ME 200 Homework 9

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1.

$$\begin{aligned} Q &= m(u_2 - u_1) + W \\ &= 1(458.8 - 496.7) + 42.4 \\ &= 4.5\text{kJ} \\ \sigma &= m(s_2 - s_1) - \frac{Q}{T} \\ &= 0.0264\text{kJ/K} \\ 0.0264 &> 0 \end{aligned}$$

It is possible that it is correct.

2. a)

$$\begin{aligned} W_{electric} &= W_{output} + Q \\ W_{electric} &= IV \\ &= 2990\text{kW} \\ W_{output} &= T\omega \\ &= 16700 \times \frac{2\pi \cdot 1800}{60} \\ &= 3147.87\text{kW} \\ Q &= -hA(T_b - T_0) \\ &= -\frac{3520(T_b - 298)}{1000}\text{kW} \\ W_{electric} &= W_{output} + Q \\ 2990 &= 3147.87 - 3520(T_b - 290)/10^3 \\ T_b &= 342.85 \end{aligned}$$

b)

$$\begin{aligned}\sigma &= \frac{Q}{T} \\ &= hA(T_b - T_0)/T_b \\ &= \frac{110 \times 32(342.85 - 298)}{342.85} \\ &= 0.4604\text{kW/K}\end{aligned}$$

3.

$$\begin{aligned}m_L &= \frac{P_L V_L}{RT_L} \\ &= 0.9526\text{lb} \\ m_R &= \frac{P_R V_R}{RT_R} \\ &= 2.0455\text{lb} \\ M_{tot} &= m_L + m_R \\ &= 2.99814 \\ \Delta U &= 0 \\ U_2 &= U_1 \\ U_2 &= \frac{m_L u_L + m_r U_r}{m_t ot} \\ &= \frac{0.9526 \times 85.20 + 2.04554 \times 115.67}{2.99814} \\ &= 103.94\end{aligned}$$

by checking the table:

$$T_2 = 149.3 \quad ^\circ F$$

$$\begin{aligned}P_2 &= \frac{m_{tot} R T_2}{v_{tot}} \\ &= \left((2.99814 \times \frac{1545}{28.97} \times 609.3) \div (12 + 10) \right) \times \frac{1}{144} \\ &= 30.76\text{lbf/in}^2\end{aligned}$$

$$
\begin{aligned}
s_2 - s_L &= s^\circ(T_2) - s^\circ(T_L) - R\ln(\frac{P_2}{P_L}) \\
&= (0.662973 - 0.58233) - \frac{1545}{98.97} \times \frac{1}{778}\ln(\frac{30.75}{14.7}) \\
&= -0.00319199 \\
s_2 - s_R &= s^\circ(T_2) - s^\circ(T_R) - R\ln(\frac{P_2}{P_R}) \\
&= 0.01403387 \\
\Delta s &= m_L \delta s_L + m_R \Delta s_R \\
&= 0.0256\text{Btu}/^\circ F
\end{aligned}
$$

4.

$$
\begin{aligned}
E_{in} - E_{out} &= \Delta E_{sys} \\
Q_c + W_c - Q_H &= 0 \\
Q_c + 3.2 - 15 &= 0 \\
Q_c &= 11.8\text{kW} \\
s^\circ_{in} - s^\circ_{out} + s^\circ_{gen} = \Delta s^\circ_{sys} \frac{Q_c}{T_{out}} - \frac{Q_H}{T_{in}} + s^\circ_{gen} &= 0 \\
s^\circ_{gen} &= 0.003436 > 0
\end{aligned}
$$

Thus it is valid.

5.

$$
\begin{aligned}
\frac{T_2}{T_1} &= \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \\
\text{for air, it is } 1.4& \\
T_2 &= 674.78\text{K} \\
mh_1 &= mh_2 + W \\
h &= c_p T \\
c_p T_1 &= c_p T_2 + W \\
W &= c_p T_1 - c_p T_2 \\
&= 527.8461 \text{ kJ/kg}
\end{aligned}
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