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Calculation of Exergy Destruction of Various Components by Performing Exergy Analysis on Stage-I of Dr. Narla Tatarao Thermal Power Station (N.T.T.P.S)

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Abstract*: For any nation to develop power generation plays a crucial role. The performance of a power plant is analyzed by using the Energy balance and it is done by using the first law of thermodynamics. But to know how much energy is being utilized in reality exergy analysis has to be performed which is also called as second law of thermodynamic analysis because the vital parameter quality is being considered in the exergy analysis. this paper deals with the exergy destruction calculation by performing exergy analysis for various components for a 210 mw plant of Vijayawada thermal power station(stage-1 unit-1) and from the analysis it is clear that exergy destruction is more in condenser

***Keywords*: Available Energy, Exergetic destruction, second law efficiency.**

I. INTRODUCTION

With the increase in the global warming along with food clothing and shelter one particular parameter playing an important role along with these basic needs that is POWER and it so essential which the life style is not at all an issue. Our country depends on both renewable and non renewable sources but the major part is occupied by conventional source that is coal.. It is used in a thermal power plant which drives the prime mover. From the facts and figures around 58.75% to 60% the power generation is from coal. Around 8.91% is from natural gas where as oil and nuclear contribute to 0.52% and 2.11%. 66.8% is from coal and petroleum. The percentage of crude oil expected around 7% and 22% by 2021-22. [1]

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To measure the life style of the people we have so many indicators to measure among them the power consumption is one which shows the living standards of the people. This particular papers deals with the evaluation of exergy destruction and calculation of second law efficiency.

Why because in general the power plant efficiency is valuated with the help of energy analysis which is on 1st law of T.D which in general will not consider the quality of the energy there by will not be getting the correct analysis of the performance which is simply a energy balance.

Here we will be calculating the exergy destruction on 2nd law of thermodynamics, which considers the energy quality. The 1st and 2nd analysis will provide a complete picture to improve the plant efficiency

II. INDIVIDUAL COMPONENTS

A. Boiler: used to convert water into steam

B. Super-heater: to ensure that only dry steam is entering into the turbine.

C. Re-heater: to make sure that dry steam is entering into intermediate pressure turbine after the expansion in the high pressure turbine

D. : the purpose is to heat the water coming from condenser in advance before reaching the boiler by which fuel supply rate can be decreased [2]

E. Turbines: In thermal power plants, the turbine takes the steam as input and gives power as output.

F. Deaerator: Is to remove any air and dissolved gases.

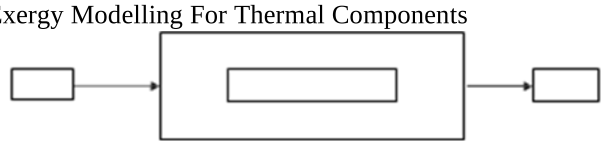
G. Condenser: This converts water into steam

H. Feed water Heater:

Like economizer feed water heaters are used to heat the water coming from the condenser by tapping the turbines.

III. MODELLING OF EXERGY

Exergy Modelling For Thermal Components



Specific Exergy for any component is given by

$$\varphi = (h - h_0) - T_0(s - s_0)\text{----}\rightarrow 1$$

Where h_o, s_o, T_o indicates reference states

Overall Exergy:

$$\dot{X} = \dot{m}[(h - h_0) - T_0(s - s_0)] \text{---}\rightarrow 2$$

$\dot{m}$ implies flow rate .

Inlet exergy =

$$Exin = \dot{m}[h_1 - h_0 - T_0(S_1 - S_0)] \text{---}\rightarrow 3$$

Outlet Exergy=

$$Exout = \dot{m}[h_2 - h_0 - T_0(S_2 - S_0)] \text{---}\rightarrow 4$$

Destruction of Exergy (I) =

$$I = Ex_{in} - Ex_{out} - W \text{-----------------}\rightarrow 5$$

%Destruction of Exergy = (Destruction in Exergy/Overall Destruction in energy of the cycle) *100---→6

2nd law efficiency is

1. Original W.D to Ideal work [3]

$$\eta_{II} = \frac{\textit{Actual work done}}{\textit{Maximum theoritical work}} \text{-------}\rightarrow 7$$

In other terms

2. Original thermal efficiency to the maximum possible thermal efficiency [4]

$$\eta_{II} = \frac{\textit{Exergy output}}{\textit{Exergy input}} \text{-------}\rightarrow 8$$

