Calculation for Exergy Parameters in Generator

This Appendix gives a sample calculation for the estimation of various exergy flow parameters such as fuel exergy, product exergy, exergy loss, exergy destruction, exergy destruction ratio, and exergetic efficiency in the generator. Appendix B1 gives the estimation of exergy at station 1. The sample calculation for various exergy related parameters in generator is given in Appendix B2. Similar calculations can be carried out for other components of the AAVAR system and pre-coolers 1 and 2.

B1 Total Exergy at Station 1

To calculate total exergy at state point 1, the values of mass flow rate of working fluid (strong solution), enthalpy and entropy at station 1 are taken from Table 5.1:

$m_1 = 18.28$ kg/sec

$h_1 = 292.80$ kJ/kg

$s_1 = 1.3760$ kJ/kgK

The enthalpy and entropy of the aqua ammonia solution at reference state (1.01 bar, 298.1 K) are found using EES and are estimated as follows:

$h_{01} = -67.73$ kJ/kg

$s_{01} = 0.3158$ kJ/kgK

Using the Eq.B1.1, the physical exergy at station 1 is calculated.

$$\dot{E}_1^{PH} = \dot{m}_1\left[\left(h_1 - h_{01}\right) - T_0(s_1 - s_{01})\right] \tag{B1.1}$$

$$E_1^{PH} = 18.28\ [((292.80) - (-67.73)) - 298.15(1.3760 - 0.3158)]$$

$$E_1^{PH} = 811.9 \text{ kW}$$

The chemical exergy at station 1 can be calculated using Eq.B1.2

$$\dot{E}_1^{CH} = \dot{m}_1\left[\left(\frac{x_1}{M_{NH_3}}\right)e^0_{CH,NH_3} + \left(\frac{1-x_1}{M_{H_2O}}\right)e^0_{CH,H_2O}\right] \tag{B1.2}$$

From Table 5.1 and Table 5.2

$x_1 = 0.27$

$$\dot{E}_1^{CH} = 18.28\left[\left(\frac{0.27}{17}\right)341250 + \left(\frac{1-0.27}{18}\right)3120\right]$$

$\dot{E}_1^{CH} = 101407$ kW Then the total exergy at station 1 is

$$\dot{E}_1 = 811.9 + 101407$$

$$\dot{E}_1 = 102219 \text{ kW}$$

B2 Estimation of Exergy Parameters at Generator

Fuel exergy,

$$\dot{E}_{F,G} = \dot{E}_{19} - \dot{E}_{20}$$

$$\dot{E}_{F,G} = 39469 - 37830$$

$$\dot{E}_{F,G} = 1640 \text{ kW}$$

Product exergy,

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

$$\dot{E}_{P,G} = 50806 + 53329 - 102220 - 352.4$$

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

Exergy loss $\dot{E}_{L,G} = 0$

Exergy destruction

$$\dot{E}_{D,G} = \dot{E}_{F,G} - \dot{E}_{P,G} - \dot{E}_{L,G}$$

$$\dot{E}_{D,G} = 1640 - 1563 - 0$$

$$\dot{E}_{D,G} = 76.43 \text{ kW}$$

$$Y_{D,G} = \dot{E}_{D,G} / \dot{E}_{F\,\text{tot}}$$

Total Exergy Input

$$\dot{E}_{\text{in tot}} = \dot{E}_{F,G} + \dot{E}_{F,sp} + \dot{E}_{F,pc1} + \dot{E}_{F,pc2}$$

$$\dot{E}_{\text{in tot}} = 1639 + 38.59 + 325.9 + 608.7$$

$$\dot{E}_{\text{in tot}} = 2612.19 \text{ kW}$$

First Destruction Ratio

$$Y_{D,G} = \dot{E}_{D,G} / \dot{E}_{\text{F tot}} \quad \text{(B2.1)}$$

$$Y_{D,G} = 76.43 / 2612.19$$

$$Y_{D,G} = 2.93\%$$

Second Destruction Ratio

$$Y^{*}_{D,G} = \dot{E}_{D,G} / \dot{E}_{D,tot} \quad \text{(B2.2)}$$

$$\dot{E}_{D,tot} = 1818.59 \text{ kW}$$

$$Y^{*}_{D,G} = 76.43 / 1818.59$$

$$Y^{*}_{D,G} = 4.20\ \%$$

Exergy Loss Ratio

$$Y_{L,G} = \dot{E}_{L,G} / \dot{E}_{\text{F tot}} \quad \text{(B2.3)}$$

$$Y_{L,G} = 0$$

Exergetic Efficiency

$$\varepsilon_{G} = \dot{E}_{P,G} / \dot{E}_{F,G} \quad \text{(B2.4)}$$

$$\varepsilon_{G} = 1563 / 1640$$

$$\varepsilon_{G} = 95.30\%$$