HW 3-5

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14-60

Shower $M_v = 0.25\,kg_v$ $\qquad q_{out} = 2450\ \frac{kJ}{kg}$

bath $M_v = 0.05\,kg_v$ $\qquad$ 4 ppl take showers

$4 \cdot 0.25 = 1\,kg$ water in air per day

$2450\ \frac{kJ}{kg} \cdot 1\ \frac{kg}{day} = \boxed{\text{Latent heat load} = 2450\ \frac{kJ}{day}}$

14-67

given:

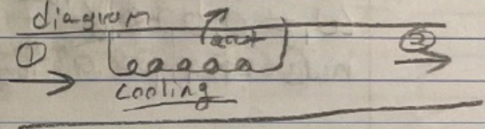
$D_1 = 0.3\,m$ $\qquad V_1 = 18\,m/s$ $\qquad \dot{Q}_{out} = 750\ \frac{kJ}{min} = 12.5\ \frac{kJ}{s}$

$P = 1\,atm \rightarrow$ psychrometic chart

$T_{db} = 35°C$

$\phi_1 = 45\%$

diagram



Formulas & chart $\qquad$ Calculations

$\dot{m} = \rho \cdot V \cdot A$

$\rho = \frac{1}{v}$ $\qquad \rho_1 = \frac{1}{v_1} = \frac{1}{0.895\ m^3/kg_a} = 1.117\ \frac{kg_a}{m^3}$

$A = \frac{\pi D^2}{4}$ $\qquad A = 0.0707\,m^2$

$\dot{m}_a = 1.117\ \frac{kg_a}{m^3} \cdot 18\ m/s \cdot 0.0707\,m^2$

$\dot{m}_a = 1.421\ \frac{kg_a}{s}$

h_1 from chart $= 76\ \frac{kJ}{kg_a}$

1st law $= \cancel{q_{in}}^0 - q_{out} + \cancel{w_{in}}^0 - \cancel{w_{out}}^0 = \Delta h$

$\dot{Q}_{out} = \dot{m}(\Delta h)$

$\frac{\dot{Q}_{out}}{\dot{m}} = \Delta h \rightarrow h_1 - h_2 \Rightarrow \frac{12.5\ kJ/s}{1.421\ kg/s} = 8.79\ \frac{kJ}{kg}$

$8.79\ \frac{kJ}{kg} = 76\ \frac{kJ}{kg_a} - h_2$

$+67.206 = h_2 \longrightarrow$ chart $\rightarrow \boxed{T_{db} = 26°C}$

$\boxed{\phi_2 = 74\%}$

$\dot{m}_a = \dot{m}_2$ $\qquad \dot{m}_{a2} = \frac{1}{v_2} \cdot V \cdot A$

$v_2 = .87\ m^3/kg_a$ $\qquad \frac{1.421\ kg/s}{0.0707\,m^2} \cdot .87\ \frac{m^3}{kg_a} = \boxed{V_2 = 17.486\ m/s}$

14-77 Find q_{out}, $\Delta\omega$

given:

$P = 1\ \text{atm}$

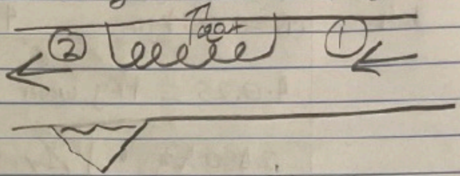
$T_{db1} = 90°F$ $\qquad$ $T_{db2} = 50°F$

$\phi_1 = 90\%$ $\qquad$ $\phi_2 = 100\%$

$T_w = 60°F$

calculations:

cooling and dehumidifying



$\dot m_{a1} = \dot m_{a2}$ $\qquad$ $\omega = \frac{\dot m_v}{\dot m_a}$ $\qquad$ $\dot m_w = \dot m_{v1} - \dot m_{v2}$

use psychrometric chart

$h_2 = 20\ \frac{btu}{lbma}$ $\qquad$ $h_1 = 52.5\ \frac{btu}{lba}$

$\omega_2 = 0.0075\ \frac{lbv}{lba}$

$\omega_1 = 0.028\ \frac{lbv}{lba}$

$h_w @ 60°F = 28.08\ \frac{btu}{lba}$

1st law

$\dot Q_{out} + \dot m_a h_2 + \dot m_w h_w = \dot m_a h_1$

$\frac{\dot Q_{out}}{\dot m_a} = \frac{\dot m_a (h_1 - h_2) - (\omega_1 - \omega_2) h_w}{\dot m_a}$

