14-73 Saturated humid air at a specified state is heated to a specified temperature. The relative humidity at the exit and the rate of heat transfer are to be determined.

Assumptions **1** This is a steady-flow process and thus the mass flow rate of dry air remains constant during the entire process $(\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a)$. **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible.

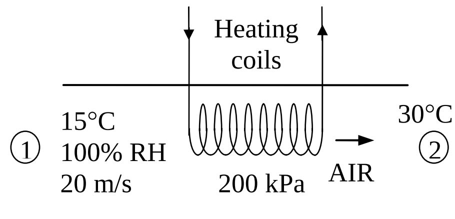
Analysis The amount of moisture in the air remains constant ($\omega_1 = \omega_2$) as it flows through the heating section since the process involves no humidification or dehumidification. The inlet state of the air is completely specified, and the total pressure is 200 kPa. The properties of the air at the inlet and exit states are determined to be

$$P_{v1} = \phi_1 P_{g1} = \phi_1 P_{\text{sat @ 15°C}} = (1.0)(1.7057\text{ kPa}) = 1.7057\text{ kPa}$$

$$h_{g1} = h_{g\text{ @ 15°C}} = 2528.3\text{ kJ/kg}$$

$$P_{a1} = P_1 - P_{v1} = 200 - 1.7057 = 198.29\text{ kPa}$$

$$\boldsymbol{v}_1 = \frac{R_a T_1}{P_{a1}} = \frac{(0.287\text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(288\text{ K})}{198.29\text{ kPa}} = 0.4168\text{ m}^3/\text{kg dry air}$$



$$\omega_1 = \frac{0.622\,P_{v1}}{P_1 - P_{v1}} = \frac{0.622(1.7057\text{ kPa})}{(200-1.7057)\text{ kPa}} = 0.005350\text{ kg H}_2\text{O/kg dry air}$$

$$h_1 = c_p T_1 + \omega_1 h_{g1} = (1.005\text{ kJ/kg}\cdot°\text{C})(15°\text{C}) + (0.005350)(2528.3\text{ kJ/kg}) = 28.60\text{ kJ/kg dry air}$$

$$P_{v2} = P_{v1} = 1.7057\text{ kPa}$$

$$P_{g2} = P_{\text{sat @ 30°C}} = 4.2469\text{ kPa}$$

$$\phi_2 = \frac{P_{v2}}{P_{g2}} = \frac{1.7057\text{ kPa}}{4.2469\text{ kPa}} = 0.402 = \mathbf{40.2\%}$$

$$h_{g2} = h_{g\text{ @ 30°C}} = 2555.6\text{ kJ/kg}$$

$$\omega_2 = \omega_1$$

$$h_2 = c_p T_2 + \omega_2 h_{g2} = (1.005\text{ kJ/kg}\cdot°\text{C})(30°\text{C}) + (0.005350)(2555.6\text{ kJ/kg}) = 43.82\text{ kJ/kg dry air}$$

Then,

$$\dot{\boldsymbol{V}}_1 = V_1 A_1 = V_1 \frac{\pi D^2}{4} = (20\text{ m/s})\left(\frac{\pi(0.04\text{ m})^2}{4}\right) = 0.02513\text{ m}^3/\text{s}$$

$$\dot{m}_a = \frac{\dot{\boldsymbol{V}}_1}{\boldsymbol{v}_1} = \frac{0.02513\text{ m}^3/\text{s}}{0.4168\text{ m}^3/\text{kg dry air}} = 0.06029\text{ kg/s}$$

From the energy balance on air in the heating section,

$$\dot{Q}_{\text{in}} = \dot{m}_a(h_2 - h_1) = (0.06029\text{ kg/s})(43.82 - 28.60)\text{kJ/kg} = \mathbf{0.918\text{ kW}}$$

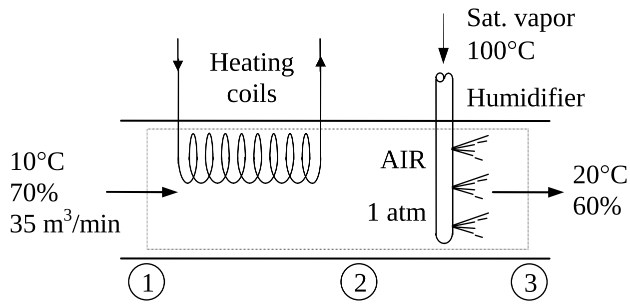
14-78 Air is first heated and then humidified by wet steam. The temperature and relative humidity of air at the exit of heating section, the rate of heat transfer, and the rate at which water is added to the air are to be determined.

