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An experimental analytical study of thermal power plants

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ABSTRACT

Around the world the supply of energy is decreasing by the day, making the increased energy demand scientifically attractive, but most power plants are designed with active performance standards based on the first law of thermodynamics alone. In fact, the first law of thermodynamics does not justify a loss of beneficial energy, as it does not differentiate between the quality and quantity of energy. This study relates to the comparison of energy analysis and thermal stimulation of a coal thermal power plant. This paper discusses the stress analysis performed on different operating loads (100%, 95%, 90%, 70%). Exercise losses occur in different plant subsystems and their components have been calculated using the mass-energy balance and stress balance. The first legal efficiency (energy efficiency) and the second legal efficiency (energy efficiency) were calculated. The comparisons between the power loss and the power loss of the individual components show that the maximum energy loss occurs in the capacitor, while the maximum energy loss occurs in the burner. The actual energy loss that there is room for improvement is given as the maximum energy loss that occurs in the burner.

LIST OF SYMBOLS

Nomenclature

e_x	specific exergy (kJ/kg)	Chemical symbols	
Ex	exergy rate (kW)	C	carbon
Ex_d	exergy destruction rate (irreversibility) (kW)	CO_2	carbon dioxide
GCV	gross calorific value	H_2	hydrogen
h	specific enthalpy (kJ/kg)	H_2O	water vapor
h_{fo}	specific enthalpy of formation (kJ/kmole)	N_2	nitrogen
m	mass flow rate (kg/s)	O_2	oxygen
n	number of moles	Superscripts	
P	pressure (kPa)	ch	chemical
Q	heat transfer rate (kW)	tm	thermo-mechanical
s	specific entropy (kJ/kg K or kJ/kmole K)		
S_{gen}	entropy generation (kJ/s K)	Subscripts	
T	temperature (C or K)	c	carbon
TMCR	turbine maximum continues rating	Comb	combustion
W	work rate (kW)	f	fuel
Greek letters		p	products
η	efficiency	r	reactants

1. INTRODUCTION

Total energy consumption is one of the most important indicators that illustrate the level of national development and society's standard of living. This increasing trend is leading to important environmental problems such as pollution and global warming impacts. Currently, 80% of the world's electricity is generated from fossil fuels (coal, petroleum, natural gas, and fuel oil) from thermal power plants (TPP), while 20% of the electricity is offset from various sources such as hydraulic, nuclear, and wind energy. Solar energy, geothermal energy, and biogas [1].

The thermal power plant performance is evaluated by energy performance criteria based on the first thermodynamic laws, including electrical energy and thermal efficiency. The enthalpy balance is calculated to measure the efficiency loss in a process due to energy loss using the first thermodynamic law, which is a conventional approach. However, this approach cannot determine whether or not a process could take place. This deficiency is also overcome by the emergence or introduction of thermodynamics, the second law [2]. However, in recent years, a second legal analysis - later called an explanatory analysis - of the energy system has attracted the interest of energy engineers and the scientific community. The superior performance based on the second law of thermodynamics has proven to be a useful method for designing, evaluating, and improving thermal power plants. The overall reason during the current second law of thermodynamics was laid via Carnot in 1824 and Clausius in 1865. Strategies for investigating and using energy have likewise been created in the accompanying nations Russia, Europe, Germany, and Poland since 1960[3,4].

The concept of exergy has aroused great interest in thermodynamic analysis of thermodynamic processes and plant systems because it has been found that the analysis of major laws is inadequate in terms of energy performance. In this case, it is necessary to revisit the serious analysis of combustion processes and thermodynamics because a normal energy analysis does not contain a documented assessment of temperature levels. In a thermodynamic cycle, it is necessary to consider the combustion, heat transfer, and energy conversion processes, which include many kinds of effective and invalid items. Hence, the introduction of exergy analysis is needed to analyse power generation and heat pump cycles against energy analysis. Recently, a large number of studies based on exergy analysis have been carried out by many researchers around the world in various system applications.

2. The main objective of this project is to perform an external thermodynamic analysis using real power plant design data. This will compare the scan results to show how over-checking can help improve system performance. This project will determine the causes of energy loss and destruction in the power plant. This will provide methods and techniques to improve system performance and reduce environmental impact. Finally, an exploratory study will be conducted to determine how system performance varies according to different operating parameters.**Literature review**

[5] Conducted a comprehensive survey of the irregularities of thermodynamics and the basis of external energy analysis in the presence of the combustion process of gaseous, liquid, and solid fuels. The primary cause of reversibility under all combustion conditions, including internal thermal energy exchange, is related to the high-temperature gradient due to the release of heat in the combustion reaction. Thermal conduction irregularities can be lessened by controlling chemical reactions and physical processes appropriate to high flame temperatures. On the other hand, the low-temperature gradient value in the system is very important to ensure energy destruction in the combustion process within acceptable limits.

[6] A comparative study of energy and energy-based energy for both coal and nuclear power plants, where losses show common features. [7] Comparison of reductions in non-reflective losses with the implementation of backlash water heaters of the cascade type and/or reheating option with the conventional energy balance approach. The results indicated that the majority of irreparable losses occur in the boiler and the losses could be reduced by incorporating heating of the feed water. The incorporation results showed a promising 18% reduction in total irreversibility and a 12% improvement in inefficiency.

120 power analysis cases were studied and its efficiency was based on different system parameters, especially boiler temperature, pressure, mass fraction ratio, and work performance. High compatibility is achieved by the basic value of energy and energy efficiency compared with the actual data. The findings indicate that the study of electrical energy will help to make decisions about the rational aspects [8].

[9] A lesson in the active analysis of a 210 MW coal-fired power plant operating in India. He notes that the main reason for non-return in the power cycle is the boiler, which causes energy destruction to 60% of its power. Running the power plant at the partial load will increase irreversibility and the effect will become more pronounced as the load is reduced. Increasing the capacitor backpressure reduces energy efficiency. [10] It is studied on capital costs and thermodynamic loss devices that help generate time such as coal, oil, and nuclear power plants. A correlation between both criteria is indicated to achieve optimal design by accurately balancing the exergy-based and economic characteristics of the overall station and its devices. The results can help in clarifying understandings of the relation between thermodynamics and economics in stations. Besides, it can in the illustration of second law analysis standards and finally extended throughout the electrical utility sector. The exergy analysis was established by applying the actual measurement parameters of a 600MW direct dry power plant in China to develop the thermodynamic analysis model. It was found that more than 70% of the energy loss in the system was usually in the boiler while more than 50% of the energy loss was in the combustion. Accordingly, it is necessary to try to reduce this large amount of boiler wastage to mainly improve the energy-saving capabilities of heat transfer and combustion [11]. It is discussed about the environmental issues that are primarily causing or related to energy production, conversion, and ultimate use. From this perspective, energy and environmental research is mostly focused on enhancing energy efficiency along with the ability to reduce impacts on the environment by minimizing energy losses [12]. It has also shown excessive energy use and utilization to increase efficiency. The sustainability findings suggested that exergy is also

necessary to be applied by researchers and engineers, along with policy and decision-makers who share green energy and technologies alongside other goals and limitations [13].

