Exergoeconomic Parameters for Generator

The Appendix deals with a sample calculation for the estimation of various exergoeconomic parameters for a typical component of AAVAR system like generator. Similar procedure of calculation may be followed for the estimation of the parameters for other components of the AAVAR plant. Firstly, the cost balance equation for the generator is written as given in Section D1. The exergoeconomic parameters such as relative cost difference and exergoeconomic factor are estimated using average product cost, exergy loss cost and exergy destruction cost and are described in Section D2.

D.1 Cost Balance Equation

For generator, exergetic cost associated with stream 1 and for 4 is the input cost whereas the cost associated with stream 2 and 3 is the output cost. If c_1 is the unit exergy cost in ₹/kJ and $\dot{E}_1$ is the exergy flow in kW then $c_1 \dot{E}_1$ will be the cost flow in ₹/sec. By cost flow balance

$$c_1 \dot{E}_1 + c_4 \dot{E}_4 - c_2 \dot{E}_2 - c_3 \dot{E}_3 + \dot{C}_s + \dot{Z}_g = 0 \qquad \text{(D1.1)}$$

All the terms in the above equation are in ₹/s.

For generator, flow 2 and 3 are the product. As per reference, unit exergy cost of each product is same. So net product [3-(1+4)] and [2-(1 + 4)]. So unit exergy cost is defined as $(cE_x)/E_x$

$$\frac{c_3 \dot{E}_3 - (c_1 \dot{E}_1 + c_4 \dot{E}_4)}{\dot{E}_3 - (\dot{E}_1 + \dot{E}_4)} = \frac{c_2 \dot{E}_2 - (c_1 \dot{E}_1 + c_4 \dot{E}_4)}{\dot{E}_2 - (\dot{E}_1 + \dot{E}_4)} \qquad \text{(D1.2)}$$

Similar equations for other component are also developed. By solving all the equations using EES software, unit exergy cost of all the flows are calculated as shown in Table 5.8.

D.2 Exergoeconomic Parameters

To calculate fuel cost and product cost for generator, steam is the fuel so average steam cost c_F is calculated as follows:

$$c_{F,G} = \frac{\dot{C}_{F,G}}{\dot{E}_{F,G}} \qquad \text{(D2.1)}$$

$\dot{C}_{F,G}$ is the cost of steam taken from industry which is 0.9 ₹/kg. Mass flow rate of steam is 3.139 kg/s.

$\dot{C}_{F,G} = 3.139 \times 0.9$ (kg/sec × ₹/kg = ₹/sec)

= 2.83 ₹/sec

Exergy of steam ($\dot{E}_{F,G} = \dot{E}_{19} - \dot{E}_{20}$) where $\dot{E}_{19}$ exergy of inlet steam and $\dot{E}_{20}$ for exit from Table 5.3

$\dot{E}_{F,G} =$ (39469 kW − 37830 kW)

= 1640 kW

$c_{F,G} = 2.83/1640$ (₹/kJ)

= 1.724 ₹/MJ

The product of generator is 2 and 3 where 1 and 4 are input. The cost of product from generator

$$\dot{C}_{P,G} = c_2 \dot{E}_2 + c_3 \dot{E}_3 - c_1 \dot{E}_1 - c_4 \dot{E}_4$$

Where c_1, c_2, c_3, c_4 are unit exergy costs and $\dot{E}_1, \dot{E}_2, \dot{E}_3, \dot{E}_4$ are exergy flows from Table 5.8

$c_1 = 0.002949$ ₹/kJ $\quad \dot{E}_1 = 102220$ kW

$c_2 = 0.002934$ ₹/kJ $\quad \dot{E}_2 = 50806$ kW

$c_3 = 0.002936$ ₹/kJ $\quad \dot{E}_3 = 53329$ kW

$c_4 = 0.003655$ ₹/kJ $\quad \dot{E}_4 = 352.4$ kW

So product $\dot{C}_{P,G} = 2.904$ ₹/sec

The average product cost for generator is given by

$$c_{P,G} = \frac{\dot{C}_{P,G}}{\dot{E}_{P,G}} \tag{D2.2}$$

$\dot{E}_{P,G}$ is the exergy of the product and given by

$$\dot{E}_{P,G} = \dot{E}_2 + \dot{E}_3 - \dot{E}_1 - \dot{E}_4$$

$\dot{E}_{P,G}$ = 1563 kW

$c_{P,G}$ = 2.904/1563 (₹/sec)/(kJ/sec) = 1.86 ₹/MJ

The cost of exergy destruction for generator is given by

$$\dot{C}_{D,G} = c_{F,G}\,\dot{E}_{D,G}$$

$c_{F,G}$ = 1.724 ₹/MJ as above and $\dot{E}_{D,G}$ = 76.43 kW from Table 5.5. Then, cost of exergy destruction for generator

$\dot{C}_{D,G}$ = 1.724 × 76.43 (₹/MJ × kJ/sec) = 474.3 ₹/hr

Loss from the generator is zero. Loss is there only in condenser assembly so

$\dot{C}_{L,G} = c_{F,G}\,\dot{E}_{L,G}$, $\dot{C}_{L,G} = 0$

Relative cost difference, r

$$r_G = \frac{c_{P,G} - c_{F,G}}{c_{F,G}} \tag{D2.3}$$

$$r_G = \frac{1.858 - 1.724}{1.724}$$

$r_G = 7.817\%$

Exergoeconomic factor

$$f_G = \frac{\dot{Z}_G}{\dot{Z}_G + (\dot{C}_{D,G} + \dot{C}_{L,G})} \tag{D2.4}$$

$$f_G = \frac{278}{278 + (474.3 + 0)}$$

$f_G = 36.96\%$