IV. TURBINE LAYOUT

The turbine house and remaining components of Dr N.T.T.P.S are shown in the below figure 2. Along with the figure the operating parameters are also shown by using the above mentioned equations. Thus the obtained results are tabulated in Table 1, 2 and 3

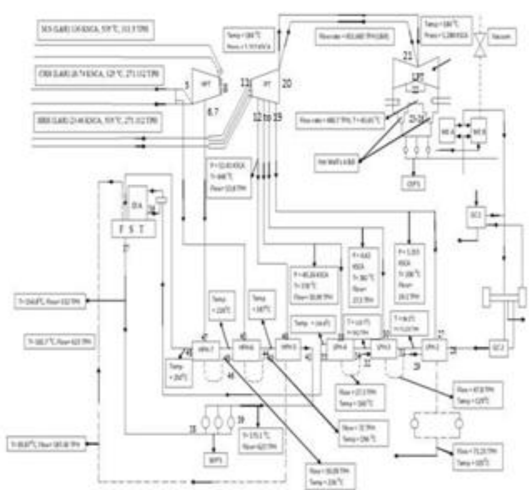


Table-I Showing Exergy, Percentage Of Exergy Destruction And Second Law Efficiency

Loading		@ 95% loading		
Components		Exergy destruction(MW)	Percentage exergy destruction (%)	2nd Law efficiency (%)
High Pressure Turbine	S-1	61.59	24.11	89.03
	S-2	8.35	3.26	68.39
Intermediate Pressure Turbine	S-1	29.97	11.73	90.28
	S-2	24.396	9.55	84.07
	S-3	33.049	12.94	98.99
	S-4	12.518	4.90	93.76
	S-5	4.954	1.94	80.79
Low Pressure Turbine	S-1	50.99	19.96	62.14
Total		225.817		77
Condenser		19.22	7.52	21.45
Pumps		2.41	0.94	60.25
LP Heaters	LPH 2	2.77	1.08	63.69
	LPH 3	0.74	0.289	91.62
	LPH 4	1.26	0.493	91.78
HP Heaters	HPH 5	0.662	0.259	97.59
	HPH 6	0.06	0.02	99.84
	HPH 7	2.413	0.94	94.89
Total		7.905		
Power Cycle		255.352		

Table II Components And Second Law Efficiencies

COMPONENT		SECOND LAW EFFICIENCY (%)
Boiler		40.20 %
Condenser		21.45 %
Heaters	LPH 2	63.69 %
	LPH 3	86.56 %
	LPH 4	90.65%
	HPH 5	97.59%
	HPH 6	99.84 %
	HPH 7	94.89 %
Turbines	HPT	77.06 %
	IPT	89.05 %
	LPT	62.14 %

Table:III Showing Exergy Values For Various Components

Economizer inlet	1	247	145	173.05	1071.81	2.741	258.99	44.81
Economizer outlet	2	278	137	173.05	1205.16	3.026	306.84	53.09
S.H inlet	3	345	128	173.05	2930	5.9	1169.48	202.37
S.H Outlet	4	535	128	173.05	3430.12	6.561	1471.3	254.6
HPT inlet	5	535	128	173.05	3430.12	6.561	1471.3	254.6
Tapping	6	378	40	173.05	3113.23	6.6911	1115.38	193.01
Tapping	7	378	40	165	3113.23	6.6911	1115.38	184.03
HPT Outlet	8	330	26	165	3078.62	6.7444	1064.78	175.68
R.H Inlet	9	330	26	165	3078.62	6.7444	1064.78	175.67
R.H outlet	10	535	23	154.20	3539.87	7.459	1311.85	202.02
IPT Inlet	11	535	23	154.20	3539.87	7.459	1311.85	202.02
Tapping 1	12	448	12	154.20	3364.39	7.522	1117.23	172.05
tapping 1	13	448	12	150.36	3364.39	7.522	1117.23	167.986
Tapping 2	14	380	6.5	150.36	3227.98	7.6081	955.03	143.59
Tapping 2	15	380	6.5	143	3227.98	7.6081	955.03	136.56
Tapping 3	16	265	2.8	143	2999.18	7.616	723.86	103.511
Tapping 3	17	265	2.8	137.5	2999.18	7.616	723.86	99.530
Tapping 4	18	200	1.5	137.5	2872.9	7.644	589.18	81.012
Tapping 4	19	200	1.5	130.80	2872.9	7.644	589.18	77.064
IPT outlet	20	184	1.3	130.80	2842.3	7.668	551.31	72.11
LPT inlet	21	184	1.3	130.80	2842.3	7.668	551.31	72.11
LPT Outlet	22	50	0.1	130.80	2600	8.16	161.48	21.12
Condenser inlet1	23	50	0.1	130.80	2600	8.16	161.48	21.12
Condenser inlet 2	24	30	1.013	808	125.83	0.436	4.21	3.40
Condenser outlet 1	25	45	0.1	130.80	191.8	0.649	6.58	0.860
Condenser outlet 2	26	40	1.013	808	167.62	0.572	5.5	4.44
DEAERATOR INLET	27	154.5	8.5	147.7	651.9	1.887	95.28	14.07
DEAERATOR OUTLET	28	165	7.16	173.05	697.35	1.992	109.23	18.90
BFP INLET	29	165	7.16	173.05	697.35	1.992	109.23	18.90
BFP OUTLET	30	165	155	173.05	705.889	1.974	123.169	21.31