Assumptions **1** This is a steady-flow process and thus the mass flow rate of dry air remains constant during the entire process $(\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a)$. **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible.

Properties The inlet and the exit states of the air are completely specified, and the total pressure is 1 atm. The properties of the air at various states are determined from the psychrometric chart (Figure A-31) to be

$$h_1 = 23.5 \text{ kJ/kg dry air}$$
$$\omega_1 = 0.0053 \text{ kg H}_2\text{O/kg dry air} (= \omega_2)$$
$$v_1 = 0.809 \text{ m}^3\text{/kg dry air}$$

$$h_3 = 42.3 \text{ kJ/kg dry air}$$
$$\omega_3 = 0.0087 \text{ kg H}_2\text{O/kg dry air}$$



Analysis (*a*) The amount of moisture in the air remains constant it flows through the heating section ($\omega_1 = \omega_2$), but increases in the humidifying section ($\omega_3 > \omega_2$). The mass flow rate of dry air is

$$\dot{m}_a = \frac{\dot{V}_1}{v_1} = \frac{35 \text{ m}^3/\text{min}}{0.809 \text{ m}^3/\text{kg}} = 43.3 \text{ kg/min}$$

Noting that $Q = W = 0$, the energy balance on the humidifying section can be expressed as

$$\dot{E}_{in} - \dot{E}_{out} = \Delta\dot{E}_{system}^{\nearrow 0 \text{ (steady)}} = 0$$
$$\dot{E}_{in} = \dot{E}_{out}$$
$$\sum \dot{m}_i h_i = \sum \dot{m}_e h_e \longrightarrow \dot{m}_w h_w + \dot{m}_{a2} h_2 = \dot{m}_a h_3$$
$$(\omega_3 - \omega_2) h_w + h_2 = h_3$$

Solving for h_2,

$$h_2 = h_3 - (\omega_3 - \omega_2) h_{g@100°C} = 42.3 - (0.0087 - 0.0053)(2675.6) = 33.2 \text{ kJ/kg dry air}$$

Thus at the exit of the heating section we have ω_2 = 0.0053 kg H_2O dry air and h_2 = 33.2 kJ/kg dry air, which completely fixes the state. Then from the psychrometric chart we read

$$T_2 = \mathbf{19.5°C}$$
$$\phi_2 = \mathbf{37.8\%}$$

(*b*) The rate of heat transfer to the air in the heating section is

$$\dot{Q}_{in} = \dot{m}_a (h_2 - h_1) = (43.3 \text{ kg/min})(33.2 - 23.5) \text{ kJ/kg} = \mathbf{420 \text{ kJ/min}}$$

(*c*) The amount of water added to the air in the humidifying section is determined from the conservation of mass equation of water in the humidifying section,

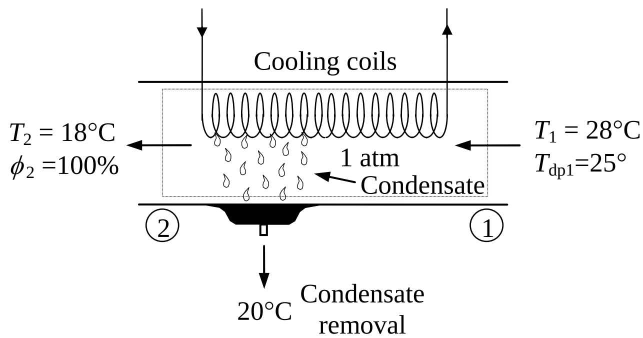
$$\dot{m}_w = \dot{m}_a (\omega_3 - \omega_2) = (43.3 \text{ kg/min})(0.0087 - 0.0053) = \mathbf{0.15 \text{ kg/min}}$$

14-82 Air is cooled and dehumidified at constant pressure. The amount of water removed from the air and the rate of cooling are to be determined.

