ENTROPY METHOD AS CRITERIA FOR ANALYSIS A STEAM POWER PLANT


ABSTRACT

In this paper a theoretical analysis of South Baghdad and Dura power plant is carried out according to second law of thermodynamic depending on entropy (irreversibility coefficient or lost work) method instead of exergy (availability) method. In the used entropy method. The power plant is divided into main blocks (boiler, turbine, condenser, and feed water heater and pumps). The irreversibility losses and coefficient for each block are calculated and then the overall irreversibility and thermal efficiency of the plant are calculated. The results of this work are compared with previous results, that depending on exergy method. The comparison of results show that both methods give approximately the same results since both of them rely the 2nd law of thermodynamic. Entropy method is simple and intellectually and intuitively satisfying and giving direct relationship between components losses of power plant and its overall efficiency.

KEYWORDS: Steam Power Plant, Analysis, Entropy Method
INTRODUCTION

With increasing fuel prices and the possibility of diminishing supplies in the years ahead, the importance of developing systems which make efficient use of energy is apparent. The second law of thermodynamic method of analysis is particularly suited for farthering the goal of more efficient energy use, for it identifies the locations, types, and the true magnitudes of energy resources waste and loss, such method can also be used to guide steps taken to reduce inefficiencies.

According to this second law different criteria are defined for analysis the performance of power plants based on the concept of exergy (availability). If all of these criteria are used, they must all give the same results. Although availability pinpointed the real losses of a steam power plant, it is difficult, complex and can not gives direct relationship between component losses and overall efficiency of plant. Thus, the criteria for selecting the best procedure to evaluate thermodynamic analysis should be, best ease of use, best degree of correspondence with the viewpoint and background of intended users and greatest breadth of application. On these grounds, the entropy method (lost work) approach was believed to be superior to other approaches in common use (Seader 1986).

The purpose of this work is to analyze performance of South Baghdad and Dura power plants according to 2nd law of thermodynamic depended on the concept of entropy method instead of exergy method. Then compare the results with that which obtained previously by other researches (Hashem and Murad 1998) and (Mathure et.al. 2000) depending on exergy method.

EXERGY METHOD ANALYSIS OF THE THERMAL POWER PLANT

The processes in steam turbine plant are steady flow processes, Where the general form of the exergy value was calculated from the following formula (Hashem and Murad 1998), (Moran 1982) and (Yunus 1994):

\[ e = (h - T_e s) - (h_e - T_e s_e) \]

For exergy analysis the plant was divided in to the following main blocks: steam boiler, steam turbine, steam condenser, feed water heaters and feed water pump. The exergy losses in each block can be defined as follows (Hashem and Murad 1998) and (Mathure et.al. 2000):

Steam Boiler

The total exergy losses of boiler are given,

\[ E_{lb} = E_f - \Delta E_w \] (1)

This total exergy losses of boiler are divided into three main losses,

a- Combustion Losses

\[ E_{le} = m_g T_o C_{pg} \ln \left( \frac{T_e}{T_o} \right) \] (2)
Where, combustion temperature ($T_c$) is roughly given by,

$$m_f . C.V. = m_g . C_{pg} . (T_c - T_o)$$

**b- Exhaust Losses**

$$E_{ex} = m_g . (h_{ex} - h_o) - T_o . (S_{ex} - S_o)$$

(3)

Where, $h_{ex} = C_{pg} . T_{ex}$, $S_{ex} = C_{pg} \ln (T_{ex} / T_o)$

**c- Heat Transfer Losses**

Exergy losses due to heat transfer ($E_{Lht}$),

$$E_{Lht} = E_f - \Delta E_w - E_{Lc} - E_{Lex}$$

(4)

Thus, the total exergy losses of boiler can be calculate from,

$$E_{Lb} = Eq . (2) + Eq . (3) + Eq . (4)$$

And the second law efficiency of boiler can be calculated as,

$$\eta = \frac{\Delta E_w}{E_f}$$

(5)

**Steam Turbine**

$$E_{Lt} = \Delta E_i - W_{out}$$

(6)

And $2^{nd}$ law efficiency of turbine,

$$\eta = \frac{W_{out}}{\Delta E_i}$$

(7)

**Steam Condenser**

Condenser effectiveness = (exergy gain by surrounding) / (exergy losses by steam through the condenser)

(8)
exergy gain by surrounding = \( Q_{\text{rej}} \left( \frac{T_{\text{max}} - T_{\text{min}}}{T_{\text{max}}} \right) \)  \( (9) \)

Where,
\( T_{\text{max}} \) – steam temperature at condenser inlet
\( T_{\text{min}} \) – surrounding temperature
Whereas, exergy losses through the condenser is equal to the exergy losses by steam.