$q_{out} = (h_1 - h_2) - (\omega_1 - \omega_2) h_w$

$q_{out} = (52.5\ \frac{btu}{lba} - 20\ btu/lba) - (0.028 - 0.0075)\ 28.08\ \frac{btu}{lba}$

$\boxed{q_{out} = 31.924\ \frac{btu}{lbma}}$

14-93

Find: exit T of air, $\dot m_w$

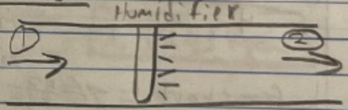
$P = 1\ atm$

$T_{db1} = 40°C$

$\phi_1 = 20\%$

$\dot V_1 = 7 \frac{m^3}{min}$

$\phi_2 = 90\%$



formulas

$\dot m_a = \frac{1}{v_1} \cdot \dot V$

$\dot m_{a1} = \dot m_{a2} = \dot m_a$

1st law

Conservation of mass

$T_{wb1} = 22°C$ $T_{wb2} = 26.6°C$

humidifying (straight up)

Calculations

$\dot m_a = \frac{1}{0.9\ m^3/kga} \cdot \frac{7\ m^3/min}{60\ sec} = 0.12963 \frac{kg}{s}$

$h_2 = 83 \frac{kJ}{kga}$ $\omega_2 = 0.0165 \frac{kgv}{kga}$

$h_1 = 65 \frac{kJ}{kga}$ $\omega_1 = 0.00925 \frac{kgv}{kga}$

$\dot m_w = (0.0165 - 0.00925)\, 0.12963$

$\boxed{\dot m_w = 0.00094\ kgv/s}$

$\omega = \frac{\dot m_v}{\dot m_a}$

$(\dot m_w = \dot m_{v2} - \dot m_{v1}) \frac{1}{\dot m_a} = \frac{\dot m_w}{\dot m_a} = (\omega_2 - \omega_1)\, \dot m_a$

$\dot m_w = (\omega_2 - \omega_1)\, \dot m_a$

$\boxed{\begin{array}{l} T_{db2} \rightarrow \text{chart} = 40°C \\ T_{wb2} = 26.6°C \end{array}}$

14-100

① $T_{1db} = 35\,°C$

$\phi = 30\%$

$\dot{V}_1 = 15\ m^3/min$

$\omega_1 = 0.011\ \frac{kg\ wtr}{kg\ dry\ air}$

Char

$\dot{m}_{a1} = \frac{\dot{V}_1}{v_1}$

$\dot{m}_{a1} = \frac{15\ m^3/min}{0.888\ \frac{m^3}{kg\ dry\ air}}$

$\dot{m}_{a1} = 16.89\ \frac{kg\ dry\ air}{min}$

② $T_{2db} = 12\,°C$

$\phi = 90\%$

$\dot{V}_2 = 25\ m^3/min$

$\omega_2 =$

$\dot{m}_{a2} = \frac{\dot{V}_2}{v_2}$

$\dot{m}_{a2} = \frac{25\ m^3/min}{0.818\ m^3/kg\ dry\ air}$

$\dot{m}_{a2} = 30.56\ \frac{kg\ dry\ air}{min}$

③ $\omega_3 = ?$

$\phi_3 = ?$

$T_3 = ?$

$\dot{V}_4 = ?$

Chart: $v_1 = 0.888\ m^3/kg\ dry\ air$

$v_2 = 0.818\ m^3/kg\ dry\ air$

$\omega_1 = 0.011\ \frac{kg\ wtr}{kg\ dry\ air}$

$\omega_2 = 0.008\ \frac{kg\ wtr}{kg\ dry\ air}$

$$\frac{\omega_2 - \omega_1}{\omega_3 - \omega_1} = \frac{\omega_2 - \cancel{\omega_3}}{\omega_3 - \omega_1} + 1 \Rightarrow \omega_3 = \frac{\omega_2 - \omega_1}{\left(\frac{\dot{m}_{a1}}{\dot{m}_{a2}} + 1\right)} + \omega_1$$

