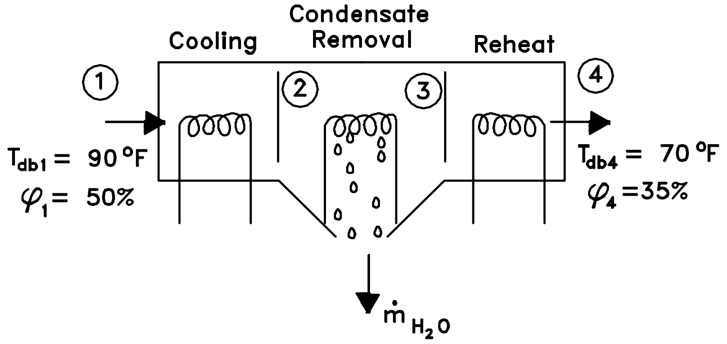
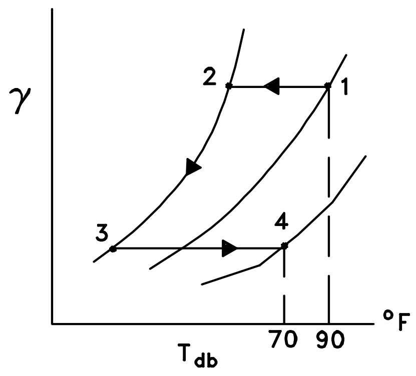
Problem: 10-41

Given: Atmospheric air at 90 $^\circ F$ and 50% relative humidity conditioned to 70 $^\circ F$ and 35% relative humidity by cooling, condensate removal and reheating. Air flow rate is 350 lbm/hr.

Find: Mass of water removed and heat transfer.





Using Psych. chart

State 1

$$\begin{aligned} T_{db_1} &= 90\ ^\circ F \\ \phi_1 &= 50\% \\ h_1^* &= 38.4\ \ Btu/lbm \\ \gamma_1 &= 106/7000 = 0.0151 \end{aligned}$$

State 4

$$\begin{aligned} T_{db_4} &= 70\ ^\circ F \\ \phi_4 &= 35\% \\ h_4^* &= 22.9\ \ Btu/lbm \\ \gamma_4 &= 38/7000 = 0.00543 \end{aligned}$$

State 2

$$\begin{aligned} T_{db_2} &= 69\ ^\circ F \\ \phi_2 &= 100\% \\ h_2^* &= 33.1\ \ Btu/lbm \\ \gamma_2 = \gamma_1 &= 106/7000 = 0.0151 \end{aligned}$$

State 3

$$\begin{aligned} T_{db_3} &= 41\ ^\circ F \\ \phi_3 &= 100\% \\ h_3^* &= 15.7\ \ Btu/lbm \\ \gamma_3 &= 38/7000 = 0.00543 \end{aligned}$$

energy balances:

$$\begin{aligned} \dot{Q}_{1\to 2} &= \dot{m}_{a_1}(h_1^* - h_2^*) \\ &= 350\ lbm/hr(38.5 - 33.1) Btu/lbm \\ &= 1890\ Btu/hr \end{aligned}$$

$$\begin{aligned}\dot{Q}_{2\to3} &= \dot{m}_{a_1}(h_2^* - h_3^*) \\ &= 350\ lbm/hr(33.1 - 15.7)Btu/lbm \\ &= 6090\ Btu/hr\end{aligned}$$

$$\begin{aligned}\dot{Q}_{3\to4} &= \dot{m}_{a_3}(h_4^* - h_3^*) \\ &= 350\ lbm/hr(23.3 - 15.7)Btu/lbm \\ &= 2660\ Btu/hr\end{aligned}$$

mass balances:
air: $\dot{m}_{a_1} = \dot{m}_{a_3}$
water: $\gamma\dot{m}_{a_1} = \gamma\dot{m}_{a_3} + \dot{m}_{H_2O}$
Therefore

$$\begin{aligned}\dot{m}_{H_2O} &= (\gamma_1 - \gamma_3)\dot{m}_{a_1} \\ &= (0.0151 - 0.00543)\ lbm_{H_2O}/lbm_{air} \cdot (350\ lbm/hr) \\ &= \boxed{3.38\ lbm/hr}\end{aligned}$$