Thermoeconomic Analysis of Supercritical 1400 MW Thermal Power Plant, Rajpura, Punjab, India

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Abstract

In this paper, a thermoeconomic analysis of a 1400 MW Rajpura supercritical thermal power plant in Punjab has been performed using principles of engineering economics and thermodynamics. Objective of the study is to find energy losses, exergy destruction and exergoeconomic evaluation of different subsystems of thermal power plant. Detailed steam circulation system of Rajpura thermal power plant was prepared and connections between various equipments were numbered. Real time operational data of thermal power plant was collected and then data was organized in tabular form. Energy analysis of thermal power plant using first law of thermodynamics was carried out under various operating conditions including temperature, pressure and different mass flow rates. The results of energy analysis show that, maximum percentage loss occur in condenser subsystem (63.44 %) followed by energy loss in turbine subsystem (25.50%) and then in boiler subsystem (11.06 %). During exergy analysis, the second law efficiency of thermodynamics of each subsystem was determined and it was found that boiler is major source of Irreversibility in the plant. The results of exergy analysis show that, there is maximum rate of exergy loss in boiler and in the turbine subsystem, and condenser subsystem has minimum loss. The exergy lost in boiler was found to be 38.79% and in condenser exergy destruction was found to be 3.025%. It was observed from energy and exergy analyses that the major energy loss occurs in condenser subsystem whereas major exergy loss occur in boiler subsystem. In last part of study exergoeconomic analysis of various subsystem of thermal power plant was carried out using the principles of engineering economics and exergy analysis based on second law of thermodynamics. Exergoeconomic factor based on capital cost and monetary loss because of exergy destruction in various subsystems were determined. Further from the Thermoeconomic evaluation it is concluded that the value of exergoeconomic factor is lowest for boiler. Exergoeconomic factor, for boiler, turbine and condenser was found to be 0.53, 0.58 and 0.85 respectively. This suggests that the overall system can be cost optimized by decreasing the exergy destruction in the boiler and making necessary investment in boiler subsystem.

Keywords

Energy, Exergy, Boiler Efficiency, Turbine Efficiency, Thermoeconomics, Exergoeconomic Factor

I. Introduction

The world of energy needs to rely heavily on fossil fuels for electricity generation. Despite the depletion of fossil fuels reserves and environment concern such as climate change, the growth in oil demand is expected to be 50% between 2003 and 2030, 90% for natural gas and 95% for coal. Therefore, given the continued reliance on fossil fuels for some time, it is important that fossil fuel plants reduce their environmental impact by operating more efficiently, has some inherent limitations like not accounting for properties of the system environment, or degradation of the energy quality through dissipative processes. An energy analysis does not characterize the irreversibility of processes within the system. In contrast, exergy analysis will characterize the work potential of a system. Exergy is the maximum work that can be obtained from the system, when its state is brought to the reference or “dead state” (standard atmospheric conditions). Exergy analysis is based on the second law of thermodynamics. This paper will examine a detailed exergy analysis of a thermal power plant, in order to assess the distribution of irreversibility and losses, which contribute to the loss of efficiency in system performance. This current paper presents an exergy analysis of a uniquely configured Rankine cycle operating in supercritical conditions. The generator power output is 1400 MW. This study mainly focuses on the exergy losses in the pulverized coal fired power plant operating in super-critical conditions. A typical steam cycle flows for the ultra super-critical plant is demonstrated in the fig. 1. The overall performance of the power plant can be analyzed on the basis of exergy concepts. The concentration rate of exergy destructions will determine the area of exergy losses. A model was developed using Microsoft Excel to determine the exergy losses and the net power out from the power plant. The model developed was based on the concepts of coal combustion, energy balances, enthalpy changes, entropy changes, heat transfer and mass transfer of the steam cycle, other the objective of this paper is energy audit of boiler and turbine unit in order to balance the total energy inputs with its use and to identify all energy streams in a facility. Energy Audit with designed condition quantifies the usage of energy according to its discrete functions. Energy audit provide attention on energy cost also. Cost involved in achieving higher performances are studied by economic analysis and the best alternative is selected. The analysis basically checked the efficiency of energy use at present. Energy economic analysis covers the overall process of data collection and carrying out economic analysis by using basic engineering economics tools. Energy Audit identifies the performance of each equipment and compares it with the base case.

