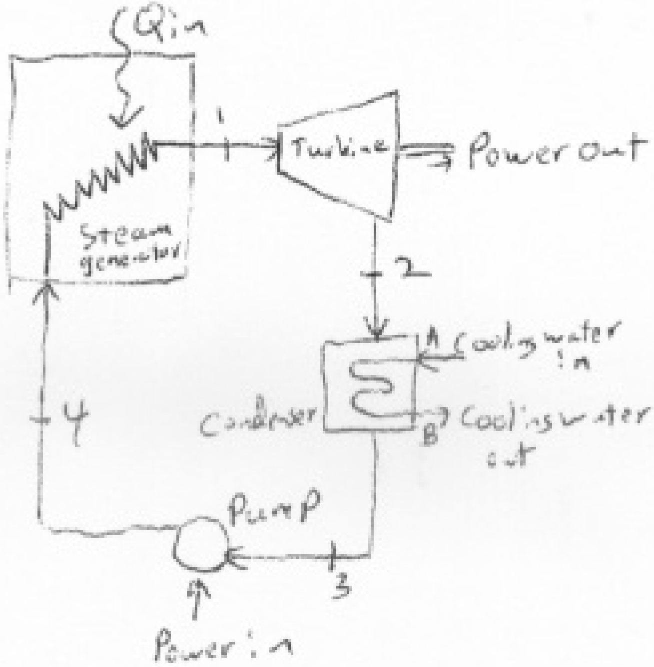
(4.77)



Steam, $\dot{m} = 130$ kg/s

$P_1 = 100$ bars
$T_1 = 520°C$

$P_2 = 0.08$ bar
$X_2 = 90\%$

$P_3 = 0.08$ bar
Sat. liquid @ 3

$P_4 = 100$ bar, $T_4 = 80°C$

assume potential and kinetic energy effects are negligable

$Q_{in} = \dot{m}(h_1 - h_4)$ $\quad h_4 = 342.83$ kJ/kg (A-5)

$h_1 = 3{,}425.1$ kJ/kg (A-4)

a) $Q_{in} = 4.01(10^5)$ kW

$\dot{W}_{out} = \dot{m}(h_1 - h_2)$ $\quad h_2 = 2{,}336.7$ kJ/kg (A-3)

$\Rightarrow W_{out} = 1.415(10^5)$ kW

$W_{in} = \dot{m}(h_3 - h_4)$ $\quad h_3 = 173.88$ kJ/kg (A-3)

$\Rightarrow W_{in} = 2.2(10^4)$ kW $\Rightarrow$ b) $\dot{W}_{net} = 1.195$ kW

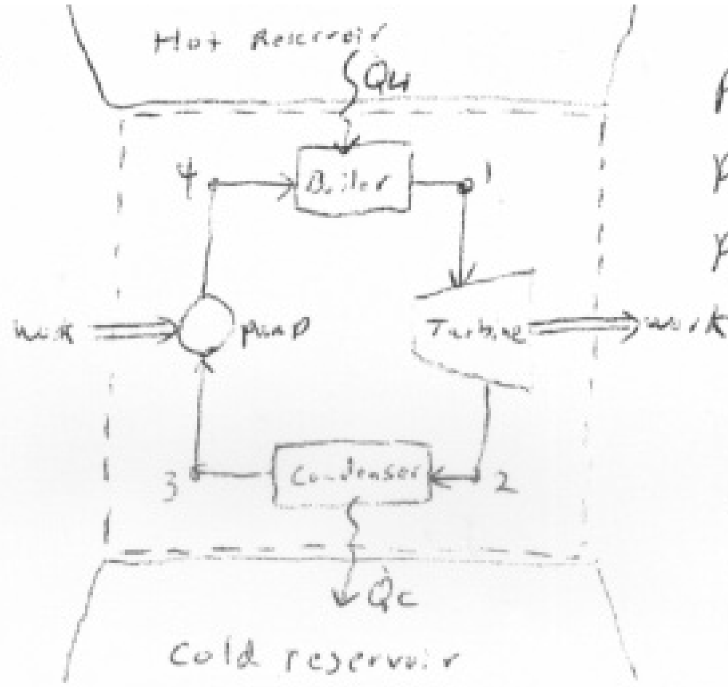
$\dot{m}_{cw}(h_B - h_A) = \dot{m}(h_2 - h_3)$

