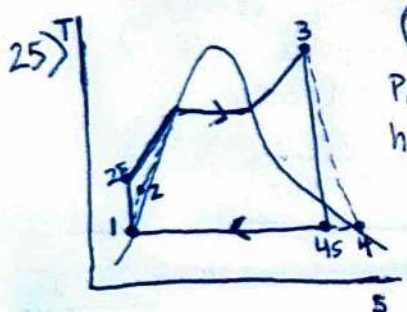
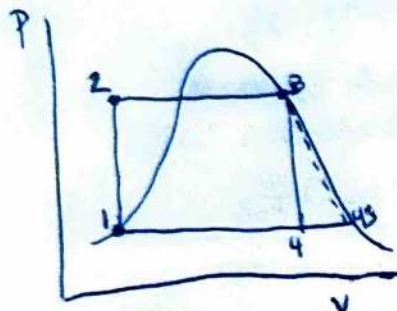
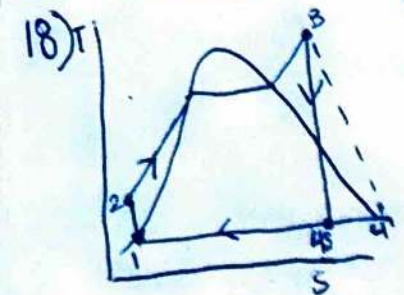


MET 350 - HW 2.1



① $h_1 = 94.02 \frac{\text{Btu}}{\text{lbm}}$ $h_2 = 98.52 \frac{\text{Btu}}{\text{lbm}}$ $T_3 = 800^\circ\text{F}$ $h_{u3} = 876 \frac{\text{Btu}}{\text{lbm}}$

$h_3 = 1363 \frac{\text{Btu}}{\text{lbm}}$ $s_3 = 1.51 \frac{\text{Btu}}{\text{lbm}}$ $s_4 = 1.51 \frac{\text{Btu}}{\text{lbm}}$ $h_4 = 925 \frac{\text{Btu}}{\text{lbm}}$

$h_2 = h_1 + v_1 \cdot (P_H - P_L)$

$h_2 = 94.02 + 0.01623 \cdot (1500 - 2) \cdot \frac{1}{5.464}$

$h_2 = 98.52 \frac{\text{Btu}}{\text{lbm}}$

$P_T = m \cdot (h_3 - h_4)$

$P_T = 5.47 \cdot (1363 - 925)$

$P_T = 2396 \frac{\text{Btu}}{\text{s}}$

$Q_D = m \cdot q_b$

$Q_D = 5.47 \cdot 1264$

$Q_D = 6914 \frac{\text{Btu}}{\text{lbm}}$

$MT = \frac{P}{Q_D}$

$MT = \frac{2500}{6914} \cdot \frac{0.94782}{1}$

$MT = 34\%$

$P = 2500 \text{ kW}$

$q_b = h_3 - h_2$ $q_c = h_4 - h_1$

$q_b = 1363 - 98.52$ $q_c = 925 - 94.02$

$q_b = 1264 \frac{\text{Btu}}{\text{lbm}}$ $q_c = 830.98 \frac{\text{Btu}}{\text{lbm}}$

$w = q_b - q_c = 1264 - 830.98 = 433.02 \frac{\text{Btu}}{\text{lbm}}$

$\dot{m} = \frac{P}{w}$ $\dot{m} = \frac{2500 \frac{\text{kJ}}{\text{s}}}{433.02 \frac{\text{Btu}}{\text{lbm}} \cdot 1 \frac{\text{kJ}}{\text{Btu}}}$

$\dot{m} = 5.47 \frac{\text{lbm}}{\text{s}}$

① $P_1 = 410 \text{ kPa}$ $h_1 = 482.2 \frac{\text{kJ}}{\text{kg}}$

② $P_2 = 3250 \text{ kPa}$ $h_2 = 522.634 \frac{\text{kJ}}{\text{kg}}$

③ $T_3 = 147^\circ\text{C}$ $h_3 = 761.04 \frac{\text{kJ}}{\text{kg}}$ $s_3 = 2.5436 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}$