II. Exergy Analysis

Exergy is a measure of the maximum capacity of a system to perform useful work as it proceeds to a specified final state in equilibrium with its surroundings. Exergy is generally not conserved as energy but destructed in the system. Exergy destruction is the measure of irreversibility that is the source of performance loss. Exergy is work potential and so, heat transfer is always accompanied by exergy transfer. Heat transfer Q at a location at thermodynamic temperature T is always accompanied by exergy transfer \( X_{\text{heat}} \) (work potential) in the amount of

\[ X_{\text{heat}} = (1 - \frac{T_0}{T})Q; \]

This relation gives the exergy transfer accompanying heat transfer Q whether T is greater than or less than \( T_0 \). When the temperature T at the location ewherer heat transfer is taking place is not constant, the exergy transfer accompanying heat transfer is determined by integration to be

\[ X_{\text{heat}} = \int (1 - \frac{T_0}{T})dQ \]
Exergy Transfer by Work, W can be expressed
\[ X_{\text{work}} = W - W_{\text{surr}} \text{ (for boundary work)} \]
\[ = W \text{ (for other forms of work)} \]
Where \( W_{\text{surr}} = P_0(V_2 - V_1) \), \( P_0 \) is atmospheric pressure, and \( V_1 \) and \( V_2 \) are the initial and final volumes of the system.

**Exergy Transfer by Mass, m** Mass contains exergy as well as energy and entropy, and the exergy, energy, and entropy contents of a system are proportional to mass.

\[ X_{\text{mass}} = m\psi \]
\[ = m[(h - h_0) - T_0(s - s_0)] + V_2/2 + gz \]

Subscript 0 denotes environment.

**Exergy Balance for Steady-Flow Systems** Most control volumes encountered in practice such as turbines, compressors, nozzles, diffusers, heat exchangers, pipes, and ducts operate steadily, and thus they experience no changes in their mass, energy, entropy, and exergy contents as well as their volumes. Therefore, \( dV_{\text{CV}}/dt = 0 \) and also, \( dX_{\text{CV}}/dt = 0 \) for such systems, and the amount of exergy entering a steady-flow system in all forms (heat, work, mass transfer) must be equal to the amount of exergy leaving plus the exergy destroyed. Then for the single stream flow (one mass inlet, one mass exit) steady-flow device reduces to

\[ X_{\text{heat}} - X_{\text{work}} + X_{\text{mass,in}} - X_{\text{mass,out}} - X_{\text{destroyed}} = 0 \]

\[ \sum (1 - T_0/T_1) Q_k - \left[ W_{\text{out}} \right] + m \left[ \Sigma \psi_{\text{in}} - \Sigma \psi_{\text{out}} \right] - X_{\text{destroyed}} = 0 \]

further simplifies to

\[ X_{\text{mass,in}} - X_{\text{mass,out}} - X_{\text{destroyed}} = 0 \]

\[ m[\Sigma \psi_{\text{in}} - \Sigma \psi_{\text{out}}] = X_{\text{destroyed}} \]

\( \psi \) subscripts 1 and 2 represent inlet and exit states.

