HEAT TRANSFER

[CH21204]

March 09, 2023

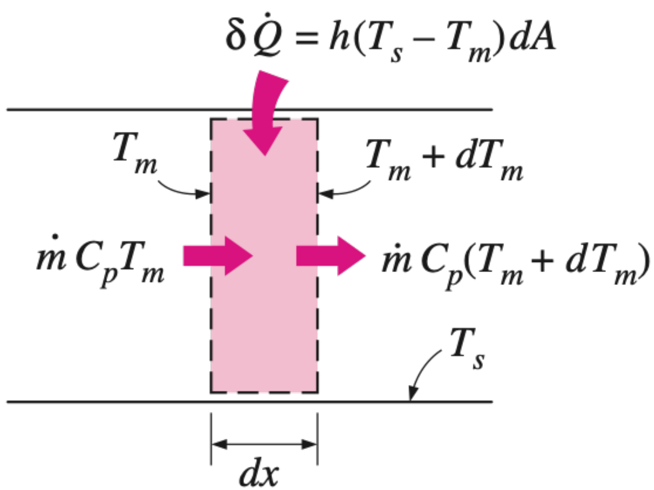
Constant Surface Temperature

$$\dot{Q} = hA_s\Delta T_{\text{ave}} = hA_s(T_s - T_m)_{\text{ave}}$$

$$\Delta T_{\text{ave}} \approx \Delta T_{\text{am}} = \frac{\Delta T_i + \Delta T_e}{2} = \frac{(T_s - T_i) + (T_s - T_e)}{2} = T_s - \frac{T_i + T_e}{2}$$

$$= T_s - T_b$$

$$T_b = (T_i + T_e)/2$$

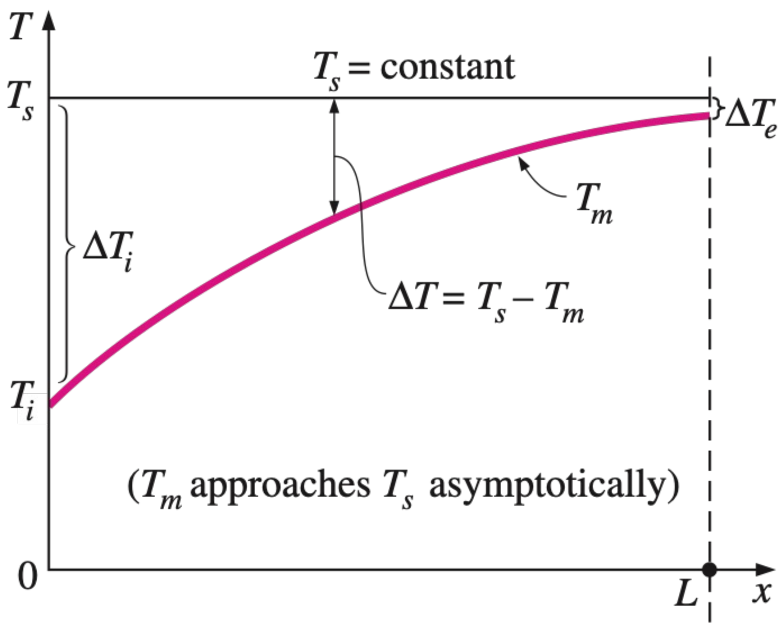


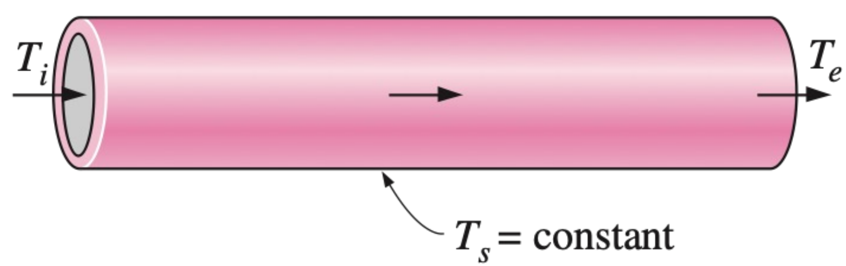
$$\dot{m}\,C_p\,dT_m = h(T_s - T_m)dA_s$$