$\frac{\dot{m}_{a1}}{\dot{m}_{a2}}$

$$\boxed{\omega_3 = 0.0089\ kg\ wtr/kg\ dry\ air}$$

using ω_3 on chart, find T_3 & ϕ_3.

$$\boxed{T_{3\,db} = 20\,°C}$$

$$\boxed{\phi_3 = 60\%}$$

Find $\dot{V}_3$:

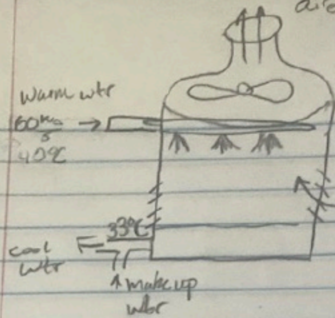
$\dot{m}_{a3} = \dot{m}_{a1} + \dot{m}_{a2} \Rightarrow \dot{m}_{a3} = 47.45\ \frac{kg\ dry\ air}{min}$

$\dot{V}_3 = \dot{m}_{a3}(v_3) \Rightarrow 47.45(0.8425)$

Chart: $v_3 = 0.8425\ \frac{m^3}{kg\ dry\ air}$

$$\boxed{\dot{V}_3 = 39.97\ m^3/min}$$

14-109



Air inlet: 1 atm

$T_{db} = 22°C$

$T_{wb} = 16°C$

Air leaving: $30°C = T_{db2}$

$\phi = 95\%$

First law: $\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = \Delta h$

$\dot{m}_{1a} = \dot{m}_{2a} = \dot{m}_a$

$\dot{m}_w(h_w) + \dot{m}_{H_2O}(h_{1\,H_2O}) + \dot{m}_{a1}(h_1) = \dot{m}_{H_2O}(h_{2\,H_2O}) + \dot{m}_{a2}(h_2)$

$\Rightarrow \dot{m}_{H_2O}(h_{1\,H_2O} - h_{2\,H_2O}) + \dot{m}_w(h_w) = \dot{m}_a(h_2 - h_1)$

$\dot{m}_w h_w = (\omega_2 - \omega_1)(h_w)$

$\dot{m}_{H_2O}(h_{1H_2O} - h_{2H_2O}) + (\omega_2 - \omega_1)(\dot{m}_a)(h_w) = \dot{m}_a(h_2 - h_1)$

$\dot{m}_a = \dfrac{\dot{m}_{H_2O}\overbrace{(h_{1H_2O} - h_{2H_2O})}^{c_p(T_{1H_2O} - T_{2H_2O})}}{(h_2 - h_1) - (\omega_2 - \omega_1)h_w} \Rightarrow$

Chart:

$h_1 = 45$ kJ/kg dry air

$\omega_1 = 0.009$ kg/kg dry air

Chart:

$\omega_2 = 0.0245$ kg wtr/kg dry air

$h_2 = 93$ kJ/kg dry air

Table: $\rightarrow h_w @ T_{cw} = 138.28$ kJ/kg

$\dot{m}_{H_2O} = 60$ kg/s

$c_{p\,wtr} @ 33°C = 4.18$ kJ/kg·K

$\dot{m}_a = \dfrac{60\text{ kg/s}\,(4.18\text{ kJ/kg·K})(40°C - 33°C)}{(93 - 45)\frac{\text{kJ}}{\text{kg dry air}} - (0.0245 - 0.009)\frac{\text{kg wtr}}{\text{kg dry air}}(138.28\text{ kJ/kg})}$

$\dot{m}_a = 40.03$ kg dry air/s

$\dot{m}_a = \dot{V}_w(\cancel{\quad})$

$v_2 = 0.849$ m³/kg dry air

$.849\frac{\text{m}^3}{\text{kg dry air}} \times 40.03\frac{\text{kg dry air}}{\text{s}}$ $= \boxed{\dot{V}_2 = 30.8\text{ m}^3/\text{s}}$

$\dot{m}_{H_2O} = \dot{m}_a(\omega_2 - \omega_1) = \boxed{0.624\text{ kg/s} = \dot{m}_{H_2O}}$