Table:IV Showing Exergy Values For Low Pressure Heaters

COMPONENTS	T (ºC)	P (bar)	$\dot{m}$ (kg/s)	H (kJ/kg)	Entropy (kJ/kgK)	Ψ (kJ/kg)	$\dot{X}$ (MW)
LPH 2 inlet 1(S)	200	1.5	6.69	2872.9	7.644	589.18	3.94
LPH 2 inlet 2(W)	87	16.68	130.80	365.60	1.156	28.28	3.69
LPH 2 Outlet	99.3	13.7	130.80	417.10	1.298	37.18	4.86
LPH 3 inlet 1(S)	265	2.78	5.5	2999.18	7.616	723.86	3.98
LPH 3 inlet 2(W)	106	13.7	130.80	417.10	1.298	37.18	5.60
LPH 3 Outlet	120	12	147.7	504.48	1.526	50.10	8.29
LPH 4 inlet 1(S)	381.5	6.49	7.23	3227.98	7.6081	955.03	7.23
LPH 4 inlet 2(W)	120	12	147.7	504.48	1.526	50.10	8.29
LPH 4 Outlet	154.5	8.5	147.7	651.90	1.887	95.28	14.07

Table:V Showing Exergy Values For High Pressure Heaters

COMPONENTS	T (ºC)	P (bar)	$\dot{m}$ (kg/s)	H (kJ/kg)	Entropy (kJ/kgK)	Ψ (kJ/kg)	$\dot{X}$ (MW)
HPH 5 inlet 1(S)	448	12.17	3.83	3364.39	7.522	1117.27	4.282
HPH 5 inlet 2(W)	173.1	155	173.05	740.81	2.053	134.39	23.25
HPH 5 Outlet	187	150	173.05	804.03	2.194	155.31	26.87
HPH 6 inlet 1(S)	325	26.24	10.49	3066.75	6.7249	1058.76	11.1
HPH 6 inlet 2(W)	187	150	173.05	804.03	2.194	155.31	26.87
HPH 6 Outlet	226	147.2	173.05	974.63	2.55	219.11	37.91
HPH 7 inlet 1(S)	378	39.5	8.35	3113.23	6.6911	1115.38	9.313
HPH 7 inlet 2(W)	226	147.2	173.05	974.63	2.55	219.11	37.91
HPH 7 Outlet	247	145	173.05	1071.81	2.741	258.99	44.81

