CHAPTER-6

EXERGETIC COST BASED DIAGNOSIS OF OPEN CYCLE GAS TURBINE POWER PLANT

6.1 INTRODUCTION

When an energy or thermal system performs, system performance may deteriorate due to any reason. Then the analysis and diagnosis of cause in the complex thermal system is very difficult. In order to analysis and diagnosis of complex thermal systems, it is important to integrate the fundamental of thermodynamics with the economic aspects of the plant under consideration. For this purpose, during the last two to three decades the exergoeconomic based techniques for the analyzing of thermal systems has been in the use. These techniques are cost accounting methods that use the average cost of exergy in terms of exergy [Lozano et al. (1993), Valero et al. (1994), Erlarch B et al. (1999), Torres C et al (2002) and Dentice M et (1998)] and average cost per unit exergy [Bejan A et al. (1996), El-Sayed (2002), Kotas T J et al. (1995) and Kwak H et al. (1998)] for assessments. The theory of exergetic cost developed by Valero has been applied to analysis of thermal systems. In this analysis, this theory has been applied to open gas turbine cycle. This especially aims at showing how the irreversibilities are distributed among the plant component and Impact on fuel on plant components when a component malfunctions. When a component of gas turbine plant performs the worse, its performance is affected and also of others. If the performance of more than one component deteriorates then cause of deterioration, becomes difficult to be diagnosed. Solving this problem would find out the exergy saving by restoring the original efficiency of a single device and also whether the substitution or repair is economical or not from the thermodynamic and economic point of view.

The theory of exergetic cost may be applied to solve the problems with no mathematical tool. The theory of exergetic cost is based on general concepts like resources, structure, efficiency and purpose [Lozano et al. (1993)]. This theory requires the implementation of two procedures. The first procedure is to perform the exergy analysis (and has been
explained in the section 5.3) to evaluate the local incremental irreversibility for each plant component and, more importantly, to calculate part of this incremental irreversibility being directly caused by local malfunction of a component (endogenous). Second procedure involves calculating the exergetic costs for all physical flows of the plant, which allows estimating the impact on fuel in other components and in plant as a whole by eliminating a local malfunction, if others are not removed.

6.2 EXERGETIC COST BASED ANALYSIS AND DIAGNOSIS

Exergetic cost based diagnosis is based on theory of exergetic cost. For any thermal system, the exergetic cost \( E' \) of any flow is quantity of exergy required to produce it [Lozano et al. (1993)]. Therefore exergetic cost is a conservative property. This allows us to as many equations of exergetic cost balance as the number of units in the installation. Additional equations are also needed to calculate the unit exergetic costs all physical flows. These additional equations are developed from the concept of unit exergetic cost \( k^* \) and fuel-product-loss definition as explained by Valero and Lozano, which states that

(a) Exergetic cost of flows entering the plant is equals to their exergy,

(b) The value of exergetic cost for the loss flow has been assigned as zero, and

(c) If a unit has a product composed of several flows, then same unit exergetic cost has been assigned to all of them.

If proper definitions of fuels, products and losses have been made, we may write for a component "i", the unit exergetic cost of fuel, that is:

\[
k^*_{fi} \equiv \left( \frac{\partial F_i}{\partial I_i} \right)_{\eta_j=const}
\]

\( F_i \) being the fuel for the overall plant and \( I_i \) the exergy destruction rate in the component considered and \( \eta_j \) the exergetic efficiency of the component \( j \). To derive the Equation (6.1), we consider a sequential process as shown in Figure 6.1. The balance of exergy for
the process will be given by \( F_T = P_T + I_T \). If the quantity of total product \( P_T \) is kept fixed, any modification in the design will cause an increase or decrease in the consumption of fuel equal to the variation in total irreversibility, e.g. \( \Delta I_T = \Delta F_T \). When a change occurs in the exergetic efficiency for the component \( i \) while efficiencies of other components remains the same.

\[
F_T = F_T \rightarrow \begin{array}{c}
I_i \\
\eta_i k_i
\end{array} 
\rightarrow P_i
\]

\[
F_T \rightarrow \begin{array}{c}
I_i \\
\eta_i k_i
\end{array} 
\rightarrow P_i
\]

\[
F_T \rightarrow \begin{array}{c}
I_n \\
\eta_n k_n
\end{array} 
\rightarrow P_n = P_T
\]

