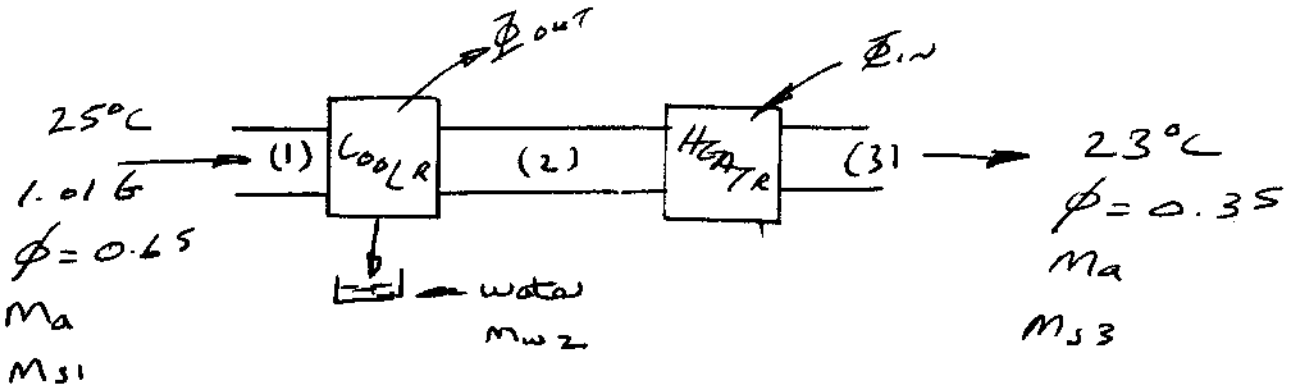
Q8 2002



m_a = Mass of dry air — constant throughout

m_s = mass of vapour m_w = mass of water

$p_g = 0.03166$ bar @ 25°C $p_s = \phi p_g$

$p_{s1} = 0.65 \times 0.03166 = 0.020579$ bar

$p_a = 1.01 - p_{s1} = 0.989421$ bar

$\omega_1 = 0.622 \frac{p_{s1}}{p_a} = 0.012937$

$m_a = pV/RT = \frac{0.989421 \times 10^5 \times V_A}{287 \times 298}$

For 1 kg of dry air $V_A = 0.864\ m^3$

$m_{s1} = \frac{p_{s1} V}{RT}$ For vapour volume of vapour is same as vol of air

$R = 462$ for water vapour

$m_{s1} = \frac{0.020579 \times 10^5 \times 0.864}{462 \times 298} = 0.012926$ kg

$\omega = m_s/m_a = 0.622\ p_s/p_a$

$\phi = p_s/p_g = 1.608\ p_a/p_g$

$p = 1.01$ b $\quad \theta = 25°C \quad \phi = 0.65$

INLET

@ 25°C $p_g = 0.03166$ bar

$\phi = p_s/p_g = 0.65$ $p_s = 0.65 \times 0.03166$

$= 0.020579$ bar

$p_a = 1.01 - 0.020579 = 0.989421$ bar

$\omega = .622 \times \frac{0.020579}{0.989421} = 0.012937$

DEW POINT = 17.8°C

EXIT $\phi_3 = 0.35 = p_{s3}/p_{g3}$

$p_{g3} = p_s$ @ 23°C $= 0.02808$ bar

$p_{s3} = 0.02808 \times 0.35 = 0.009828$ bar

$p_{a3} = 1.01 - 0.009828 = 1.000172$ bar

$\omega_3 = 0.622\, p_s/p_a = 0.622 \times \frac{0.009828}{1.000172}$

$\omega_3 = 0.0061119\,64$

$M_{s3} = 0.006112\, M_a$

$M_{s1} = 0.0129206\, M_a$

CONDENSATE FORMED $= M_{s1} - M_{s3} = 0.00681\, M_a$

ENERGY BALANCE ON COOLER

$p_{s2} = p_{s3} = 0.009828$ bar

$M_a C_a (T_{a1} - T_{a2}) - M_w C_w T_w + M_{s1} h_{s1}$

$- M_{s2} h_{s2} = \phi_{out}$

h_{s1} @ 25°C 0.0206 bar $= 2550$ kJ/kg (chart)

h_{s2} @ 17.8°C 0.00983 bar $= h_g = 2533$ kJ/kg

$M_{a1} = 1$ kg $C_a = 1.004$ kJ/kg K

$M_{s2} = M_{s3}$ $C_w = 4.186$ kJ/kg K

$1 \times 1.004 (25 - 17.8) - 0.00681 \times 4.186 \times 17.8$

$+ 0.0129206 \times 2550 - 0.006112 \times 2533 = \phi_{out}$

$\phi_{out} = 24.187$ kJ for 1 kg of DRY AIR

ENERGY BALANCE ON HEATER

$h_{s3} = 25.45\ kJ/kg$ (23°C 0.009828 G)

$$M_a C_a \Theta_3 + M_{s3} h_{s3} = M_a C_a \Theta_2 + M_{s2} h_{s2} + \not{Q}(in)$$

$$1 \times 1.004 \times 23 + 0.006112 \times 25.45$$
$$= 1 \times 1.004 \times 17.8 + 0.006112 \times 25.33 + \not{Q}(in)$$

$\not{Q}(in) = 5.3\ kJ$ per kg of DRY AIR

$M_a = 1\ kg$ AT EXIT $M = M_a + M_{s3}$

$$M = 1.006112\ kg$$

$\not{Q}(out) = 24.04\ kJ/kg$

$\not{Q}(in) = 5.27\ kJ/kg$

} per kg of CONDITIONED AIR