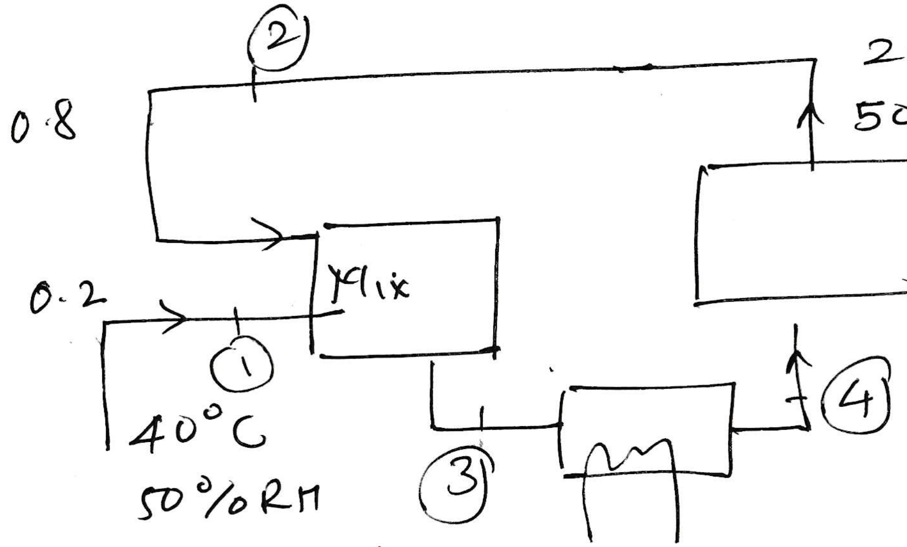
The room sensible and latent head loads of an AC space is 25 kW and 5 kW respectively. The room condition is 25C and 50% RH. The outdoor condition is 40C and 50% RH. The ventilation requirements is such that on mass flow rate basis 20% fresh air is introduced and 80% supply air is recirculated. The by-pass ratio of the cooling coil is 0.15. Determine the supply air flow rate and the coil temperature.



26°C
50% RH

$\omega_2 = 10.8$

$h_2 = 53.5$

SH = 25 kW $\quad V_2 = 0.862$

LH = 5 kW

$h_1 = 101$ kJ/kg

$\omega_1 = 23.5$ g/kg d.a

$v_1 = 0.92$ m^3/kg

1 $\quad \omega_3 = (0.2)\omega_1 + (0.8)\omega_2$

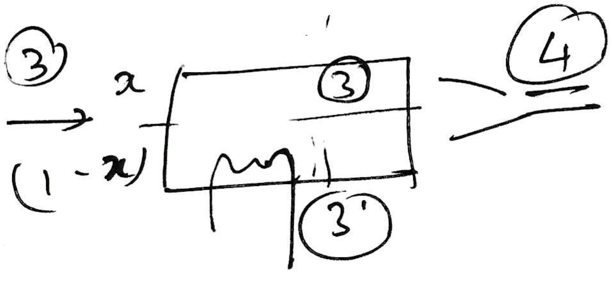
$\omega_3 = (0.2)(23.5) + (0.8)(10.8)$

$= 13.34$ g/kg d.a.

$h_3 = (0.2)(101) + (0.8)(53.5)$

$= 63$ kJ/kg

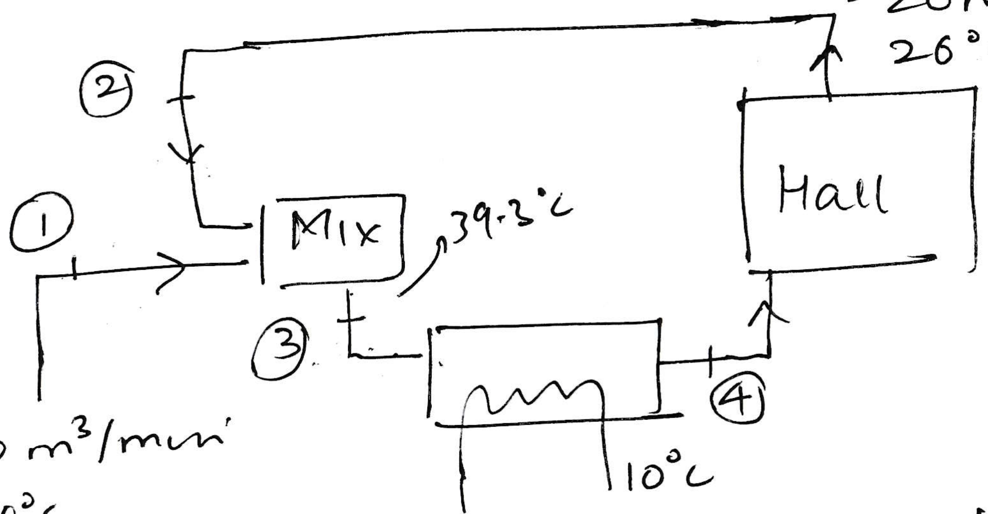
$$T_3 = \frac{63 - 2500\,\omega_3}{C_p} = 29.5°C$$



$$x h_3 + (1-x) h_3' = h_4$$

$$\left.\begin{aligned} SH &= \dot{m}_a\, c_{ph} (T_2 - T_4) \\ LH &= \dot{m}_a\, h_{fg} (\omega_2 - \omega_4) \end{aligned}\right\} \quad \frac{SH}{LH} = \frac{c_{ph}(T_2 - T_4)}{h_{fg}(\omega_2 - \omega_4)}$$

Air flow at the rate of $100\ m^3/min$ at 40C and 50% RH is mixed with another stream flowing at the rate of $20m^3$/min at 26C and 50% RH that is recirculated from a hall. The mixture flows over a cooling coil whose surface temperature is 10C and by-pass factor is 0.2. Find the temperature and RH leaving the coil. Find the cooling capacity of the coil. Determine the sensible heat and latent heat gain in the hall.