If not specific, \( X_{\text{mass}} = \psi_1 - \psi_2 = (H_1 - H_2) - T_0(S_1 - S_2) + m(V_1^2 - V_2^2)/2 \]
\[ + mg(Z_1 - Z_2) \]

**Second-Law Efficiency of Steady-Flow Devices**

\[ \eta_{II} = \frac{\eta_{th,rev}}{\eta_{rev}} \quad \text{(heat engine)} \]

\[ \eta_{II} = \frac{\text{ExergyRecovered}}{\text{ExergySupplied}} = 1 - \frac{\text{ExergyDestroyed}}{\text{ExergySupplied}} \]

![Fig. 1](image)

**III. Energy and Exergy Calculations**

By noting the temperature, pressure and mass flow rate at different points, calculate the exergy and energy at different points by using the exergy and energy mathematical equation as mentioned above here we illustrate calculation of exergy and energy at point 1, calculation for all other points is shown in table and corresponding point mentioned in fig. 1.

**At point 1: Economizer input at point**: Energy = m \((h_1-h_0)\) = 595.163(1361.512-113.2922)

= 742894.248 kW

Exergy = m \([(h_1-h_0) - T_0(s_1 - s_0)]

= 595.163 [(1248.198) - 300.15(3.2305-0.395)]

= 236365.6972 kW

**Table 1: Calculation of Exergy and Energy at Different Points**

<table>
<thead>
<tr>
<th>1</th>
<th>description</th>
<th>m(kg/sec)</th>
<th>T(c)</th>
<th>P(bar)</th>
<th>h</th>
<th>S</th>
<th>energy</th>
<th>exergy</th>
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<tr>
<td>2</td>
<td>Atm</td>
<td></td>
<td>27</td>
<td>1.032</td>
<td>113.29</td>
<td>3.396</td>
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<td>3</td>
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<td>308.91</td>
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<td>334</td>
<td>281.7</td>
<td>1514.67</td>
<td>3.495</td>
<td>834046.43</td>
<td>280269.03</td>
</tr>
<tr>
<td>5</td>
<td>Superheater in</td>
<td>595.16</td>
<td>334</td>
<td>281.7</td>
<td>1514.67</td>
<td>3.495</td>
<td>834046.43</td>
<td>280269.03</td>
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<tr>
<td>6</td>
<td>Superheater out</td>
<td>595.16</td>
<td>565</td>
<td>242.22</td>
<td>3395.44</td>
<td>6.262</td>
<td>1953412.93</td>
<td>905414.22</td>
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<tr>
<td>7</td>
<td>Hpt in</td>
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<td>565</td>
<td>242.22</td>
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<td>6.262</td>
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<td>8</td>
<td>Hpt out</td>
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<td>349.8</td>
<td>59.063</td>
<td>3045</td>
<td>6.262</td>
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<td>9</td>
<td>Reheat in</td>
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<td>59.063</td>
<td>3045</td>
<td>6.345</td>
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<tr>
<td>10</td>
<td>Reheat out</td>
<td>495.31</td>
<td>593</td>
<td>54.328</td>
<td>3647</td>
<td>7.2</td>
<td>1750280.81</td>
<td>738570.2</td>
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<tr>
<td>11</td>
<td>Ipt in</td>
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<td>593</td>
<td>54.328</td>
<td>3647</td>
<td>7.2</td>
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<tr>
<td>12</td>
<td>Ipt out</td>
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<td>358.8</td>
<td>11.836</td>
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<td>1336002.24</td>
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<td>7.251</td>
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<td>7.251</td>
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<tr>
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<td>Lp htr 1 out</td>
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<td>67</td>
<td>25.33</td>
<td>282.52</td>
<td>.9167</td>
<td>78877.28</td>
<td>5550.81</td>
</tr>
</tbody>
</table>
IV. Analysis of Results from Above Calculations

A. Steam Generator Subsystem

Calorific Value of Coal used = 4400 kcal/kg (as given by NPL)
= 4400 x 4.18 (kJ/kg)
= 18392.48 (kJ/kg)

