ME 200 Homework 11

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1. a)

$$\begin{aligned} P &= m[(h_1 - h_2) - (h_3 - h_4)] \\ &= 595.54 \text{ kW} \end{aligned}$$

b)

$$\begin{aligned} \eta_R &= \frac{P}{\dot{Q}} \\ &= \frac{P}{m(h_1 - h_4)} \\ &= 25.81\% \\ \eta_C &= \frac{P}{m(h_1 - h_4)} \\ &= 29.92\% \\ P_C &= m[(h_1 - h_2) - (h_4' - h_3')] \\ &= 470.1 \text{ kW} \end{aligned}$$

Carnot cycle efficiency has been improved, But the power output has been decreased.

2. a)

$$\begin{aligned} 0 &= \dot{Q} + \dot{m}(h_4 - h_1) \\ \frac{\dot{Q}}{\dot{m}} &= (h_1 - h_4) \\ &= 3155.5 \text{ kJ/kg} \end{aligned}$$

b)

$$\begin{aligned} \eta &= \frac{\dot{W}_t + \dot{W}_p}{\dot{Q}} \\ &= \frac{\dot{m}(h_1 - h_2) + \dot{m}(h_3 - h_4)}{\dot{Q}} \\ &= 32.8\% \end{aligned}$$

c)

$$\begin{aligned} 0 &= \dot{Q} + \dot{m}(h_1 - h_3) \\ \frac{\dot{Q}}{\dot{m}} &= (h_3 - h_2) \\ &= -2120.6 \text{ kJ/kg} \end{aligned}$$

3. a)

$$\begin{aligned} \dot{E}_{in} + \dot{E}_{out} &= 0 \\ \dot{m}(h_2 - h_3) &= \dot{m} c_p \Delta T \\ \dot{m} &= 2.4996 \text{kg/s} \end{aligned}$$

b)

$$\begin{aligned} \eta &= \frac{W_T - W_p}{Q} \\ &= \frac{(h_1 - h_2) - (h_4 - h_3)}{h_1 - h_4} \\ &= 31.03\% \end{aligned}$$

4.

$$\begin{aligned} W_t &= \dot{m}[(h_1 - h_2) + (h_3 - h_4)] \\ &= 1580.28 \text{ kW} \\ W_p &= \dot{m}(h_6 - h_5) \\ &= 18.85 \text{kW} \\ W_{net} &= W_t - W_p \\ &= 1561.43 \text{kW} \\ Q_{in} &= \dot{m}(h_1 - h_6) + (h_3 - h_2) \\ &= 4496.88 \text{ kW} \\ \eta_{thermal} &= \frac{W_n}{Q_{in}} \\ &= 34.72\% \end{aligned}$$

5. a)

$$\begin{aligned} q_s &= h_3 - h_2 \\ &= 3320.58 - 697.203 \\ &= 2623.377 \text{ kJ/kg} \end{aligned}$$

b)

$$\begin{aligned}
\dot{Q} &= \dot{W} + KE + Pe + \Delta H \\
0 &= \Delta \dot{H} \\
\dot{m}_1(h_2 - h_b) &= \dot{m}_2(h_a - h_c) \\
f = \frac{\dot{m}_2}{\dot{m}_1} &= \frac{h_2 - h_b}{b_a - h_c} \\
&= 0.2696\eta \qquad\qquad = \frac{W}{\dot{q}} \\
&= \frac{(h_3 - h_a) + (1-f)(h_a - h_4) - (h_b - h_1)}{h_3 - h_2} \\
&= 42.69\%
\end{aligned}$$

c)

$$\begin{aligned}
\dot{Q} &= (\dot{m}_1 - \dot{m}_2)(h_4 - h_1) + \dot{m}(h_d - h_1) \\
\frac{\dot{Q}}{\dot{m}_1} &= 1503.58 \text{ kJ/kg}
\end{aligned}$$