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Optimization of Energy Utilization in Thermal Power Plant by Exergy Analysis of Boiler and Turbine

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Abstract: ***Power generation industry plays the major role in the economic growth of 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. By understanding the world's energy resources are limited, many country have revaluated their polices and are taking measures for eliminating the waste. The increasing demand of power has made the power plants of scientific interest, but most of the power plants are designed by the energetic performance which is based on first law of thermodynamics only. This paper presents the exergy and energy analysis of a unit of 600MW of kalisindh super thermal power plant. This is designed on the first law of thermodynamics approach which does not differentiate between the quality and quantity of energy, so exergy analysis of the plant components (boiler, turbine, condenser, and pump) are also carried out. This analysis provides a quantitative measure of the quality of the energy in terms of its ability to perform work. The losses at various components are calculated using the energy and exergy balance equation. By this analysis we find out the actual losses and this helps to improve the plant efficiency.***

Keywords: Energy, Exergy, Analysis, Entropy, Enthalpy, Thermal power plant

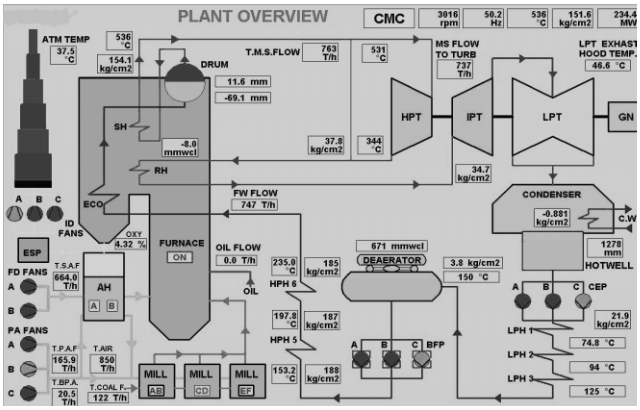
1. Introduction

Energy consumption is the major problem in the world today in front of any developing country. Population increment, urbanization, industrializing, and technologic development result directly in increasing energy consumption. Currently, 80% of electricity in the world is approximately produced from fossil fuels (coal, petroleum, fuel-oil, natural gas) fired thermal power plants, whereas 20% of the electricity is compensated from different sources such as hydraulic, nuclear, wind, solar, geothermal and biogas. India expects that its projected rapid growth in electricity generation over the next couple of decades is expected to be largely met by thermal power plants. But the present thermal power plants which are in India will not be able to meet the future demands. Now by understanding that world's that world's energy resources are limited, many countries have revaluated their energy policies and are taking measure for eliminating the waste. This paper presents a review of the methodology to evaluate the performance of coal based power plant by using both energy and energy analysis. After comparing these two analysis we see that the actual losses are come from energy analysis.

2. Plant Description

Present analysis is done on a 600mw unit of the kalisindh super thermal power plant .it is located in Nimoda village of tehsil jhalarapatan dist. jhalawar, Rajasthan. The total installed capacity of the plant is 1200mw. The project site is about 12 km from NH-12, 2km from state highway and 8 km from proposed Ramganj Mandi - Bhopal broad gauge rail line.

Plant working is based on Rankine cycle. A thermal power plant continuously converts the energy stored in coal into shaft work and ultimately into electricity. The working fluid is water which is sometimes in the liquid phase and sometimes in the vapor phase during its cycle operations.in this plant the energy released by the burning of fuel is transferred to water in the boiler to generate steam at high temperature and pressure, which then expands in the turbine to a low pressure to produce shaft work. The steam leaving the turbine is condensed into water in the condenser where cooling water from a river circulates carrying away the heat released during condensation. The water is then fed back to the boiler by the pump; the cycle goes on repeating itself.



Operating Parameters

S.No.	*Component Name*	*Inlet Temp.*	*Inlet pressure*	*Outlet Temp.*	*Outlet Pressure*
1.	Boiler	320	170	530	170
2.	Turbine	530	170	250	.7
3.	Condenser	250	.7	40	.7
4.	Pump	150	3.8	150	188

3. Energy and Exergy Analysis

Energy analysis is based on the first law of thermodynamics, which is related to the conversion of energy. Here in present analysis we use the steady flow energy equation for calculating the energy for each component and neglecting the changes in kinetic and potential energy changes.

Q-W= dh + dke + dpe

Exergy of a given system is defined as the maximum work that can be extracted from it till it reaches the state of thermodynamic equilibrium with its surroundings. While energy is always conserved, exergy is not generally conserved it is destroyed by irreversibieities

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The method of exergy based on second law of thermodynamics and the concept of irreversible production of entropy. The exergy concept has gained considerable interest in the thermodynamic analysis of thermal process and plant system since it has been insufficient from an energy performance stand point. In recent decades , exergy analysis are found out useful method in the design, evaluation, optimization and improvements of thermal power plant.

The exergy analysis is done with the help of exergy balance equation .from this equation we get the max available energy of the system

For Turbine

Inlet exergy

$\Psi_1 = (h_1\text{-}h_1)\text{-}T_0(s_1\text{-}s_0)$

= (3281.1-419)-310(6.259-1.307)

=1326.98 kj/kg .k

Outlet exergy

$\Psi_2 = (h_2\text{-}h_0)\text{-}T_0\ (s_2\text{-}s_0)$

= (2975.2-419)-310(8.167-1.307)

= 429.6 kj/kg.k

Exergy Destruction $=\psi_1 - \psi_2$

Ψ=1326.98-429.6

ψ=897.38 kj/kg.k

Energy loss (E) = $h_1\text{-}h_2$

E=3281.1-2975.2

E=305.9 kj/kg.k

For Boiler

Inlet exergy

Ψ_1= (856.9-419)-310(1.370-1.307)

Ψ_1=418.37 kj/kg.k

Outlet exergy

Ψ_2=1326.98

$\Psi=\psi_2\text{-}\psi_1$

Ψ=908.61 kj/kg.k

Energy (E) =h1-h2=Cp dT

E=4.18*(803-593)

=877.61 kj/kg.k

S.No.	*Component Name*	*Exergy*	*Energy*	*Losses*
1	Boiler	908.61	877.8	30.81
2	Turbine	897.38	305.9	591.48

4. Result and Conclusion

The exergy analysis is very important tool to find the actual irreversibilities in different components of any cycle/system and performance based on exergy analysis gives the real assessment of the system. Exergy analysis and Second law of thermodynamics has been performed in this study is able to help to understand the performance of thermal power plant and justify possible efficiency improvements. It gives logical solution for improving the performance opportunities in thermal power plants.

Here in this analysis we see from the energy and exergy calculations the major losses is take place in Turbine.

5. Future Scope

Second law or Exergy analysis has been performed on kalisindh thermal power plant is able to help to understand the performance of this power plant and justify possible efficiency improvements .It gives logical solution improving the power production opportunities in thermal power plants**.**

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