Fuel mass flow rate = 92.22 kg/sec for one unit

Total Energy released by coal = m (CV);  = 92.22 x 18392 Kw = 1696151.11 Kw
So, this is the total energy released by the coal in the furnace at temperature 1405℃. Hence, the maximum useful work, exergy which would be equal to the reversible work that could be done by a reversible engine supplied by the above calculated heat energy, working between the temperature-range from 30℃ to 1300℃, would be

\[ \text{Exergy Supplied} = X_{\text{heat}} = \left(1 - \frac{T_0}{T}\right) Q \]

\[ = (1 - 303.15/1573.15) x 1696151.11 \]

\[ = 1369298.458 \text{ kW} \]

Energy gained = Energy at super heater outlet – Energy at economizer inlet

Exergy recovered = Exergy at 2 – Exergy at 1

= 905414 – 236365.69 (from the table)
= 669048.5269 kW

total Exergy recovered by steam in steam generator

\[ \text{Total Exergy recovered} = 171040.323 \text{ kW} + 669048.5269 \text{ kW} = 840088.8499 \text{ kW} \]

In similar way total heat gain by reheater, condenser, turbine is calculated

The first-law efficiency of steam generator would be

\[ \eta_1 = \frac{\text{Energy Gained by steam}}{\text{Energy Supplied by fuel}} \]

\[ = \frac{1508694.1}{1696151.11} = 0.8994 = 89.94\% \]

The second-law efficiency is calculated as follows

\[ \eta_2 = \frac{\text{Exergy Recovered}}{\text{Exergy Supplied}} \]

Exergy destroyed in steam generator would be
Ex_{DES} = 1372646.15 kW - 840088.4049 kW
= 532557.7451 kW = 38.79% of total exergy input

This is the difference between first-law and second-law. The NPL steam generator was working with \( \eta_I \) of 89.94%, although the second-law efficiency gives a different output. This analysis shows that the second-law efficiency of the steam generator being used at NPL is 61.35%.

Exergy destroyed in steam generator would be

\[ Ex_{DES} = 1372646.15 kW - 840088.4049 kW = 532557.7451 kW = 38.79\% \text{ of total exergy input} \]

**B. Turbine Subsystem**

\[ W_{act, HPT} = \text{inlet energy} - \text{outlet energy}; \]
= 1953412.931 - 1452104.19 (from the table)
= 501308.031 kW

\[ W_{act, IPT} = \text{inlet energy} - \text{outlet energy}; \]
= 1336002.243 - 1750280.80
= 414278.557 kW

\[ W_{act, LPT1} = \text{inlet energy} - \text{outlet energy}; \]
= 668007.49 - 445489.28
= 222518.21

\[ W_{act, LPT2} = \text{inlet energy} - \text{outlet energy}; \]
= 222518.21

So, total work output of the turbines is the sum of both

\[ W_{act, total} = W_{HPT} + W_{IPT} + W_{LPT1} + W_{LPT2}; \]
= 222518.21 + 222518.21 + 414278 + 501308.03 kW
= 680311.225 kW

\[ \eta_H = \frac{\text{Actual Work Output}}{\text{Reversible or Maximum Work Output}}; \]
\[ \eta_H = \frac{680311.211}{1032594.49} = 0.6588 = 65.88\% \]

At each level

\[ Hpt = 67, IPT = 66, Lpt1 = 64, Lpt2 = 639 \]

Hence, the second-law efficiency of the turbine sub-system at NPL is 65.88%. The exergy destruction is

\[ Ex_{DES} = 1032594.44 kW - kW \]
= 352282.78 kW

The percentage exergy destroyed would be

\[ Ex_{DES} = \frac{\text{Exergy Destroyed}}{\text{Total Exergy Input in Steam Generator}}; \]
\[ \eta_H = 0.1789 = 17.89\% \text{ of the total exergy input in the steam generator} \]

**C. Condensate Subsystem**

Condenser is the most important part of the condensate cycle. Here, net loss of exergy is computed and not only exergy destroyed. Because we want to see the extent of exergy that is lost in condenser and not only to the irreversibilities. For this purpose let us first calculate the exergy supplied to the condenser