3-Exergy formulation of power plant The process flow diagram for the power plant is shown in Fig. 1, 2, 3, and 4. The process parameters for the power plant are shown in Tables 1and 2. The following thermodynamic analysis of the power plant will consider the balances of mass, energy, entropy, and exergy. Unless otherwise specified, the changes in kinetic and potential energies will be neglected, and steady-state flow will be assumed. The process parameters and data are based on actual plant design data for [70, 90, 95,100 MW]. For static operations, the mass balance of the volume control system can be written as:

$$\sum_i \dot{m}_i = \sum_0 \dot{m}_i \qquad 1$$

The energy balance for a control volume system is written as

$$\sum_i \dot{m}_i + \dot{Q} = \sum_0 \dot{m}_0 + \dot{w} \qquad 2$$

The entropy balance for a control volume system is

$$\sum_i \dot{S} + \sum_i \frac{\dot{Q}}{T} + \dot{S}_{gen} = \sum_0 \dot{S} + \sum_0 \frac{\dot{Q}}{T} \qquad 3$$

The exergy balance for a control volume system is written as

$$\sum_i \dot{Ex}_i + \sum_k \left(1-\frac{T}{T_K}\right)\dot{Q}_k = \sum_0 \dot{Ex}_0 + \dot{W} + \dot{Ex}_d \qquad 4$$

where the exergy rate of a stream is

$$E_x = \dot{m}(e_x) \quad \ldots\ldots \qquad 5$$

$$\dot{m}(e_x) = \dot{m}(e_x^{tm} + e_x^{ch}) \qquad 6$$

The above exergy balance is written in a general form. For the combustion process, the heat input will be included when calculating the chemical exergy of coal. The heat exergy term in Eq. (4) will be used to calculate the exergy loss associated with heat loss to the surroundings. The specific exergy is given by:

$$e_x^{tm} = (h - h_0) - T_0(s - s_0) \qquad 7$$

The exergy balance equation for the reaction is [14],

$$\sum N_p(\bar{h}_{f0} - \bar{h}_0 - T_0\dot{s})_p = \sum N_r(\bar{h}_{f0} - \bar{h}_0 - T_0\dot{s})_r \qquad 8$$

The exergy content of coal for the mass of carbon in coal is written as

$$E_{x,coal} = (E_{x,reaction} \times n_c \times m_f) / M_c \qquad 9$$

Then, the energy and exergy efficiencies of the power plant are written as

$$\eta_{energy} = \frac{W_{output}}{m_f \times cv} \qquad 10$$

$$\eta_{energy} = \frac{W_{output}}{E_{x,coal}} \qquad 11$$

In the next section, the predicted results and sensitivity studies based on this exergy formulation will be presented.

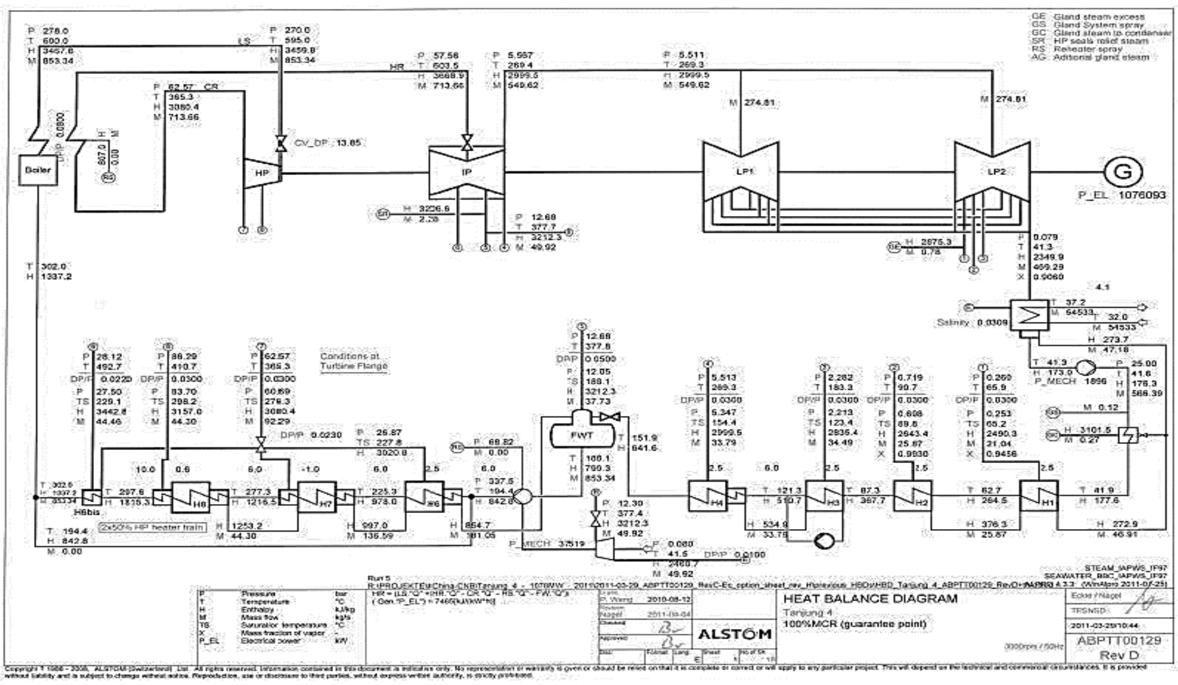
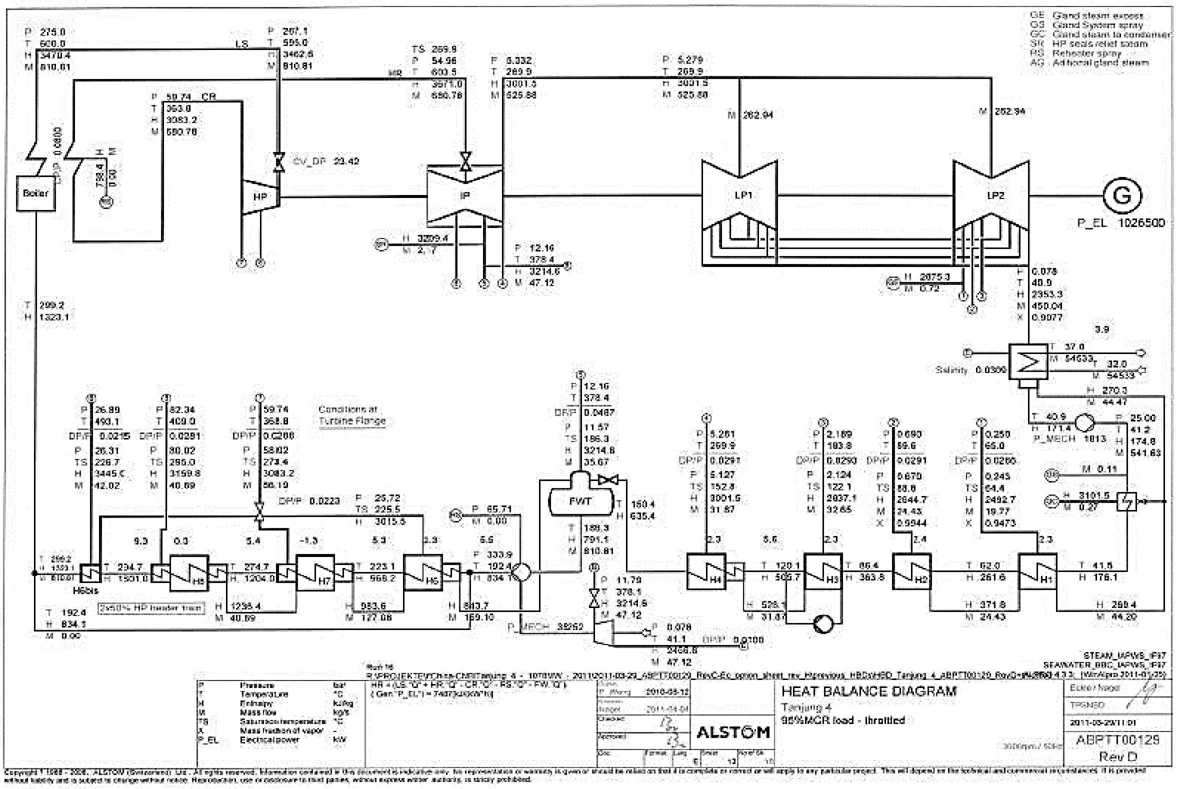