Assumptions **1** This is a steady-flow process and thus the mass flow rate of dry air remains constant during the entire process $(\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a)$. **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible.

Properties The inlet and the exit states of the air are completely specified, and the total pressure is 1 atm. The properties of the air at various states are determined from the psychrometric chart (Figure A-31) to be

$$h_1 = 79.6 \text{ kJ/kg dry air}$$
$$\omega_1 = 0.0202 \text{ kg } H_2O\text{/kg dry air}$$
$$\boldsymbol{v}_1 = 0.881 \text{ m}^3\text{/kg dry air}$$



and

$$\phi_2 = 1.0$$
$$h_2 = 51.0 \text{ kJ/kg dry air}$$
$$\omega_2 = 0.0130 \text{ kg } H_2O\text{/kg dry air}$$

Also,

$$h_w \cong h_{f\,@\,20°C} = 83.915 \text{ kJ/kg} \quad \text{(Table A-4)}$$

Analysis The amount of moisture in the air decreases due to dehumidification ($\omega_2 < \omega_1$). The mass flow rate of air is

$$\dot{m}_{a1} = \frac{\dot{\boldsymbol{V}}_1}{\boldsymbol{v}_1} = \frac{(10{,}000/3600) \text{ m}^3/\text{s}}{0.881 \text{ m}^3/\text{kg dry air}} = 3.153 \text{ kg/s}$$

Applying the water mass balance and energy balance equations to the combined cooling and dehumidification section,

Water Mass Balance:

$$\sum \dot{m}_{w,i} = \sum \dot{m}_{w,e} \longrightarrow \dot{m}_{a1}\omega_1 = \dot{m}_{a2}\omega_2 + \dot{m}_w$$

$$\dot{m}_w = \dot{m}_a(\omega_1 - \omega_2) = (3.153 \text{ kg/s})(0.0202 - 0.0130) = \mathbf{0.0227 \text{ kg/s}}$$

Energy Balance:

$$\dot{E}_{in} - \dot{E}_{out} = \Delta\dot{E}_{system}^{\nearrow 0 \text{ (steady)}} = 0$$
$$\dot{E}_{in} = \dot{E}_{out}$$
$$\sum \dot{m}_i h_i = \dot{Q}_{out} + \sum \dot{m}_e h_e$$
$$\dot{Q}_{out} = \dot{m}_{a1}h_1 - (\dot{m}_{a2}h_2 + \dot{m}_w h_w) = \dot{m}_a(h_1 - h_2) - \dot{m}_w h_w$$

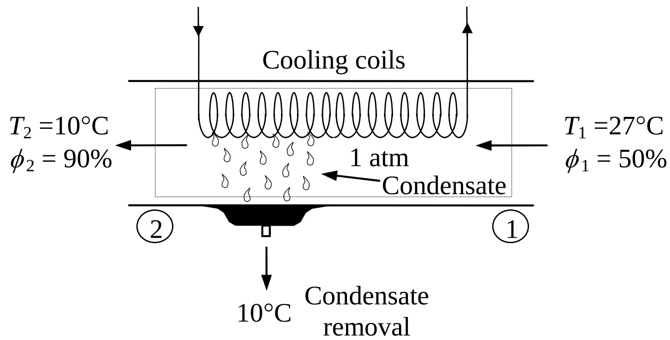
$$\dot{Q}_{out} = (3.153 \text{ kg/s})(79.6 - 51.0)\text{kJ/kg} - (0.02227 \text{ kg/s})(83.915 \text{ kJ/kg})$$
$$= \mathbf{88.3 \text{ kW}}$$

14-90 Atmospheric air enters the evaporator of an automobile air conditioner at a specified pressure, temperature, and relative humidity. The dew point and wet bulb temperatures at the inlet to the evaporator section, the required heat transfer rate from the atmospheric air to the evaporator fluid, and the rate of condensation of water vapor in the evaporator section are to be determined.