\( \text{Figure 6.1 A sequential process} \)

then

\[
k_F^* = \frac{F_T}{F_i} \equiv \frac{(F_T + \Delta F_T)}{(F_i + \Delta F_i)} \equiv \text{const.} \quad (6.2)
\]

Also the product of unit \( i \) remains the constant. Therefore \( \Delta F_i = \Delta I_i \) and increase in fuel \( \Delta F_T \) due to malfunction of unit \( i \), represented by \( \Delta I_i \), will be

\[
\Delta F_T = \Delta I_T \equiv k_F^* \Delta F_i \equiv k_F^* \Delta I_i \quad 6.3)
\]

It is easy to obtain the Equation (6.1) from Equation (6.2). When more than one component is affected by malfunction, the fuel consumption increase to be ascribed to device \( i \), also called “Impact on fuel”, \( IF_i \) can be approximately estimated from

\[
IF_i \equiv k_F^* \Delta I_i \quad (6.4)
\]

\( \Delta I_i \) represents the fraction of exergy destruction increase in the component \( i \) due its malfunctioning called endogenous irreversibility. \( IF_i \) also represents the overall exergy saving achievable by restoring the original efficiency. The endogenous irreversibility and
structural irreversibility can be performed by using exergy balance for the component \( i \), we have

\[ I_i = F_i - P_i = (k_i - 1)P_i \]  \hspace{1cm} (6.5)

where \( k_i = F_i / P_i \) is unit fuel consumption. When a change in operating condition occurs, we have

\[ dI_i = P_i dk_i + (k_i - 1) dP_i \]  \hspace{1cm} (6.6)

Equation (6.6) shows that the irreversibility destruction rate for the component \( i \) has two causes (i) variation of its efficiency and/or (ii) variation of its product. Integrating the Equation (6.6), we get approximately

\[ \Delta I_i = \Delta I_{iu} + \sum_{j \neq i} \Delta I_{ij} = P_i \Delta k_i + (k_i - 1) \Delta P_i \]  \hspace{1cm} (6.7)

The term \((k_i - 1) \Delta P\) of Equation (6.7) represents incremental irreversibility or structural contribution induced in component due to malfunctioning of other components, whereas \( P_i \Delta k_i \) represents the endogenous additional irreversibility.

Equations (6.4) and (6.7) allows to evaluate the “Impacts on fuel” \( IF_i \) for all components of the plant,

\[ IF_i = k_i^* P_i \Delta k_i \]  \hspace{1cm} (6.8)

Smaller the disturbances, better the accuracy. Finally if we multiply \( IF_i \) by the unit cost of fuel, economic saving can be evaluated by using such diagnosis. The knowledge of economic saving achievable by eliminating a single malfunction allows to decide whether restoring the original efficiency is profitable or not.
6.3 SYSTEM DESCRIPTION

A schematic of a 137MW open gas turbine plant is given in Figure 6.2 and shows the main work and exergy flows and state points which has been accounted in this analysis. The system consists of an air compressor, a combustion chamber and a gas turbine. Table 6.1 shows the fuel-product definition. The mass flow rate of air to the compressor at 27° C is 543.60 kg per second and air fuel ratio 50.13 on a mass basis.

![Figure 6.2 Open gas turbine cycle](image)

The incoming air has a temperature of 27° C and a pressure of 1.013 bars. The pressure increases to 11.14 bars through the compressor which has an isentropic efficiency of 80%. The inlet temperature to turbine is 1060° C. The turbine has an isentropic efficiency of 80 %. The exhaust gases from turbine at 540° C and 1.10 bars are exhausted to atmosphere. The fuel (natural gas) is injected at 27° C and 22 bars.

