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Energy and Exergy Analysis Based on a Unit of 135 MW Wardha Power Company Limited

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ABSTRACT

The objective of this study is to evaluate the energy and exergy efficiencies and exergy destruction rate of the power plant system components, with a view to identifying systems that have potential for significant performance improvement.

This work is based on the energy and exergy analysis which is carried out for thermal power plant, for which WPCL Thermal Power Plant has been taken into consideration. Exergy analysis is a useful concept for ecology and sustainability because it can used as a common measure of resourse quality along with quantity. By analysis the exergy destroyed by each component in a process, we can see where we should be focusing our efforts to improve system efficiency. The main objective is to analyse the various system components to identify the parts due to which loss of energy and exergy at large amount takes place. The result of the research can enable to find the desirable modifications to maximize the efficiency of system components and to minimize the loss of exergy in the power plant. On the basis of energy and exergy destruction analysis, 95% of exergy destruction and 36.64% of energy loss contributed through boiler system. Through analysis it is examined that the majority of energy losses due to boiler and condenser system but some amount of exergy destruction rate in boiler can be recovered through reheating phenomena. The effect of reheating is a process by which exergy destruction can be minimize, without any change of fuel consumption.

Keywords: Exergy analysis; exergy efficiency; Exergy destruction; dead state; steam power plant**.**

1. Introduction

1.1 Exergy definition

It is evident that the content of energy in the universe is constant. But very often, we come through different dialogues and articles on the topic that “How to conserve energy”. Since time immemorial it is known that energy is constant in nature, what need to conserve the energy which is already conserved. The content required to be conserved is exergy which is the vital parameter and work potential of the energy. Exergy is irrecoverable i.e. once it is wasted can never be recovered. Simply, it means that when energy is used, the conversion of energy in a less powerful form i.e. exergy is used not the energy. Hence, energy is never exhausted.

Exergy defines the maximum capacity of a system to produce useful work as it proceeds from a specified state to a final state which is in equilibrium with its surroundings. Exergy cannot be conserved like energy as it is destructed in the system. Exergy destruction is the measure of irreversibility that is the source of performance loss. Therefore, exergy analysis enables us to identify the location, the magnitude and the source of thermodynamic inefficiencies in the overall system The minimum exergy that has to be rejected to the sink by the second law is called unavailable energy (U.E.).

1.2 Present scenario of power sector

Now-a-days, electricity is a basic need to human life. From personal to professional life, from home accessories to industrial machineries nothing can be imagined making aside the electricity. As such, power generation industry reflects a major role in the economic upliftment of the country. Presently, 80% approx. of total electricity consumed in the world is being produced from fossil fuels i.e. coal & petroleum products and only 20% approx. is produced from other sources like wind, water, hydraulic, solar, biogas, geothermal etc.

Now a day exergy analysis of power plant is of scientific interest for making efficient utilization of energy resources as they are constant in nature. The analysis of an energy conversion process is normally carried out by the first law of thermodynamics. But now a day, there is an increasing interest in the combined utilization of the first and second laws of thermodynamics, using both the law exergy and irreversibility can be calculated. By which one can evaluate the efficiency with which the maximum available energy is consumed. Exergy analysis method is a tool for clear distinction between the energy losses to the environment and internal irreversibility of the process.

1.3 Thermal power plant

Thermal power plants are the back bone of Indian power sector. In India 68.14 % of electricity is generated by the thermal power plant. A thermal power plant continuously convert the energy stored in fossil fuels (coal, oil, natural gas) into shaft work and ultimately into electricity. Thermal power plant converts heat energy of the working fluid into electrical energy. The working fluid is sometime in the liquid phase and sometime in the vapour phase during its cyclic operations.

1.4 Working Principle of thermal power plant

The thermal power station is a power plant in which the prime mover is driven by steam. Water is heated in a boiler converts into steam and the steam passes through a nozzle which impact force on the turbine blade. This impact force produces turning moment to rotate the turbine shaft which drives an electrical generator to produce electricity. After expansion of stem in the steam turbine, it passes to the condenser where heat is taken away by the cooling water coming from the cooling tower or river bed. Makeup water is supplied to make the water level constant in the boiler. The condensed steam along with the makeup water is recycled to the boiler by a feed pump where it is again heated. The cycle is repeated continuously. This is known as a "Rankine cycle".