④ $T_4 = 79.5^\circ\text{C}$ $h_4 = 688.79 \frac{\text{kJ}}{\text{kg}}$ $s_4 = 2.5436 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}$

$h_2 = h_3 - \frac{Q_H}{\dot{m}}$

$h_2 = 761.04 - \frac{72856.81}{305.6}$

$h_2 = 522.634 \frac{\text{kJ}}{\text{kg}}$

b) $W_{\text{net}} = m \cdot (h_3 - h_4) - W_{\text{pump}}$

$W_{\text{net}} = 9722.97 \frac{\text{kJ}}{\text{s}}$

$Q_H = \dot{m} \cdot w \cdot C_p (T_3 - T_6)$

$Q_H = 555.9 \cdot 1.8723 \cdot (433 - 363)$

$Q_H = 72856.81 \frac{\text{kJ}}{\text{s}}$

$W_{\text{pump}} = \frac{W_{\text{pump}}}{\eta_{\text{pump}}}$

$W_{\text{pump}} = \frac{5.226}{0.9}$

$W_{\text{pump}} = 5.807 \frac{\text{kJ}}{\text{kg}}$

$W_{\text{pump},s} = v_1 \cdot (P_2 - P_1)$

$W_{\text{pump},s} = 0.00184 \cdot (3250 - 410)$

$W_{\text{pump},s} = 5.226 \frac{\text{kJ}}{\text{kg}}$

$h_2' = h_1 + W_{\text{pump}}$

$h_2' = 212.38 + 5.807$

$h_2' = 218.187 \frac{\text{kJ}}{\text{kg}}$

c) $\eta_{\text{th}} = \frac{W_{\text{net}}}{Q_H}$

$\eta_{\text{th}} = \frac{(h_3 - h_4) - W_{\text{pump}}}{h_3 - h_2}$

$\eta_{\text{th}} = \frac{(761.04 - 688.79) - 40.434}{761.04 - 522.634}$

$\eta_{\text{th}} = 0.133$

$W_{\text{pump}} = h_2 - h_1$

$W_{\text{pump}} = 522.6 - 482.2$

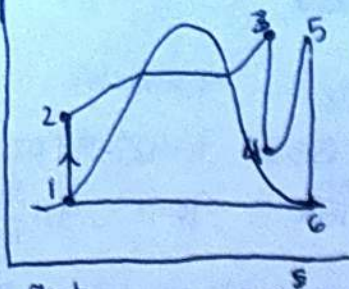
$W_{\text{pump}} = 40.434 \frac{\text{kJ}}{\text{kg}}$

a) $\eta_{\text{s,turb}} = \frac{h_3 - h_4}{h_3 - h_{4s}}$

$\eta_{\text{s,turb}} = \frac{761.04 - 688.79}{761.04 - 669.77}$

$\eta_{\text{s,turb}} = 0.766$

34)



① $h_1 = 251.42 \frac{\text{kJ}}{\text{kg}}$ $v_1 = 0.001017 \frac{\text{m}^3}{\text{kg}}$
 ② $h_2 = 256.48$
 ③ $h_3 = 3008.31 \frac{\text{kJ}}{\text{kg}}$ $T_3 = 328.8^\circ\text{C}$
 ④ $h_4 = 2704.31 \frac{\text{kJ}}{\text{kg}}$ $s_4 = 6.3495 \frac{\text{kJ}}{\text{kgK}}$
 ⑤ $T_5 = 482^\circ\text{C}$ $h_5 = 3438.21 \frac{\text{kJ}}{\text{kg}}$
 ⑥ $h_6 = 2514.62 \frac{\text{kJ}}{\text{kg}}$ $s_6 = 7.6242 \frac{\text{kJ}}{\text{kgK}}$

