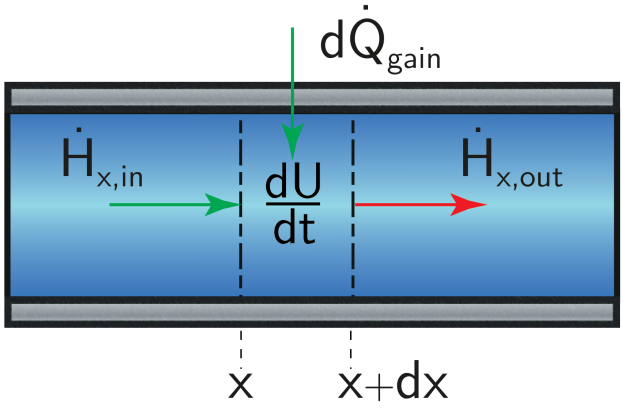
EB - Conv. - IE 2

A fluid flows through a long cylindrical tube. A constant heat flux density $\dot{q}''$ is imposed on the fluid.

Derive the transient differential energy balance for the averaged temperature in the fluid, using a stationary coordinate system in the x–direction. Axial heat conduction is negligible in this case.



Energy balance:

$$\dot{H}_{x,in} - \dot{H}_{x,out} + d\dot{Q}_{\text{loss}} = \frac{\partial U}{\partial t}$$

Energy fluxes:

$$\dot{H}_{x,in} = \dot{m} \cdot c \cdot T$$

$$\dot{H}_{x,out} = \dot{H}_{x,in} + \frac{\partial \dot{H}_{x,in}}{\partial x} \cdot dx$$

$$d\dot{Q}_{\text{gain}} = \dot{q}'' \cdot \pi \cdot D \cdot dx$$

$$\frac{\partial U}{\partial t} = \frac{\pi \cdot D^2}{4} \cdot dx \cdot \rho \cdot c \cdot \frac{\partial T}{\partial t}$$

Mass flow rate:

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