\[ T_2 = T_1 \times \left( \frac{p_2}{p_1} \right)^{\frac{k-1}{k}} = 303 \times \left( \frac{150}{450} \right)^4 = 195.3 \text{K} \]

\[ \frac{p_1 V_1}{p_2 V_2} = \frac{m_1 RT_1}{m_2 RT_2} \]

\[ m_2 = m_1 \frac{T_1}{T_2} \times \frac{p_2}{p_1} = 4 \text{kg} \times \frac{303}{195.3} \times \frac{150}{450} = 2.068 \text{kg} \]

\[ s_{2is} = s_1 = 6.7240 \]

\[ x_{2is} = \frac{s_{2is} - s_f}{s_{fg}} \quad @ \text{30kPa} \]

\[ x_{2is} = \frac{6.7240 -.9439}{6.8247} = .8469 \]

\[ h_{2is} = h_f + x \times h_{fg} \]

\[ h_{2is} = 289.23 + .8469 \times 2336.1 = 2267.7 \text{kJ/kg} \]

\[ \eta_{turbine} = \frac{h_1 - h_2}{h_1 - h_{2is}} \]

\[ h_2 = h_1 - \eta \times (h_1 - h_{2is}) \]

\[ h_2 = 3398.3 - .9 \times (3398.3 - 2267.76) \]

a) \( h_2 = 2380.81 \text{kJ/kg}, \quad T_{2is} = T_{sat} \quad @ \text{30 kPa} = 69.1 \text{C} \)

b) \( W_{turbine} = m \times (h_1 - h_2) = 3 \text{kg/sec} \times (3398.3 - 2308.8) = 3052.5 \text{kJ/sec} \)
6-103

\[ p_{r2} = p_{rl} \times \left( \frac{p_2}{p_1} \right) = 1.386 \times \left( \frac{600}{95} \right) = 8.75 \]

@ \( p_{r2} = 8.57 \) Table A – 17 \( T_{2is} = 503.85 \), \( h_{2is} = 507 \).

\[ \eta = \frac{h_{2is} - h_1}{h_2 - h_1} = \frac{503.85 - 300.19}{555.74 - 300.19} = 79.7\% \]

6-106

\[ \eta_{nozzle} = \frac{V_{2is}^2}{V_2^2} \]

\[ h_1 + \frac{V_1^2}{2gJ} = h_2 + \frac{V_2^2}{2gJ} \]

\[ h_1 - h_2 = \frac{V_2^2}{2gJ} \]

\[ \eta_{nozzle} = \frac{h_1 - h_2}{h_1 - h_{2is}} \]

\[ \eta_{nozzle} = \frac{V_2^2}{2gJ} \]

\[ h_{2is} = h_1 - \frac{V_2^2}{2gJ \eta} = 363.89 - \frac{800^2}{2 \times 32.2 \times 778 \times 0.9} = 349.7 \text{ BTU/lb} \]

\[ h_2 = h_1 - \frac{V_2^2}{2gJ \eta} = 363.89 - \frac{800^2}{2 \times 32.2 \times 778} = 351.12 \text{ BTU/lb} \]

@ \( h_2 = 351.12 \), \( T_2 = 1431 \text{ R} \)

\[ p_2 = p_1 \times \left( \frac{T_2}{T_1} \right)^{\frac{k}{k-1}} = \left( \frac{h_2/c_p}{h_1/c_p} \right)^{\frac{k}{k-1}} = 60 \times \left( \frac{349.74}{363.89} \right)^{3.5} = 52.2 \text{ psia} \]
\[ Q_{\text{lost by glycol}} = Q_{\text{gained by water}} \]
\[ (m \times c_p \times \Delta T)_{\text{glycol}} = (m \times c_p \times \Delta T)_{\text{water}} \]
\[ m_{\text{water}} = \frac{2 \text{ kg/sec} \times 2.56 \times (80 - 40)}{4.18 \times (55 - 20)} = 1.4 \text{ kg} \]

Both streams are at a constant pressure.

\[ \Delta S_{\text{glycol}} = m \times c_p \ln \left( \frac{T_2}{T_1} \right) = 2 \text{ kg/sec} \times 2.56 \times \ln \left( \frac{40 + 273}{80 + 274} \right) = -0.6158 \text{ kJ/K} \]
\[ \Delta S_{\text{water}} = m \times c_p \ln \left( \frac{T_2}{T_1} \right) = 1.4 \text{ kg/sec} \times 4.18 \times \ln \left( \frac{55 + 273}{20 + 274} \right) = 0.6603 \text{ kJ/K} \]

\[ S_{\text{generated}} = \Delta S_{\text{glycol}} + \Delta S_{\text{water}} = -0.6158 \text{ kJ/K} + 0.6603 \text{ kJ/K} = 0.0445 \text{ kJ/K sec} \]
6-130

\[ W = m \times (h_2 - h_1) - Q \]

\[ 4000 = 6.944 \text{ kg/sec} \times (3272 - 2645.9) - Q \]

\[ Q = 347.6 \text{ kJ/sec} \]

\[ S_{\text{generated}} = \Delta S_{\text{steam}} + \Delta S_{\text{heatloss}} \]

\[ S_{\text{generated}} = m \times (s_1 - s_2) + \frac{Q}{T} \]

\[ S_{\text{generated}} = 6.944 \text{ kg/sec} \times (7.5939 - 6.5551) + \frac{347.6}{25 + 273} \]

\[ S_{\text{generated}} = 7.213 + 1.166 = 8.37 \text{ kJ/K sec} \]