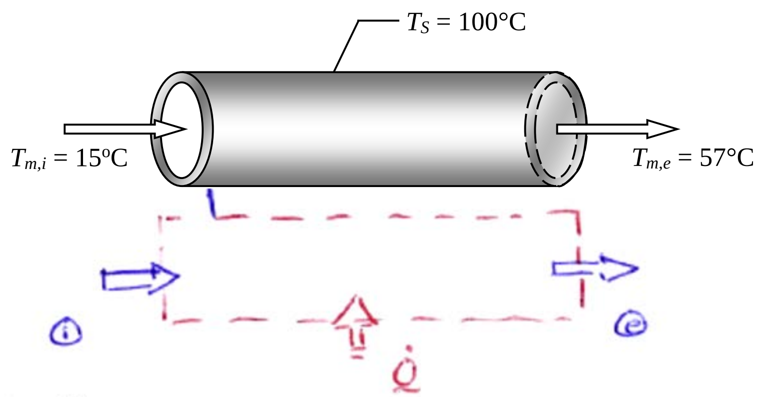
Example

The average convection coefficient for water flowing through a circular tube is to be determined *experimentally*. In the experiment, steam condenses on the outer surface of a thin-walled circular tube with 50-mm diameter and 6-m length. This maintains the tube at a uniform surface temperature of 100°C. Water flows through inside the tube at a rate of $\dot{m}$ = 0.25 kg/s, and its inlet and outlet temperatures are $T_{m,i}$ = 15°C and $T_{m,e}$ = 57°C, respectively. What is the experimentally determined average convection coefficient associated with the water flow?



→ Means we <u>don't</u> need to use a Nu-relation.

Use: $\dot{Q} = hA\Delta T_{LM}$

<u>Co. E.</u>

$$\frac{d}{dt}(E_{sys}) = \dot{Q} + \dot{W} + \sum_{in} \dot{m}(h + \dots) - \sum_{out} \dot{m}(h + \dots)$$

$$0 = \dot{Q} + \dot{m}(h_i) - \dot{m}(h_o)$$

$$\dot{Q} = \dot{m}(h_e - h_i) = \dot{m}(c_p[T_e - T_i] + v[P_e - P_i])$$

$$T_B = \frac{T_i + T_e}{2} = \frac{15°C + 57°C}{2} = 36°C$$

$$c_p(@\,T_B) = 4178\ J/kg\cdot°C$$

$$\dot{Q} = (0.25\ \tfrac{kg}{s})(4178\ \tfrac{J}{kg\cdot°C})(57°C - 15°C) = 43{,}869\ \tfrac{J}{s} = 43{,}869\ W$$

What is ΔT_{LM}?

$$\Delta T_{LM} = \frac{(T_s - T_e) - (T_s - T_i)}{\ln\left[\frac{T_s - T_e}{T_s - T_i}\right]} = \frac{(100 - 57)°C - (100 - 15)°C}{\ln\left[\frac{(100 - 57)°C}{(100 - 15)°C}\right]} = 61.6°C$$

What is A?

$$A = \pi D L = (\pi)(0.050\ m)(6.0\ m) = 0.94348\ m^2$$

CAREFUL!

And so

$$\dot{Q} = h_{AVG} A \Delta T_{LM}$$

$$h_{AVG} = \frac{\dot{Q}}{(A)(\Delta T_{LM})} = \frac{43{,}869\ W}{(0.9435\ m^2)(61.6°C)}$$

$$= \boxed{756\ W/m^2\text{-}°C}$$