Fig-1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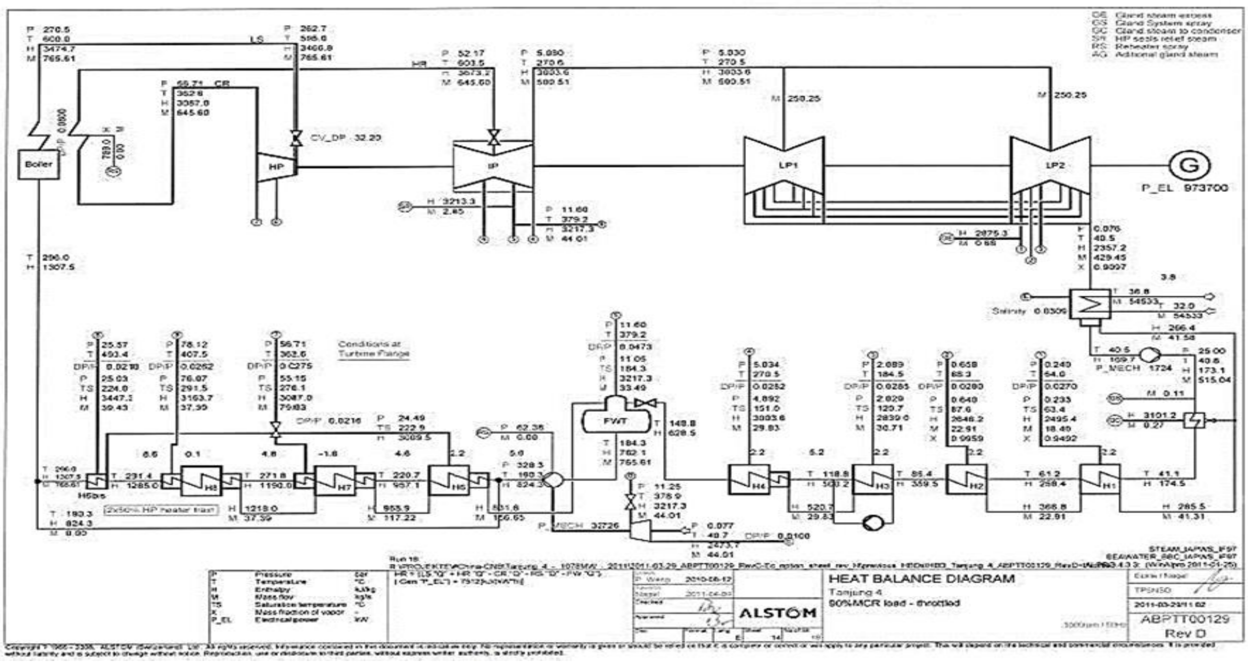
IP
LP1
LP2
G
P_EL 1026500
FWT
Conditions at Turbine Flange
HEAT BALANCE DIAGRAM
Tanjung 4
95%MCR load - throttled
ALSTOM
ABPTT00129
Rev D

Fig. 2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HEAT BALANCE DIAGRAM
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90%MCR load - throttled
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Fig. 3

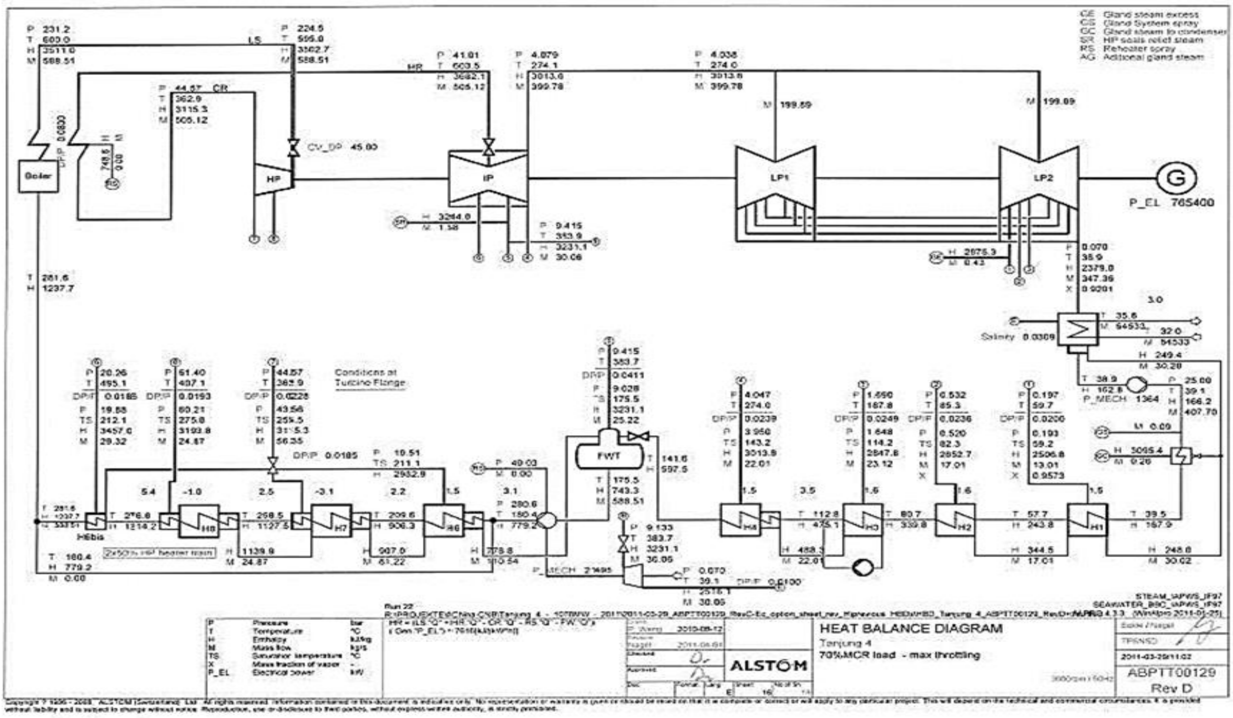


Fig. 1The process parameters for the power plant

4. Results and discussion

Power plant fuel is provided by coal as a fuel for the combustion process Figures 1, 2, 3, and 4 show that the reference temperature has no effect on energy efficiency but affects external energy efficiency. It is taken into account that the reference environment is pressure and temperature are 101.3 kPa and 298.15 K, respectively. Power plants operate at different loads (100%, 95%, 90%, 70%) with temperature, pressure, enthalpy, and entropy as parameters. The thermodynamic properties of power plants are calculated for different operating loads and are summarized in Tables 1 and 2 respectively.