Table 6.1 Fuel product definition for gas turbine plant

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Fuel</th>
<th>Product</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor</td>
<td>E1+E12</td>
<td>E2</td>
<td>----</td>
</tr>
<tr>
<td>Combustor</td>
<td>E2+E10</td>
<td>E4</td>
<td>----</td>
</tr>
<tr>
<td>Gas turbine</td>
<td>E4</td>
<td>E13+E12</td>
<td>E5</td>
</tr>
<tr>
<td>Plant</td>
<td>E1+E10</td>
<td>E13</td>
<td>E5</td>
</tr>
</tbody>
</table>

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6.4 RESULTS AND DISCUSSIONS

The Table 6.2 shows the property values of, exergy flow rates, exergetic costs and unit exergetic costs for the various flows for the designed conditions. The exergetic cost for the various flows has been calculated by using the exergetic cost balance equations that are given in the Appendix III. These equations have been developed by applying the laws stated in section 6.2. It has been observed that maximum exergetic cost goes for the flow at exit of combustor with a value of 1448MW. The exergetic cost of the fuel supplied to the plant is same as that of its exergy flow rate and this is the minimum to the combustor having a value of 562MW whereas the compressor lies between the combustor and turbine with a value of 886MW. The maximum unit exergetic cost of the fuel is for the compressor with a value of 4.11 and therefore is a critical component and this is the component where more attention is required.

Now if the plant operates at lower efficiency by disturbing the compressor efficiency, compression ratio or inlet temperature to combustor and turbine inlet temperature (TIT). Following reductions are assumed: compressor efficiency of 0.72, pressure ratio of 10 and TIT of 1303K. The exergetic efficiency of plant for new state of system is 19.81%. The values of exergy and exergetic costs for new state of system are shown in Table 6.3. Again maximum exergetic cost goes for the combustor exit and increases by 53% and exergetic cost of the exergy at exit of the compressor increases by 72%. The unit exergetic cost for compressor fuel is 5.05 and is the component with the highest fuel cost. If the plant operates under such condition the compressor is the component for which product exergetic cost is highest. By applying Equation 6.7 for the plant components additional irreversibility may be calculated as shown in Table 6.4. For the combustor and gas turbine, malfunctioning of other devices improve the performances with endogenous irreversibility contribution of -2.27 MW and -0.65 MW respectively, but the structural contributions of 59.67 MW and 3.57 MW cause the deterioration. Due to the malfunctioning of other devices, 82.36MW is added as additional irreversibility to plant. The maximum additional irreversibility equal to 70% goes to the combustor and remaining 27% and 3% goes to the compressor and turbine respectively.
Table 6.2 Property values, exergy flow rates and exergetic costs for the design operating condition

<table>
<thead>
<tr>
<th>Stream</th>
<th>( m ) (kg/s)</th>
<th>( P ) (bar)</th>
<th>( T ) (K)</th>
<th>Exergy Flow rate, ( E ) (MW)</th>
<th>Exergetic cost, ( E^* ) (MW)</th>
<th>Unit exergetic cost, ( k^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>543.60</td>
<td>1.01</td>
<td>300.15</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>543.60</td>
<td>11.14</td>
<td>673.19</td>
<td>187.54</td>
<td>886.36</td>
<td>4.73</td>
</tr>
<tr>
<td>10</td>
<td>10.85</td>
<td>22.00</td>
<td>300.15</td>
<td>562.42</td>
<td>562.42</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>554.44</td>
<td>8.59</td>
<td>1333.00</td>
<td>515.44</td>
<td>1448.80</td>
<td>2.81</td>
</tr>
<tr>
<td>5</td>
<td>554.44</td>
<td>1.10</td>
<td>813.00</td>
<td>147.19</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>12</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>215.91</td>
<td>886.36</td>
<td>4.11</td>
</tr>
<tr>
<td>13</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>137.00</td>
<td>562.42</td>
<td>4.11</td>
</tr>
</tbody>
</table>

\( m \) - are calculated values

Table 6.3 Exergy flow rates and exergetic costs for the perturbed operating condition (Compressor efficiency=0.72, TIT=1303 K and Pr ratio=10)

<table>
<thead>
<tr>
<th>Stream</th>
<th>Exergy Flow rate, ( E ) (MW)</th>
<th>Exergetic cost, ( E^* ) (MW)</th>
<th>Unit exergetic cost, ( k^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>250.95</td>
<td>1521.60</td>
<td>6.06</td>
</tr>
<tr>
<td>10</td>
<td>691.67</td>
<td>691.67</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>650.72</td>
<td>2213.20</td>
<td>3.40</td>
</tr>
<tr>
<td>5</td>
<td>194.08</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>12</td>
<td>301.38</td>
<td>1521.60</td>
<td>5.05</td>
</tr>
<tr>
<td>13</td>
<td>137.00</td>
<td>691.67</td>
<td>2.30</td>
</tr>
</tbody>
</table>