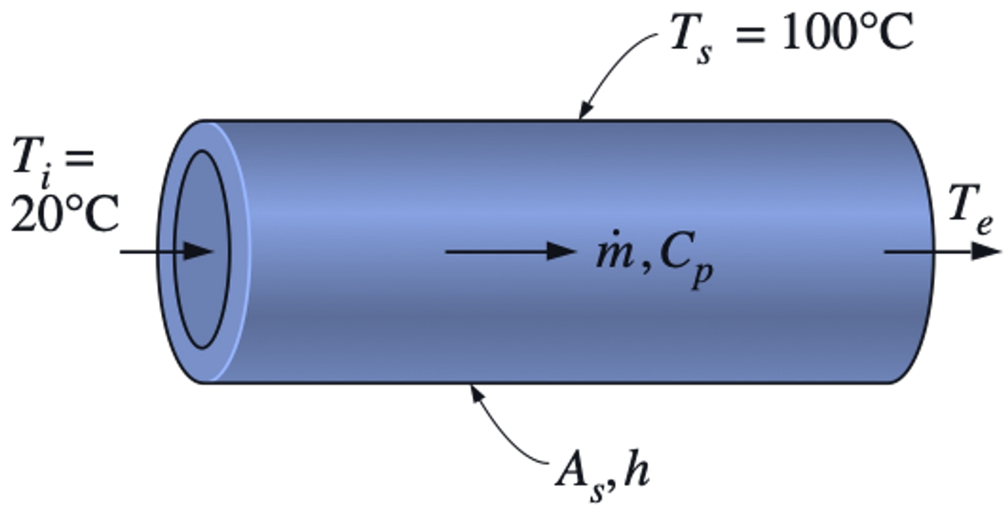
$$\frac{d(T_s - T_m)}{T_s - T_m} = -\frac{hp}{\dot{m}C_p}\,dx$$

$$\ln\frac{T_s - T_e}{T_s - T_i} = -\frac{hA_s}{\dot{m}C_p}$$

$$T_e = T_s - (T_s - T_i)\exp(-hA_s/\dot{m}\,C_p)$$







$NTU = hA_s / \dot{m}C_p$	T_e, °C
0.01	20.8
0.05	23.9
0.10	27.6
0.50	51.5
1.00	70.6
5.00	99.5
10.00	100.0

$$\dot{m}C_p = -\frac{hA_s}{\ln[(T_s - T_e)/(T_s - T_i)]}$$

$$\dot{Q} = \dot{q}_s A_s = \dot{m}C_p(T_e - T_i)$$

$$\dot{Q} = hA_s \Delta T_{\ln}$$

$$\Delta T_{\ln} = \frac{T_i - T_e}{\ln[(T_s - T_e)/(T_s - T_i)]} = \frac{\Delta T_e - \Delta T_i}{\ln(\Delta T_e/\Delta T_i)}$$

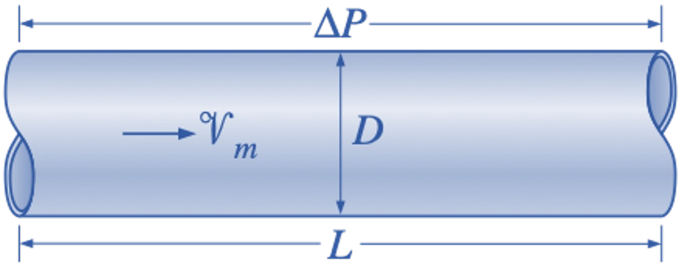
logarithmic mean temperature difference

LAMINAR FLOW IN TUBES

$$\mathcal{V}(r) = 2\mathcal{V}_m\left(1 - \frac{r^2}{R^2}\right)$$

mean velocity is half of the maximum velocity

$$\Delta P = \frac{8\mu L\,\mathcal{V}_m}{R^2} = \frac{32\mu L\,\mathcal{V}_m}{D^2}$$



$$\boxed{f = \frac{64\mu}{\rho D\mathcal{V}_m} = \frac{64}{\text{Re}}}$$

Pressure drop: $\Delta P = f\,\dfrac{L}{D}\,\dfrac{\rho\mathcal{V}_m^2}{2}$

Darcy friction factor

$$C_f = \tau_s(\rho\mathcal{V}_m^2/2) = f/4$$