Table 1

Process parameters for 100% and 95% load

NO	**100% load**				**95% load**			
	Temperature Ti (°C)	Pressure Pi (par)	Enthalpy (KJ/Kg)	Entropy (KJ/kg- k)	Temperature Ti (°C)	Pressure Pi (par)	Enthalpy (KJ/Kg)	Entropy (KJ/kg- k)
1	600	278	3467.5	6.2912	600	275	3470.3	6.2987
2	595	270	3459.7	6.2939	595	267.1	3462.4	6.3014
3	365.3	62.57	3080.5	6.3766	363.8	59.74	3083.1	6.3996
4	603.5	57.56	3668.9	7.1995	603.5	54.96	3671	7.2227
5	269.4	5.567	2999.5	7.296	269.9	5.332	3001.3	7.3188
6	269.3	5.511	2999.5	7.3005	269.9	5.279	3001.5	7.3236
7	41.3	0.079123	2350	7.5129	41.029	0.078	2353.5	7.5301
8	41.27	0.079	172.84	0.58932	40.9	0.078	171.3	0.5844
9	41.6	25	176.42	0.5927	41.2	25	174.75	0.5874
10	41.9	25	177.67	0.59668	41.5	25	176	0.59138
11	62.7	25	264.55	0.86372	62	25	261.62	0.85499
12	87.3	25	367.58	1.1598	86.4	25	363.81	1.1493
13	121.3	25	515	1.5398	120.1	25	510	1.5269
14	151.9	25	641.61	1.8588	150.4	25	635.15	1.8436

15	151.9	25	641.61	1.8588	150.4	25	635.15	1.8436
16	188.1	12.05	798.97	2.2173	186.3	11.57	790.96	2.2
17	194.4	337.5	842.6	2.2321	192.4	333.9	833.77	2.2141
18	225.3	337.5	977.91	2.5123	223.1	333.9	968.01	2.4933
19	277.3	337.5	1216.6	2.9675	274.7	333.9	1204.2	2.9458
20	297.6	337.5	1315.5	3.1439	294.7	333.9	1301.2	3.1196
21	302	337.5	1337.5	3.1824	299.2	333.9	1323.6	3.1589
22	302	337.5	1337.5	3.1824	299.2	333.9	1323.6	3.1589
23	365.3	62.57	3080.5	6.3766	363.8	59.74	3083.1	6.3996
24	410.7	86.29	3157	6.361	409	82.34	3159.9	6.3843
25	492.7	28.12	3443	7.2465	493.1	26.89	3445.3	7.2697
26	377.8	12.86	3212.2	7.2737	378.4	12.16	3214.7	7.303
27	269.3	5.513	2999.5	7.3003	269.9	5.281	3001.5	7.3234
28	65.9	0.26067	2491.6	7.4398	64.053	0.24	2492.1	7.4773
29	90.7	0.72068	2644.7	7.4253	88.783	0.67	2644.7	7.4584
30	183.3	2.282	2835.5	7.3721	183.8	2.189	2837	7.3944
31	65.187	0.26	272.9	0.89597	64.329	0.243	269.4	0.88561
32	37.2	0.079	155.83	0.53486	37	0.078	154.99	0.53217
33	32	0.079	134.1	0.46424	32	0.078	134.1	0.46424
34	89.824	0.698	376.3	1.1908	88.755	0.67	371.8	1.1784
35	127.26	5.347	534.9	1.6054	125.67	5.127	528.1	1.5884
36	200.44	26.87	854.7	2.3329	197.99	26.31	843.7	2.3097
37	227.8	26.87	3020.8	2.5898	225.5	25.72	3015.5	6.2452
38	231.32	60.69	997	2.6158	228.46	58.02	983.6	2.5898
39	283.3	83.7	1253.2	3.0932	280.07	80.02	1236.4	3.0638
40	377.4	12.3	3212.3	7.2941	378.1	11.79	3214.7	7.317
41	41.5	0.01	2578.5	9.193	41.029	0.078	2466.6	7.8901
42	124.43	2.282	522.65	1.5755	122.12	2.124	512.83	0.5508
43	121.3	25	510.94	1.5398	120	25	505.43	1.5258
44	123.44	2.213	518.43	1.5649	122.12	2.124	512.83	1.5508

Table 2
Process parameters for 90% and 70% load

NO	90% load				70% load			
	Temperature Ti (°C)	Pressure Pi (par)	Enthalpy (KJ/Kg)	Entropy (KJ/kg- k)	Temperature Ti (°C)	Pressure Pi (par)	Enthalpy (KJ/Kg)	Entropy (KJ/kg- k)
1	600	270.5	3474.5	6.3101	600.00	231.2	3510.8	6.4153
2	595	262.7	3466.6	6.3128	595	224.5	3502.5	6.4178
3	362.6	56.71	3086.9	6.4272	362.9	44.57	3115.3	6.5731
4	603.5	52.17	3673.2	7.2487	603.5	41.01	3682.1	7.3675
5	270.6	5.08	3003.5	7.3449	274.1	4.079	3013.7	7.4635
6	270.5	5.03	3003.5	7.3493	274	4.038	3013.6	7.4679
7	40.539	0.076	2357.3	7.5532	38.9	0.069627	2379.1	7.6596