Exergy supplied = Exergy added from the exit of LPT 1 + Exergies added by the exiting hot stream of LPT 2 + Exergies added by the exiting hot stream of LPH 1
= 18927.466 + 24932 + 248.696 (from the table)
= 44108.106 kW

Now Exergy leaving the condenser would be the exergy that left the condenser with the outgoing stream from the condenser only, as there is no work done by the stream in condenser and also, no heat exchange to increase entropy

Exergy Left = Exergy left with hot stream = 2686.11 kW (from the table)

Hence, the exergy lost (total, including irreversibilities and the exergy given to the cooling water in condenser)

\[ Ex_{Lost} = \frac{\text{Exergy lost}}{\text{Total Exergy Input in Steam Generator}}; \]
\[ = 0.6588 \]

Energy Lost = Energy input – Energy outlet; (from the table)
= 445489.28 + 448498 + 7225.431 - 32473.65
= 868739.061 kW

So, calculating the percentage energy loss at condenser

\[ En\% = \frac{\text{Energy Lost}}{\text{Total Energy Input in Steam Generator}}; \]
\[ = 0.63444 = 63.44\% \]

This analysis has been done on the UNIT-1 OF 700 MW AT RAJPURA THERMAL POWER PLANT (NPL) AT 100% TMCR AND %MU.

1. First law efficiency and the second law efficiency are identified as the performance parameters of thermal power plants.
2. This analysis further shows that boiler is the source of the major irreversibility in the plant. And that is about 38.79% of exergy released by coal in boiler is lost in the boiler itself, which is 531MW in magnitude. This power could have been converted into work provided the thermal plant had better technology. The 531MW unit is not able to convert another 531MW of useful power.
3. At condenser, only 3.025% of exergy is being lost which is very small as compare to the exergy loss in the boiler.
4. The first law of thermodynamics calculates the loss at boiler to be about 10.06% of the total energy input which is 1369298 KW
5. At condenser about 63.44% of energy is lost.

This 63.44 % loss in the condenser energy is not exergy. This massive energy cannot be converted into work because the energy is at very low temperature. Hence, the quality of the energy is low

**V. Economic Analysis of Thermal Power Plant**

**About Economic Analysis**

Economic analysis of thermal power plant is of various types; it can be analysed through various ways factor responsible in economic analyses are:
1. Capital cost of boiler, turbine, condenser, boiler feed pump, heaters, coal coal pulverizing mill, various types of pump, economizer, cooling tower,
2. Operating cost of each component
3. Maintains cost of each component
4. Running cost, in which included the cost to employer, security, charges.

In our thesis work we study only about the operational cost, how much loss happened at important components of plant here during the analysis we assumed the approximate value of cost of component, not absolute cost in available due to confidentiality of rajpura thermal power plant. Many of researchers have developed methods of performing economic analyses based on exergy, which are referred to by a variety of names (e.g. thermoeconomic, second law costing, cost accounting and exergoeconomics). All of these analysis techniques have the following common characteristics: Each company has its own preferred approach for conducting an economic analysis and calculating the cost of the main product. Method used is based on basic engineering and economic concepts. With this approach, the cost of the main product can be calculated through the following four steps:

**Step 1.** Estimate the total capital investment.
**Step 2.** Determine the economic, financial, operating, and market input
**Step 3.** Calculate the total revenue requirement.
**Step 4.** Calculate the levelized product cost. Parameters for the detailed cost calculation

**VI. Cost Analysis**

Nabha power limited has setup 2*700 MW power project at nalash village within 420 acre land. Project cost is 8500 crore including interest during construction and financing charges. Cost per MW of installed capacity comes out to be 6 crore app.

**A. Unit Generation Cost**

RAJPURU thermal power plant functioning under punjab state electricity regulatory commission authority have power to decide upon the the tariff for electricity generated by various power stations within punjab.