**Feed Water Heater**

Exergy losses = \( \Sigma \) exergy input - \( \Sigma \) exergy output  \( (10) \)

the effectiveness of feed water heater = (exergy gain by cold water)/(exergy lost by steam) \( (11) \)

**Feed Water pump**

Exergy losses = \( W_{\text{input}} \) – exergy increasing of working fluid  \( (12) \)

Effectiveness of pump = (exergy increase of working fluid)/(\( W_{\text{input}} \))  \( (13) \)

According to 2\textsuperscript{nd} law steam cycle efficiency is given as,
\[ \eta_{\text{IIc}} = \frac{W_{\text{output}}}{m_{\text{steam}} \Delta e_{\text{w}}} \]  \( (14) \)

So from Eq. (5) \( \eta_{\text{IIb}} = m_{\text{c}} \Delta e_{\text{w}}/E_{\text{d}}, \)

then the 2\textsuperscript{nd} law efficiency of the power plant is given as,
\[ \eta_{\text{IIplant}} = \eta_{\text{IIc}} \cdot \eta_{\text{IIb}} \]  \( (15) \)

The schematic diagram of one unit of South Baghdad power plant is shown in Fig.1 . The description data of its steam cycle is given in **Table.1** (Mathur et.al. 2000). Whereas, the schematic diagram of one unit of Dura power plant and the description data of its steam cycle are shown in Fig.2 and **Table .2**, respectively (Hashem and Murad 1998).

Using **Tables. 1 and 2** and above equations, exergy analysis of each component was calculated for South Baghdad (Mathur et.al. 2000) and Dura (Hashem and Murad 1998) and the results are summarized in **Tables. 3 and 4**, respectively.

**ENTROPY METHOD**

According to (Gashteen and Varkevker 1986) and (Yunus 1994) irreversibility losses (lost work) are given as,
Irreversibility losses = $W_{is} - W_{act}$

Irreversibility losses = $(Q_{add} - Q_{rej})_{rev} - (Q_{add} - Q_{rej})_{irr}$

Irreversibility losses = $(Q_{rej})_{irr} - (Q_{rej})_{rev}$ \hspace{1cm} (16)

But for reversible engine,

$\Delta s_{sys} = \Sigma \Delta s = \frac{(Q_{rej})_{rev}}{T_o} - \frac{Q_{add}}{T_1} = 0$

Then,

$\frac{(Q_{rej})_{rev}}{T_o} = \frac{Q_{add}}{T_1}$ \hspace{1cm} (17)

For irreversible engine,

$\Delta s_{sys} = \Sigma \Delta s = \frac{(Q_{rej})_{irr}}{T_o} - \frac{Q_{add}}{T_1}$

From Eq. (17), \( \frac{Q_{add}}{T_1} = \frac{(Q_{rej})_{rev}}{T_o} \), then

$\Delta s_{sys} = \frac{(Q_{rej})_{rev}}{T_o} - \frac{(Q_{rej})_{rev}}{T_o}$

\( T_o (\Delta s)_{sys} = (Q_{rej})_{irr} - (Q_{rej})_{rev} \) \hspace{1cm} (18)

Sub. Eq. (16) in Eq. (18), then

Irreversibility losses = $T_o (\Delta s)_{sys} = T_o \Sigma \Delta s$ \hspace{1cm} (19)

For example for the arbitrary system shown below the irreversibility losses can be calculated as follows,
Irreversibility losses (\(\Phi\)) = \(T_o \left[ m_1.s_2 + m_2.s_4 + (m_3 + m_4).s_7 - m_1.s_1 - m_2.s_3 - m_3.s_3 - m_4.s_6 + Q_o / T_o \right]

\[
\Phi = T_o \left[ \sum_{i=1}^{n} (m_i.s_i)_{out} - \sum_{i=1}^{m} (m_i.s_i)_{in} \right] + Q_o
\]  
(20)

If there is no heat transfer across the boundary (\(Q_o = 0\)) then,

\[
\Phi = T_o \left[ \sum_{i=1}^{n} (m_i.s_i)_{out} - \sum_{i=1}^{m} (m_i.s_i)_{in} \right]
\]  
(21)