8	40.5	0.076	169.62	0.57907	38.9	0.07	162.94	0.55769
9	40.8	25	173.08	0.58208	39.1	25.00	165.98	0.55942
10	41.1	25	174.33	0.58607	39.5	25.00	167.65	0.56476
11	61.2	25	258.28	0.845	57.7	25.00	243.65	0.80102
12	85.4	25	359.5	1.1376	80.7	25.00	339.9	1.0823
13	118.8	25	506.35	1.5129	112.8	25.00	480.267	1.4476
14	148.8	25	628.27	1.8273	141.6	25.00	597.39	1.7535
15	148.8	25	628.27	1.8273	141.6	25.00	597.39	1.7535
16	184.3	11.6	782.11	2.1807	175.5	9.415	743.24	2.0955
17	190.3	328.3	824.41	2.1953	180.4	280.6	779.18	2.1082
18	220.7	328.3	957.15	2.4726	209.6	280.6	906.15	2.3794
19	271.8	328.3	1190.4	2.9218	258.5	280.6	1127.5	2.8159
20	291.4	328.3	1285	3.0923	276.8	280.6	1214.5	2.9768
21	296	328.3	1307.8	3.1325	281.6	280.6	1237.8	3.019
22	296	328.3	1307.8	3.1325	281.6	280.6	1237.8	3.019
23	362.6	56.71	3086.9	6.4272	362.9	44.57	3115.3	6.5731
24	407.5	78.12	3163.8	6.4117	407.1	61.4	3193.8	6.5565
25	493.4	25.57	3447.4	7.2953	495.1	20.26	3457.1	7.4135
26	379.2	11.6	3217.4	7.3285	383.7	9.415	3230.8	7.4437
27	270.5	5.034	3003.4	7.3489	274	4.047	3013.6	7.4669
28	64.053	0.24	2496.6	7.4906	59.7	0.19671	2507.6	7.6104
29	88.312	0.658	2647.4	7.474	85.3	0.532	2652.7	7.5856
30	184.5	2.089	2839	7.42	187.8	1.69	2847.8	7.5359
31	63.397	0.233	265.5	0.87405	59.24	0.193	247.83	0.82174
32	32	1.01	134.18	0.46421	35.8	0.07	149.98	0.51597
33	36.8	1.01	154.24	0.52944	32	0.07	134.1	0.46424
34	87.566	0.64	366.8	1.1646	82.259	0.52	344.5	1.1023
35	123.93	4.892	520.7	1.5699	116.31	4.047	488.3	1.4877
36	195.3	24.49	831.6	2.2844	180.31	280.6	778.8	2.1073
37	222.9	24.49	2801.8	6.2639	281.6	19.51	2982.6	6.7054
38	225.3	55.15	968.9	2.5611	211.87	44.57	907	2.4377
39	276.51	76.07	1218	3.0314	261.04	61.4	1139.9	2.8907
40	378.9	11.25	3217.4	7.3423	383.7	9.133	3231.3	7.4583
41	40.786	0.077	2473.7	7.9184	39.1	0.07	2516.1	8.2751
42	121.59	2.089	510.58	1.5451	114.97	1.69	482.45	1.4733
43	118.8	25	500	1.5129	112.8	25	475.1	1.44
44	123.25	2.2	517.63	1.5628	112.8	25	475.1	1.44

Table 3 shows the exergy of the working fluid at 100%, 95%, 90%, and 70% load. They contain the value of mass flow rate and exergy of the steam flow at the various points of the thermodynamic model of the plant. The predicted results and sensitivity studies were obtained based on this exergy formulation

Table 3
Exergy of the working fluid at various state points

NO	100% load		95% load		90% load		70% load	
	Exergy (Kj/kg)	Mass flow ratemi (kg/s)	Exergy (Kj/kg)	Mass flow ratemi (kg/s)	Exergy (Kj/kg)	Mass flow ratemi (kg/s)	Exergy (Kj/kg)	Mass flow ratemi (kg/s)
1	1755	853.34	1755.6	810.81	1756.4	765.61	1761.3	588.51
2	1746.4	853.34	1746.9	810.81	1747.7	765.61	1752.3	588.51
3	1342.6	713.66	1338.3	608.78	1333.9	645.6	1318.8	505.12
4	1685.6	713.66	1680.8	680	1675.3	645.6	1648.7	505.12
5	987.51	549.62	982.46	525.88	976.9	500.51	951.73	399.78
6	986.12	549.62	981.18	525.88	975.54	500.51	950.32	399.78
7	273.25	469.29	271.65	450.04	268.61	429.45	258.63	347.36
8	160.4	469.29	160.32	541.63	160.23	515.04	159.92	407.7
9	162.96	566.39	162.88	541.63	162.79	515.04	162.45	407.7
10	163.03	566.39	162.94	541.63	162.85	515.04	162.53	407.7
11	170.29	566.39	169.97	541.63	169.6	515.04	168.08	407.7
12	185.05	566.39	184.4	541.63	183.69	515.04	180.48	407.7
13	215.1	634.56	213.87	606.15	212.54	575.47	206.62	452.83
14	250.66	634.56	248.74	606.04	246.71	575.47	237.84	452.83
15	250.66	634.56	248.74	606.04	246.71	575.47	237.84	452.83
16	301.14	853.34	298.28	810.81	295.19	765.61	281.74	588.51
17	340.35	853.34	336.91	810.81	333.15	765.61	313.89	588.51
18	392.12	853.34	387.9	810.81	383.2	765.61	359.98	588.51
19	495.07	853.34	489.16	810.81	482.52	765.61	451.16	588.51
20	541.37	853.34	534.31	810.81	526.27	765.61	490.2	588.51
21	551.94	853.34	545	810.81	537.07	765.61	500.94	588.51
22	551.94	853.34	545	810.81	537.07	765.61	500.94	588.51
23	1342.6	92.29	1338.3	86.19	1333.9	79.83	1318.8	56.35
24	1423.8	44.3	1419.7	40.89	1415.4	37.39	1402.3	24.87
25	1445.7	44.46	1441	42.02	1435.6	39.43	1410.1	29.32
26	1206.8	37.73	1200.6	35.67	1195.7	33.49	1174.7	25.22
27	986.17	33.79	981.23	31.87	975.64	29.83	950.61	22.01
28	436.67	21.04	426.04	19.77	426.56	18.4	401.82	13.01
29	594.12	25.87	584.27	24.43	582.29	22.91	554.3	17.01
30	800.75	34.49	795.64	32.65	789.97	30.71	764.21	23.12
31	169.03	46.91	168.61	44.2	168.16	41.31	166.24	30.02
32	159.62	54533	159.59	54533	159.04	54533	159.4	54533
33	158.94	54533	158.94	54533	159.65	54533	158.94	54533
34	184.51	25.87	183.71	24.43	182.84	22.91	181.55	17.01
35	219.52	33.79	217.78	31.87	215.9	29.83	208	22.01
36	322.41	181.05	318.31	169.1	313.75	156.65	313.76	110.54
37	370.98	44.46	1103.6	42.02	1097.5	39.43	1146.6	29.32
38	380.37	136.59	374.72	127.03	368.58	117.22	343.45	81.22
39	494.23	44.3	486.2	40.89	477.46	37.39	441.28	24.87
40	1200.9	49.92	1196.4	74.12	1191.5	44.01	1170.8	30.06
41	0.82543	49.92	277.42	74.12	276.09	44.01	267.96	30.06
42	216.18	68.28	213.73	64.52	213.18	60.54	206.44	45.13
43	215.1	566.39	213.77	541.63	212.54	515	204.81	407.7
44	215.12	68.28	213.77	64.52	214.92	60.54	204.81	45

Fig. 5 shows the exergy and energy efficiency for all loads. The exergy efficiency shows a higher percentage compared with energy efficiency. Therefore, the efficiency of exergy and energy for four loads show that 70% gave lower efficiency in contrast to 100% that gave higher efficiency.

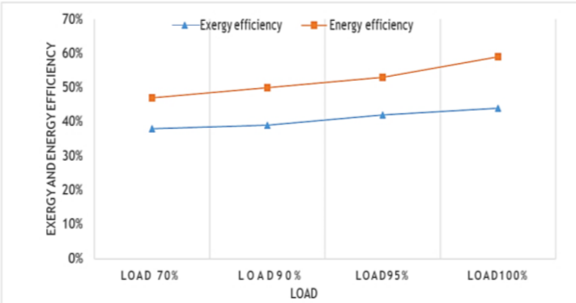


Fig. 2. Energy and exergy efficiencies vs. generator output (load)

From Fig 5 it is obvious that the efficiency and the performance of the power plant—by taking into consideration both exergy and energy increase with higher generator output. This indicates that the operating of the power plant in the maximum capacity is more economical compared with other operating loads.