Tariff charges = capacity charges (fixed cost)+ energy charges (variable cost)

Fixed charge depend upon various factors
- Return on equity
- Interest on capital loan
- Depreciation
- Interest on working capital
- Operation and maintenance cost
- Cost of secondary fuel

Fixed cost calculation for RAJPURU THERMAL POWER PLANT
Approximate life term of power plant = 20 years
Intial Capital cost for 700 MW = 6 crore/MW (app)
Depreciation rate for power plant components is = 5.28% as per CERC norms
Operation and maintenance cost as illusterated above per MW= 30 lakh(app)
Auxiliary energy consumption =6 % of total power generated
Debt and equity ratio= 70:30

**Plant load factor = 85 %**
Specific oil consumption = 1 ml /KWH (as per data book from thermal power plant )
Price of oil =RS 70/L
Gross calorific value of oil =5550 kcal/l
Cost of coal =RS 1200 /tonne
Plant life = 20 years
Gross calorific value of coal = 4000 kcal/kg
Capital cost =1400*6=8400 crore at start of plant
Debt/equity ratio =70:30(assumed )
Equity=.7*8400=5880crore
Debt= 2520 crore
Return on equity=5880*.14 (14 % as per data from PERC) = 823.2crore
Interest on loan =10 % of 2520 = 252 crore
Interest on working capital =1% of total cost = 84 crore
Depreciation = 5.28 % of equipment cost =2851.2 crore
Operating and maintenance cost= 18 lakh =.18 crore
Total operating maintenance = 150 crore
Total fixed cost =4162.3.4crore
Total power generation =1400 *365*24*.70*1000=551880000
0/1000000=8584.8
FIXED COST PER UNIT=3.91 rupee per unit

**B. How to Prepare Cost Equation for Plant Component and Exergoeconomic Factor**

Cost is an increasing, non-conserved quantity. The general balance equation can be written for cost as

Cost Input - Cost Generation = Cost Output = Cost Accumulation

Cost input, output and accumulation represent, respectively, the cost associated with all inputs, outputs and accumulations for the system. Cost generation corresponds to the appropriate capital and other costs associated with the creation and maintenance of a system.

Cost Generation = Capital Cost of Equipment + All Other Creation and Maintenance Costs
Other costs include, for example, interest and insurance costs. The “cost generation rate” term in a differential cost balance represents the total cost generation levelized over the operating
life of the system. The “amount of cost created” term in an integral cost balance represents the fraction of the total cost generation accounted for in the time interval under consideration. All costs due to owning and operating a plant depend on the type of financing, the required capital, the expected life of a component, and so on. The annualized (levelized) cost method was used to estimate the capital cost of system components in this study

$$PW = PEC - (SV) PWF (i, n)$$

Where the Salvage Value (SV) at the end of the nth year is taken as 10% of the initial investment for component (or purchase equipment cost, PEC). The Present Worth (PW) of the component may be converted to the annualized cost by using the capital recovery factor, CRF (i,n)

$$\dot{C} (\text{Rs/year}) = PW \times CRF (i,n)$$

$$CRF(i, n) = i / 1 - (1 + i)^{-n}$$

where i is the interest rate and it is taken to be 17%, n is the total operating period of the plant in years and was obtained from the selected plants. PEC is the purchased equipment cost.

$$PWF = (1 + i)^{-n}$$

Capital recovery cost for the kth component of the plant

$$Z = \phi_k C / (3600 \times 8000).$$

Dividing the leveled cost by annual operating hours, N, we obtain capital cost rate for the kth component of the plant. The maintenance cost is taken into consideration through the factor \( \phi_k = 1.06 \) for each plant component. Annualized cost and corresponding monetary flow rate for each component by putting data in above equations, considering operating time = 8000 hr per year, interest rate =17 %, lifetime =20 years, salvage value =10 %