2. Literature Survey

Arpit et. al. (2023) In the present paper, a rigorous analysis of a sub-critical steam power plant (120 MW) with reheating and regenerative configuration is presented, using energy and exergy analysis. The total work output from the power plant is 121.80 MW, which is close to the real value of 120 MW. The calculated energy efficiency of the steam power plant is 34.7%, while its exergy efficiency is 32%

Omar J. Khaleel et. al. (2022) This study is a comparative evaluation of the energy & exergy analyses of coal and gas-fired TPPs. Details of different studies on TPPs over the years were critically reviewed, followed by independent thermodynamics analysis of each component of the TPPs system. Improvements in the performance of power plants were also highlighted. From the outcome of the comparative analysis, combustion chambers were identified as the main contributors to exergy destruction owing to their associated high irreversibility. The results show that the exergy efficiency of the entire system is about 20%. The main exergy loss were occurred in the boiler and the steam turbine in the system.

Xianzhi Tang et. al. (2022) The main role of advanced exergy analysis is to help engineers improve system design and performance by providing information. This provision of information is done by isolating the exergy destruction. Separation of exergy destruction into endogenous/exogenous and unavoidable/avoidable components presents a new development in the exergy analysis of energy conversion systems, which in this paper combines both concepts. This separation increases the accuracy of the exergy analysis and facilitates the improvement of a system. The method used in this paper for separation is the thermodynamic cycle method, which is based on determining the temperature levels for ideal and irreversible cycles.

P. Stephan Heyns et. al. (2021) In this article, energy, exergy, and environmental (3E) analysis of a 400 MW thermal power plant is investigated. First, the components of the power plant are examined in terms of energy consumption, and subsequently the energy losses, exergy destruction, and exergetic efficiency are obtained. It is shown that the highest energy losses are in the closed feedwater heaters Nos. 1 and 5 and the boiler with amounts of 7.6 × 10 J/s and 6.5×10^7 J/s, respectively. The highest exergy destruction occurs in the boiler and amounts to 4.13×10^8 J/s. The highest exergetic efficiency is 0.98 and is associated with the closed feedwater heaters Nos. 4 and 8. It is observed that the exergetic efficiency and exergy destruction in the boiler are the primarily affected by changes in the environmental temperature.

Osman Shamet et. al. (2021) In this study, the energy and exergy analysis of Garri 4 power plant in Sudan is presented. The primary objective of this paper is to identify the major source of irreversibilities in the cycle. The equipment of the power plant has been analyzed individually. Values regarding heat loss and exergy destruction have been presented for each equipment. The results confirmed that the condenser was the main source for energy loss (about 67%), while exergy analysis revealed that the boiler contributed to the largest percentage of exergy destruction (about 84.36%) which can be reduced by preheating the inlet water to a sufficient temperature and controlling air to fuel ratio.

Abdullah Duzcan et. al. (2021) Exergoeconomic analysis is conducted by using specific exergy costing (SPECO) method and cost values corresponding to each exergy flows are calculated. According to exergoeconomic analysis, unit exergy cost and exergy cost of steam sent to high-pressure turbine are calculated as 17.94 $/GJ and 22,854 $/h, respectively. The highest exergoeconomic factor is measured in pump (*P*2) and followed by *P*3. For the life cycle assessment (LCA) analysis, eco-indicator 99 impact assessment method is selected.

Davor Poljancic et. al. (2021) This paper presents a calculation of energy and exergy efficiency with energy and exergy losses of the entire nuclear power plant and all of its constituent components. The main idea of the performed analysis is to be a baseline for further improvements and optimizations of the entire nuclear power plant or any of its components.

Aisha Saad et. al. (2021) focuses on identifying the type, location and causes of thermodynamic losses in the plant. The first as well as the second law of thermodynamics was applied to each component of the plant and the exergy balance for each of the plant components derived. The analysis was conducted by varying the ambient temperature between 294 and 306 K through the use of the Microsoft excel software. The results show that the combustion chamber with the highest exergy destruction efficiency of 53.5% for Jatropha biodiesel, 50.7% for conventional diesel and 50.2% for natural gas while the turbine component of the engine had the least of 13%, 24% and 4% for Jatropha biodiesel, conventional diesel and natural gas respectively at maximum ambient temperature. On the other hand the highest exergy efficiency was obtained with natural gas but was observed to drop with increase in the ambient temperature.