Fig. 6 shows the exergy destructions of steam consumed for the devices in the integrated system. It was obvious that the energy consumed by a boiler is very high in all four loads. On the contrary, the condenser shows a very low value of exergy destruction. It explains the importance of exergy for the analysis of components.

Table 4
Comparisons of energy and exergy efficiencies with loads

LOAD	Exergy efficiency	Energy efficiency
LOAD 70%	38%	47%
LOAD 90%	39%	50%
LOAD95%	42%	53%
LOAD100%	44%	59%

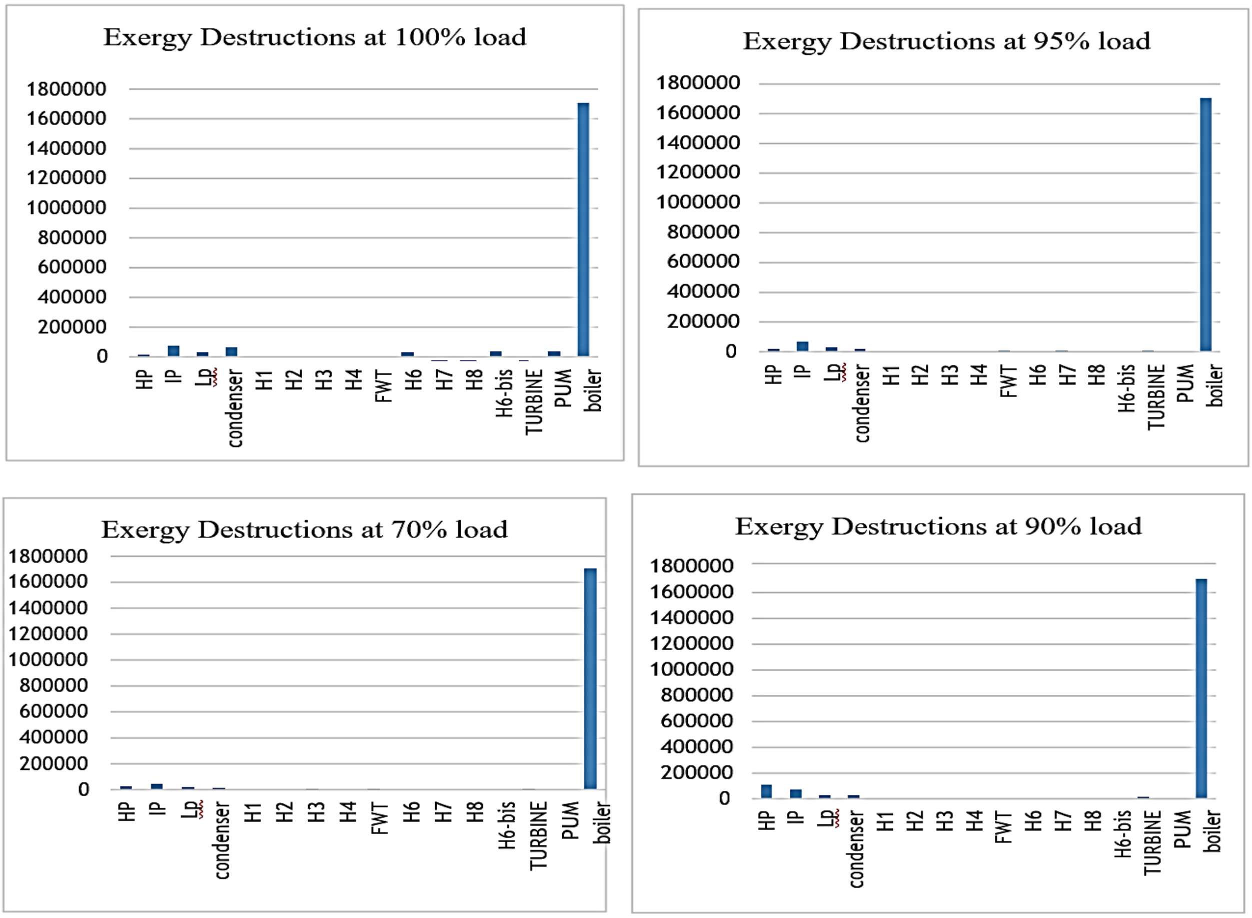
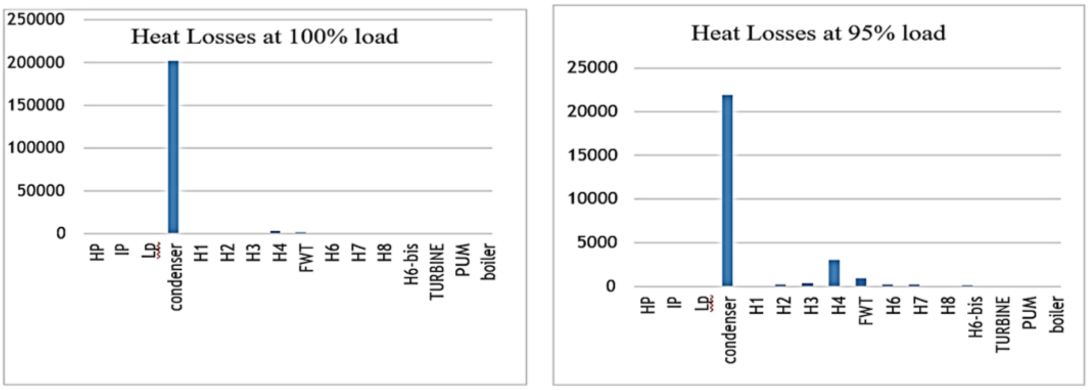


Fig. 3. Comparison of exergy destructions (kW) of various components

Fig. 7 shows the comparison of heat losses between different components of the power plant. It is obvious from the figure there is a great difference in the value of heat loss between the condenser and other components in the plant. The load of 95% and 70% gave a lower value of heat loss while 100% and 90% loads show a higher value of heat loss.