From Eq.(21) irreversibility losses can be calculated depending only on the change of entropy. This is why this method was given name of entropy by (Gashteen 1963). Irreversibility coefficient (\(\Omega\)) for each component of the power plant is equal to,

\[
\Omega_i = \Phi_i / (\text{exergy input to the plant})
\]  
(22)

And the overall irreversibility coefficient for any power plant,

\[
\Omega_{total} = \frac{\sum_{i=1}^{n} \Phi}{\text{input}}
\]

\[
\Omega_{total} = \Omega_1 + \Omega_2 + \Omega_3 \ldots \ldots \ldots \Omega_n = \sum_{i=1}^{n} \Omega_i
\]  
(23)

Plant thermal efficiency is defined as,

\[
\eta = \frac{\text{output}}{\text{input}} = \frac{\text{input-\Sigma losses}}{\text{input}}
\]
\[ \eta = \frac{\text{Input} - \sum_{i} \phi_{i}}{\text{Input}} = 1 - \sum_{i=1}^{n} \Omega_{i} \tag{24} \]

By using entropy method to analyze thermal power plant, the plant was divided into main blocks and irreversibility losses for each block was calculated according to Eqs. (20) or (21) and then irreversibility coefficient for each block was calculated from Eq. (22). The overall irreversibility coefficient of the plant was found from Eq. (23) and then from Eq. (24) the thermal efficiency of plant can be calculated (Gashteon and Varkeyker 1986).

The main blocks of thermal power plants and their irreversibility coefficient are as the following,

**Steam Boiler**

The total irreversibility losses of steam boiler are divided into three parts,
(a) Exhaust losses (b) combustion losses (c) heat transfer losses.

(a) Exhaust losses
These losses are calculated as follows,

Irreversibility exhaust losses = \( Q - Q_{\eta_{b}} \)

Irreversibility exhaust losses = \( Q (1 - \eta_{b}) \) \tag{25}

Where \( Q = \frac{m_{s} \Delta h_{w}}{\eta_{b}} \)

(b) Combustion losses
Combustion leads to appearance irreversibility losses which are depended on temperature of combustion.
Thus when this temperature increases the irreversibility losses decreases as shown on T-S diagram below:
The area abb’a’a represents the heat released during combustion at $T_c$. The equal area cdd’a’c represents the same heat released when combustion occurs at $T_c’$.

Irreversibility losses of combustion at $(T_c) = Q - Q\left[\frac{T_c - T_o}{T_c}\right] = Q\frac{T_o}{T_c}$  \hspace{1cm} (26)

Irreversibility losses at temperature $(T_c’) = Q\frac{T_o}{T_c’}$  \hspace{1cm} (27)

So $T_c < T_c’$, then irreversibility losses at $T_c$ are less than that at $T_c’$. These losses are shown on T-s diagram which are equals to area efb’a’e and egd’a’e at $T_c$ and $T_c’$ respectively.

(c) Heat transfer losses
Irreversibility losses= $T_o'(m_o(s_1 - s_2) - \frac{Q}{T_o'})$  \hspace{1cm} (28)

When combustion temperature is $T_c$, whereas these losses at $T_c$ become,

$T_o'(m_o(s_1 - s_2) - \frac{Q}{T_o'})$  \hspace{1cm} (29)

From Eqs.(28) and (29) it is clear that these losses are increasing when combustion temperature is increasing. Thus, Eq.(26) + Eq.(28) and Eq.(27) + Eq.(29) give the sum of irreversibility losses due to combustion and heat transfer at different combustion temperatures. From which a conclusion can be achieved that irreversibility losses due to combustion and heat transfer are given as,

$m_o T_o'(s_1 - s_2)$  \hspace{1cm} (30)
Where \( s_1 \) & \( s_2 \) are the entropy of working fluid at outlet and inlet of boiler respectively Eq.(30) is valid whatever the temperature of combustion is. Thus, the total irreversibility losses of steam boiler can be calculated as follows,

Total irreversibility losses of boiler = \( \text{Eq.(25)} + \text{E q. (30)} \)

**Steam Turbine**

Irreversibility losses of turbine can be calculated from Eq. (21).

**Steam Condenser**

This irreversibility losses can be calculated from Eq.(20) in which \( Q = m_s \Delta h_s \).