Dr. Rakesh Kumar Jain et. al. (2020) in this paper we present how to improve the efficiencies and whether a further inspection required of 125 MW coal fired power plant. So Energy and Exergy analysis have been carried out in order to evaluate the energetic and exergetic efficiencies of the plant and its components at 100% loading condition, but most of the power plants are designed on the basis of energetic performance and is based on the First Law of Thermodynamics only. The real useful energy loss cannot be justified by the First Law of Thermodynamics because it does not differentiate between the quality and quantity of energy. Energy analysis presents only quantity based result while Exergy analysis presents quality along with quantity based results of the power plant and is based on the principle of Second law of thermodynamics. This paper presents that how the Exergy analysis is more useful as Energy analysis for coal fired thermal power plants.

PDF

Altug Alp Erdogan et. al. (2020) This study investigates the exergetic effects of the hot-windbox repowering option for a coal-fired thermal power plant. The hot-windbox repowering option consists of a gas turbine, an air-to-water heat exchanger for feedwater heating, and an air-to-air heat exchanger to preheat the combustion air. An air dilution part is also needed for the required temperature set at the inlet of burners. A burner modification can also be necessary without air dilution dampers. Exergy calculations for the power plant before repowering were performed according to the design data of Soma-A Thermal Power Plant and were repeated for the hot-windbox repowering (HWB) scheme. According to the results, the percent exergy destruction in the boiler decreased from 84.70% to 68.80%, which that in the combustion chamber of the gas turbine (GT) was 14.77%.

Louay Elmorsy et. al. (2020) In this paper, a novel natural gas-fired integrated solar combined-cycle power plant was proposed, evaluated, and optimized with exergy-based methods. The proposed system utilizes the advantages of combined-cycle power plants, direct steam generation, and linear Fresnel collectors to provide 475 MW baseload power in Aswan, Egypt. The proposed system is found to reach exergetic efficiencies of 50.7% and 58.1% for day and night operations, respectively. In economic analysis, a weighted average levelized cost of electricity of 40.0 $/MWh based on the number of day and night operation hours is identified. In exergoeconomic analysis, the costs of thermodynamic inefficiencies were identified and compared to the component cost rates. Different measures for component cost reduction and performance enhancement were identified and applied.

Omar J Khaleel et. al. (2020) In this paper, exergy analysis method is theoretically studied and modeled, and the exergy matrix equation is established. The exergy analysis method based on the second law of thermodynamics is studied and modeled, and the exergy matrix equation is derived. The main contents include: the overall analysis and partial quantitative analysis of the thermal system of the unit from the perspective of thermal equilibrium analysis, the exergy analysis of the thermal system under variable operating conditions from the perspective of exergy analysis, to find out the system's defects and deficiencies.

Maryam Fani et. al. (2020) In the present study, a new suggested sketch of adding latent heat storage (LHS) filled with commercial phase change material (PCM) to a 500-kW STPP case study has been investigated. Solar system details and irradiation amounts for a case study, including total and beam radiation have been determined. Also, the theoretical energetic and exergetic analysis of adding PCM storage to STTP is conducted, which showed a 19% improvement in the exergetic efficiency of the power plant to reach 30%. Besides, an optimized storage tank and appropriate PCM material have been investigated and selected concerning the practical limitations of the case study.

Bayu Rudiyanto et. al (2019) The exergy analysis of steam power plant system in PT. Jawa Power-YTL, East Java unit 5 was performed based on the first and second law of thermodynamics. Exergy flow and exergy efficiency were calculated for each component of the plant i.e. the boiler, HTP, IPT, LPT, deaerator, condenser, HPH, LPH, CEP and FWP. The exergy steam-flow of 970288 kW produced 610.000 kW of electricity with an exergy efficiency of 26.36%. Sankey diagram showed the exergy loss on each component of the steam power plant.