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By applying Equation 6.8, impacts on fuel have been calculated and shown in Table 6.4. About 53% of incremental irreversibility in plant may be attributed to malfunction of combustor while 43 and 4% may be attributed to malfunction of gas turbine and compressor respectively. Finally, if we multiply the Impacts on Fuel by unit cost of natural gas supplied to combustor, we may estimate the economic saving that is achievable for each component. The same results are summarized in Figure 6.3 and 6.4. Figure 6.3 shows, for each device, the additional irreversibility induced by malfunctions of other components, also indicating their endogenous and structural contributions, whereas in Figure 6.4, the ratio between Impact on Fuel and total fuel required by plant is shown.

### Table 6.4 Additional irreversibility and impacts on fuel
(Compressor efficiency=0.72, TIT=1303K and Pr ratio=10)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>$\Delta I_1 (MW)$</th>
<th>$\Delta I_1 / \Delta I_Y$ (%)</th>
<th>$\Delta I_y (MW)$</th>
<th>$\sum \Delta_y (MW)$</th>
<th>$k_F^*$</th>
<th>$IF^*_y (MW)$</th>
<th>$\sum \frac{IF^<em>_y}{IF^</em>} (%)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor</td>
<td>22.05</td>
<td>26.78</td>
<td>7.75</td>
<td>14.30</td>
<td>5.05</td>
<td>111.35</td>
<td>43.49</td>
</tr>
<tr>
<td>Combustor</td>
<td>57.39</td>
<td>69.68</td>
<td>-2.27</td>
<td>59.66</td>
<td>2.35</td>
<td>134.74</td>
<td>52.63</td>
</tr>
<tr>
<td>Gas Turbine</td>
<td>2.92</td>
<td>3.55</td>
<td>-0.65</td>
<td>3.57</td>
<td>3.40</td>
<td>9.34</td>
<td>3.88</td>
</tr>
<tr>
<td>Plant</td>
<td>82.36</td>
<td>100.00</td>
<td>4.83</td>
<td>77.53</td>
<td></td>
<td>256.026</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Figure 6.3 Additional irreversibility distribution between the plant components

Figure 6.4 Ratio of impacts on fuel in subsystems
Figure 6.5 to Figure 6.7 show the effect on unit exergetic cost of fuel, irreversibility distribution and impacts on fuel for the components on inducing the malfunction in one component while other components remain undisturbed. Figure 6.5 shows effect on the unit exergetic cost of fuel to compressor, combustor and gas turbine. It was observed that unit exergetic costs for all components decreases from that of designed condition when pressure ratio of compressor lowered to 10 while compressor efficiency and TIT to gas turbine remains the undisturbed. The unit exergetic costs of the fuel to the compressor, combustor and gas turbine are 3.87, 1.82 and 2.68 respectively. The unit exergetic costs of fuel increases only when TIT lowered to 1303 K and these values are 4.63, 2.12 and 3.09 for the compressor, combustor and turbine respectively and increases further from this value when only compressor efficiency is lowered to 0.72 and values are 4.78, 2.30 and 3.28 for compressor, combustor and gas turbine respectively.

\[ \text{Pr. ratio}=11, \text{ TIT}=1333 \text{ K} \]
\text{compressor efficiency}=0.80

\[ \text{Pr. ratio}=10, \text{ TIT}=1333 \text{ K} \]
\text{compressor efficiency}=0.80

\[ \text{Pr. ratio}=11, \text{ TIT}=1303 \text{ K} \]
\text{comp. efficiency}=0.80

\[ \text{Compressor efficiency}=0.7, \text{ TIT}=1333 \text{ K} \text{ and Pr ratio}=1 \]

*Figure 6.5 Unit exergetic cost of fuel for subsystems at various conditions*
Figure 6.6 and Figure 6.7 show the effects on irreversibility distribution and impacts on fuel by inducing the malfunction only in one component while other components remain undisturbed. Figure 6.6 shows that when compressor efficiency is lowered to 0.72 then approximately 20 MW of additional irreversibility goes to compressor while 37 and 3 MW of additional irreversibility goes to combustor and gas turbine respectively. Similar considerations can be made from Figure 6.6 when pressure ratio and TIT is lowered turn by turn. It was observed that when pressure ratio is lowered to 10, then plant performance is improved by 22 MW and maximum irreversibility can be avoided in combustor equal to 12 MW. Figure 6.7 shows the impact on fuel for components of plant and for the overall plant for the same operating conditions and same considerations can be made from Figure 6.7 also. Once the unit exergetic costs have been calculated for the system under analysis, impacts on fuel corresponding to any malfunction can be easily estimated by applying the approximate method as described above. So it will be possible to analyze economic feasibility for eliminating the detected malfunction in plant as stated previously.
Compressor Combustor Gas Turbine Plant