**Feed Water Heaters And Pumps**

This can be calculated from Eq. (21)

**Mechanical And Generator Losses**

These can be calculated as follows,

Mechanical irreversibility losses =\( w_t - \eta_m.w_t \) \hspace{1cm} (31)

Generator irreversibility losses =\( \eta_m \cdot w_t - \eta_m.\eta_g \cdot w_t \) \hspace{1cm} (32)

For all above components the irreversibility coefficient (\( \Omega \)) for each component can be calculated by dividing \( \Phi_{\text{component}} \) by fuel exergy, which is in our calculated equal to \( m_f.C.V. \). Then,

\[
\eta = 1 - \sum_{i=1}^{n} \Omega_i
\]

The results obtained from entropy method are summarized in Table.5 and 6 for South Baghdad and Dura power plant respectively.

**CONCLUSION**

- Both exergy and entropy methods give approximately the same results Figs.3 and 4, since the second law of thermodynamic is unambiguous.

- Entropy method (irreversibility) independent on dead state except for the value of \( T_0 \). Whereas the exergy is determined in relative to restricted dead state, which can be somewhat misleading.

- Entropy method which is simple and easy to apply is superior to exergy method. Since the former method requires only one property (entropy) to obtain the results, while the later method requires two properties (entropy and enthalpy).
- The entropy method is pinpointing the real losses in each component and giving direct relationship between them and the overall efficiency of the plant. By this the effect of inefficient components can be directly reduced to improve the performance of plant.

- The entropy method show that combustion temperature not posses influence on the irreversibility losses of the boiler. This is in contrast with what (Hashem and Murad 1998) previously concluded.

REFERENCES


NOTATION

C.V. caloric value of fuel (kJ/kg)
h specific enthalpy (kJ/kg)
s specific entropy (kJ/kg.K)
e,E specific exergy (kJ/kg), power (W)
C_p Specific heat at constant pressure (kJ/kg K)
T temperature (K)
Q total heat (kJ)
W work (kJ)

GREEK

η efficiency
Φ irreversibility loss
Ω irreversibility coefficient
Δ difference

**SUBSCRIPTS**

add added irre irreversible
act actual is isentropic
b boiler L losses
combustion m mechanical
ex exhaust max maximum
f fuel min minimum
g gas, generator o ambient
ht heat transfer rej rejected
II second law rev reversible
s steam sys system
w water t turbine

