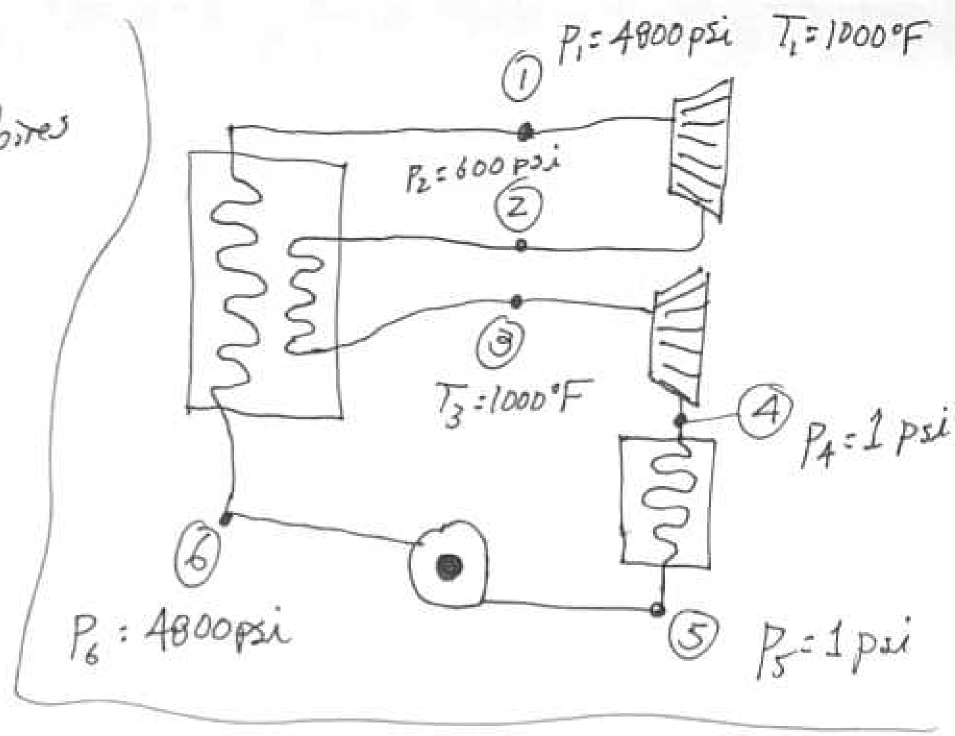
$\boxed{8.32}$ Given: Steam

η_t : 85% for both turbines

$\dot{W}_{net}$ = 100MW



Get h & s for the different states

① P_1 : 4800psi T_1 = 1000°F $\boxed{h_1 = 1317.4 \text{ Btu/lb}}$ s_1 = 1.4078 Btu/lb·°R

② P_2 = 600 psi $s_2 = s_1 = 1.4078$ Btu/lb·°R ← For isentropic case only

$s_2 = 1.4078 = (1-x_2)s_f + x_2 s_g$ $x_2 = 0.95$

$\boxed{\eta_t = \frac{h_1 - h_2}{h_1 - h_{2s}}}$ h_{2s} : 1167.5 Btu/lb η_t : 0.85 ∴ $\boxed{h_2 = 1189.9 \text{ Btu/lb}}$

③ $P_3 = P_2$ = 600psi T_3 = 1000°F $\boxed{h_3 : 1517.8 \text{ Btu/lb}}$ s_3 : 1.7155 $\frac{\text{Btu}}{\text{lb °R}}$

④ $s_4 = s_3$ = 1.7155 Btu/lb·°R P_4 = 1 psi ⇐ sat. state

For isentropic case

x_4 = 0.86

h_{4s} = 960.8 Btu/lb η_t = 0.85 → $\boxed{h_4 = 1044 \text{ Btu/lb}}$

⑤ P_5 = 1 psi (sat. liquid) $\boxed{h_5 = h_{f5} = 69.74 \text{ Btu/lb}}$ s_5 : .1327 Btu/lb·°R

v_5 = .01614 ft³/lb

⑥ P_6 : 4800 psi $s_6 = s_5$ = 0.1327 Btu/lb·°R compressed liquid, but no chart

initial isentropic assumption

8.32 continued

$$\underset{0}{T\cancel{ds}} = dh - v\,dp$$

constant assuming incompressible liquid.