Eflita Yohana et.al. (2019) This research is used to analyze energy and exergy on the components of a steam power plant. From the results of this research, the largest of destruction exergy boiler is 881.08 MW and the exergetic efficiency is 48.66%. While the rate of the smallest destruction exergy in LPH 3 is 0.6 MW and the exergetic efficiency is 94.45%. The contribution of the largest Losses energy in the boiler is 231 MW and energetic efficiency is 87.05%. While the contribution of the smallest energy Losses in HPH 6 is 0.74 MW and energetic efficiency is 99.23%

Onyejekwe et. al. (2018) A component based energy and exergy evaluation was performed on a 220MW thermal power plant in Nigeria. The component based exergy analysis examines and compares the energetic and exergetic performances of each component by identifying the deficiencies of each component. Design and operating data were obtained from Egbin power plant in Nigeria. The result of the analysis showed that the total exergy that was destroyed in the power plant was 400.015 MW. The major contributors to the exergy destruction in the power plant were the boiler (87%), the three turbines (a combined total of 9%) and the condenser (2 %).The effect of increasing the High Pressure turbine (HPT) inlet temperature at constant boiler pressure incresses the exergy efficiency of the component as well as the second law efficiency of the power plant, thus reducing the exergy destruction of the component.

3. Research Methodology

The aim of this chapter is to describe the data collection and processing, to develop the theoretical concept and introduce the various parameters that are used in the research. Data has been collected from SAI WARDHA POWER LTD, B-2 Warora Growth centre, MIDC Warora, Dist.- Chandrapur.

Calculations of energy use, energy and exergy efficiencies, exergy destruction, energy efficiency of motor, energy savings and emissions reduction are discussed here. It is also introduced and deduced the related equations that are used in the research.

3.1 Main Boiler Specification

Super high pressure, single reheat, single furnace, natural circulation, coal fired, corner-fired, balanced ventilation, solid slag ,medium-speed mill, cold primary fan, positive pressure direct injection type coal pulverizing system, medium-speed roller pulverizer with type of ZGM, ele- ctronic gravimetric pressure-resisting type belt coal feeder with two tri-section air pre-heaters set in the rear pass, made by Dongfang boiler group co., ltd

3.2 Major Operating Parameters:

Sl. No.	Parameters	Unit	Value
1	Boiler maximum continuous rate	TPH	440
2	Rated superheated steam pressure	MPa	14.29
3	Rated superheated steam temp	oC	540
4	Rated reheat steam flow	TPH	358.7
5	Rated reheat steam pressure, inlet	MPa	2.586
6	Rated reheat steam temp. Inlet	oC	320
7	Rated reheat steam pressure, outlet	MPa	2.449
8	Rated reheat steam temp. Outlet	oC	540
9	Feed water temp	oC	248.9
10	Exhaust gas temp	oC	136
11	The lowest steady firing load without supporting oil	% BMCR	40
12	Boiler steam generation with HP heater out of service	TPH	366.6
13	Boiler Efficiency	%	92.78

3.3 Energy and Exergy analysis

The necessary steps to perform energy and exergy analysis are listed below:

1. First of all, the thermodynamic model of the plant is prepared showing the steam flow in the plant as shown in figure. The various channels are connecting different the elements are represented.

2. The data is taken from the plant related to the mass flow rate, pressure and temperature of steam flow at each point of thermodynamic model of the plant. All the data taken is real time data taken.

3. With the help of Mollier Diagram and with the values of pressure and temperature at each point of thermodynamic model, the values of enthalpy and entropy can be find out at each point.

4. With the energy and exergy formula, the values of energy and exergy can be calculated at different point of the thermodynamic model of the plant.

3.4 Mathematical Formulation

In the form of enthalpy, the energy can be expressed

Energy (E_n) = m (h_1-h_0)

Exergy is the maximum theoretical useful work obtained as the system interacts with the environment. In the absence of nuclear, magnetic, electrical, and surface tension effects, the total exergy of a system (E_x) can be divided into four components: physical exergy $E_{X(PH)}$, kinetic exergy $E_{x(KN)}$, potential exergy $E_{x(PT)}$, and chemical exergy $E_{x(CH)}$.

$$E_x = E_{x(PH)} + E_{x(KN)} + E_{x(PT)} + E_{x(CH)}$$

If the kinetic, potential and chemical exergy are considered to be negligible then exergy can be defined as by equation.

$$E_x = m[(h_1 - h_0) - T_0(s_1 - s_0)]$$

3.5 Exergy Transfer by Work

Exergy Transfer by Mass contains exergy as well as energy and entropy. The rate of exergy transfers to or from a system is proportional to the flow rate.

$$E_{x(mass)} = m[(h - h_0) - T_0(s - s_0) + v^2/2 + g z]$$

First of all, the thermodynamic model of the plant is prepared showing the steam flow in the plant as shown in figure. The various channels connecting different elements are numbered as 1, 2 etc.

