Week 10: Lecture 3

Psychrometric Applications

- studies involving mixtures of dry air and water vapour
- used in the design of air-conditioning systems, cooling towers and most processes involving the control of vapour content in air
- for $T \leq 50°C \quad (P_{sat} \leq 13\ kPa) \quad \Rightarrow \quad h \approx h(T)$
- water vapour can be treated as an ideal gas

Moist Air

$$P = P_a + P_w$$

$$P_a = \frac{m_a R_a T}{V}$$

$$P_w = \frac{m_w R_w T}{V}$$

where

P_a is the partial pressure of air and P_w is the partial pressure of water vapour.

Relative Humidity

$$\phi = \frac{P_w(T)}{P_{sat}(T)} = \frac{\text{vapour pressure at the prevailing T}}{\text{saturation pressure at the prevailing T}}$$

The relative humidity can also be written as

$$\phi = \frac{P_w}{P_{sat}} = \frac{\rho_w}{\rho_s at} = \frac{v_g}{v_w}$$

where v_g is the mixture specific volume and v_w is water specific volume.

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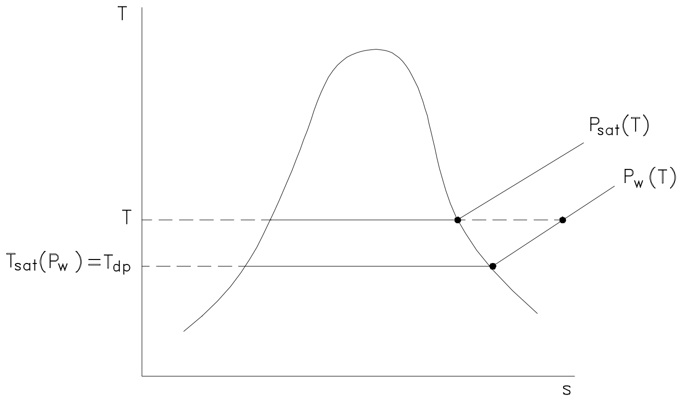

Specific Humidity (Humidity ratio)

$$\begin{aligned}\gamma \ = \omega \quad &= \quad \frac{m_w}{m_a} = \frac{\text{mass of water vapour}}{\text{mass or air}} \\ &= \quad \left(\frac{\tilde{M}_w}{\tilde{M}_a}\right)\left(\frac{P_w}{P_a}\right) \\ &= \quad 0.622 \left(\frac{P_w}{P_a}\right)\end{aligned}$$

In addition γ can be written as

$$\gamma = 0.622 \left(\frac{P_w}{P_a}\right) = 0.622 \left(\frac{P_w}{P - P_w}\right) = 0.622 \left(\frac{\phi P_{sat}}{P - \phi P_{sat}}\right)$$

which can be rearranged in terms of relative humidity

$$\phi = \frac{P\gamma}{P_{sat}\left(\gamma + \dfrac{\tilde{M}_w}{\tilde{M}_a}\right)} = \frac{P\gamma}{P_{sat}(\gamma + 0.622)}$$

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Psychrometric Chart