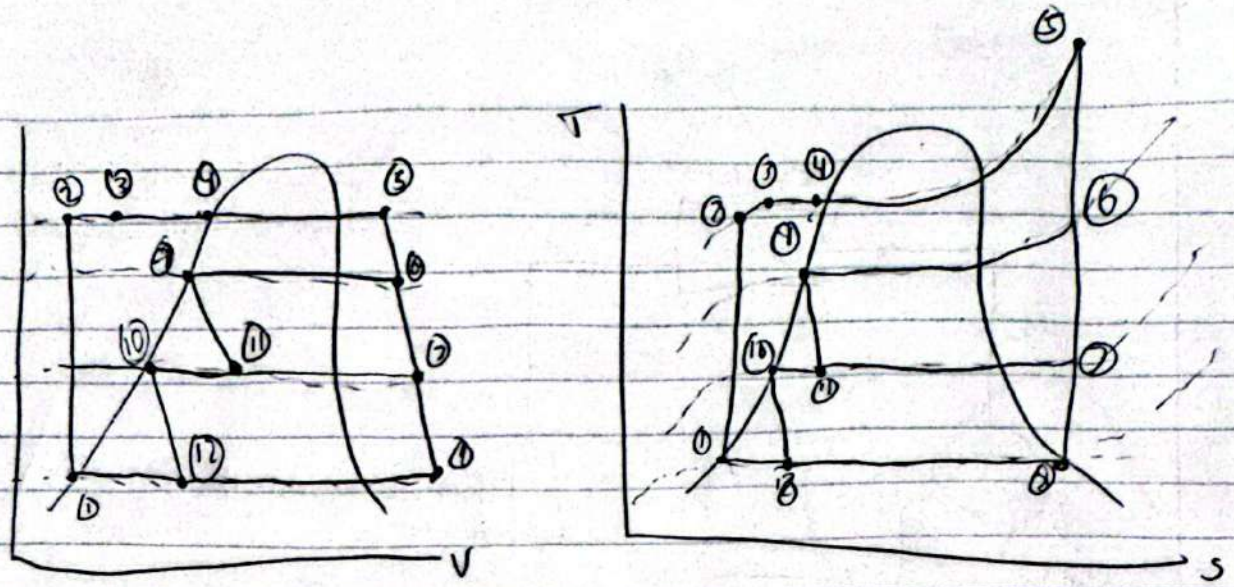
10-57



① $P_1 = 70\,kPa$ $h_1 = 251.4$ $v_1 = .001017$

② $P_2 = 5\,MPa$ $h_2 = 256.48$

③ $P_3 = P_2$ $h_3 = 537$

④ $P_4 = P_2$ $h_4 = 829.96$

⑤ $P_5 = P_2$ $T_5 = 700°C$ $h_5 = 3900.3$ $s_5 = 7.5136$

⑥ $P_6 = 1.4\,MPa$ $h_6 = 3406$ $s_6 = s_5$

$h_2 - h_1 = v_1(P_2 - P_1)$

⑦ $P_7 = 245\,kPa$ $h_7 = 2911.6$ $s_7 = s_6$

⑧ $P_8 = 70\,kPa$ $h_8 = 2477$ $s_8 = s_7$

⑫ $P_{12} = P_1$ $h_{12} = 533$

⑨ $P_9 = 1.4\,MPa$ $h_9 = 829.96$ see sig table

⑩ $P_{10} = 245$ $= h_{10} = 829.96$

⑪ $P_{11} = P_{10}$ $h_{11} = 533$ sat liquid

1st law $h_3 - h_2 = z(h_7) + y(h_{10}) - (z+y)(h_{12}) \rightarrow h_3 = (62.75 - 120.3 = 01)$

$h_3 = 533$

$h_4 - h_3 = y\,(h_8 - h_9)$

$y(h_{10}) + z(h_7 + h_2 = (y+z)h_{12} + h_4 \quad h_4 = 829.95$

$$\dot{m}_{wat} = \frac{\dot{m}_a(1-y-z)h_8 + (y+z)h_{12} - h_1)}{C_p \cdot \Delta T} = \frac{75(1075.93 + 179 - 251.17)}{4.1 \cdot 10}$$

$$\dot{m}_{wat} = 31.96$$

$$W_{out} = h_5 - yh_6 - zh_3 - (1-z-y)h_8 = 3900.3 - 497.5 - 286.186 - 1075.83 + 2$$