$(h_B - h_A) = c\Delta T$ $\quad (c = 4.179)$

$\dot{m}_{cw} = \dot{m}\left(\frac{h_2 - h_3}{c\Delta T}\right)$

c) $\dot{m}_{cw} = 4{,}485$ kg/s

(6.33)



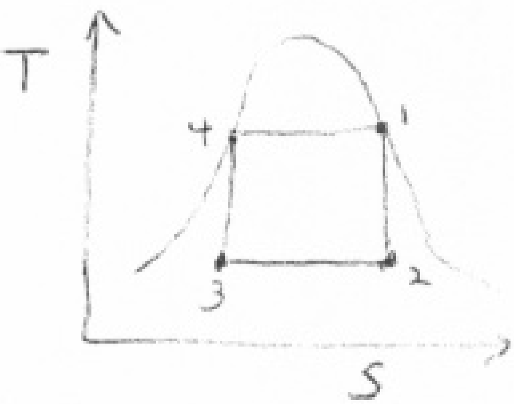
$p_1 = 10$ bar, sat. vapor

$p_2 = 0.2$ bar, $x_2 = 88\%$

$p_3 = 0.2$ bar, $x_3 = 18\%$

$p_4 = 10$ bar, sat. liquid.

Assume the turbine and pump operate adiabatically



$h_1 = 2,778.1$ kJ/kg (A-3)

$h_2 = 2,326.7$ kJ/kg (A-3)

$h_3 = 675.9$ kJ/kg (A-3)

$h_4 = 762.81$ kJ/kg (A-3)

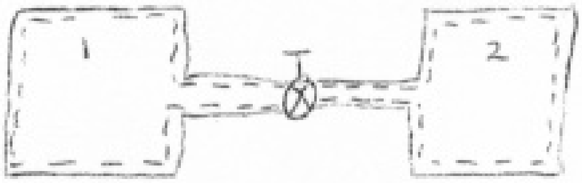
$\dot{W}_{out} = h_2 - h_1 = -451.4$ kJ/kg, $\dot{W}_{in} = h_4 - h_3 = 86.91$ kJ/kg

$Q_{in} = h_1 - h_4 = 2,015.29$ kJ/kg

$\eta_{th} = \frac{W_{net}}{Q_{in}} = \boxed{18\%}$

$\eta_{th,carnot} = 1 - \frac{T_C}{T_H} = 1 - \frac{333.21}{453.05} = \boxed{26\%}$

(6.69)



$m_1 = 0.5\,kg,\ T_1 = 80°C,\ p_1 = 1\,bar$

$m_2 = 1.0\,kg,\ T_2 = 50°C,\ p_2 = 2\,bar$

Air

$m_3 = m_1 + m_2 = 1.5\,kg$

Assume the process is adiabatic, and no work is done

$Q = \Delta U + W = 0 \Rightarrow \Delta U = 0$

$U_3 = U_1 + U_2$

$m_3 c_v T_3 = m_1 c_v T_1 + m_2 c_v T_2$

$T_3 = \frac{1}{3} T_1 + \frac{2}{3} T_2 = \boxed{333\,K}$

$pV = n\bar{R}T \Rightarrow V_1 = \frac{0.5}{29}(8.314)(353)(10^{-3}) = 0.0506\ m^3$

$V_2 = \frac{1.0}{29}(8.314)(323)(10^{-3})(2)^{-1} = 0.000463\ m^3$

$\Rightarrow V_3 = 9.7(10^{-4})\ m^3$

$p_3 = \frac{1.5}{29}(8.314)(333)(9.7)^{-1}(10^{4}) = 147781$

$\boxed{p_3 = 1.48\ bar}$

$\Delta s = \int_1^2 \left(\frac{\delta Q}{T}\right)_b dT + \sigma$

$\sigma = \Delta S = S_3 - S_2 - S_1 = (1.5)\left[1.8068 - \frac{8.314}{29}\ln\left(\frac{1.48}{1.0}\right)\right]$

$-(0.5)[1.86554] - (1.0)\left[1.7763 - \frac{8.314}{29}\ln\left(\frac{2}{1}\right)\right]$

$\boxed{\sigma = 0.032\ kJ/K}$