The exergoeconomics factor \(= z/(z+c)\)

Where c is the exergy loss in terms of money

We are now divided the entire cost between three subsystems and calculate economic factor for each one

1. Generation subsystem: It consist of mainly boiler, coal handling, ash handling, preheater

2. Turbine subsystem: High pressure turbines, low pressure turbines, high pressure heaters, low pressure heaters, piping system, power motor system, control valves, oil system

3. Condenser subsystems: It consist pump, DM plant, cooling tower

Table 2: Exergoeconomics Factor Calculation

<table>
<thead>
<tr>
<th>Type of subsystem</th>
<th>Initial capital cost (PEC)</th>
<th>PWF</th>
<th>PW</th>
<th>CRF</th>
<th>C</th>
<th>Z in Rs/hr</th>
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<td>Generation subsystem</td>
<td>3400</td>
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<td>.0433</td>
<td>21904.7</td>
<td>.1167</td>
<td>278.3</td>
<td>102.6</td>
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<td>Condenser Subsystem</td>
<td>1200</td>
<td>.0433</td>
<td>1194.35</td>
<td>.1167</td>
<td>139.2</td>
<td>51.29</td>
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<table>
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<tr>
<th>Sr no</th>
<th>Exergy loss in 1 day</th>
<th>Loss Value in 1 hour</th>
<th>Loss value*generation cost in Rs/hr</th>
<th>Exergoeconomics factor F = z/(c+z)</th>
</tr>
</thead>
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<tr>
<td>Gen</td>
<td>532.557 MWH</td>
<td>24.56</td>
<td>127.5</td>
<td>1.145.5(127.5+145.5)= .5331</td>
</tr>
<tr>
<td>Turb</td>
<td>352.282 MWH</td>
<td>14.67</td>
<td>72.066</td>
<td>.5874</td>
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<tr>
<td>Cond</td>
<td>41.4 MWH</td>
<td>1.725</td>
<td>8.46</td>
<td>.8584</td>
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VII. Conclusion from Economic Analysis in Steam Generator

In economic analysis we have calculate the capitalised annual cost, The capitalized cost is often used in Decision-making processes to compare the total cost of competing equipment Options with different economic lives. The low value of exergoeconomics factor indicate exergy loss in term of money is more. In case of steam generator system its value comes out to .5331. Which suggests that cost savings in the entire system might be achieved by improving the component Efficiency (reducing the exergy destruction) even if the capital investment for this component will increase. It is suggested that increasing investment at the expense of increasing efficiency is beneficial in this system.

VIII. Conclusion from Economic Analysis for Turbine Subsystem

here in turbine economic analysis we also have calculate the capitalised annual cost, The capitalized cost is often used in Decision-making processes to compare the total cost of competing equipment Options with different economic lives. In this turbine subsystem value of economic factor comes out to be .5853 which is higher than steam generator. It mean exergy loss is less in turbine subsystem as compared to boiler subsystem which suggested that there is need of moderate investment in turbine subsystem at the cost of efficiency improvement. It is suggested that increasing

Fig. 2:

VII. Conclusion from Economic Analysis in Steam Generator

In economic analysis we have calculate the capitalised annual cost, The capitalized cost is often used in Decision-making processes
investment at the expense of increasing efficiency is moderate beneficial in this system.

**IX. Conclusion from Economic Analysis for Condenser Subsystem**

Here in turbine economic analysis we also have calculate the capitalised annual cost. The capitalized cost is often used in Decision-making processes to compare the total cost of competing equipment Options with different economic lives. The exergoeconomics factor value comes out to be very high app .8584 in this case so it means as we concluded in exergy analysis that exergy losses are less in terms of monetary value. It suggests that Cost savings in the entire system achieved by improving the component Efficiency (reducing the exergy destruction) is not much beneficial. It is suggested that increasing investment at the expense of increasing efficiency is not much beneficial in this system.

**Reference**


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