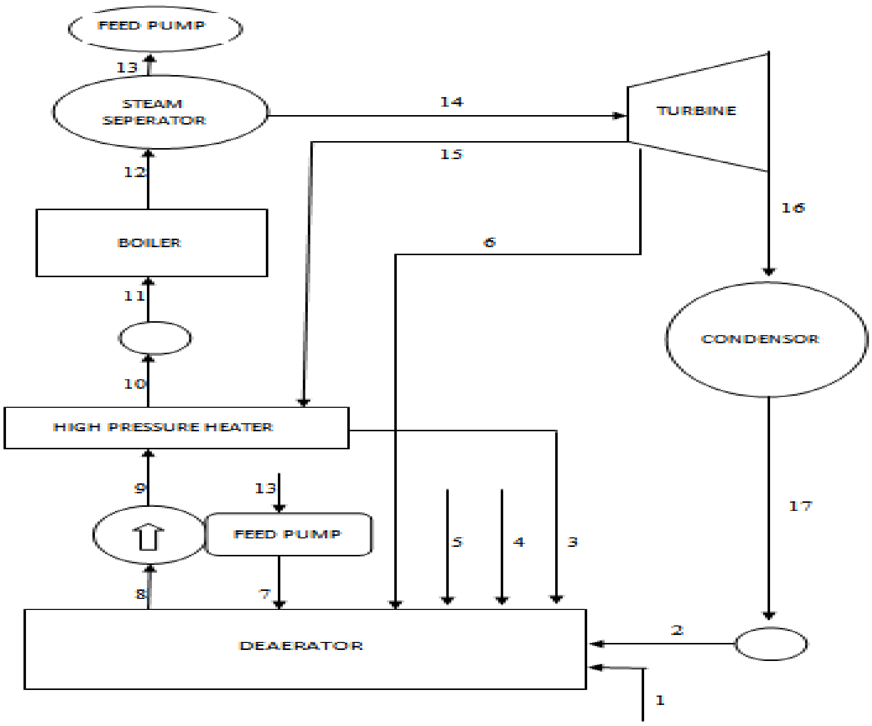

Fig. 3.1 Diagramatic representation of flow chart of power plant

Now, the data is taken from the plant related to the mass flow rate, pressure and temperature of steam flow at each point of thermodynamic model of the plant. With the help of Mollier Diagram and with the values of pressure and temperature at each point of thermodynamic model, the values of enthalpy and entropy can be find out at each point.

The properties steam at different temperature and pressure are summarized in below table with the help steam table are as follows;

Table 3.1 Properties of Steam at various temperature and pressure

Point	M (kg/s)	P (bar)	T (ºC)	h_f (kj/kg)	h_g (kj/kg)	h_{fg} (kj/kg)	S_f (kj/kg)k	S_g (kj/kg)k	S_{fg} (kj/kg)k
1	48.62	5.06	63.2	263.47	2615.237	2351.237	0.8682	7.84	6.972
2	8.78	5.58	64.5	271.14	2619.73	2348.59	0.890	7.825	6.935
3	10.98	10.72	181.63	771.6	2779.53	2007.93	2.12	6.31	4.19
4	0.61	1.93	200	2871.23	1196.71	1674.52	7.531	2.197	5.334
5	1.72	2.04	211.4	2893.68	1152.20	1741.477	7.55	2.24	5.307
6	0	0	0	-	-	-	-	-	-
7	3.69	1.92	232	2934.37	1069.94	1864.43	7.658	2.323	5.335
8	74.91	4.18	115.6	481.6	2698.7	2217.1	1.52	7.121	5.61
9	74.91	128.23	116.27	486.35	2706.41	2220.06	1.50	7.1	5.6
10	74.91	128.23	197	827.18	2799.74	1972.56	2.29	6.38	4.098
11	69.54	120.18	193	825.03	2795.8	1972.01	2.24	6.34	4.10
12	68.98	103.10	509	3398.86	1424.7	1974.16	6.624	4.42	2.202
13	3.68	99.34	499.5	3370.53	1402.655	1967.875	6.606	4.356	2.255
14	21.17	97.41	495	3367.2	1420.98	1946.22	6.601	4.32	2.281
15	10.89	15.46	312	3061.58	1179.93	1881.65	6.972	2.89	4.075
16	9.70	0.18	62.5	261.73	2614.16	2352.43	0.858	7.468	6.61
17	9.70	0.18	60	251.03	2610.112	2359.08	0.835	7.907	7.072