$$W_{out} 1245.712$$

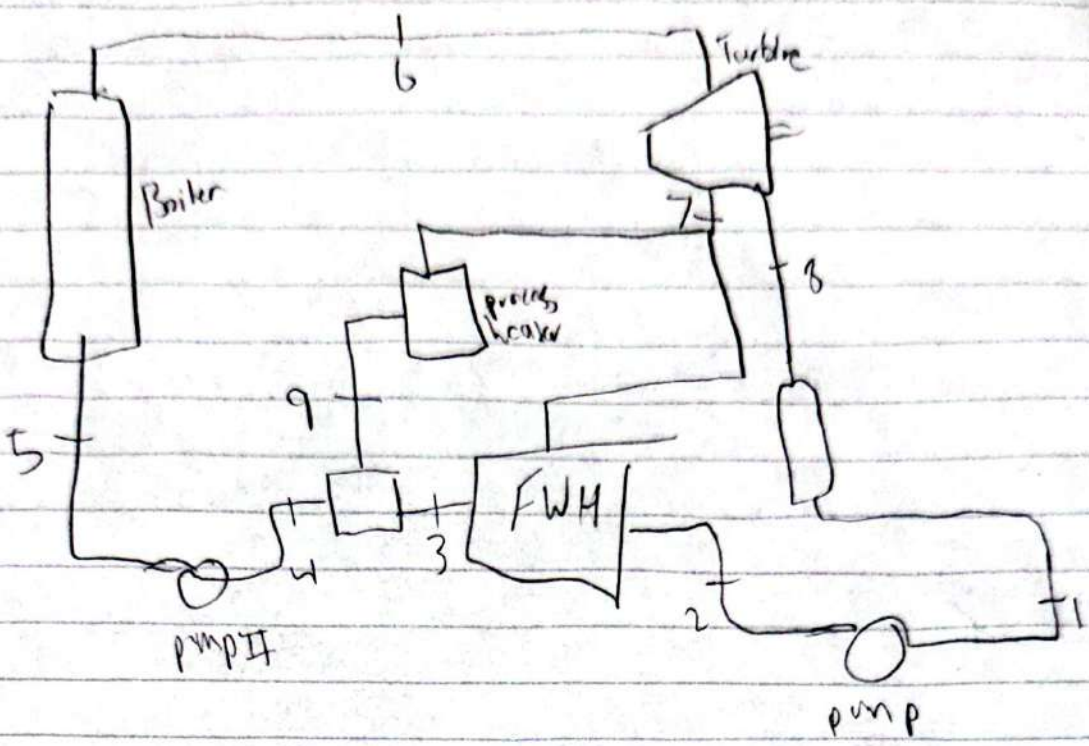
$$W_{net} = W_{out} + W_{in} = 1245.712 - 5.065 = 1240.6460$$