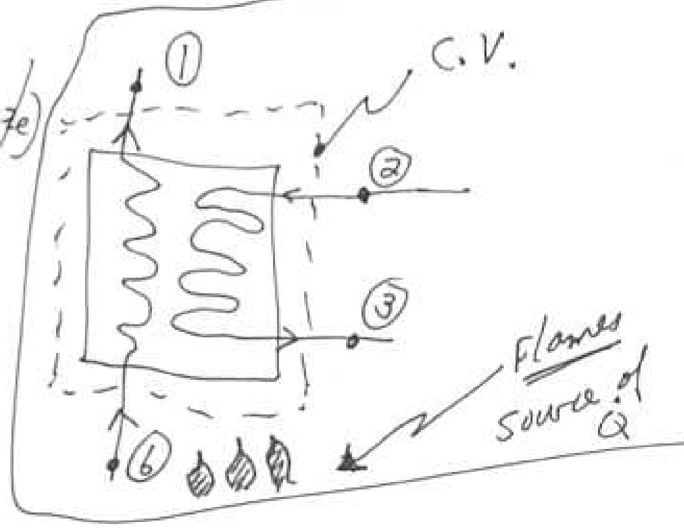
$$h_{6s} - h_5 = v_5 (P_6 - P_5)$$

$$h_{6s} = h_5 + (.01614\ ft^3/lb)\left(691{,}200\ \frac{lbf}{ft^2} - 144\ \frac{lbf}{ft^2}\right)\frac{1\ Btu}{778.17\ ft\cdot lbf}$$

$$h_{6s} = 84.07\ Btu/lb \qquad \eta_t = \frac{h_{6s} - h_5}{h_6 - h_5} \Rightarrow \boxed{h_6 = 86.6\ Btu/lb}$$

(a) $\dot{Q}$ for working fluid passing through the boiler

$$\cancel{\frac{dE}{dt}} = \dot{Q} - \cancel{\dot{W}} + \sum_i \dot{m}_i \left(h_i + \cancel{\frac{V_i^2}{2}} + \cancel{gz_i}\right) - \sum_e \dot{m}_e \left(h_e + \cancel{\frac{V_e^2}{2}} + \cancel{gz_e}\right)$$



$$\boxed{-\dot{Q} = \dot{m}(h_6 - h_1 + h_2 - h_3)}$$

How do we get $\dot{m}$?

We know $\dot{W}_{net} = 100\ MW$

$$\dot{W}_{net} = \dot{W}_{t1} + \dot{W}_{t2} - \dot{W}_{pump}$$

$$\dot{W}_{net} = \dot{m}(h_1 - h_2 + h_3 - h_4 + h_5 - h_6)$$

$$\frac{\dot{W}_{net}}{\dot{m}} = 584.4\ Btu/lb = 616.6\ kJ/lb$$

$$\dot{m} = \frac{100 \times 10^3\ kJ/s}{616.6\ kJ/lb} = \underline{\underline{162.2}}\ lb/s$$

$$\dot{Q} = \left[+2.53 \times 10^5\ Btu/s\right] \cdot \left[\frac{1.0551\ kJ}{Btu}\right] \cdot \left[\frac{1\ MW}{1000\ kW}\right]$$

$$\boxed{\dot{Q}_H = 267\ MW}$$

8.32 (continued)

(b) $\dot{Q}_{condenser} = ?$

$$\dot{Q}_{cond} = \dot{m}(h_4 - h_5) = \left[158{,}024\ Btu/s\right] \cdot \left[\frac{1.0551\ kJ}{Btu}\right] \cdot \left[\frac{1\ MW}{1000\ kW}\right]$$

$\boxed{\text{Rate of heat leaving the condenser} = 167\ MW}$

(c) $$\eta_{cycle} = \frac{\dot{W}_{net}}{\dot{Q}_H} = \frac{100\ MW}{267\ MW} = \boxed{0.375}$$