Assumptions **1** This is a steady-flow process and thus the mass flow rate of dry air remains constant during the entire process $(\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a)$. **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible.

Analysis The inlet and exit states of the air are completely specified, and the total pressure is 1 atm. The properties of the air at the inlet and exit states may be determined from the psychrometric chart (Fig. A-31) or using EES psychrometric functions to be (we used EES)

$$T_{dp1} = \mathbf{15.7°C}$$
$$T_{wb1} = \mathbf{19.5°C}$$
$$h_1 = 55.60 \text{ kJ/kg dry air}$$
$$\omega_1 = 0.01115 \text{ kg H}_2\text{O/kg dry air}$$
$$v_1 = 0.8655 \text{ m}^3 \text{/ kg dry air}$$
$$h_2 = 27.35 \text{ kJ/kg dry air}$$
$$\omega_2 = 0.00686 \text{ kg H}_2\text{O/kg dry air}$$



The mass flow rate of dry air is

$$\dot{m}_a = \frac{\dot{V}_1}{v_1} = \frac{V_{car}\text{ACH}}{v_1} = \frac{(2 \text{ m}^3\text{/change})(5 \text{ changes/min})}{0.8655 \text{ m}^3} = 11.55 \text{ kg/min}$$

The mass flow rates of vapor at the inlet and exit are

$$\dot{m}_{v1} = \omega_1 \dot{m}_a = (0.01115)(11.55 \text{ kg/min}) = 0.1288 \text{ kg/min}$$

$$\dot{m}_{v2} = \omega_2 \dot{m}_a = (0.00686)(11.55 \text{ kg/min}) = 0.07926 \text{ kg/min}$$

An energy balance on the control volume gives

$$\dot{m}_a h_1 = \dot{Q}_{out} + \dot{m}_a h_2 + \dot{m}_w h_{w2}$$

where the the enthalpy of condensate water is

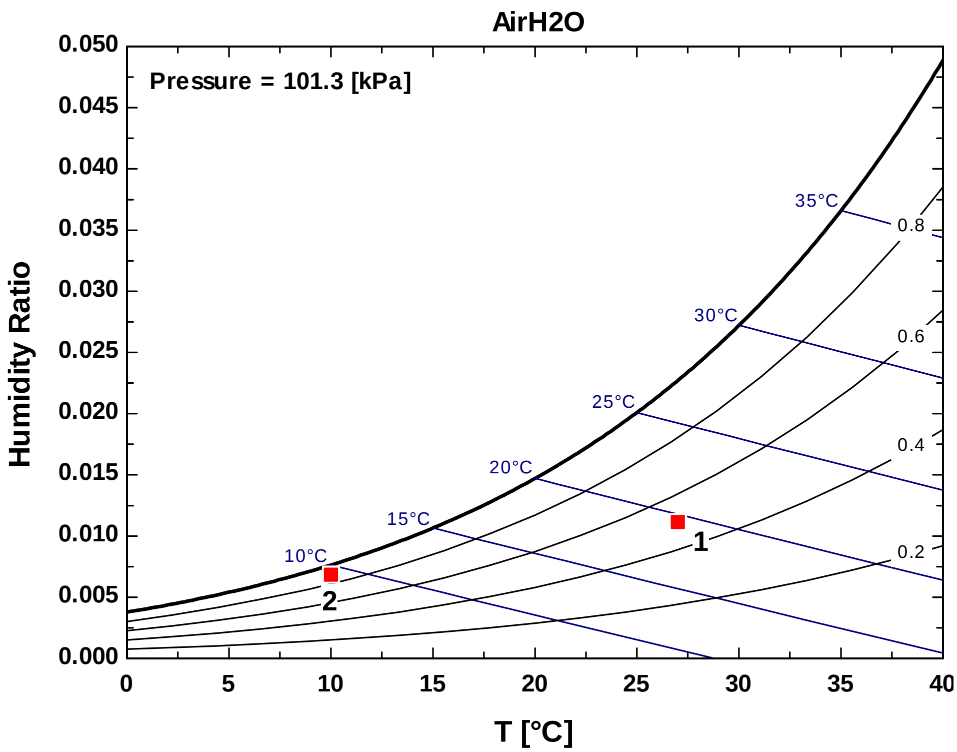
$$h_{w2} = h_{f@10°C} = 42.02 \text{ kJ/kg} \quad \text{(Table A-4)}$$