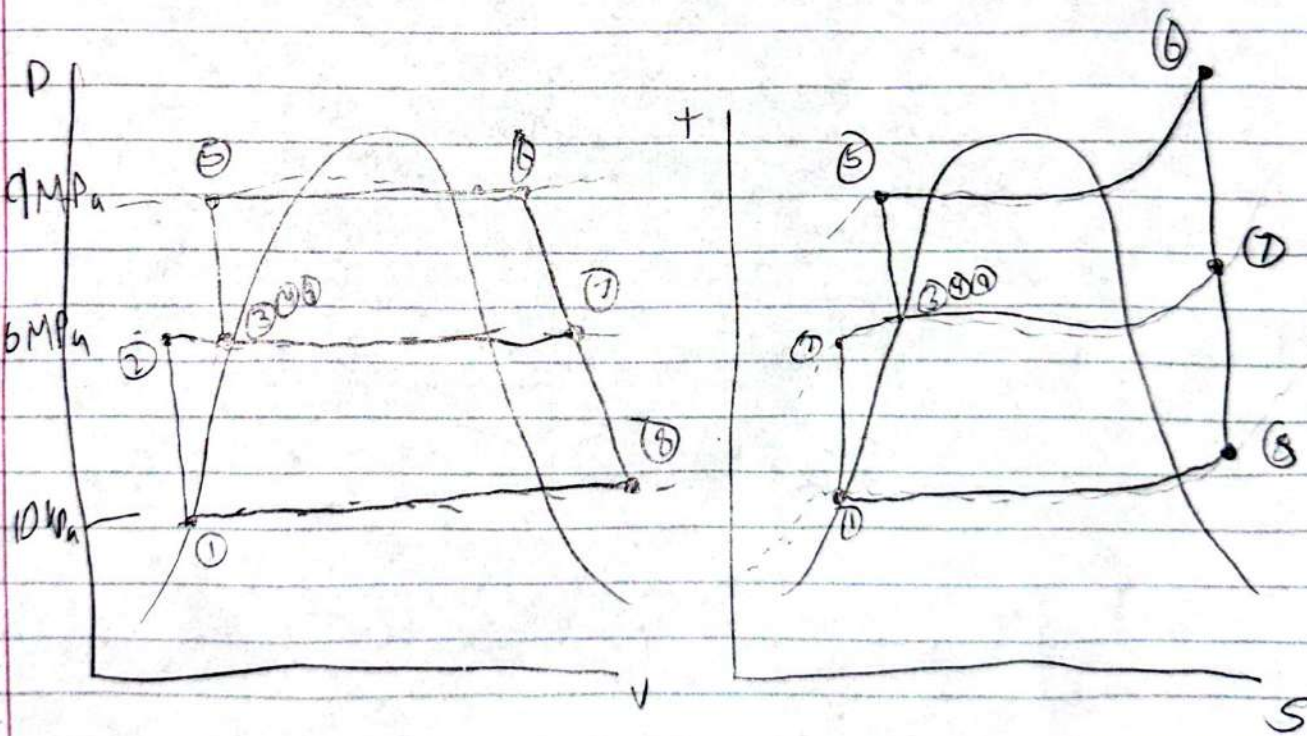
$$\eta_{th} = \frac{W_{out}}{q_{in}}$$

$$q_{in} = h_5 - h_4 = 3900.3 - 829.96 = 3070.34$$

$$\eta_{th} = \frac{1240.646}{3070.34} = .404 = 40.4\%$$

10-72


6
Turbine
Boiler
7
8
pressure loss
9
5
FWH
4
3
2
1
pump II
pump


P
9MPa
1.6MPa
10kPa
5
6
7
8
1
2
3
4
v
T
s

① $P_1 = 10\,kPa$

$x_1 = 0$

$h_1 = 191.81\,kJ/kg$

$v_1 = .001010$

② $P_2 = 1.6MPa$

$h_2 = h_1 + v_1(P_2 - P_1)$

$h_2 = 191.10$

$h_2 = (191.81) + (.001010)(1.6 - .01)$

③ $P_3 = 1.6MPa$

$x_3 = 0$

$h_3 = 857.994$

interp

④ $P_4 = 1.6MPa$

$x_4 = 0$

$h_4 = 857.994$

$v_4 = .001156$

interp

⑤ $P_5 = 5MPa$

$h_5 = h_4 + v_4(P_5 - P_4)$

$h_5 = (857.994) + (.001156)(5 - 1.6)$

$h_5 = 857.998$

⑥ $P_6 = 5MPa$

$T_6 = 400°$

superheated vapor

$x_6 = 6.2870$

$h_6 = 3196.7\,kJ/kg$

$v_6 = .05704$

⑦ sat vapor

$P_7 = 1.6MPa$

$s_7 = s_6$

$s_7 = 6.2870$

$h_f = 858.5$

$h_{fg} = 1934.5$

$s_f = 1.34$

$s_{fg} = 4.009$

$s_7 = s_f + x_7(s_{fg})$

$6.2870 = 2.3440 + x_7(4.0730)$

$x_7 = .9675$

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

$h_7 = 2729.935$

⑧ $P_8 = 10\,kPa$

$h_8 = 1880$

⑨ $P_9 = 1.6MPa$

$x_9 = 0$

$w_{out} = (h_6 - h_7) + (1 - m)(h_7 - h_8)$

$(3110 - 2729) + (1 - .35)(2729 - 1996.19)$

$w_{out} = 869.49\,kJ/kg$

$w_{in} = (1 - .35)(1.606) + 8.370$

$= 9.61m$

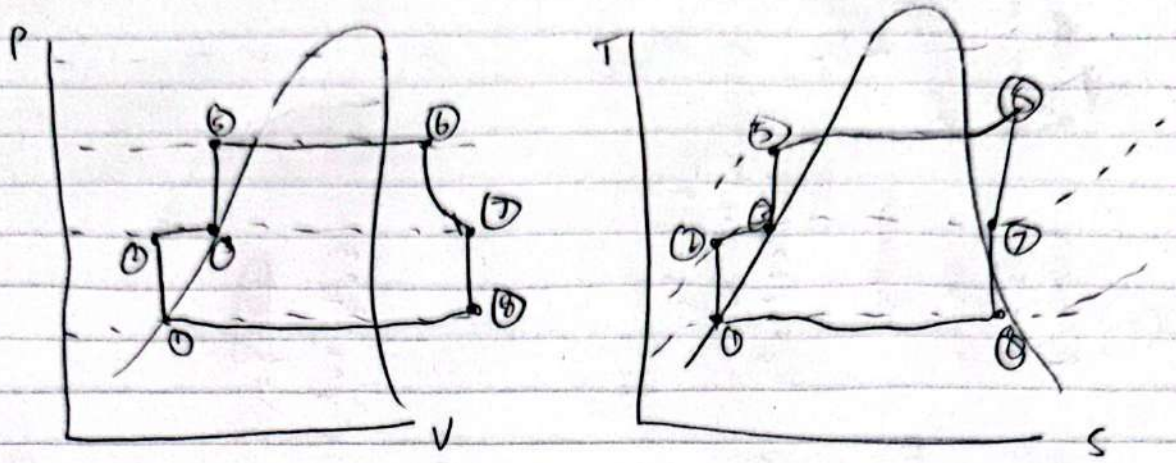
$w_{net} = w_{out} - w_{in}$

$w_{net} = 869.69 - 9.6191 = 860\,kJ/kg$

$P = \dot{m} \cdot w_{net}$

$\dot{m} = \frac{25 \times 10^3}{860} = \boxed{\dot{m} = 29.1\,kg/s}$

10-69



① $P_1 = 10\ kPa$, $x_1 = 0$, $h_1 = 191.81$, $s_1 = .6492$, $v_1 = .00101$