4. Result and Calculation

Now calculating specific exergy and energy flow at various point on the components of power plant by using formula;

Specific exergy in (kj/kg) is given by;

$e_x = (h_g – h_f) – t (s_g – s_f)$

$e_x = (h_{fg}) – t (s_{fg})$

Total exergy flow at any point is given by;

E_x = Mass flow rate x Specific exergy

$E_x = m \times e_x$

Now Energy flow is given by;

E = mass flow rate x Specific enthalpy

E = m x h

The above formula are used for the calculation of energy and exergy flow which is summarized in tabular form are as follows;

Table 4.1 Exergy and Energy chart at various temperature and pressure

Point	M (kg/s)	P (bar)	T (ºC)	h (kj/kg)	S(kj/kg)k	e_x(kj/kg)	E(MW)	E_x(MW)
1	48.62	5.06	63.2	263.47	0.8682	7.25	12.804	0.352
2	8.78	5.58	64.5	271.14	0.890	8.027	2.382	0.071
3	10.98	10.72	181.63	771.6	2.12	103.03	8.472	1.2
4	0.61	1.93	200	2871.23	7.531	608.52	1.175	0.371
5	1.72	2.04	211.4	2893.68	7.55	621.17	4.977	1.068
6	0	0	0	-	-	-	-	-
7	3.69	1.92	232	2934.37	7.658	626.71	10.81	2.312
8	74.91	4.18	115.6	481.6	1.52	37.05	36.12	2.775
9	74.91	128.23	116.27	486.35	1.50	40.148	37.35	3.007
10	74.91	128.23	197	827.18	2.29	46.56	61.964	3.5
11	69.54	120.18	193	825.03	2.24	61.41	57.572	4.270
12	68.98	103.10	509	3398.86	6.624	854.36	234.453	5.89
13	3.68	99.34	499.5	3370.53	6.606	843.99	12.42	3.105
14	21.17	97.41	495	3367.2	6.601	832.47	71.283	17.62
15	10.89	15.46	312	3061.58	6.972	611.81	33.34	6.66
16	9.70	0.18	62.5	261.73	0.858	134.775	25.38	1.307
17	9.70	0.18	60	251.03	0.835	4.104	2.434	0.039

4.1 Energy balance equation and its analysis

With the help of below relationship energy and exergy analysis on various component of plant are calculated;

a. Boiler

Energy loss in boiler is given by = fuel energy supplied + energy flow at pt. 11 – energy flow at pt. 12

Now fuel energy = mass flow rate of fuel x C.V. of fuel

= 4.186 kg/sec x 46500 kj/kg

= 194649 kj/sec

= 194649000 W (1 kj/sec = 1000 W)

= 194.649 MW

Energy loss in boiler = 194.649 + 57.572 – 234.453

= 16.24 MW

b. Deaerator

Energy loss in deaerator is given by = energy flow at pt. 7 + energy flow at pt.5 + energy flow at pt.4 + energy flow at pt.3 + energy flow at pt.2 + energy flow at pt.1 - energy flow at pt.8

= 10.81+4.977+1.175+8.472+2.382+12.804 - 36.12

= 4.5 MW

c. Turbine

Energy loss in turbine is given by = energy flow at pt.14 - energy flow at pt.15 - energy flow at pt.6 - energy flow at pt.16 - W_T

