ME 200 Homework 12

James Liu

Due: Nov 22 Edit: November 22, 2024

1.

$$\begin{aligned}\dot{m} &= \frac{P_1 \dot{V}}{R T_1} \\ &= 5.81\end{aligned}$$

a) 6:

$$\begin{aligned}\frac{T_2}{T_1} &= r_p^{\frac{\gamma-1}{\gamma}} \\ T_2 &= 500.55 \text{ K} \\ \frac{T_3}{T_4} &= r_p^{\frac{\gamma-1}{\gamma}} \\ T_4 &= 839.07 \text{ K} \\ \eta &= 1 - \frac{1}{r_p^{\frac{\gamma-1}{\gamma}}} \\ &= 40.06\%\end{aligned}$$

8:

$$\begin{aligned}\frac{T_2}{T_1} &= r_p^{\frac{\gamma-1}{\gamma}} \\ T_2 &= 543.43 \text{ K} \\ \frac{T_3}{T_4} &= r_p^{\frac{\gamma-1}{\gamma}} \\ T_4 &= 772.86 \text{ K} \\ \eta &= 1 - \frac{1}{r_p^{\frac{\gamma-1}{\gamma}}} \\ &= 44.79\%\end{aligned}$$

12:

$$\frac{T_2}{T_1} = r_p^{\frac{\gamma-1}{\gamma}}$$
$$T_2 = 610.18 \text{ K}$$
$$\frac{T_3}{T_4} = r_p^{\frac{\gamma-1}{\gamma}}$$
$$T_4 = 688.32 \text{ K}$$
$$\eta = 1 - \frac{1}{r_p^{\frac{\gamma-1}{\gamma}}}$$
$$= 50.83\%$$

b) 6:

$$r_b = \frac{\dot{m}C_p(T_2 - T_1)}{\dot{m}C_p(T_3 - T_4)}$$
$$= 0.357$$

8:

$$r_b = \frac{\dot{m}C_p(T_2 - T_1)}{\dot{m}C_p(T_3 - T_4)}$$
$$= 0.388$$

12:

$$r_b = \frac{\dot{m}C_p(T_2 - T_1)}{\dot{m}C_p(T_3 - T_4)}$$
$$= 0.436$$

c) 6:

$$W_{net} = mC_p(T_3 - T_2 - T_4 + T_1)$$
$$= 2104.28\text{kW}$$

8:

$$W_{net} = mC_p(T_3 - T_2 - T_4 + T_1)$$
$$= 2240.5\text{kW}$$

12:

$$W_{net} = mC_p(T_3 - T_2 - T_4 + T_1)$$
$$= 2344.38\text{kW}$$

2. a)

$$\begin{aligned} W_t &= \dot{m}(h_3 - h_4) = 82753.993\text{kW} \\ W_c &= \dot{m}(h_2 - h_1) = 25355.488\text{kW} \\ W_{net} &= W_t - W_c = 57.4\text{MW} \end{aligned}$$

b)

$$Q_{in} = m(h_3 - h_2) = 59.7312(2377.7 - 704.6232) = 99934.9 \text{ kW}$$

c)

$$\begin{aligned} \eta &= \frac{P}{Q_{in}} \\ &= 57.44\% \end{aligned}$$

3. a)

$$\begin{aligned} P &= \dot{m}(h_3 - h_4 - h_2 + h_1) \\ 10 \times 10^3 &= \dot{m}(463.5) \\ \dot{m} &= 21.575\text{kg/s} \end{aligned}$$

b)

$$\begin{aligned} Q_s &= \dot{m}(h_3 - h_x) \\ &= 21.575 \times (1574 - 800) \\ &= 16699 \text{ kW} \end{aligned}$$

c)

$$\begin{aligned} \eta &= \frac{P_{net}}{Q_s} \\ &= \frac{10^4}{16699} \\ &= 0.598837\% \end{aligned}$$

4. a)

$$\begin{aligned} W_{t1}/\dot{m} &= h_1 - h_2 = 365.68\text{kJ/kg} \\ W_{t2}/\dot{m} &= h_3 - h_4 = 1277.79 - 906.85 = 370.94 \end{aligned}$$

b)

$$\frac{\dot{Q}}{\dot{m}} = h_3 - h_2 = (1277.79 - 912.11) = 365.7 \text{ kJ/kg}$$

c)

$$
\begin{aligned}
P_{ta} &= \frac{p_a}{p_1} p_{t1} \\
P_{ta} &= 19.833, \Rightarrow h_1 = 638.58 \text{ kJ/kg} \\
\frac{\dot{w}}{\dot{m}} &= (h_1 - h_a) \\
&= 639.21 \text{ kJ/kg} \\
p_{increm} &= \frac{365.68 + 370.94 - 639.2}{639.2} \\
&= 15.2\%
\end{aligned}
$$

5. d)

$$
\begin{aligned}
Q_{in} &= u_3 - u_2 \\
u_3 &= u_2 + Q_{in} \\
&= 1903.06 \\
u_3 &= 1903.06 \\
v_{r3} &= 1.9192 \\
T_3 &= 2231.5 \text{ K}
\end{aligned}
$$

a)

$$
\begin{aligned}
Q_{out} &= u_4 - u_1 \\
&= 892.95 - 214.07 \\
&= 678.88 \text{kJ/kg} \\
W_{net,out} &= Q_{in} - Q_{out} \\
&= 721.12 \text{kJ/kg}
\end{aligned}
$$

b)

$$
\begin{aligned}
\eta &= \frac{W_{net,out}}{p_1} \\
&= 51.51\%
\end{aligned}
$$

c)

$$
\begin{aligned}
v_1 &= \frac{RT_1}{P_1} \\
&= 0.861 \text{ m}^3/kg \\
\bar{P} &= \frac{W_{net,out}}{v_1 - v_2} \\
&= 9.492 \text{bar}
\end{aligned}
$$