$$h_2 = h_1 + v_1(p_2 - p_1)$$

$$= (251.42 + 0.001017(5000 - 20))$$

$$h_2 = 256.48$$

$$h_4 = h_{1q,1200} + q_{4\text{heup},1200}$$

$$= (798.33 + 0.96 \cdot 1985.4)$$

$$h_4 = 2704.31 \frac{\text{kJ}}{\text{kg}}$$

$$s_4 = s_{1q,1200} + q_{4\text{heup},1200}$$

$$= (2.2159 + 0.96 \cdot 4.3058)$$

$$s_4 = 6.3495 \frac{\text{kJ}}{\text{kgK}}$$

$$h_6 = h_{1q,20} + q_{6\text{heup},20}$$

$$= (251.42 + 0.96 \cdot 2357.5)$$

$$h_6 = 2514.62 \frac{\text{kJ}}{\text{kg}}$$

$$s_6 = s_{1q,20} + q_{6\text{heup},20}$$

$$= (0.832 + 0.96 \cdot 7.0752)$$

$$s_6 = 7.6242 \frac{\text{kJ}}{\text{kgK}}$$

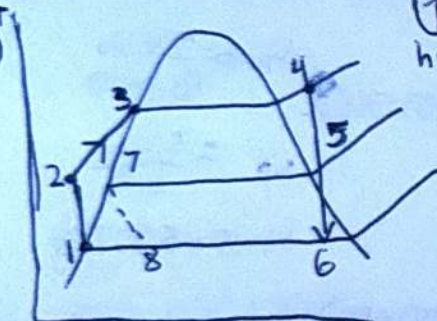
$$\eta = 1 - \frac{q_{\text{out}}}{q_{\text{in}}}$$

$$= 1 - \frac{h_6 - h_1}{h_3 - h_2 + h_5 - h_4}$$

$$= \frac{2514.62 - 251.42}{3008.31 - 256.48 + 3438.21 - 2704.31}$$

$$= 0.351$$

48)



① $h_1 = 251 \frac{\text{kJ}}{\text{kg}}$ $v_1 = 0.00102 \frac{\text{m}^3}{\text{kg}}$
 ② $h_2 = 254.04 \frac{\text{kJ}}{\text{kg}}$
 ③ $h_3 = 764 \frac{\text{kJ}}{\text{kg}}$ $p_3 = 800 \text{ kPa}$
 ④ $h_4 = 3120 \frac{\text{kJ}}{\text{kg}}$ $p_4 = 3000 \text{ kPa}$ $T_4 = 350^\circ\text{C}$ $s_4 = 6.740 \frac{\text{kJ}}{\text{kgK}}$
 ⑤ $h_5 = 2850 \frac{\text{kJ}}{\text{kg}}$ $p_5 = 1000 \text{ kPa}$
 ⑥ $h_6 = 2220 \frac{\text{kJ}}{\text{kg}}$ $p_6 = 200 \text{ kPa}$
 ⑦ $h_7 = 763 \frac{\text{kJ}}{\text{kg}}$ $p_7 = 1000 \text{ kPa}$
 ⑧ $h_8 = 763 \frac{\text{kJ}}{\text{kg}}$