= 71.28 – 33.34 – 25.38 - W_T

= 12.56 - W_T MW

d. Condensor

Energy loss in turbine is given by = energy flow at pt.16 - energy flow at pt.17

= 25.38 – 2.43

= 22.95 MW

e. Feed pump

Energy loss in turbine is given by = energy flow at pt.8 + energy flow at pt.13 - energy flow at pt.7 - energy flow at pt.9

= 36.12 + 12.42 – 10.827 -35.35

= 0.38 MW

f. High pressure heater

Energy loss in turbine is given by = energy flow at pt.9 + energy flow at pt.15 - energy flow at pt.10 - energy flow at pt.3

= 37.35 + 33.34 – 66.96 – 8.472

= 0.254 MW

Table 4.2 Component with their energy losses

S. No.	Component	Energy loss	Percentage energy loss
1	Boiler	16.24 MW	36.64
2	Feed pump	0.38 MW	0.85
3	Deaerator	4.5 MW	10.15
4	Turbine	12.56 - W_T MW	1
5	Condensor	22.95 MW	51.78
6	High pressure heater	0.254 MW	0.58
Total		44.32 MW (neglecting turbine loss)	100

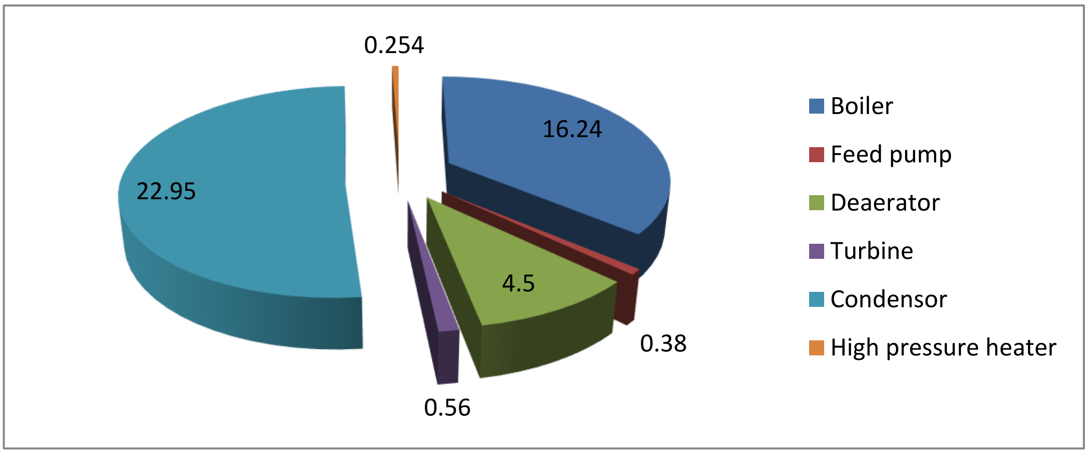

Fig. 4.1 Chart showing energy loss data at various components

4.2 Exergy balance equation and is analysis

Exergy destruction at various component in power plant is given by;

a. Boiler

Exergy destruction in boiler = exergy of fuel + exergy flow at pt.11 - exergy flow at pt.12

Now exergy of fuel is given by = mass of fuel x C.V. of fuel

= 194.65 MW

Now exergy destruction = 194.65 + 4.27 – 5.89

=189.03 MW

b. High pressure heater

Exergy destruction in high pressure heater = exergy flow at pt.9 + exergy flow at pt.15 - exergy flow at pt.10 - exergy flow at pt.3

= 3.007 + 6.66 – 3.50 – 1.20

= 4.96 MW

c. Feed pump

Exergy destruction in feed pump = exergy flow at pt.8 + exergy flow at pt.13 - exergy flow at pt.7 - exergy flow at pt.9

= 2.775 + 3.105 – 2.312 – 3.007

= 0.561MW

d. Turbine

Exergy destruction in turbine = exergy flow at pt.14 - exergy flow at pt.15 - exergy flow at pt.16 - W_T

= 17.16 – 6.66 – 1.307 - W_T

= 9.13 - W_T MW

e. Condensor

Exergy destruction in condensor = exergy flow at pt.16 - exergy flow at pt.17

= 1.307 – 0.039

= 1.268 MW

f. Deaerator

Exergy destruction in deaerator = exergy flow at pt.1 + exergy flow at pt.2 + exergy flow at pt. 3 + exergy flow at pt.4 + exergy flow at pt.5 + exergy flow at pt.7 - exergy flow at pt.8