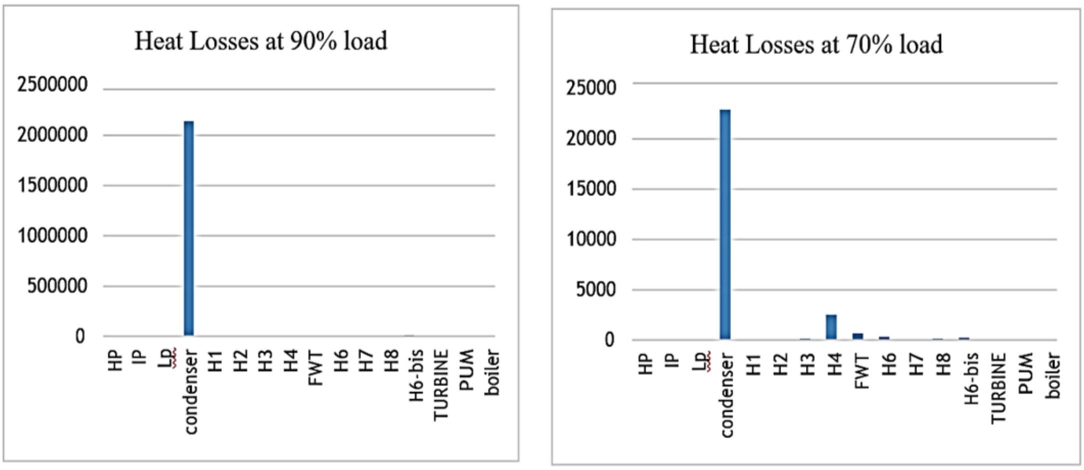


Fig. 4. Comparison of heat losses (kW) in major components of the power plant

Fig. 8 shows the comparison of exergy losses in all components of the four loads. It was observed that the maximum exergy loss occurred in the condenser component in 100% and 90% loads but it shows a lower value of exergy load in 95% and 70%

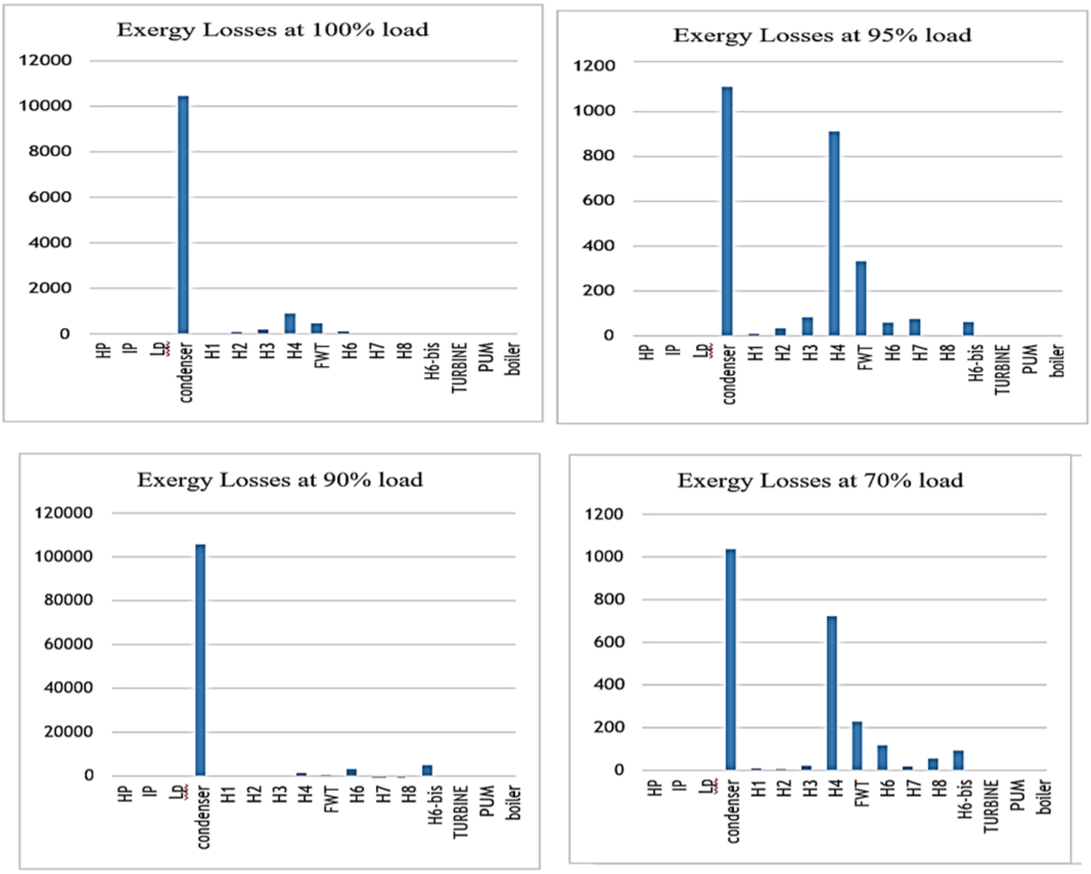


Fig. 5. Comparison of exergy losses (kW) in major components of the power plant

It is clear from Fig. 9 that at design load, the boiler gave lower efficiency than other components for all four loads. The boiler efficiency which was 28.7% gave similar values in all four loads. In contrast, the condenser gave higher efficiency in all four loads.

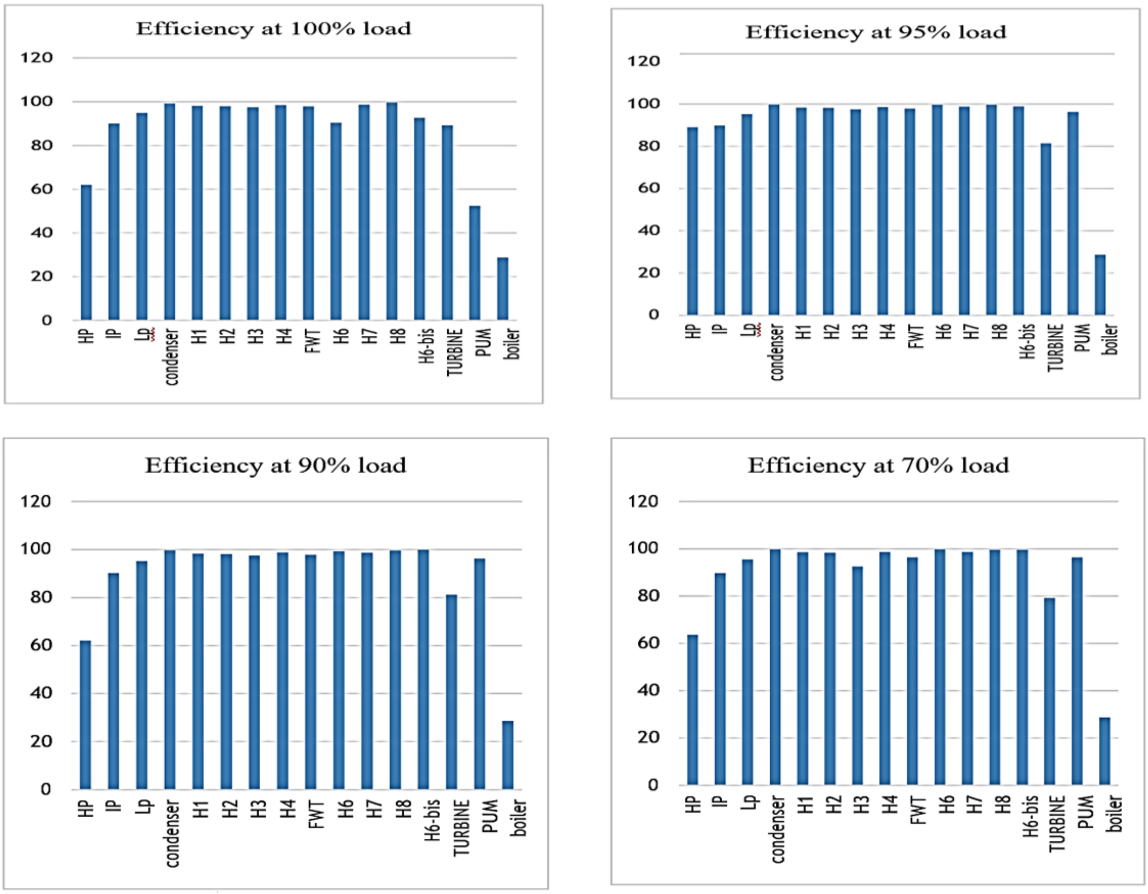


Fig. 6 Comparison of efficiency in major components of the power plant

Minimizing the irreversible exergy losses of the system can reduce the environmental impact. Table 5 shows the exergy destruction in all components of the four loads. Fig. 10 demonstrates the similarity in exergy destruction in all components for the four loads