and the rate of condensation of water vapor is

$$\dot{m}_w = \dot{m}_{v1} - \dot{m}_{v2} = 0.1288 - 0.07926 = \mathbf{0.0495 \text{ kg/min}}$$

Substituting,

$$\dot{m}_a h_1 = \dot{Q}_{out} + \dot{m}_a h_2 + \dot{m}_w h_{w2}$$
$$(11.55 \text{ kg/min})(55.60 \text{ kJ/kg}) = \dot{Q}_{out} + (11.55 \text{ kg/min})(27.35 \text{ kJ/kg}) + (0.0495 \text{ kg/min})(42.02 \text{ kJ/kg})$$
$$\dot{Q}_{out} = 324.4 \text{ kJ/min} = \mathbf{5.41 \text{ kW}}$$



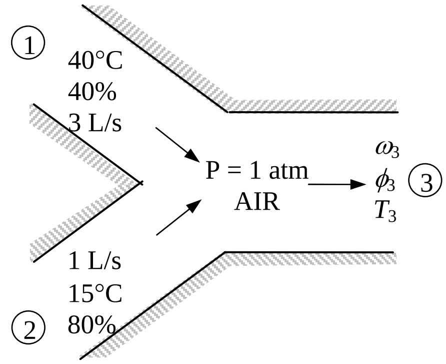
Discussion We we could not show the process line between the states 1 and 2 because we do not know the process path.

14-110 Two airstreams are mixed steadily. The temperature and the relative humidity of the mixture are to be determined.

Assumptions **1** Steady operating conditions exist **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible. **4** The mixing section is adiabatic.

Properties Properties of each inlet stream are determined from the psychrometric chart (Fig. A-31 or from EES) to be

$$h_1 = 88.5 \text{ kJ/kg dry air}$$
$$\omega_1 = 0.0187 \text{ kg } H_2O\text{/kg dry air}$$
$$v_1 = 0.914 \text{ m}^3\text{/kg dry air}$$



and

$$h_2 = 36.7 \text{ kJ/kg dry air}$$
$$\omega_2 = 0.0085 \text{ kg } H_2O\text{/kg dry air}$$
$$v_2 = 0.828 \text{ m}^3\text{/kg dry air}$$

Analysis The mass flow rate of dry air in each stream is

$$\dot{m}_{a1} = \frac{\dot{V}_1}{v_1} = \frac{0.003 \text{ m}^3\text{ / s}}{0.914 \text{ m}^3\text{ / kg dry air}} = 0.003282 \text{ kg/s}$$

$$\dot{m}_{a2} = \frac{\dot{V}_2}{v_2} = \frac{0.001 \text{ m}^3\text{ / s}}{0.828 \text{ m}^3\text{ / kg dry air}} = 0.001208 \text{ kg/s}$$

From the conservation of mass,

$$\dot{m}_{a3} = \dot{m}_{a1} + \dot{m}_{a2} = (0.003282 + 0.001208) \text{ kg/s} = 0.00449 \text{ kg/s}$$

The specific humidity and the enthalpy of the mixture can be determined from Eqs. 14-24, which are obtained by combining the conservation of mass and energy equations for the adiabatic mixing of two streams:

$$\frac{\dot{m}_{a1}}{\dot{m}_{a2}} = \frac{\omega_2 - \omega_3}{\omega_3 - \omega_1} = \frac{h_2 - h_3}{h_3 - h_1}$$

$$\frac{0.003282}{0.001208} = \frac{0.0085 - \omega_3}{\omega_3 - 0.0187} = \frac{36.7 - h_3}{h_3 - 88.5}$$

which yields

$$\omega_3 = 0.0160 \text{ kg } H_2O\text{/kg dry air}$$
$$h_3 = 74.6 \text{ kJ/kg dry air}$$

