ME 200 Homework 13

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1. a)

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^k = r^k$$

$$\frac{7.2 \times 10^3}{95} = r^{1.4}$$

$$r = 22$$

b)

$$\frac{T_2}{T_1} = r^{k-1}$$

$$\frac{T_2}{300} = 22^{1.4-1}$$

$$T_2 = 1032.98\text{K}$$

$$r_c = \frac{T_3}{T_2}$$

$$= \frac{2150}{1032.98}$$

$$= 2.08$$

c)

$$\eta = 1 - \frac{1}{r^{k-1}}\left[\frac{r_c^k - 1}{k(r_c - 1)}\right]$$

$$= 65.66\%$$

d)

$$\text{mep} = \frac{W_{net}}{\Delta V}$$

$$Q_s = C_p(T_3 - T_2) = 1122.605$$

$$Q_r = C_v(T_4 - T_1) = 385.523$$

$$v_1 = \frac{RT_1}{P_1} = \frac{0.287 \times 300}{95} = 0.9063$$

$$v_2 = \frac{v_1}{r} = 0.0412$$

$$\text{mep} = \frac{1122.605 - 385.523}{0.9063 - 0.0412}$$

$$= 852.02 \text{ kPa}$$

2.

$$r = \frac{V_1}{V_2} = 15$$

$$W_{cyc} = Q_{in} - Q_{out}$$

$$= Q_{23} - Q_{41}$$

$$= m[(h_3 - h_2) - (u_4 - u_1)]$$

$$= (6.6205 \times 10^{-3})[(2281.697 - 869.629) - (885.329 - 214.07)]$$

$$= 4.9045\text{kJ/cycle}\eta \qquad\qquad = \frac{W_{cycle}}{Q_{in}}$$

$$= 1 - \frac{u_4 - u_1}{h_3 - h_2}$$

$$= 52.46\%$$

3. a)

$$W = \dot{m}(h_2 - h_1)$$

$$= 0.1167 \times (275.05 - 246.38)$$

$$= 3.34\text{kW}$$

b)

$$Q_{evap} = \dot{m}(h_1 - h_4)$$

$$= 0.1167(246.38 - 95.47)$$

$$= 17.63 \text{ kW}$$

$$\frac{17.63}{3.517} = 5.01 \text{ tone}$$

c)

$$\text{COP} = \frac{Q_{evap}}{W_{comp}} = 5.28$$

4.

134a a)

$$p_{evaporator} = p_1 = 14.718 \text{ lbf/in}^2$$
$$p_{condensor} = p_2 = 161.04 \text{ lbf/in}^2$$

b)

$$\dot{m} = \frac{Q_{in}}{h_1 - h_4}$$
$$= \frac{900}{106.37 - 44.23} \div 60$$
$$= 0.241 \text{ lb/min}$$

c)

$$W_{comp} = \dot{m}(h_2 - h_1)$$
$$= 0.241(137.68 - 106.37) \times \frac{60}{2545}$$
$$= 0.178 \ hp$$

d)

$$\beta = \frac{h_1 - h_4}{h_2 - h_1}$$
$$= \frac{106.37 - 44.23}{137.68 - 106.37}$$
$$= 1.985$$

propane a)

$$p_{evaporator} = p_1 = 28.65 \text{ lbf/in}^2$$
$$p_{condensor} = p_2 = 214.3 \text{ lbf/in}^2$$

b)

$$\dot{m} = \frac{Q_{in}}{h_1 - h_4}$$
$$= \frac{900}{202.2 - 84.56} \div 60$$
$$= 0.1275 \text{ lb/min}$$

c)

$$W_{comp} = \dot{m}(h_2 - h_1)$$
$$= 0.1275(264 - 202.2) \times \frac{60}{2545}$$
$$= 0.186 \ hp$$

d)

$$\begin{aligned} \beta &= \frac{h_1 - h_4}{h_2 - h_1} \\ &= \frac{202.2 - 84.56}{264 - 202.2} \\ &= 1.9 \end{aligned}$$

5. a)

$$\begin{aligned} \dot{m} &= \frac{\dot{Q}_{out}}{h_2 - h_3} \\ &= \frac{20}{276.2 - 93.42} \\ &= 0.1094 \text{ kg/s} \end{aligned}$$

b)

$$\begin{aligned} \dot{W}_{comp} &= \dot{m}(h_2 - h_1) \\ &= 0.1094(276.2 - 241.30) \\ &= 3.818 \text{ kW} \end{aligned}$$

c)

$$\begin{aligned} \eta &= \frac{\dot{Q}_{out}}{\dot{W}_{comp}} \\ &= \frac{20}{3.818} \\ &= 5.238 \end{aligned}$$

$$\begin{aligned} \eta_{carnot} &= \frac{T_H}{T_H - T_C} \\ &= \frac{21 + 273}{21 - 0} \\ &= 14 \end{aligned}$$