### Table 1: Description Data Of Steam Cycle For South Baghdad Power Plant (Mathur et.al. 2000)

<table>
<thead>
<tr>
<th>Pt</th>
<th>mass kg/s</th>
<th>pressure bar</th>
<th>x%</th>
<th>saturation temp. °C</th>
<th>h kJ/kg</th>
<th>s kJ/kg.K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>74.433</td>
<td>87.2</td>
<td>510</td>
<td>301</td>
<td>3414.5</td>
<td>6.7085</td>
</tr>
<tr>
<td>2</td>
<td>0.0756</td>
<td>87.2</td>
<td>510</td>
<td>301</td>
<td>3414.5</td>
<td>6.7085</td>
</tr>
<tr>
<td>3</td>
<td>74.358</td>
<td>87.2</td>
<td>510</td>
<td>301</td>
<td>3414.5</td>
<td>6.7085</td>
</tr>
<tr>
<td>4</td>
<td>0.1767</td>
<td>87.2</td>
<td>510</td>
<td>301</td>
<td>3414.5</td>
<td>6.7085</td>
</tr>
<tr>
<td>5</td>
<td>0.051</td>
<td>87.2</td>
<td>510</td>
<td>301</td>
<td>3414.5</td>
<td>6.7085</td>
</tr>
<tr>
<td>6</td>
<td>0.1106</td>
<td>71.02</td>
<td>482.222</td>
<td>286.722</td>
<td>3367.3</td>
<td>6.742</td>
</tr>
<tr>
<td>7</td>
<td>0.1616</td>
<td>75.84</td>
<td>493.333</td>
<td>291.277</td>
<td>3382.2</td>
<td>6.7336</td>
</tr>
<tr>
<td>8</td>
<td>0.0504</td>
<td>75.84</td>
<td>493.333</td>
<td>291.277</td>
<td>3382.2</td>
<td>6.7336</td>
</tr>
<tr>
<td>9</td>
<td>0.0315</td>
<td>75.84</td>
<td>493.333</td>
<td>291.277</td>
<td>3382.2</td>
<td>6.7336</td>
</tr>
<tr>
<td>10</td>
<td>0.0797</td>
<td>75.84</td>
<td>493.333</td>
<td>291.277</td>
<td>3382.2</td>
<td>6.7336</td>
</tr>
<tr>
<td>11</td>
<td>0.8343</td>
<td>71.02</td>
<td>482.222</td>
<td>286.722</td>
<td>3367.35</td>
<td>6.742</td>
</tr>
<tr>
<td>12</td>
<td>73.1855</td>
<td>87.2</td>
<td>510</td>
<td>301</td>
<td>3397.3</td>
<td>6.7253</td>
</tr>
<tr>
<td>13</td>
<td>5.418</td>
<td>32.9</td>
<td>388.888</td>
<td>239</td>
<td>3199.87</td>
<td>6.83417</td>
</tr>
<tr>
<td>14</td>
<td>67.766</td>
<td>32.9</td>
<td>388.888</td>
<td>239</td>
<td>3199.87</td>
<td>6.83417</td>
</tr>
<tr>
<td>15</td>
<td>3.9858</td>
<td>16.81</td>
<td>308.888</td>
<td>203.666</td>
<td>3046.129</td>
<td>6.8886</td>
</tr>
<tr>
<td>16</td>
<td>63.781</td>
<td>16.81</td>
<td>308.888</td>
<td>203.666</td>
<td>3046.129</td>
<td>6.8886</td>
</tr>
<tr>
<td>17</td>
<td>3.377</td>
<td>7.177</td>
<td>215.555</td>
<td>165.888</td>
<td>2876.5</td>
<td>6.9388</td>
</tr>
<tr>
<td>18</td>
<td>60.403</td>
<td>7.177</td>
<td>215.555</td>
<td>165.888</td>
<td>2876.5</td>
<td>6.9388</td>
</tr>
<tr>
<td>19</td>
<td>4.012</td>
<td>2.7</td>
<td>132.222,0.995</td>
<td>130</td>
<td>2713.5</td>
<td>7.0016</td>
</tr>
<tr>
<td>20</td>
<td>56.391</td>
<td>2.7</td>
<td>132.222,0.995</td>
<td>130</td>
<td>2713.5</td>
<td>7.0016</td>
</tr>
<tr>
<td>21</td>
<td>4.845</td>
<td>0.792</td>
<td>92.22,0.967</td>
<td>92.888</td>
<td>2539.99</td>
<td>7.1105</td>
</tr>
</tbody>
</table>
Table 2: Description Data Of Steam Cycle For Dura Power Plant (Hashem and Murad 1998)

<table>
<thead>
<tr>
<th>Pt</th>
<th>t (°C)</th>
<th>pressure (bar)</th>
<th>m kg/s</th>
<th>h kJ/kg</th>
<th>s kJ/kg.K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>535</td>
<td>133.4</td>
<td>135.95</td>
<td>3426</td>
<td>6.549</td>
</tr>
<tr>
<td>2</td>
<td>360.7</td>
<td>39.11</td>
<td>19.03</td>
<td>3124</td>
<td>6.645</td>
</tr>
<tr>
<td>3</td>
<td>361.9</td>
<td>40.45</td>
<td>115.1</td>
<td>3124</td>
<td>6.627</td>
</tr>
<tr>
<td>4</td>
<td>535</td>
<td>36.29</td>
<td>115.1</td>
<td>3528</td>
<td>7.253</td>
</tr>
<tr>
<td>5</td>
<td>374</td>
<td>11.13</td>
<td>4.837</td>
<td>3208</td>
<td>7.345</td>
</tr>
<tr>
<td>6</td>
<td>269.8</td>
<td>4.435</td>
<td>6.557</td>
<td>3004</td>
<td>7.387</td>
</tr>
<tr>
<td>7</td>
<td>164.1</td>
<td>1.603</td>
<td>5.548</td>
<td>2800</td>
<td>7.232</td>
</tr>
<tr>
<td>8</td>
<td>X=0.995</td>
<td>0.563</td>
<td>6.789</td>
<td>2639</td>
<td>7.52</td>
</tr>
<tr>
<td>9</td>
<td>X=0.922</td>
<td>0.068</td>
<td>91.38</td>
<td>2384</td>
<td>7.688</td>
</tr>
<tr>
<td>10</td>
<td>------</td>
<td>0.068</td>
<td>91.38</td>
<td>161.7</td>
<td>0.553</td>
</tr>
<tr>
<td>11</td>
<td>38.6</td>
<td>0.068</td>
<td>105.5</td>
<td>161.6</td>
<td>0.554</td>
</tr>
<tr>
<td>12</td>
<td>38.8</td>
<td>15.57</td>
<td>105.5</td>
<td>163.7</td>
<td>0.552</td>
</tr>
<tr>
<td>13</td>
<td>45.1</td>
<td>------</td>
<td>12.34</td>
<td>188.8</td>
<td>0.639</td>
</tr>
<tr>
<td>14</td>
<td>81.4</td>
<td>6.886</td>
<td>105.5</td>
<td>341.2</td>
<td>1.089</td>
</tr>
<tr>
<td>15</td>
<td>113.4</td>
<td>------</td>
<td>5.548</td>
<td>475.6</td>
<td>1.456</td>
</tr>
<tr>
<td>16</td>
<td>110.4</td>
<td>6.396</td>
<td>105.5</td>
<td>463.5</td>
<td>1.421</td>
</tr>
</tbody>
</table>
Table 3: Exergy Analysis Summary Of South Baghdad Power Plant *(Mathure et. Al. 2000)*