These two properties fix the state of the mixture. Other properties of the mixture are determined from the psychrometric chart:

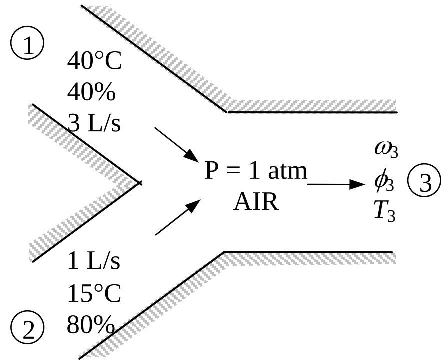
$$T_3 = \mathbf{33.4°C}$$
$$\phi_3 = 0.493 = \mathbf{49.3\%}$$

14-111 Two airstreams are mixed steadily. The rate of exergy destruction is to be determined.

Assumptions **1** Steady operating conditions exist **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible. **4** The mixing section is adiabatic.

Properties Properties of each inlet stream are determined from the psychrometric chart (Fig. A-31 or from EES) to be

$$h_1 = 88.5 \text{ kJ/kg dry air}$$
$$\omega_1 = 0.0187 \text{ kg H}_2\text{O/kg dry air}$$
$$v_1 = 0.914 \text{ m}^3\text{/kg dry air}$$



and

$$h_2 = 36.7 \text{ kJ/kg dry air}$$
$$\omega_2 = 0.0085 \text{ kg H}_2\text{O/kg dry air}$$
$$v_2 = 0.828 \text{ m}^3\text{/kg dry air}$$

The entropies of water vapor in the air streams are

$$s_{g1} = s_{g\,@\,40°\text{C}} = 8.2556 \text{ kJ/kg}\cdot\text{K}$$
$$s_{g2} = s_{g\,@\,15°\text{C}} = 8.7803 \text{ kJ/kg}\cdot\text{K}$$

Analysis The mass flow rate of dry air in each stream is

$$\dot{m}_{a1} = \frac{\dot{V}_1}{v_1} = \frac{0.003 \text{ m}^3\text{ / s}}{0.914 \text{ m}^3\text{ / kg dry air}} = 0.003282 \text{ kg/s}$$
$$\dot{m}_{a2} = \frac{\dot{V}_2}{v_2} = \frac{0.001 \text{ m}^3\text{ / s}}{0.828 \text{ m}^3\text{ / kg dry air}} = 0.001208 \text{ kg/s}$$

From the conservation of mass,

$$\dot{m}_{a3} = \dot{m}_{a1} + \dot{m}_{a2} = (0.003282 + 0.001208) \text{ kg/s} = 0.00449 \text{ kg/s}$$

The specific humidity and the enthalpy of the mixture can be determined from Eqs. 14-24, which are obtained by combining the conservation of mass and energy equations for the adiabatic mixing of two streams:

$$\frac{\dot{m}_{a1}}{\dot{m}_{a2}} = \frac{\omega_2 - \omega_3}{\omega_3 - \omega_1} = \frac{h_2 - h_3}{h_3 - h_1}$$
$$\frac{0.003282}{0.001208} = \frac{0.0085 - \omega_3}{\omega_3 - 0.0187} = \frac{36.7 - h_3}{h_3 - 88.5}$$

which yields

$$\omega_3 = 0.0160 \text{ kg H}_2\text{O/kg dry air}$$
$$h_3 = 74.6 \text{ kJ/kg dry air}$$

