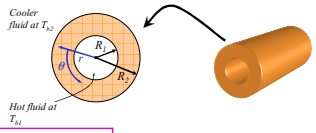
Example 4: Heat flux in a cylindrical shell



Solution for Heat Flux:

$$\frac{q_r}{A} = \left(\frac{(T_{b1} - T_{b2})}{\frac{1}{h_2 R_2} + \frac{1}{k} \ln\left(\frac{R_2}{R_1}\right) + \frac{1}{h_1 R_1}} \right) \left(\frac{1}{r}\right)$$

Calculate Total Heat flow:

$$Q = \left(\frac{q_r}{A}\right) 2\pi r L$$

$$= \frac{(T_{b1} - T_{b2})\, 2\pi L}{\frac{1}{h_2 R_2} + \frac{1}{k} \ln\left(\frac{R_2}{R_1}\right) + \frac{1}{h_1 R_1}}$$

note that total heat flow is proportional to **bulk ΔT** and (almost) **area of heat transfer**

Overall Heat Transfer Coefficient, **U**

$$Q = UA\Delta T$$
$$= UA(T_{b1} - T_{b2})$$

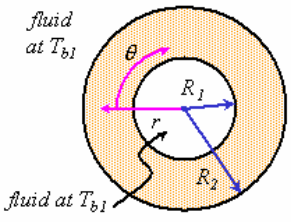
this equation serves as the definition of U

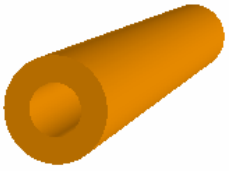
A = *area of heat transfer (not always unambiguous)*

ΔT = *driving temperature difference*

Example: in a pipe

do we use inner or outer area?





overall heat xfer coeffs in pipe

Area must be specified when U is reported

$$Q = U_1 A_1 \Delta T$$

$$= \left(\frac{\frac{1}{R_1}}{\frac{1}{h_2 R_2} + \frac{1}{k} \ln\left(\frac{R_2}{R_1}\right) + \frac{1}{h_1 R_1}} \right) (2\pi R_1 L)(T_{b1} - T_{b2})$$

$$Q = U_2 A_2 \Delta T$$

$$= \left(\frac{\frac{1}{R_2}}{\frac{1}{h_2 R_2} + \frac{1}{k} \ln\left(\frac{R_2}{R_1}\right) + \frac{1}{h_1 R_1}} \right) (2\pi R_2 L)(T_{b1} - T_{b2})$$