong [2016] By using the derived expressions, we examine a typical hybrid solar system with 330 MW coal-fired power plants and evaluate thermal performance of solar-to-power. In addition, the influences of key operation parameters on the solar thermal performance are disclosed such as solar irradiation, incident angle and turbine load. The results obtained here would be expected to provide a possibility for designing and evaluating practical hybrid solar and coal-fired power plant.[9].

Ahmet Ege [2014] Results of the black box method showed that uncertainties varied between 1.8–1.9% for energy efficiency and 1.3–1.4% for energy efficiency of the plant at an operating power level of 41–100% of full power. It was concluded that LHV determination was the most important uncertainty source of energy efficiency of the plant. The uncertainties of the extreme case analysis were determined between 2.32% and 2.38% for energy efficiency while 1.66% and 1.71% for energy efficiency for 41–100% power output respectively. Proposed method was shown to be an approach for understanding major uncertainties as well as effects of some measurement parameters in a large scale thermal power plant.

BOILER PLANT EQUIPMENT AND SPECIFICATION:

Manufacture	:	BHEL
Basic capacity	:	180 Tons/hr
Pressure	:	98 bar (gauge)
Temperature	:	510 °C
Total		: 3 nos.
Boiler type	:	Tangentially fired, Balanced draught, Natural Circulation, Radiant dry bottom with direct Fired
Location	:	Outdoor plant

SYSTEMATIC BOILER SETUP



IV. RESULT AND DISCUSSION-

After finding out the various losses the efficiency of the Boiler is calculated, which take place in a Boiler. First law analysis shows the efficiency of the Indian coal fired Boiler is 76.54%, 83.03%, 80.60% and 88.20%. This causes loss of 23.46%, 16.97%, 19.40% and 11.80% respectively. The energy distribution and losses of various thermodynamic states of Boiler with various fuels used is given in the table.

By assuming that the plant is operating under full load condition, total fuel energy utilized by every unit is taken as 100 units for reference purpose for the energy analysis of Boiler unit. The energy utilized at different points has been shown as percentage of the energy supplied to every Boiler unit.

In the Sankey Diagrams for Boiler which is gives the graphical representation of the various losses of the energy distribution which is maximum in dry flue gases (stack losses). We can show that in the diagrams 100% energy of fuel supply and at the last 14% to 24% of the energy is losses and then remaining energy is supplied to steam. Show that maximum energy losses in the stack exhausts.

Energy analysis and heat balance has been done as per sample calculation of Indian coal for another fuel like imported coal, 60% imported + 40 % Indian coal and L.S.H.S. oil. The result on energetic efficiency and heat balance is shown in following table.

ENERGY DISTRIBUTION AND LOSSES IN INDIAN COAL FIRED BOILER

Components	Symbol	Quantity In KJ / Kg	Quantity In Units
Heat Input		13994.47	100
Losses in Boiler			
Dry flue gas	L_1	826.11	5.91
Loss due to Hydrogen in fuel	L_2	511.19	3.66
Loss due to Moisture in fuel	L_3	333.46	2.39
Loss due to Moisture in air	L_4	22.77	0.17
Partial combustion of C to CO	L_5	360.04	2.58
Surface heat losses	L_6	63.33	0.46
Loss due to Unburnt in fly ash	L_7	246.68	1.77
Loss due to Unburnt in bottom ash	L_8	911.46	6.52
Total		3274.04	23.46

V. CONCLUSION

The following conclusions are drawn from the energy analysis of the Boiler plant

- From the energy analysis of the Boiler Plant (Indian coal, imported coal, 60% imp + 40% ind. Coal and L.S.H.S. oil as a fuel), it is seen that the energy analysis attributes all the inefficiencies to losses as 23.46%,16.97%,19.40% and 11.80 respectively.
- In general operating the boiler at proper air – fuel ratio, supplying fuel – air mixture at higher temperature use of suitable combustion catalyst

selection of appropriate size of coal, proper insulation, reduction in steam and gland leakages and adoption of absorption cooling to utilize heat of condensing steam may help in improving overall energetic efficiency of the plant.

- From the present exercise, we have obtained the energetic efficiency of various fuels used in boiler; we conclude that imported coal to be used in view of the efficiency.