These two properties fix the state of the mixture. Other properties of the mixture are determined from the psychrometric chart:

$$T_3 = 33.4°\text{C}$$
$$\phi_3 = 0.493$$

The entropy of water vapor in the mixture is

$$s_{g3} = s_{g\,@\,33.4°\text{C}} = 8.3833 \text{ kJ/kg}\cdot\text{K}$$

An entropy balance on the mixing chamber for the water gives

$$\Delta\dot{S}_w = \dot{m}_{a3}\omega_3 s_3 - \dot{m}_{a1}\omega_1 s_1 - \dot{m}_{a2}\omega_2 s_2$$
$$= 0.00449\times 0.0160\times 8.3833 - 0.003282\times 0.0187\times 8.2556 - 0.001208\times 0.0085\times 8.7803$$
$$= 5.426\times 10^{-6}\ \text{kW/K}$$

The partial pressures of water vapor and dry air for all three air streams are

$$P_{v1} = \phi_1 P_{g1} = \phi_1 P_{\text{sat @ 40°C}} = (0.40)(7.3851\ \text{kPa}) = 2.954\ \text{kPa}$$
$$P_{a1} = P_1 - P_{v1} = 101.325 - 2.954 = 98.37\ \text{kPa}$$
$$P_{v2} = \phi_2 P_{g2} = \phi_2 P_{\text{sat @ 15°C}} = (0.80)(1.7057\ \text{kPa}) = 1.365\ \text{kPa}$$
$$P_{a2} = P_2 - P_{v2} = 101.325 - 1.365 = 99.96\ \text{kPa}$$
$$P_{v3} = \phi_3 P_{g3} = \phi_3 P_{\text{sat @ 33.4°C}} = (0.493)(5.150\ \text{kPa}) = 2.539\ \text{kPa}$$
$$P_{a3} = P_3 - P_{v3} = 101.325 - 2.539 = 98.79\ \text{kPa}$$

An entropy balance on the mixing chamber for the dry air gives

$$\Delta\dot{S}_a = \dot{m}_{a1}(s_3 - s_1) + \dot{m}_{a2}(s_3 - s_2)$$
$$= \dot{m}_{a1}\left(c_p \ln\frac{T_3}{T_1} - R\ln\frac{P_{a3}}{P_{a1}}\right) + \dot{m}_{a2}\left(c_p \ln\frac{T_3}{T_2} - R\ln\frac{P_{a3}}{P_{a2}}\right)$$
$$= 0.003282\left[(1.005)\ln\frac{306.4}{313} - (0.287)\ln\frac{98.79}{98.37}\right] + 0.001208\left[(1.005)\ln\frac{306.4}{288} - (0.287)\ln\frac{98.79}{99.96}\right]$$
$$= (0.003282)(-0.02264) + (0.001208)(0.06562)$$
$$= 4.964\times 10^{-6}\ \text{kW/K}$$

The rate of entropy generation is

$$\dot{S}_{\text{gen}} = \Delta\dot{S}_a + \Delta\dot{S}_w = 4.964\times 10^{-6} + 5.426\times 10^{-6} = 10.39\times 10^{-6}\ \text{kW/K}$$

Finally, the rate of exergy destruction is

$$\dot{X}_{\text{dest}} = T_0 \dot{S}_{\text{gen}} = (298\ \text{K})(10.39\times 10^{-6}\ \text{kW/K}) = \mathbf{0.0031\ kW}$$

14-115 Water is cooled by air in a cooling tower. The relative humidity of the air at the exit and the water's exit temperature are to be determined.

Assumptions **1** Steady operating conditions exist and thus mass flow rate of dry air remains constant during the entire process. **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible. **4** The cooling tower is adiabatic.

