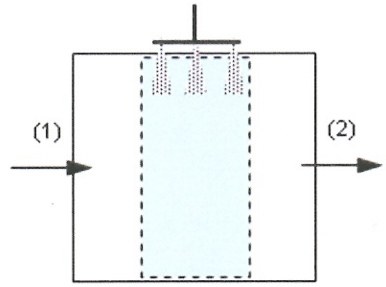
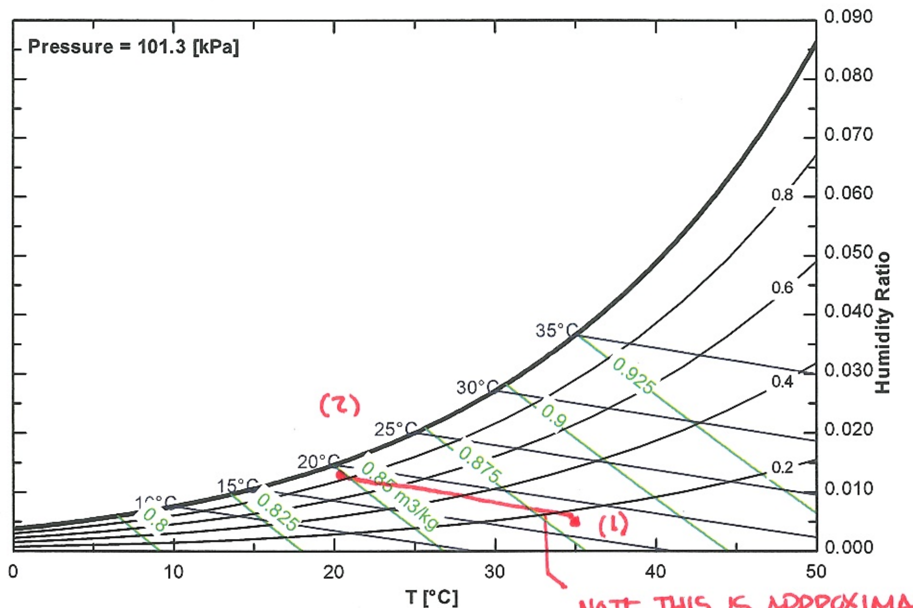
Example

Air at a total pressure of 1 atm has a dry bulb temperature of 35°C and ϕ = 15% is passed through an evaporative cooler.

(a) Sketch the process on a psychrometric chart.
(b) Determine the minimum dry bulb temperature that could be attained in the process.
(c) If the air leaves the cooler at a dry bulb temperature of 20°C, find the relative humidity of the air.
(d) If the cross sectional area of the cooler is constant, what happens to the velocity of the air as it passes through? Why? How might you calculate the new velocity?





NOTE THIS IS APPROXIMATELY ALONG A CONST T_{wb} LINE

(b) MIN. OCCURS WHEN (2) IS SATURATED; I.E., $\phi_2 = 100\%$

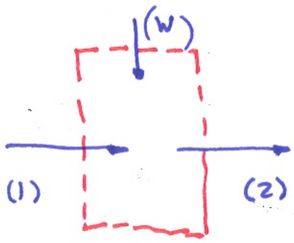
$\Rightarrow$

$T_{MIN} = T_{as}!! = T_{wb}$

$T_{wb} = T_{wb}(T_1 = 35°C, \phi = 15\%)$

$= \boxed{17.4°C}$

(c) $\phi_2 = \phi(T_2 = 20°C, \overset{?}{\_\_\_\_\_\_})$



Cons of mass

AIR: $0 = \dot{m}_{a1} - \dot{m}_{a2}$

$\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a$

WATER:

$0 = \dot{m}_a \omega_1 + \dot{m}_w - \dot{m}_a \omega_2$

$\overset{?}{\dot{m}_w} = \overset{?}{\dot{m}_a}(\overset{?}{\omega_2} - \omega_1)$ (1)

$\omega_1 = \omega(35°C, \phi = 15\%) = \_\_\_\_\_\_$

Cons of energy

$$0 = 0 - 0 + \dot{m}_a h_1 + \dot{m}_w h_w - \dot{m}_a h_2$$

USING (1)

$$0 = \cancel{\dot{m}_a} h_1 + (\omega_2 - \omega_1)\cancel{\dot{m}_a} h_w - \cancel{\dot{m}_a} h_2$$

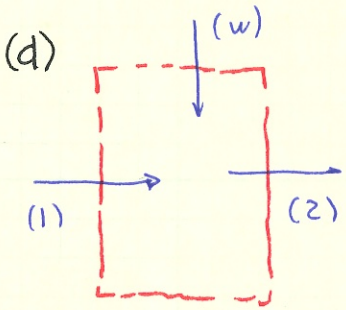
ACTUALLY CAN'T SOLVE UNLESS WE KNOW T_w, P_w. BUT, $h_w \approx h_f(T_w)$ IS ALWAYS $<< h_1$. SO:

$$0 \approx h_1 - h_2 \qquad h_2 \approx h_1 \qquad h_1 = h(T_1 = 35°C, \phi_1 = 15\%)$$

$$= 48.63 \text{ KJ/kg}$$

$$\therefore \phi_2 = \phi(T_2 = 20°C, h_2 = 48.63 \text{ kJ/kg}) = \boxed{76.9\%}$$

(d)



Cons of mass (AIR

$$0 = \dot{m}_{a1} - \dot{m}_{a2}$$

$$\downarrow$$

$$0 = \frac{V_1 A}{v_1} - \frac{V_2 A}{v_2}$$

$$V_2 = \frac{v_2}{v_1} V_1$$

$v_2 < v_1$, SO $V_2 < V_1$!!