<table>
<thead>
<tr>
<th>No</th>
<th>Components</th>
<th>Exergy loss %</th>
<th>$\eta_{II}%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boiler</td>
<td>56.8</td>
<td>Boiler-43.2</td>
</tr>
<tr>
<td>2</td>
<td>Turbine</td>
<td>7.4</td>
<td>Steam cycle-74.76</td>
</tr>
<tr>
<td>3</td>
<td>Condenser and hot well</td>
<td>2.08</td>
<td>Overall efficiency-29.61 take to account</td>
</tr>
<tr>
<td>4</td>
<td>Pumps</td>
<td>------</td>
<td>power use factor =0.917</td>
</tr>
<tr>
<td>5</td>
<td>Feed water heaters</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Exergy Analysis Summary Of Dura Power Plant *(Hashem and Murad 1998)*

<table>
<thead>
<tr>
<th>No</th>
<th>Components</th>
<th>Exergy loss %</th>
<th>$\eta_{II}%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boiler</td>
<td>50.00</td>
<td>Boiler – 50.0</td>
</tr>
<tr>
<td>2</td>
<td>Turbine</td>
<td>4.17</td>
<td>Steam cycle-84.0</td>
</tr>
<tr>
<td>3</td>
<td>Condenser</td>
<td>2.05</td>
<td>Overall efficiency-42.0%</td>
</tr>
<tr>
<td>4</td>
<td>Feed water heating</td>
<td>1.45</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Feed water pump</td>
<td>0.105</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mec.&amp;generator</td>
<td>0.65</td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Entropy Method Analysis Summary Of South Baghdad Power Plant

<table>
<thead>
<tr>
<th>No</th>
<th>Components</th>
<th>Irreversibility coefficient $\Omega_i%$</th>
<th>$\eta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boiler</td>
<td>58.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Turbine</td>
<td>6.60</td>
<td></td>
</tr>
</tbody>
</table>
3 Condenser and hot well 2.3
4 Feed water heaters 4.8
5 Mechanical 0.3
6 Generator 0.4  Overall efficiency=27.6
7 total 72.4

Table 6: Entropy Method Analysis Summary Of Dura Power Plant

<table>
<thead>
<tr>
<th>No</th>
<th>Components</th>
<th>Irreversibility coefficient $\Omega_i %$</th>
<th>$\eta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boiler</td>
<td>51.03</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Turbine</td>
<td>4.12</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Condenser</td>
<td>1.998</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Feed water heaters</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Mechanical</td>
<td>0.4</td>
<td>Overall efficiency=40.2</td>
</tr>
<tr>
<td>6</td>
<td>Generator</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>total</td>
<td>59.8</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 2: The Heat Cycle Of The Unit Of Dura Power Plant

Fig. 3: Exergy And Entropy Method Analysis For South Baghdad Power Plant
X-Axis: 1- Boiler 2- Turbine 3- Condenser And Hot Well 4- Overall Plant
Fig. 4: Exergy And Entropy Method Analysis For Dura Power Plant
X-Axis: 1- Boiler  2- Turbine  3- Condenser  4- Feed Water Heaters
      5- Mec.& Gen.  6- Overall Plant