Energy and Exergy Analysis of Captive Power Plant

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Abstract - In the recent years, India has emerged as one of the fastest growing economies of the world necessitating equally rapid increase in modern energy consumption. With an imminent global climate change threat, India will have difficulties in continuing with this rising energy use towards achieving high economic growth. It will have to follow an energy-efficient pathway in attaining this goal. In terms of energy intensity,India occupies a relatively high position of 9 among the top 30 energy consuming countries of the world [1]. Energy efficiency is one of the most important measures, among others, to address these challenges. Energy efficiency makes available additional energy resources, which can partially address the issues of inadequacy and equity. Energy efficiency also reduces energy consumption as well as carbon intensity,which is a necessary condition for addressing climate change. India will have to follow an energy-efficient pathway to address the above three challenges [2].

I - Introduction

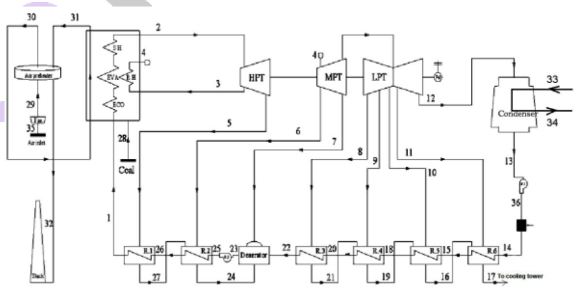
A considerable amount of energy, in a refinery, is utilized in Boiler, Heat Exchanger, Cooling Tower, Pump, Pan, Compressor, wouldyieldvaluableinformation.Insulationofequipment and pipe work, heat recovery from processed fluids, etc., are all seen as an area where heat could be saved, which in turn saves fuel[6].

Industrial energy efficiency has emerged as one of the key issues in India. The industrial sector uses about 40% of total energy in the country [4]. India accounts for 4.5% ofindustrialenergyuseworldwide[5].AccordingtotheInternationalEnergyAgency (IEA) World Energy Outlook energy consumption in Indian industry is projected to more than double by 2030 and so increases its share of total final energyconsumption to 31%[5].

Exergydefinethe theoreticalusefulamountenergy availablefromthe process,anddestructioninexergy iscalledasenergy.Exergy identifiesthemajorsourcesoflossand areasforimprovingtheperformanceof thesystem.It characterizeswork potentialof asystemwith reference toenvironmentwere maximumtheoreticalwork donecanbeobtained.Destructioninexergy isproportionaltoentropy generation,whichaccountsfor inefficiencies.Boilerefficiency thereforehasagreat influence onheating related energysavings. It is thereforeimportanttomaximizethe heattransferto thewaterandminimizethe heatlossesintheboiler. Heatcanbe lostfromboilersbyavarietyofmethods, includinghotflue gas losses,radiationlossesand,in thecaseof steamboilers,blow-downlossesetc.

II - Methodology

Case study on thermal power plant major components of power plant of are listed points are selected carefully such that it measure the temperature mass flow rate pressure is noted down at each inlet and outlet of components of the system. At full load condition reading is noted down. For these point enthalpy andentropyvalueisnotedfromsteamtable.Individualenergy andexergy analysis calculatedforeachcomponentsofthesystem.Theexergydestructioniscalculatedateachpointandtheloss is determinedwithlocationandmagnitude.The energyandexergyefficiency and effectivenessisalsocalculatedandthisidentifythe lossoccurring inpowerplantcomponent.



General Layout of Power Plant

Energy Balance Equation for Plant Competent

(1) Energy balance for Boiler $m1 \times h1 + m13 \times h13 + (m14 \times h14)] = [m2 \times h2 + m11 \times h11 + (boiler)$ (1) Energy balance for Turbine $m2 \times h2 = [\ 3 \times h3 + m4 \times h4 + m5 \times h5 + Eturbine + Wturbine\ ]$

(2) Energy balance for Condenser
$m18 \times h18 + (condensor)$

(3) Energy balance for Condenser pump
$m6 \times h6 + wpump = m7 \times h7 + Econdensorpump$

(4) Energy balance for Low pressure Heater $m7 \times h7 + m4 \times h4 = m8 \times h8 + Elowpressureheater$