② $P_2 = 1700\ kPa$, $s_2 = .6492$, $h_2 = 192$

③ $P_3 = 1700\ kPa$, $x_3 = 0$, $h_3 = 798.33$

④ $P_4 = 1700\ kPa$, $h_4 = 344.3$, $v_4 = .001031$, interp

⑤ $P_5 = 4000\ kPa$, $h_5 = 347.2$

⑥ $P_6 = 7\ MPa$, $T_6 = 500^\circ C$, $h_6 = 3476$, $s_6 = 7.0772$

⑦ $P_7 = 1700\ kPa$, $s_7 = s_6$, $h_7 = 308$, interpolation

⑧ $P_8 = 10\ kPa$, $s_8 = 7.0772$, $x_8 = \frac{s_8 - s_f}{s_{fg}}$, $\downarrow$ $.8591$

$h_2 - h_1 = v_1(P_2 - P_1)$

$h_2 = (191.81) + (.00101)(1700-10)$

$h_2 = 193$

$W_p = -\frac{1}{4}(55)(193 - 191.81) = -16.5\ kW$

$Q_T - W_T = \Sigma_{out} \dot{m}_e - \Sigma_{in} \dot{m} h$

$W_T = -\dot{m}_6\left(\frac{1}{4}h_7 + \frac{3}{4}h_8 - h_6\right)$

$W_T = 5.476 \times 10^4\ kW$

$W_{net} = W_T + W_{P_1} + W_{P_2}$

$(5.49 \times 10^4 - 16.5 - 158.7)$

$\dot{W}_{net} = 5.427 \times 10^4\ kW$

$\eta_{th} = \frac{W_{net} + Q_{PH}}{QB}$

$\frac{(5.427 \times 10^4) + (3.139 \times 10^4)}{1.704 \times 10^5} = .5017$

$h_5 - h_4 = v_4(P_5 - P_4)$

$h_5 = (344.3) + (.001031)(4000-1200)$

$h_5 = 347.2$

$h_8 = h_f + x_8 h_{fg}$

$(191.81) + (.8591)(2392.1)$

$h_8 = 2247$

$\dot{m}_4 h_4 = \dot{m}_2 h_2 + \dot{m}_3 h_3$

$\dot{m}_6 h_6 = \dot{m}_8 h_2 + \dot{m}_1 h_3$

$h_4 = \left(\frac{\dot{m}_8}{\dot{m}_6}\right)h_2 + \left(\frac{\dot{m}_7}{\dot{m}_6}\right)h_3 - \frac{3}{4}h_2 + \frac{1}{4}h_3$

$h_4 = \frac{3}{4}(193) + \frac{1}{4}(798.33) = 344.3$

process heater

$Q_{PH} - W = \dot{m}_7(h_2 - h_7)$

$Q = \frac{1}{4}(55)(198.33 - 308)$

$Q - W = \dot{m}_8(h_1 - h_8)$

$Q_1 = \frac{3}{4}(55)(191.81 - 2247)$

$= -8.178 \times 10^4\ kW$