HPr ratio=11, TIT=1333 K and compressor efficiency=0.72

Pr. Ratio=10, TIT=1333 K and compressor efficiency=0.80

Pr. Ratio=11, TIT=1303 K and compressor

Figure 6.7 Impact on fuel on plant components

Figure 6.8 Effect of compressor pressure ratios on additional irreversibility
Figure 6.8 to Figure 6.10 show the effects of variation of compressor pressure ratio, compressor isentropic efficiency and turbine inlet temperature on the additional irreversibility. In Figure 6.8 the pressure ratio of compressor is varied from 10 to 16, it was observed that additional irreversibility increases for all components above the designed compressor pressure of 11. This added irreversibility is higher at higher pressure ratio in the compressor. If the plant compressor operates below the designed pressure ratio, the irreversibility is reduced in all components and also for the overall plant.

Figure 6.9 shows the effects of compressor isentropic efficiency on the additional irreversibility. The Figure shows that if the compressor isentropic efficiency is lower than the designed efficiency, due to this malfunctioning added irreversibility is very much high. If the efficiency is about the 60% then added irreversibility to the whole plant is 326MW and maximum added irreversibility of about 207MW goes to the combustor of the plant whereas about 17MW goes to the gas turbine and compressor is between combustor and gas turbine with a value of 102MW. If the compressor efficiency is greater than the designed value then the plant performance is improved by reduced irreversibility. If the compressor efficiency is about the 89%, plant performance is improved by 42MW and maximum improvement was observed in the combustor. Figure 6.10 shows the effect of TIT on the added irreversibility. At the low TIT than the designed value of 1333K, the added irreversibility is very high and maximum added irreversibility goes to the combustor and if the TIT is greater than the 1333K, plant performance is improved. When the TIT is 1373K, the plant performance is improved by 45MW.
Figure 6.9 Effect of compressor isentropic efficiency on additional irreversibility

Figure 6.10 Effect of TIT on additional irreversibility
In Figure 6.11 to 6.13, the effects on endogenous added irreversibility have been shown. The Figure 6.11 shows effect of compressor pressure ratio on endogenous irreversibility, when the pressure ratio is greater than the 11, the gas turbine performance deteriorates but at pressure ratio of less than 11 situations get reversed. Figure 6.12 shows the effect of compressor isentropic efficiency on endogenous irreversibility and it was observed that when the compressor efficiency is greater than 80%, the compressor and gas turbine performance with endogenous irreversibility gets improved but combustor performance gets deteriorates with endogenous irreversibility and if the compressor efficiency is less than 80% situations get reversed. Figure 6.13 shows the effect of TIT on endogenous irreversibility and it was observed that when the TIT is greater than 1333K, combustor and gas turbine performance with endogenous irreversibility gets improved but compressor performance gets deteriorates with endogenous irreversibility and if TIT is less than 1333K situations get reversed.

![Figure 6.11 Effect of compressor pressure ratio on endogenous additional irreversibility for components](image-url)
Figure 6.12 Effect of compressor isentropic efficiency on endogenous additional irreversibility for components

Figure 6.13 Effect of TIT on endogenous additional irreversibility for components
Figure 6.14 to Figure 6.16 show the effect on the structural irreversibility of various components. Figure 6.14 shows the effect of compressor pressure ratio on structural irreversibility and it was observed that when the compressor pressure ratio is greater than 11, the compressor, combustor and the gas turbine performance with structural irreversibility gets deteriorates but performance gets improved with structural irreversibility if compressor pressure ratio is less than 11. Figure 6.15 shows the effect of compressor isentropic efficiency on structural irreversibility and it was observed that when the compressor isentropic efficiency is greater than 80%, the compressor, combustor and the gas turbine performance with structural irreversibility gets improved but performance gets deteriorates with structural irreversibility if compressor isentropic is less than 80%. Figure 6.16 shows the effect of TIT on structural irreversibility and it was observed that when the TIT is greater than 1333K, the compressor, combustor and the gas turbine performance with structural irreversibility gets improved but performance gets deteriorates with structural irreversibility if TIT is less than 1333K.

