

(1)
Reynolds Analogy

* For Flow over plane

$$\frac{h}{\rho \cdot C_p \cdot u_s} = \frac{R}{\rho u_s^2}$$
$$\frac{h_D}{u_s} = \frac{R}{\rho u_s^2}$$
$$\frac{h}{\rho \cdot C_p \cdot u_s} = \frac{h_D}{u_s}$$

Simple Reynold Analogy

$$\frac{R}{\rho u_s^2} = 0.03 Re_x^{-0.2}$$

Point Value

$$\frac{R}{\rho u_s^2} = 0.037 Re_x^{-0.2}$$

mean Value

$$\frac{h}{\rho C_p u_s} = \frac{h_D}{u_s} = \frac{h_D}{u_s} \frac{C_{Bw}}{C_T} = \frac{R}{\rho u_s^2} = 0.03 Re^{-0.2}$$

$$\frac{h}{\rho \cdot C_p \cdot u_s} = \frac{h_D}{u_s} = 0.037 Re^{-0.2}$$

mean Value

Modified Reynold analogy :-

$$\frac{h}{\rho \cdot C_p \cdot u_s} = \frac{R}{\rho u_s^2} \cdot \frac{1}{1 + \alpha (Pr - 1)}$$

or

$$\frac{h_0}{u_s} = \frac{R}{\rho u_s^2} \cdot \frac{1}{1 + \alpha (Sc - 1)}$$

where :-

$$Pr = \frac{C_p \cdot \mu}{K}$$

$$Sc = \frac{\mu}{\rho \cdot D}$$

$$\alpha = 2.1 Re^{-0.1}$$

D = diffusivity

$$D = \frac{4.3 T^{1.5}}{\rho (V_A^{1/3} + V_B^{1/3})^2} \sqrt{\frac{1}{M_A} + \frac{1}{M_B}} \quad (\text{gas-gas})$$

$$D = \frac{7.7 \times 10^{-16}}{\mu (V - V_0)^{1/3}}$$

for gas into liquid

Flow in Pipe &

(3)

a. Simple Reynold Analogy

$$\frac{h}{\rho \cdot u \cdot C_p} = \frac{h_D}{u} = \frac{R}{\rho u^2} = 0.032 Re^{-1/4}$$

b. Modified Reynold analogy

$$\frac{h_i}{\rho \cdot C_p \cdot u} = \frac{0.032 Re^{-1/4}}{1 + \alpha (Pr - 1)} \quad Pr = \frac{C_p \mu}{k}$$

$$\frac{h_D}{u} = \frac{0.032 Re^{-1/4}}{1 + \alpha (Sc - 1)} \quad Sc = \frac{\mu}{\rho \cdot D}$$

$$\alpha = 2 Re^{-1/8}$$

$$\frac{R}{\rho u^2} = 0.0396 Re^{-1/4}$$

c. Chilton and Colburn

$$\frac{h}{\rho C_p u} = 0.023 Re^{-0.2} Pr^{-0.67}$$

$$\frac{h_D}{u_s} = 0.023 Re^{-0.2} Sc^{-0.67}$$

Ex1:- Water flows at 0.5 m/s through a 20mm tube lined with B-naphthol. What is the mass transfer coefficient if the Schmidt No $Sc = 2330$

Ans:-

$$\frac{h_D}{u_s} = 0.023 Re^{-0.2} Sc^{-0.67}$$

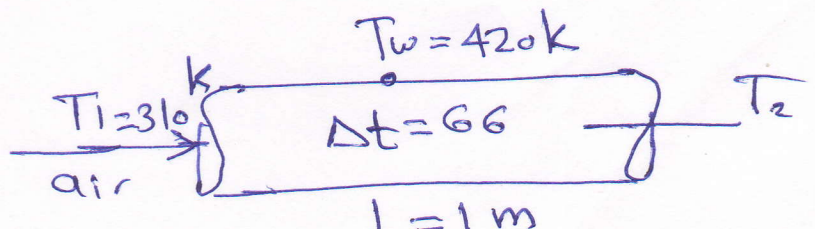
$$Re = \rho u d / \mu = 1000 \times 0.5 \times 0.02 / 10^{-3} = 10000$$

$$\therefore \frac{h_D}{0.5} = 0.023 (10000)^{-0.2} \cdot (2330)^{-0.67}$$

$$h_D = 1.01 \times 10^{-5} \text{ m/s}$$

Ex2:- If the temperature rise per meter length along a pipe carrying air at 12.2 m/s is 66K what will be the corresponding pressure drop for a pipe temperature of 420K and air temperature of 310K. The density of air at 310K is 1.14 kg/m³.

Ans:-



(5)

$$\Delta P = 4f \frac{L}{d} \rho U_s^2$$

$$f = \frac{R}{\rho U_s^2}$$

$$\Delta P = 4 \frac{R}{\rho U_s^2} \frac{L}{d} \rho U_s^2$$

$$\frac{R}{\rho U_s^2} = \frac{h}{\rho C_p U_s}$$

$$\therefore \Delta P = 4 \left(\frac{h}{\rho C_p U_s} \right) \cdot \frac{L}{d} \cdot \rho U_s^2$$

Heat balance along the tube

$$hA \Delta T = m C_p \Delta t$$

$$h \cdot \pi d L \cdot \Delta T = \left(\rho \cdot U_s \cdot \frac{\pi}{4} \cdot d^2 \right) C_p \cdot \Delta t$$

$$\therefore \frac{h}{\rho C_p U_s} = \frac{d/4 \cdot \Delta t}{L \Delta T}$$

$$\therefore \Delta P = 4 \left(\frac{d/4 \cdot \Delta t}{L \Delta T} \right) \cdot \frac{L}{d} \cdot \rho U_s^2$$

$$\therefore \Delta P = \frac{\rho U_s^2 \Delta t}{\Delta T} = \frac{1.14 \times 12.2^2 \times 66}{420 - \left(\frac{T_1 + T_2}{2} \right)}$$

$$\Delta P = 101.8 \text{ N/m}^2$$

$$T_1 + T_2 / 2 = \frac{(310 + 376)}{2}$$

$$= 343 \text{ K}$$