Analysis The mass flow rate of dry air through the tower remains constant $(\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a)$, but the mass flow rate of liquid water decreases by an amount equal to the amount of water that vaporizes in the tower during the cooling process. The water lost through evaporation must be made up later in the cycle to maintain steady operation. Applying the mass and energy balances yields

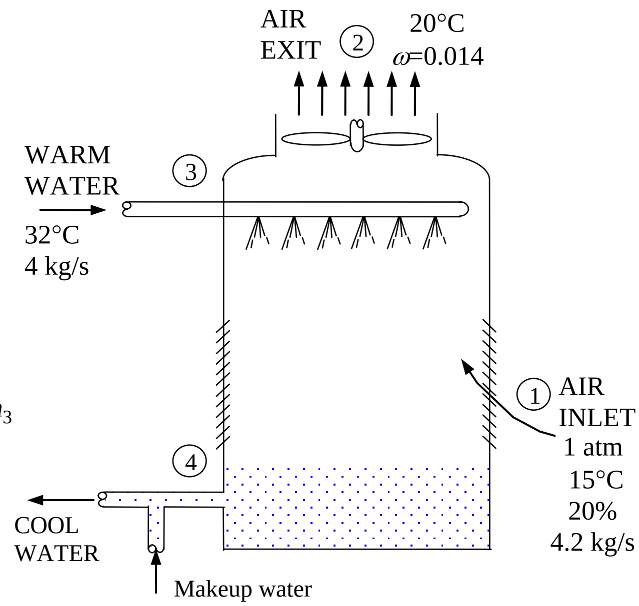
Dry Air Mass Balance:

$$\sum \dot{m}_{a,i} = \sum \dot{m}_{a,e} \longrightarrow \dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a$$

Water Mass Balance:

$$\sum \dot{m}_{w,i} = \sum \dot{m}_{w,e} \rightarrow \dot{m}_3 + \dot{m}_{a1}\omega_1 = \dot{m}_4 + \dot{m}_{a2}\omega_2$$

$$\dot{m}_3 - \dot{m}_4 = \dot{m}_a(\omega_2 - \omega_1) = \dot{m}_{\text{makeup}}$$



Energy Balance:

$$\dot{E}_{\text{in}} - \dot{E}_{\text{out}} = \Delta\dot{E}_{\text{system}}^{\nearrow 0\,(\text{steady})} = 0$$

$$\dot{E}_{\text{in}} = \dot{E}_{\text{out}}$$

$$\sum \dot{m}_i h_i = \sum \dot{m}_e h_e \quad (\text{since } \dot{Q} = \dot{W} = 0)$$

$$0 = \sum \dot{m}_e h_e - \sum \dot{m}_i h_i$$

$$0 = \dot{m}_{a2}h_2 + \dot{m}_4 h_4 - \dot{m}_{a1}h_1 - \dot{m}_3 h_3$$

$$0 = \dot{m}_a(h_2 - h_1) + (\dot{m}_3 - \dot{m}_{\text{makeup}})h_4 - \dot{m}_3 h_3$$

Solving for h_4,

$$h_4 = \frac{\dot{m}_3 h_3 - \dot{m}_a(h_2 - h_1)}{\dot{m}_3 - \dot{m}_{\text{makeup}}}$$

From the psychrometric chart (Fig. A-31),

$$h_1 = 20.4 \text{ kJ/kg dry air}$$

$$\omega_1 = 0.00211 \text{ kg H}_2\text{O/kg dry air}$$

$$v_1 = 0.819 \text{ m}^3\text{/kg dry air}$$

and

$$h_2 = 55.7 \text{ kJ/kg dry air}$$

$$\phi_2 = 1 = \mathbf{100\%}$$

From Table A-4,

$$h_3 \cong h_{f\,@\,32°\text{C}} = 134.1 \text{ kJ/kg H}_2\text{O}$$

Also, $\dot{m}_{\text{makeup}} = \dot{m}_a(\omega_2 - \omega_1) = (4.2 \text{ kg/s})(0.014 - 0.00211) = 0.050 \text{ kg/s}$

Substituting,

$$h_4 = \frac{\dot{m}_3 h_3 - \dot{m}_a(h_2 - h_1)}{\dot{m}_3 - \dot{m}_{\text{makeup}}} = \frac{(4)(134.1) - (0.12)(55.7 - 20.4)}{4 - 0.050} = 98.31 \text{ kJ/kg H}_2\text{O}$$

The exit temperature of the water is then (Table A-4)

$$T_4 = T_{\text{sat}\,@\,h_f = 98.31 \text{ kJ/kg}} = \mathbf{23.4°C}$$