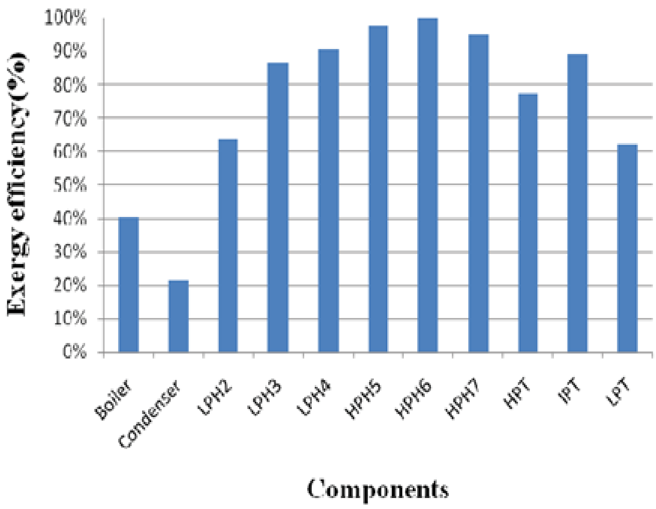
V. RESULT ANALYSIS AND DISUCSSIONS

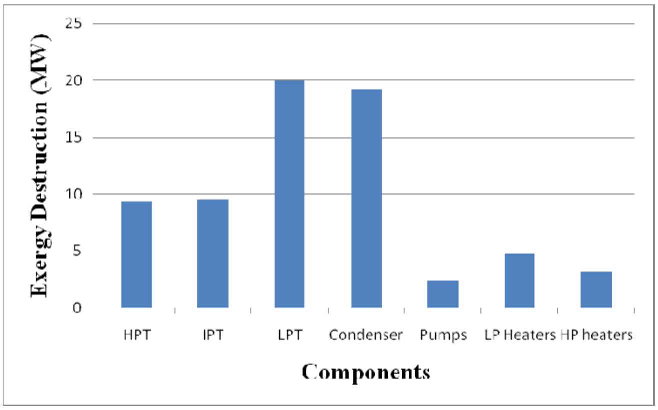
In this study the exergetic analysis of 210 MW plant of Dr N.T.T.P.S is performed. With the obtained values which are shown in the tables 3, 4and 5. The exergy destruction percentage, 2nd law efficiency and the destruction of exergy is calculated and are shown in the table 1 and 2. All the calculations are done at 95% condition and the graphs are plotted and are shown below and in tables 1 and 2

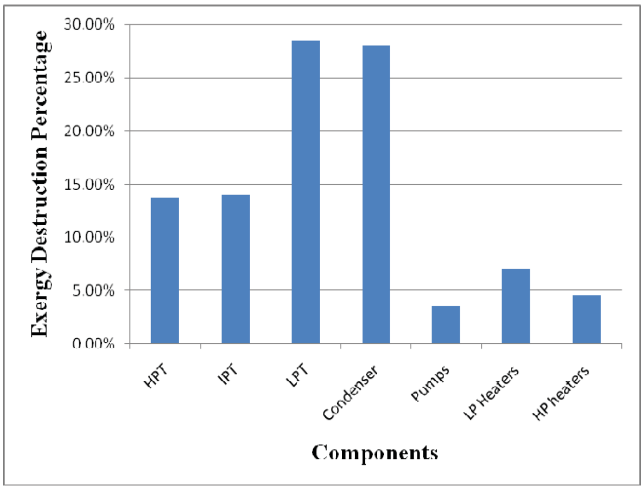
The second law efficiency is more for High Pressure Heater and can be observed from graph 4.In the power generating components it is found to be high for INTERMEDIATE PRESSURE TURBINE and Low Pressure Turbine is having low efficiency. This shows both these components are having higher entropy generation rate and there is room for improvement. The destruction in exergy is more in condenser the reason is it runs at low temperature and so as the work capacity. Even the amount of losses in the exergy is more we will not consider because of its quality of energy which is low.

Graphs are drawn between

- Components Vs Exergy Efficiency
- Components Vs Exergy Destruction
- Components Vs Percentage Exergy Destruction







VI. CONCLUSIONS

The Exergy destruction for a 210 MW plant of V.T.P.S has been performed and it can be seen that the condenser is having the highest exergy destruction rate and there is scope for improvement but practically its feasibility is low because of its Physical and environmental factors.

NOMENCLATURE

h =Specific enthalpy (J/kg)
s =Specific entropy (J/kgK)
h_o =Specific enthalpy at ambient condition (J/kg)
s_o =Specific entropy at ambient condition (J/kgK)
$\dot{I}$ =Exergy destruction rate (W)
T =Temperature (°C)
$m^{\cdot}$ = Mass flow rate (kg/s)
$W^{\cdot}$ =Work done rate or power done by the system (W)
P= Pressure (bar)
$\dot{X}$ =Total energy rate (W)
Q = Heat transfer rate to the system (W)

SYMBOLS

$\eta_{II} = Efficiency$
Ψ =Specific Exergy (J/kg)

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