REFERENCES

[1] **C.A. Martinson _ G. van Schoor __ K.R. Uren (2017)** Energy and exergy analyses of a subcritical pulverised coal-fired boiler based on the effects of slagging and fouling, Volume 140, Part 1, December 2017,

[2] **Yong Zhu, Rongrong Zhai, Hao Peng, Yongping Yang (2017)** Exergy Destruction Analysis of Solar Tower Aided Coal-fired Power Generation System Using Exergy and Advanced Exergetic Methods, Applied Thermal Engineering, S1359-4311(16)31249-2(2017).

[3] **Sairam Adibhatla (2017)** Exergy and thermoeconomic analyses of 500 MWe Sub critical thermal power plant with solar aided feed water heating. Volume 21, June 2017

[4] **C.A. Martinson (2017)**Energy and exergy analyses of a subcritical pulverised coal-fired boiler based on the effects of slagging and fouling. IFAC- Volume 50, Issue 1, July 2017

[5] **Hadi Rostamzadeh (2017)** Energy and Exergy Analysis of Novel Combined Cooling and Power (CCP) Cycles. Volume 124, September 2017.

[6] **Yang Cao (2017)** Energy and exergy investigation on two improved IGCC power plants with different CO2 capture schemes" Volume 125, October 2017.

[7] **Meryem Terhan (2017)** Energy and exergy analyses of natural gas-fired boilers in a district heating a system. Volume 114, July 2017.

[8] **Shihe Chen (2017)** Energy-loss Analysis of Thermal Power Unit Based on Multifactor Disturbance Theory. Volume 123, August 2017

[9] **Ravinder Kumar (2016)** A critical review on energy and Exergy economic and economic (4-E) Analysis of thermal power plants. Volume 20, Issue 1, February 2016.

[10] **S. C. Kaushik (2016)** Energy, exergy, economic and environmental (4E) analyses of aconceptual solar aided coal fired 500 MWe thermal power plant with thermal energy storage option. Volume 109, 1 February 2016.

[11] **Mert Gürtürk (2016)** energy analysis of a circulating fluidized bed boiler Cogeneration power plant. Volume 120, 15 July 2016.

[12] **Rauf Terzi(2016)** Energy and exergy analyses of a VVER type nuclear power plant. Volume 41, Issue 29, 3 August 2016.

[13] **Harun okgedik(2016)** Improvement potential of a real geothermal power plant using advanced exergy analysis. Volume 111, 1 March 2016.

[14] **Chao Fu(2015)** Thermal efficiency of coal-fired power plants From theoretical to practical assessments. Fuel, Volume 151, 1 July 2015.

[15] **Hayato Hagi (2015)** Efficiency evaluation procedure of coal-fired power plants with CO2capture, cogeneration and hybridization. Energy, Volume 91, November 2015.

[16] **Ningling Wang (2014)** Exergy Evaluation of a 600MWe Supercritical Coal-fired Power Plant Considering Pollution Emissions. Energy Procedia, Volume 61, 2014.

[17] **J. Taillon(2014)** Exergy efficiency graphs for thermal power plants Ningning Si (2014) Exergy analysis of a 1000 MW double reheat ultra-supercritical Power plant . Energy, Volume 88, August 2014.

[18] **Ahmet Ege (2014)** Determination of uncertainties in energy and exergy analysis of a power Plant . Energy Procedia, Volume 63, 2014.

[19] **Yong Li (2012)** Exergy Analysis of 300MW Coal-Fired Power Plant. Volume 66, March 2012.

[20] **Kumar D. S.** 2008 Thermal Science and Engineering, Ktaria & Sons. Volume 61, 2008.

[21] **Hasan, Huseyin, Erdem**, "Comparative energetic and exergetic erformance analyses for coal-fired thermal power plant in Turkey Thermal Sciences, Volume 48, Issue 11, November 2009.

[22] **NenadFerdelji, Antun and Zvonimir,** "Exergy analysis of a co-generation Plant, "Journal of Thermal Science Vol. 12 , No.4, pp. 75-88.septmber 2008.

[23] **Domkundwar & Arora,** "A course in Power Plant Engineering", Dhanpat Rai & Co. 2006. Volume 29, Issues 2–3, February 2006.

[24] **Ballaney P.L.,** "Thermal Engineering", Khanna Publishers, Volume 88, August 2006.