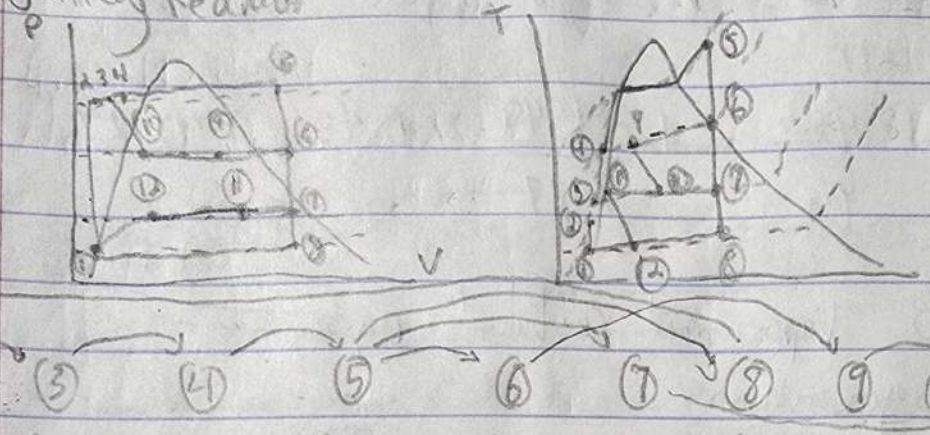
HW 2.2

Jeffrey Redmon

10-57

a)



$P_1 = 20$ kPa $P_2 = 5000$ kPa $h_3 = 5000$ kPa $h_4 = 5000$ kPa $P_5 = 5000$ kPa $P_6 = 40$ kPa $h_7 = 245$ $P_8 = 40$ $P_9 = 40$ $P_{10} = 40$ $P_{11} = 40$ $P_{12} = 245$

$X_1 = 0$ $h_2 = 256.41$ $X_3 = 0$ $h_3 = 533.$ $h_4 = 1191.5$ $T_5 = 700°C$ $h_6 = 3406$ $h_7 = 2918$ $h_8 = 2479$ $h_{10} = 330$ $h_{11} = 533$ $h_{12} = 533$

$T_1 = 60.06°C$ $V_3 = 0.001236$ $h_5 = 3900$ $S_6 = 7.512$ $S_8 = 9.512$ $S_9 = 9.512$ $h_9 = 820$

$h_1 = 251.42$ $T_4 = 263.94$ $S_5 = 7.512$

$V_1 = 0.001017 \, m^3/kg$

$$h_2 = V_1 (P_2 - P_1) + h_1 = 0.001017 (5000 - 20) + 251.42$$

$$h_2 = z h_7 + y h_{10} = h_3 + (y + z) h_{11}$$

b) $$z = \frac{(h_3 - h_2) + y(h_{11} - h_{10})}{h_7 - h_{11}} = \frac{(533 - 256.08) + 0.1446 (533 - 330)}{2918 - 533} = 0.09812$$

$$m_w (h_2 - h_1) = m_8 h_8 + m_{12} h_{12} - m_1 h_1$$

$$m_w = \frac{m_8 ((1 - y - z) h_8 + (y + z) h_{12} - h_1)}{c_p \Delta T}$$

$$m_w = \frac{75 (1 - 0.1446 - 0.09812) 2479 + (0.1446 + 0.09812) 533 - 251}{4.18 \cdot 10}$$

c) $m_w = 3147.6$ kg/s

$$w_T = h_5 - y h_6 - z h_7 - (1 - y - z) h_8$$

$$w_T = 3900 - 0.1446 \cdot 3406 - 0.09812 \cdot 2918 - (1 - 0.1446 - 0.09812) \cdot 2479 = 1295.4 \text{ kJ/kg}$$

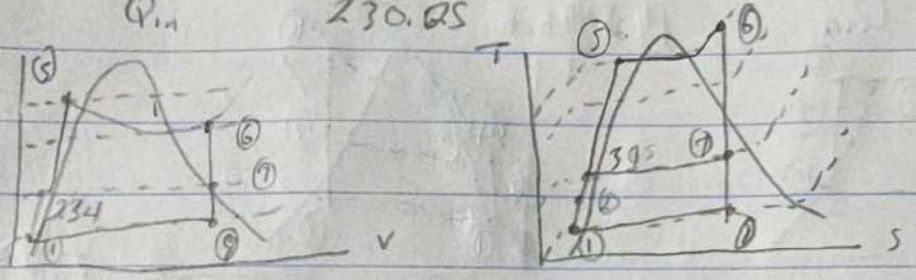
$$w_{net} = 1295 - (0.09812 (5000 - 20)) = 1240.3 \text{ kJ/kg}$$

$\dot{m}W_{net} = 75 \cdot 1240.3 = 93,022.71\ kW = 93.023\ MW$

$Q_{in} = \dot{m}(h_5 - h_4) = 75 \cdot (3960 - 836) = 230,250\ kW = 230.5\ MW$

d) $\eta_{th} = \frac{W_{net}}{Q_{in}} = \frac{93.023}{230.25} = 0.404 = 40.4\%$

10-69



(1) Pump → (2) Turb Pump → (3) Pump → (4) Turb Pump → (5) Pump → (6) Turb EXP → (7) Turb EXP → (8) Pump

(5) Pump

$P_1 = 10kPa$ $P_2 = 1200kPa$ $P_3 = 1200kPa$ $P_4 = 1200kPa$ $P_5 = 7MPa$ $P_6 = 4MPa$ $P_7 = 1200kPa$ $P_8 = 10kPa$