$$h_2 = h_1 + v_1(p_2 - p_1)$$

$$h_2 = 251 + 0.00102 \cdot (3000 - 20)$$

$$h_2 = 254.04 \frac{\text{kJ}}{\text{kg}}$$

$$E_s = E_c$$

$$m_s \cdot (h_5 - h_7) = m_c \cdot (h_3 - h_2)$$

$$y \cdot (h_5 - h_7) = (h_3 - h_2)$$

$$y \cdot (2850 - 763) = (764 - 254.04)$$

$$y = 0.2444$$

$$w_{p2} = v_1(p_2 - p_1)$$

$$w_{p2} = 0.00102 \cdot (3000 - 20)$$

$$w_{p2} = 3.04 \frac{\text{kJ}}{\text{kg}}$$

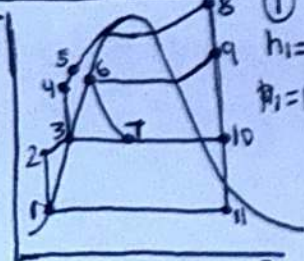
$$q_b = h_4 - h_3 = 3120 - 764 = 2356 \frac{\text{kJ}}{\text{kg}}$$

$$w_t = (h_4 - h_5) + (1 - y)(h_5 - h_6)$$

$$w_t = (3120 - 2850) + (1 - 0.2444)(2850 - 2220)$$

$$w_t = 746.03 \frac{\text{kJ}}{\text{kg}}$$

53)



① $h_1 = 192 \frac{\text{kJ}}{\text{kg}}$ $p_1 = 10 \text{ kPa}$
 ② $h_2 = 192.60$ $p_2 = 600 \text{ kPa}$
 ③ $h_3 = 670 \frac{\text{kJ}}{\text{kg}}$ $p_3 = 600 \text{ kPa}$
 ④ $h_4 = 670.66 \frac{\text{kJ}}{\text{kg}}$ $p_4 = 1200 \text{ kPa}$
 ⑤ $h_5 = 803 \frac{\text{kJ}}{\text{kg}}$ $p_5 = 10000 \text{ kPa}$
 ⑥ $h_6 = 798 \frac{\text{kJ}}{\text{kg}}$ $p_6 = 1200 \text{ kPa}$ $T_6 = 158^\circ\text{C}$
 ⑦ $T_7 = 600^\circ\text{C}$ $p_7 = 400 \text{ kPa}$
 ⑧ $p_8 = 10000 \text{ kPa}$ $T_8 = 10000 \text{ kPa}$
 ⑨ $h_9 = 2670 \frac{\text{kJ}}{\text{kg}}$ $p_9 = 10000 \text{ kPa}$
 ⑩ $h_{10} = 2820 \frac{\text{kJ}}{\text{kg}}$ $p_{10} = 600 \text{ kPa}$
 ⑪ $h_{11} = 2990 \frac{\text{kJ}}{\text{kg}}$ $p_{11} = 10 \text{ kPa}$

$$h_2 = h_1 + v_1(p_2 - p_1)$$

$$h_2 = 192 + 0.00101 \cdot (600 - 10)$$

$$h_2 = 192.60$$

$$h_4 = h_3 + v_3(p_4 - p_3)$$

$$h_4 = 670 + 0.0011 \cdot (1200 - 600)$$

$$h_4 = 670.66 \frac{\text{kJ}}{\text{kg}}$$

$$Z \cdot h_{10} + (1 - y - Z) \cdot h_2 + y \cdot h_7 = 1 \cdot h_3$$

$$Z \cdot 2820 + (1 - y - Z) \cdot 192.60 + y \cdot 798 = 670$$

$$Z = 0.1677$$

$$q_c = (1 - 0.0609 - 0.1677)(2990 - 192)$$

$$q_c = 1541.26 \frac{\text{kJ}}{\text{kg}}$$

$$q_b = h_8 - h_5 = 3670 - 803$$

$$q_b = 2827 \frac{\text{kJ}}{\text{kg}}$$

$$w = q_b - q_c = 2827 - 1541.26 = 1326.74 \frac{\text{kJ}}{\text{kg}}$$

$$m = \frac{P}{w} = \frac{400000}{1326.74} = 301 \frac{\text{kg}}{\text{s}}$$

$$\eta = 1 - \frac{q_c}{q_b} = 1 - \frac{1541.26}{2827} = 45.48\%$$

$$m = 301 \frac{\text{kg}}{\text{s}}$$