(5) Energy balance for DE aerator
$m3 \times h3 + m8 \times h8 = [(m9 \times h9 + Edeareator)]$

(6) Energy balance for boiler feed pump
$m9 \times h9 + Wpump = [m10 \times h10 + Eboilerfeedpump]$

(7) Energy balance for Economizer
$m10 \times h10 + m11 \times h11 = [m1 \times h1 + m12 \times h12 + Eeconomizer]$

(8) Energy balance for Air Pre Heater

$m12 \times h12 + m16 \times h16 = [m13 \times h13 + m15 \times h15 + Eairpreheater]$

Balance Exergy Equation

(10) Exergy balance for Boiler
$[m1 \times a1 + m13 \times a13 + (m14 \times a14)] = [m2 \times a2 + m11 \times a11 + (boiler)$

(11) Exergy balance for Turbine
$m2 \times a2 = [m3 \times a3 + m4 \times a4 + m5 \times a5 + Aturbine + Wturbine]$

(12) Exergy balance for Condenser $m5 \times a5 + m17 \times a17 = m6 \times a6 + m18 \times a18 + A\ (condensor)$

(13) Exergy balance for Condenser pump
$m6 \times a6 + wpump = m7 \times a7 + Acondensorpump$

(14) Exergy balance for Low pressure Heater
$m7 \times a7 + m4 \times a4 = m8 \times a8 + Alowpressureheater$

(15) Exergy balance for DE aerator
$m3 \times a3 + m8 \times a8 = [m9 \times a9 + Adeareator]$ (16) Energy balance for boiler feed pump
$m9 \times a9 + Wpump = [m10 \times a10 + Aboilerfeedpump]$

(17) Exergy balance for Economizer
$m10 \times a10 + m11 \times a11 = [m1 \times a1 + m12 \times a12 + Aeconomizer]$

(18) Exergy balance for Air Pre Heater
$m12 \times a12 + m16 \times a16 = [m13 \times a13 + m15 \times a15 + Aairpreheater]$

III - Exergy Efficiency of Plant

- Boiler =54%
- Turbine=63.7%
- Condenser=11.68%
- Condenser Pump=79.23%
- Low Pressure Heater=87.11%
- DE aerator= 67.67%
- Boiler feed Pump =95.54%
- Economizer=73.00%
- Air Pre Heater=71.09%

IV - Result & Discussion

The energy and exergy losses of various point of power plant are noted down and from the graph we can determine that major & minor loss occurring in the plant through Boiler, feed water pump, Turbine and condenser. These results are based on first law and second law of thermodynamics. On x-axis there are different point of power plant and y-axis represents the amount of heat lost in kW.