$x_1 = 0$ $h_2 = 193.012$ $T_3 = 187.96$ $h_4 = 804.93$ $T_5 = 285.83$ $T_6 = 500°C$ $s_7 = 7.0422$ $s_8 = 7.6922$

$T_1 = 45.81$ $v_3 = .001138$ $h_5 = 1267.5$ $v_6 = 0.08644$ $h_7 = 368.41$ $h_8 = 2246.8$

$v_1 = 0.001010$ $h_3 = 748.33$ $s_6 = 7.0922$

$h_1 = 191.81$ $h_6 = 3446$

$h_2 = v_1(P_2 - P_1) + h_1 = 0.001010(1200 - 10) + 191.81 = 193.012$

$h_4 = v_3(P_4 - P_3) + h_3 = 0.001138(7000 - 1200) + 748.33 = 804.93$

$x_7 = \frac{s_7 - s_f}{s_{fg}} = \frac{7.0922 - 2.2159}{4.3058} = 1.1325$

$\dot{m}_6 = \frac{1}{4} \cdot 55 = 13.75\ kg/s$ $\dot{m}_7 = \dot{m}_5 - \dot{m}_6 = 55\ kg/s - 13.75 = 41.25$

$W_T = \dot{m}_6(h_6 - h_7) + \dot{m}_8(h_7 - h_8)$

$W_T = 55(3446 - 3081.41) + 41.25(3081.41 - 2246.8) = 54477.6\ kW$

$54.477\ MW$

$W_{p_1} = \dot{m}_1 \cdot w_{p_1} = 41.25 \cdot 1.213 = 50.069\ kW$

$W_{p_2} = \dot{m}_3 \cdot w_{p_2} = 55 \cdot 3.184 = 175.252\ kW$

$W_{net} = W_{T_{in}} - W_{p_1} - W_{p_2} = 54477.6 - 50.069 - 175.252$

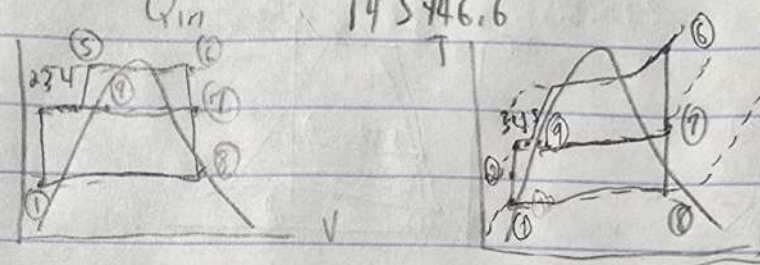
a) $W_{net} = 54252.28\ kW$

$Q_{in} = \dot{m}_6 \cdot q_{in} = 55(h_6 - h_5) = 55(3446 - 801.5164)$

$Q_{in} = 145446.6$ kW

b) $\eta_{th} = \frac{W_{net}}{Q_{in}} = \frac{54252.28}{145446.6} = 0.3730 = 37.3\%$

10-72



1 Isen Pump 2 Pconst 3 Pconst 4 Isen Pump 5 Pconst 6 Isen exp 7 T-const 8 Pconst 4 9 Pconst

$P_1 = 10$ kPa $P_2 = 1.6$ MPa $P_3 = 1.6$ MPa $P_4 = 1.6$ MPa $P_5 = 9$ MPa $P_6 = 9$ MPa $P_7 = 1.6$ MPa $P_8 = 10$ kPa $P_9 = 1.6$ MPa

$h_1 = 191.81$ $h_2 = 193.416$ $h_3 = 858.5$ $h_4 = 858.4$ $h_5 = 867.076$ $T_6 = 400°C$ $x_7 = 0.9675$ $x_8 = 0.7518$ $h_9 = 858.5$

$V_1 = 0.00101$ $V_4 = 0.001159$ $h_6 = 3118.9$ $h_7 = 2729.935$

$S_6 = 6.2876$ $h_8 = 1990.19$

$h_2 = v_1(P_2 - P_1) + h_1 = 0.00101(1600 - 10) + 191.81 = 193.416$

$h_5 = v_4(P_5 - P_4) + h_4 = 0.001159(9000 - 1600) + 858.5 = 867.076$

$S_7 = S_f + x_7(S_{fg}) = 6.2876 = 2.3435 + x_7(4.0764)$

$x_7 = 0.9675$

$h_7 = h_f + x_7(h_{fg}) = 858.5 + 0.9675(1934.2)$

$h_7 = 2729.935$ kJ/kg

$S_8 = S_f + x_8(S_{fg}) = 6.2876 = 0.6492 + x_8(7.4996)$

$x_8 = 0.7518$

$h_8 = h_f + x_8(h_{fg}) = 191.81 + 0.7518(2,392.1) = 1990.19$ kJ/kg

$W_T = (h_6 - h_7) + (1 - m)(h_7 - h_8)$

$= (3118.9 - 2729.735) + (1 - 0.35)(2729.935 - 1990.19)$

$W_T = 869.67$ kJ/kg

$W_p = (1 - m)w_{p1} + w_{p2} = (1 - 0.35)(193.416 - 191.81) + (867.076 - 858.4)$

$W_p = 9.6197$ kJ/kg

$W_{net} = W_T - W_p = 869.69 - 9.5149 = 860$ KJ/Kg

$P = \dot{m} \cdot W_{net} = \frac{25000\ kw}{860} = \dot{m} \cdot \frac{860}{860}$ KJ/Kg

$\dot{m} = 29.1$ Kg/s