. Table 5
Component exergy destructions

Component	Exergy Destructions 90%	Exergy Destructions 100%	Exergy Destructions 70%	Exergy Destructions 95%
HP	21044.437	15413.843	23225.258	107204.121
IP1	67990.5862	77077.8135	45497.3495	71218.7829
LP2	27704.7557	31306.8378	19498.7636	29662.7135
Condenser	20551.31144	65299.60261	13634.78455	26877.13672
H1	1598.901202	1901.707045	1056.454881	1642.445041
H2	1874.314118	2178.048103	1281.55321	1938.610559
H3	3072.52344	3507.105413	6382.02024	3300.470389
H4	1840.973773	2450.882945	1484.705638	2310.398789
FWT	4894.94832	5533.757726	5974.635438	5217.366641
H6	2143.48671	34213.05165	411.2715453	1253.875171
H7	5175.507991	6018.742478	3749.695525	5599.656793
H8	1247.3831	1727.295	1045.014	1559.3985
H6bis	173.2810647	38763.75489	1312.661067	5572.281045
Turbine	7556.9571	3821.6715	5640.4584	12665.6256
PUM	3100.5408	35835.2386	2270.889	3255.1963
Boiler	2068768.243	2270653.85	1706170.535	2782097.52

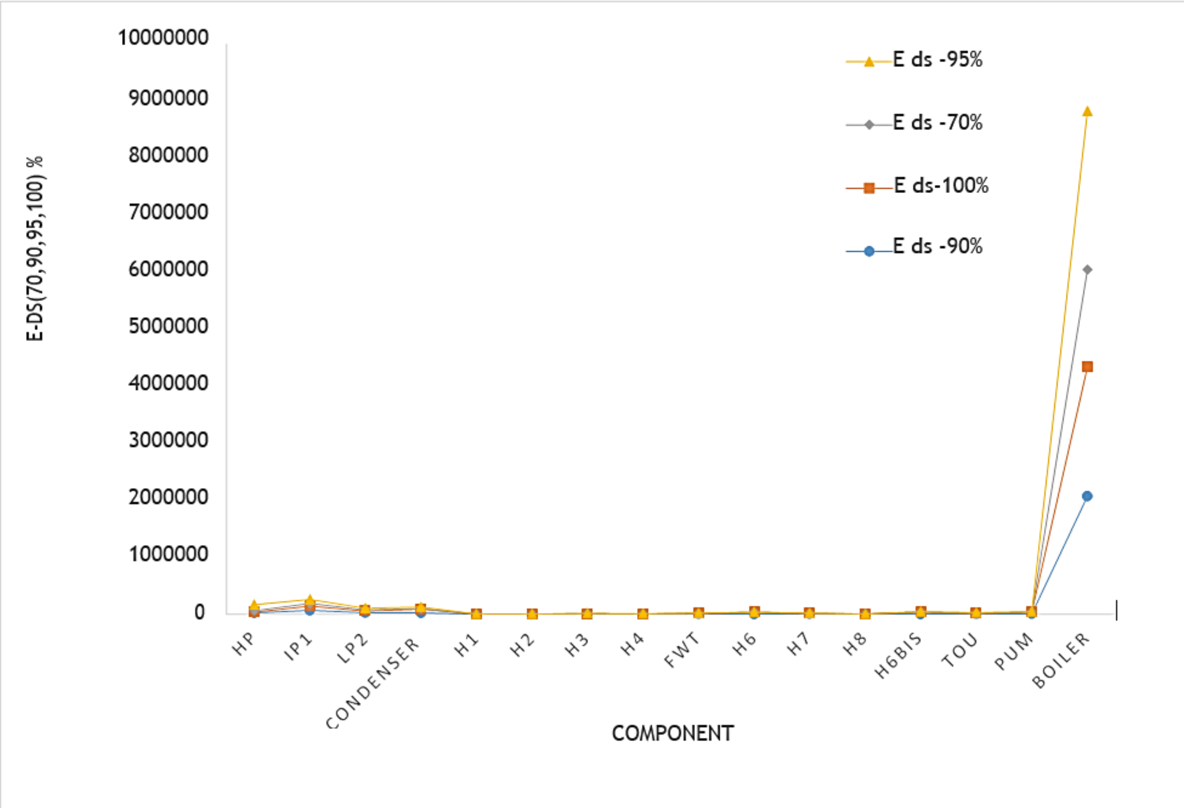


Fig. 7. Component exergy destructions

5 Improvement potentials

Kelly [15] carried out the manners of enhancing the exergy of a coal-fired thermal power plant system. Moreover, by affirming the irreversibility (exergy destruction) inside the component of energy conversions linked to a component has the ability to be defined into two parts. Both the first and second parts rely on the inefficiencies but the first is for the specific component only unlike the second part which depends on the rest of the components of the overall system and the structure of the system. Accordingly, the exergy destruction taking place within a component is eligible to be rifted into two categories: a) endogenous exergy destruction exclusively, as a result, the component performance being added to considerations; b) exogenous exergy generated through inefficiencies within the overall system remaining components. The research demonstrated four different methods. The calculations of exergy destruction of endogenous parts by [16] along with the technique are following the structural hypothesis presenting the positive and negative consequences and limitations linked beside the way that has been shown. Kotas [17] clarified the concept of mismatching heat capacities of heat transfer media, taking into accounts the heat transfer occurred in a parallel flow mode when the heat capacities of the streams are mismatched in a counter flow heat exchanger. Although heat exchanger temperature difference is insignificant, a noticeable amount of irreversibility rate will remain

Conclusion

Performance analysis recommends that to achieve optimum efficiencies for maximum energetic or energetic efficiency of the overall plant, the plant ought to operate at designed or full load. The plant load and efficiency are indirect proportional relation so when the load decreases, the efficiency will consequently decrease. On the contrary, the condenser is the only plant component exception as its load decreases will result in the energy or exergy leap. The justification is that with the increase of design load, exergy destruction or energy of the rest of the components increases, that energy will be released to the environment via condenser furthermore the condenser effectiveness and size is similar as operating in full load. Thus, exergy efficiency will increase at off-design load highest quantity of exergy destruction in the boiler component so that high attention required to be drawn towards boiler in terms of design or technical change. Besides that, boiler is considered as the significant root cause of irreversibility in a power plant. Around 68% of the exergy supplied is lost in the steam generator itself, so more efforts should be made in this path in order to achieve the best results. The plant should always operate on its maximum loads or maximum available load in order to accomplish the optimal exergetic or energetic efficiency and to decrease exergy destruction or energy loss.

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