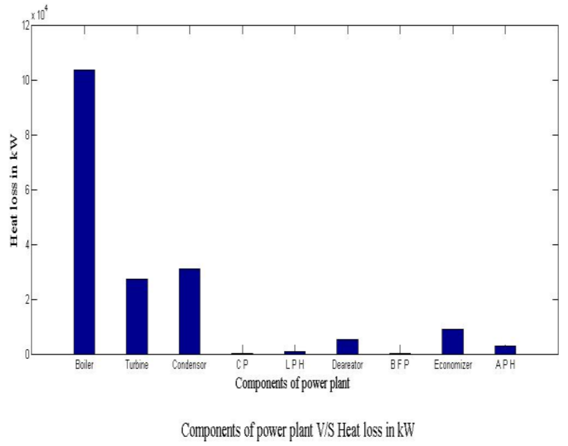


Fig: 5.1 Heat loss in of energy

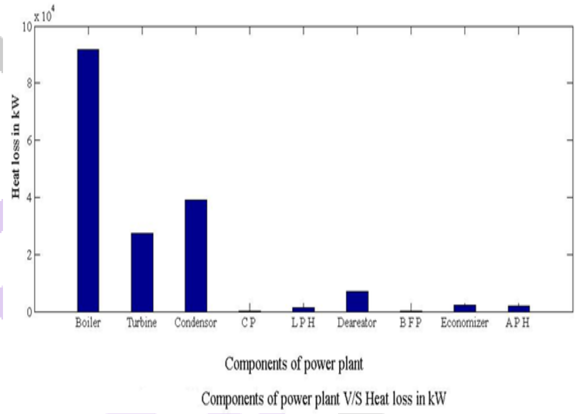


Fig: 5.3% Heat loss in kW of Exergy

The Energy and Exergy analysis at major points are to be done, where from the above graph we can identify the useful energylosses that is taking at some point in the plant are determined i.e. through Boiler, feed water pump and turbine even though major losses are in boiler and turbine both in energy and exergy calculation, but the loss are accurate as compared to energy calculation with exergy calculation. In second order calculation; results are more accurate. On comparing graph in figure 5.1 and 5.2 we can see that the energy loss is more in figure 5.2. Hence the Boiler, turbine is to be redesigned or replaces to reduce the heat losses and better heat transfer in boiler, condenser and by redesigning the turbine.

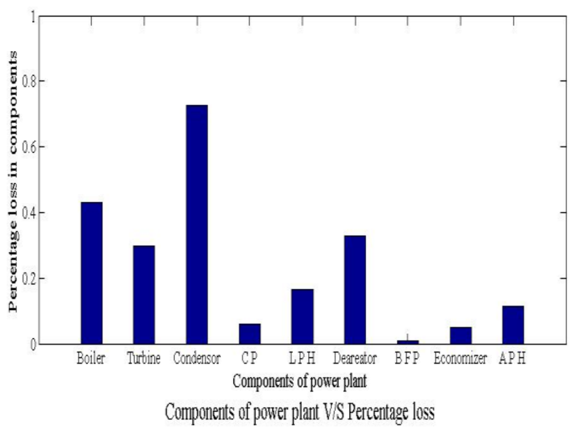


Fig: 5.2 % of energy loss in components

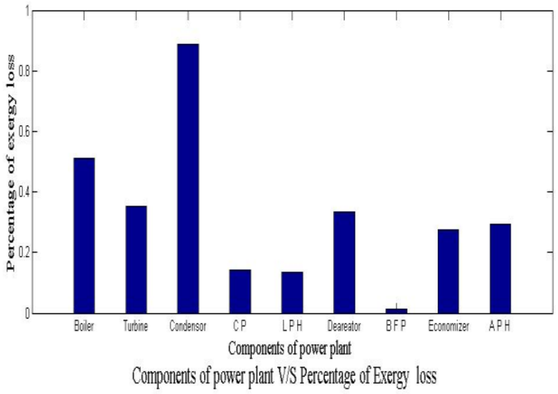


Fig: 5.4 % of Exergy loss in components

The efficiency of components in the power plant is found using energy and exergy calculation. From the above graph we can see that the efficiency of loss in Boiler and turbine is more as compared to other components of power plant, hence we should improve the efficiency of boiler and turbine by redesign. Even though the percentage loss in condenser is more the quality of the energy is not good. By comparing the graph figure 5.3 and 5.4 we came to on conclusion that the major losses is taking place in boiler, feed water pump and turbine. Hence scope of saving energy is more in these components.

V - Conclusion

The following conclusions have been drawn from the drawn from the site study at thermal power plant,

- The exergy and energy analysis of the power plant component identifies where most of the useful energy is loss and discusses potential of the lost energy &improvement of the plant energy efficiency& effectiveness.
- It shows that the boiler, feed water pump and turbine of a power plant is the major source of useful energy losses. Only negligible amounts of useful waste energy can be recovered through implementing some heat recovery system.
- In order to achieve efficient improvement of energy in boiler, feed water pump and turbine systems need to be altered, which required further thermo economic study.
- By doing ultimate analysis of boiler we can see that complete combustion is take place but up-ward pressure of air, fuel contains fines unwanted components which flies with flue gas and burns at the top of boiler by in-creasing the temperature of super heater and leaving the boiler at very high temperature.
- Percentage of fines unwanted component is to be reduced fuel injection type should be changed by studying the design of boiler. So, efficiency can be improved.
- Though losses in condenser is more than quality of energy obtained not, hence we had to concentrate on boiler, feed water pump and turbine to increase the efficiency& effectiveness of the plant.

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