ME 200 Homework 10

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1.

$$\begin{aligned} m_1 + m_2 &= 80 \\ m_1 &= 80 - m_2 \\ m_1 h_1 + m_2 h_2 &= m_3 h_3 \\ m_1(150 - 86) + (80 - m_1)(2552.2) &= 80(561.47) \\ m_1 &= 66.32\text{kg/s} \\ m_2 &= 13.68 \\ s_{in} - s_{out} + s_{gen} &= \Delta s_{sys} \\ m_1 s_1 + m_2 s_2 - m_3 s_3 + s_{gen} &= 0 \\ s_{gen} &= 9.5102\text{kw/k} \end{aligned}$$

2. a)

$$\begin{aligned} m &= \rho_1 A_1 V_1 \\ &= \frac{P_1}{RT_1} A_1 V_1 \\ &= \frac{200}{0.287 \times 325} \\ &= 0.5\text{kg/s} \\ m(h_1 + v_1^2/2) &= m(h_2 + v_2^2/2) \\ v_2 &= 256.072\text{m/s} \end{aligned}$$

b)

$$\begin{aligned} s_{gen} &= m(s_2^\circ - s_1^\circ - R(\ln(P_2/P_1))) \\ &= 0.14385\text{kW/K} \end{aligned}$$

3. a)

$$Q + W + m((h_1 - h_2) + \frac{v_1^2 - v_2^2}{2} + g(z_1 - z_2)) = 0$$

$$\begin{aligned} Q &= -10.85 - 0.11667(241.30 - 324.01) \\ &= -1.20047 \text{ kW} \end{aligned}$$

b)

$$\begin{aligned} s_{gen} &= \frac{Q}{T} + m(s_2 - s_1) \\ &= \frac{1.20047}{323} + 0.11667(1.0707 - 0.9253) \\ &= 0.0206\text{kW/K} \end{aligned}$$

c)

$$\begin{aligned} s_{gen} &= \frac{Q}{T} + m(s_2 - s_1) \\ &= \frac{1.20047}{300} + 0.11667(1.0707 - 0.9253) \\ &= 0.0209\text{kW/K} \end{aligned}$$

4.

$$\begin{aligned} h_2 &= h_f + xh_{fg} \\ &= 2392.54 \\ s_2 &= s_f + xs_{gf} \\ &= 7.5488 \end{aligned}$$

a)

$$m = \frac{Q_1}{v_1} = 0.36/0.38378 = 9.38\text{kg/s}$$

b)

$$\begin{aligned} w(h_2 - h_1) &= 9.38(3625.8 - 2392.54) \\ &= 11.568\text{MW} \end{aligned}$$

c)

$$\begin{aligned} s_{gen} &= m(h_2 - h_1) \\ &= 9.38(7.5488 - 6.9045) \\ &= 6.0435 \text{ kW/K} \end{aligned}$$

d)

$$\begin{aligned} s_1 = s_2 &= 6.9045 \\ s_2 &= s_g + xs_{gf} \\ x &= 0.8341 \\ h_2 &= 2187.10 \\ \eta &= \frac{w}{m(h_2 - h - 2)} \\ &= 11567.98/13495.01 \\ &= 85.72\% \end{aligned}$$

5. a)

$$w_{in} = (h_2 - h_1)/m = 197.6 \text{ kJ/kg}$$

b)

$$\begin{aligned} s_{gen} = \Delta S &= \frac{1}{m}(s_2^\circ - s_1^\circ - R\ln(P_2/P_1)) \\ &= 0.06 \text{ kJ/kg}\cdot \text{ K} \end{aligned}$$

c)

$$\begin{aligned} s_2^\circ - s_1^\circ - R\ln(P_2/P_1) &= 0 \\ s_2^\circ - 213.915 - 8.314\ln(10) &= 0 \\ s_2^\circ &= 233.06 \\ h_{2s} &= 166.174 \\ \eta &= \frac{h_{2s} - h_1}{h_2 - h_1} \\ &= 84.95\% \end{aligned}$$