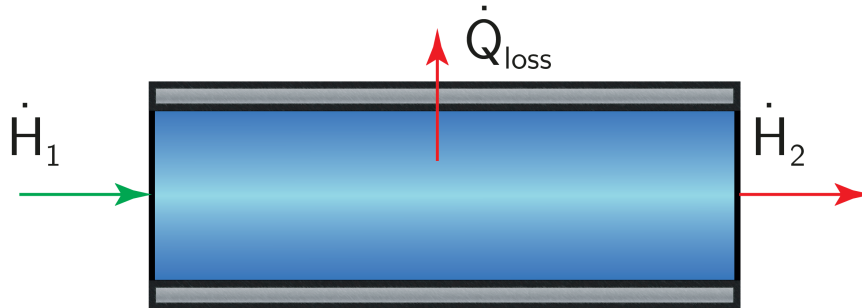# EB - Conv. - Body 1

Water flows through a pipe an average velocity u and inlet temperature T_1. Provide the energy balance to determine the water temperature T_2.

Hint: $T_w < T_2 < T_1$

Energy balance:

$$\dot{H}_1 - \dot{H}_2 - \dot{Q}_{\text{loss}} = 0$$

Definition of fluxes:

Enthalpies entering and leaving:

$$\dot{H}_1 = \dot{m} \cdot c \cdot T_1$$

$$\dot{H}_2 = \dot{m} \cdot c \cdot T_2$$

Convective heat losses:

$$\dot{Q}_{\text{loss}} = \alpha \cdot \pi \cdot D \cdot L \cdot \Delta T$$

Logarithmic mean temperature difference:

$$\Delta T = \frac{\dot{m} \cdot c}{\alpha \cdot \pi \cdot D \cdot L} \left(T_1 - T_2\right) = \frac{T_1 - T_2}{\ln\left(\frac{T_1 - T_w}{T_2 - T_w}\right)}$$

Mass flow rate:

$$\dot{m} = u \cdot \frac{\pi \cdot D^2}{4} \cdot \rho$$

Substituting and rewriting:

$$\dot{H}_1 - \dot{H}_2 - \dot{Q}_{\text{loss}} = 0$$

$$u \frac{\pi D^2}{4} \rho \, c \, T_1 - u \frac{\pi D^2}{4} \rho \, c \, T_2 - \alpha \, \pi \, D \, L \frac{T_1 - T_2}{\ln\left(\frac{T_1 - T_w}{T_2 - T_w}\right)}$$

$$\Rightarrow 0 = \frac{u \rho c \pi D^2}{4}(T_1 - T_2) - \alpha \pi D L \frac{T_1 - T_2}{\ln\left(\frac{T_1 - T_w}{T_2 - T_w}\right)}$$