= 0.352 + 0.071 + 1.2 + 0.371 + 1.068 +2.312 – 2.775

= 2.599 MW

Table 4.3 Component with their exergy destructions

S. No.	Component	Exergy destruction	Percentage exergy loss
1	Boiler	189.03 MW	95.26
2	Feed pump	0.561 MW	0.28
3	Deaerator	2.599 MW	1.31
4	Turbine	9.13 - W_T MW	1
5	Condensor	1.268 MW	0.64
6	High pressure heater	4.96 MW	2.5
Total		198.42 MW (neglecting turbine loss)	100

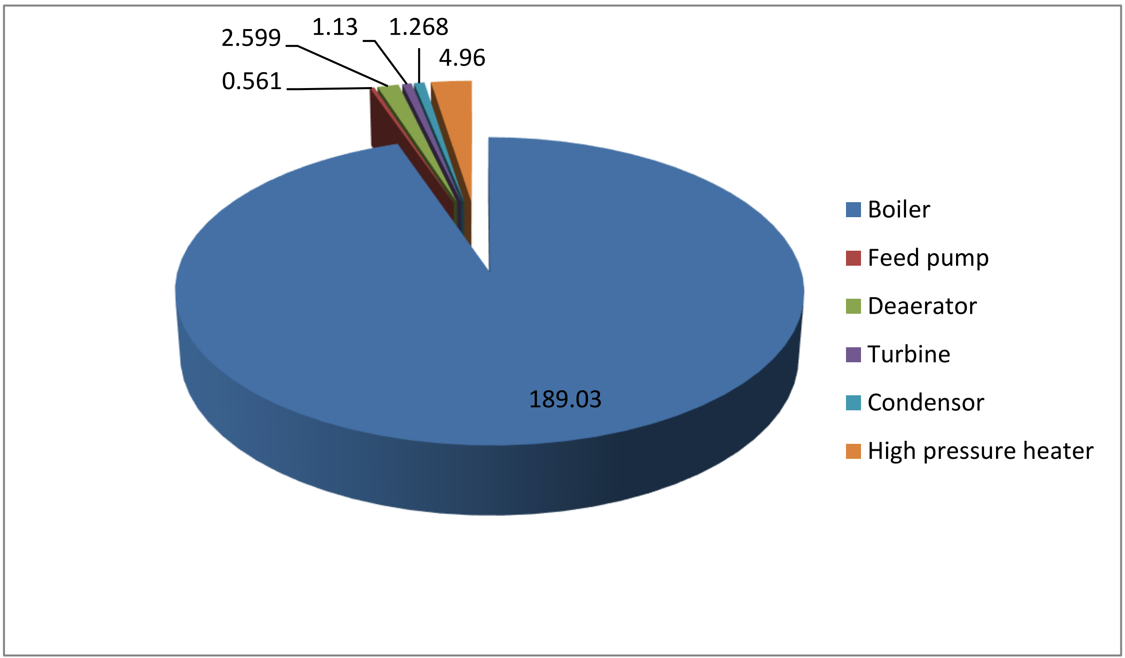

Fig. 4.2 Chart showing exergy destructions data at various components

5. Conclusion and Future Scope

In this study, a component based energy and exergy evaluation of a unit of 135 MW thermal power plant was performed. The result of the analysis showed that the total exergy that was destroyed in the power plant was about 200 MW. The major contributors to the exergy destruction in the power plant were the boiler, high pressure heater, and condenser. Their contributions were 189MW (95%), 4.2MW (2.5%), 1.2MW (1%) respectively. It is apparent from the analysis that the highest exergy destruction occurs in the boiler component. Its effect on the overall plant exergy efficiency is significant. In terms of energy loss, boiler and the condenser responsible for higher rate of losses with 16.24 MW and 22.95 MW respectively. The total energy loss in the power plant was about 44.35 MW.

If increasing the high Pressure turbine (HPT) inlet temperature at constant boiler pressure increases the exergy efficiency of the component as well as the second law efficiency of the power plant, thus reducing the exergy destruction of the component. At the variation of environmental or dead state temperature, there were no appreciable changes in the values of exergy efficiency of the boiler/steam generator

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