*Figure 6.14 Effect of compressor pressure ratio on structural irreversibility for components*
Figure 6.15 Effect of compressor isentropic efficiency on structural irreversibility for components

Figure 6.16 Effect of TIT on structural irreversibility for components
Figure 6.17 to Figure 6.19 show the effect on the unit exergetic cost of the fuel for the components. Figure 6.17 shows the effect of the compressor pressure ratio. It was observed that as the compressor pressure ratio is increased unit exergetic cost of fuel for the components increases. Compressor is the most affected component and unit exergetic cost for fuel for it is higher at the higher pressure ratio. Figure 6.18 shows effect of compressor isentropic efficiency on the unit exergetic cost of the fuel for the various components and it was observed that costs are on higher side when the efficiency is about 60% and cost decreases as the efficiency increases and this decrease slight after 80% compressor efficiency. Figure 6.19 shows effect of TIT on the unit exergetic cost of fuel for the components and same pattern was observed in Figure 6.18. At low TIT cost is high and at high TIT cost is low.

![Graph showing the effect of compressor pressure ratio on unit exergetic cost of fuel to components](image)

*Figure 6.17 Effect of compressor pressure ratio on unit exergetic cost of fuel to components*
Figure 6.18 Effect of compressor isentropic efficiency on unit exergetic cost of fuel cost components

Figure 6.19 Effect of TIT on unit exergetic cost of fuel cost for components
Figure 6.20 to Figure 6.22 shows the effect of the compressor isentropic efficiency, compressor pressure ratio and TIT on the ratio of impact on fuel to impact on the fuel for the plant various components.

Figure 6.20 Effect of compressor isentropic efficiency on impact of fuel in various components

Figure 6.21 Effect of compressor pressure ratio on impact on fuel in components
6.5 CONCLUSIONS

Thermoeconomics and so called theory of exergetic cost have been applied to evaluation of 137-MW open cycle gas turbine plant. In particular, the application of the thermoeconomic theory has been applied to the diagnosis of the plant. Plant was allowed to operate at lower efficiency by inducing the malfunctions to components, aiming at what happens to plant components in terms of irreversibility and fuel consumption. The exergetic costs have been calculated for physical flows of plant for design system and for the new state of system; additional irreversibilities and Impact of fuel were also calculated. It has been observed that exergy can be saved by thermoeconomic analysis. If unit cost of fuel is known, potential of economic saving can be estimated by eliminating its malfunction. The maximum unit exergetic cost of the fuel is for the compressor and therefore is a critical component and even if the plant operates at lower efficiency due to the malfunctioning of the components, the compressor remains component with the highest unit exergetic cost for the fuel. The impact on the fuels has been calculated and maximum incremental irreversibility in the plant is attributed to the malfunctioning of the combustor. If the plant operates at low TIT and compressor isentropic efficiency than
designed value, the unit exergetic cost of the fuel for the components increases whereas at low the compressor pressure ratio than designed pressure ratio, the unit exergetic cost of fuel for all components decreases.

The effects of the variation of compressor pressure ratio, compressor isentropic efficiency and turbine inlet temperature (TIT) has been studied on additional irreversibility, endogenous irreversibility, structural irreversibility, unit exergetic of fuel for various components and impacts on fuel in the components. At compressor pressure ratio less than the designed one, additional irreversibility improves, endogenous irreversibility deteriorates for the combustor and gas turbine, structural irreversibility improves for combustor and compressor, unit exergetic cost decreases for all components and improved impacts on fuels for all components has been observed. For the compressor isentropic efficiency less than the designed, higher additional irreversibility for all components, endogenous irreversibility improves for combustor and gas turbine, structural irreversibility deteriorates for all components, high unit exergetic cost of fuel and deteriorated impact on fuel for all components has been observed. Similarly for turbine inlet temperature less than the designed one, higher additional irreversibility for all components, deteriorated additional irreversibility for the combustor and gas turbine, highly deteriorated structural irreversibility for all components, high unit exergetic of fuel cost for all components and deteriorated impact on fuel for all components has been observed.