50% RH.

$\omega_2 = 10.8$

$h_2 = 53.5$

$v_2 = 0.862\ m^3/kg$

$\dot{m}_{a_2} = \frac{20}{0.862} = 23.2\ kg/min$

$\dot{V}_1$ 100 m³/min

T_1 40°C

RH = 50%.

$\omega_1 = 23.5$

$h_1 = 101\ kJ/kg$

$v_1 = 0.92\ m^3/kg$

$\dot{m}_{a_1} = \frac{\dot{V}}{v_1} = \frac{100}{0.92} = 108.7\ kg/min$

$\dot{m}_{a_3} = \dot{m}_{a_1} + \dot{m}_{a_2}$

$108.7 + 23.2 = 131.9\ kg/min$

$\dot{m}_{a_1}\omega_1 + \dot{m}_{a_2}\omega_2 = \dot{m}_{a_3}\omega_3$

$(108.7)(23.5) + (23.2)(10.8) = 131.9\ \omega_3$

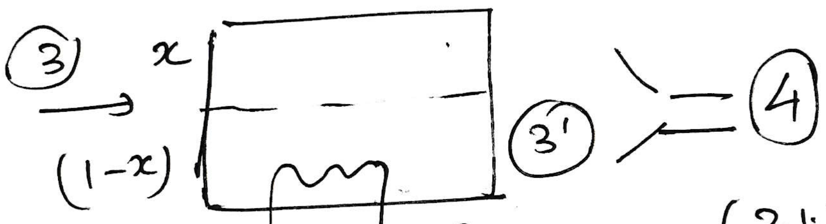
$\Rightarrow \omega_3 = 21.27\ g/kg.d.a.$

$\dot{m}_{a_1}h_1 + \dot{m}_{a_2}h_2 = \dot{m}_{a_3}h_3$

$(108.7)(101) + (23.2)(53.5) = (131.9)\ h_3$

$h_3 = 92.65\ kJ/kg$

$h_3 = C_p T_3 + \omega_3\ 2500 \Rightarrow T_3 = 39.3°C$



$10°C$

$RH = 100$

$x = 0.2$

$\omega_3' = 7.6$

$h_3' = 29$

$$\omega_3 x + (1-x)\omega_3' = \omega_4$$

$$h_3 x + (1-x) h_3' = h_4$$

$$(21.27)(\cancel{7.6})(0.2) + (1-0.2)(7.6) = \omega_4$$

$$= 10.33 \ \frac{g}{kg\,da}$$

$$(92.65)(0.2) + (1-0.2)(29) = h_4$$

$$= 41.73 \ kJ/kg$$

$$h_4 = C_p T_4 + \omega_4 (2500)$$

$$T_4 = 15.9°C$$

$$P_{v_4} = \frac{P\omega_4}{0.622 + \omega_4} = \frac{(101.325)(0.01033)}{0.622 + 0.01033} = 1.655$$

$$P_{sat} = 0.01818 \ bar = 1.818 \ kPa$$

$$RH = \frac{1.655}{1.818} = 91\%$$

$$\dot{m}_a h_3 - \dot{m}_a h_4 + \dot{Q} = 0$$

$$\dot{Q} = \dot{m}_a (h_4 - h_3)$$

$$= (131.9)(41.73 - 92.65)$$

$$= -6716.35 \ kJ/min$$

$$= -111.9 \ kW.$$

$$LH = \dot{m}_a (\omega_2 - \omega_4) h_{fg}$$

$$= (131.9)(10.8 - 10.33)2500$$

$$= 155 \ kJ/min = 2.6 \ kW$$

$$SH = \dot{m}_a C_{ph} (T_{d2} - T_{d4})$$

$$= (131.9)(1.022)(26 - 15.9) = 1361.5 \ kJ/min$$

$$\frac{LH}{SH} = \frac{h_{fg}(\omega_2 - \omega_4)}{C_{ph}(T_2 - T_4)} \Rightarrow \frac{\omega_2 - \omega_4}{T_2 - T_4} = \frac{C_{ph}}{h_{fg}} \frac{LH}{SH}.$$

$$\text{slope} = \frac{\omega_2 - \omega_4}{T_2 - T_4} = \left(\frac{1.022}{2500} \frac{5}{25}\right)(1000)$$

$$\theta = 4.67^\circ$$

to convert from g for the chart

Coil temp

From chart, $\boxed{T_3' = 14^\circ C}$ $h_3' = 39$ $\omega_3' = 10$

Subs in $x h_3 + (1-x) h_3' = h_4$

$$(0.15)(63) + (1-0.15)(39) = h_4$$

$$\Rightarrow h_4 = 42.6 \text{ kJ/kg}$$

$$(0.15)(13.34) + (1-0.15)(10) = \omega_4 \Rightarrow \omega_4 = 10.5 g$$

$$\Rightarrow T_4 = 16^\circ C \quad RH = 90\%$$

$$SH = \dot{m}_a C_{ph} (T_2 - T_4)$$

$$25 = \dot{m}_a (1.022)(26 - 16) \Rightarrow \boxed{\dot{m}_a = 2.45 \text{ kg/s}}$$