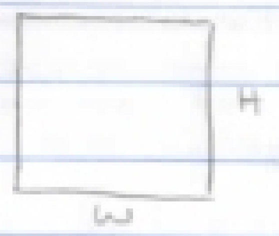
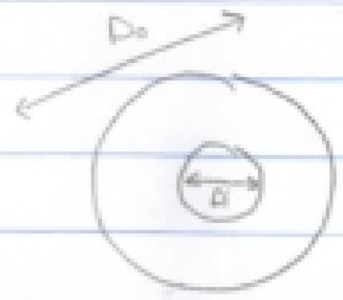
A typical Pipes

$Re_L \quad L = D_H = \frac{4A_{cs}}{P}$





$\frac{4A_{cs}}{P} = \frac{4\pi\left(\frac{D_o^2}{4} - \frac{D_i^2}{4}\right)}{\pi(D_o + D_i)}$

$\frac{4A_{cs}}{P} = \frac{D_o^2 - D_i^2}{D_o + D_i}$

$= \frac{(D_o + D_i)(D_o - D_i)}{D_o + D_i}$

$D_H = D_o - D_i$

$D_H = \frac{4A_{cs}}{P} = \frac{4HW}{2(H+W)} = \frac{2HW}{H+W} \longrightarrow \frac{2HW}{H+W}\frac{\frac{1}{W}}{\frac{1}{W}} = \frac{2H}{\frac{H}{W}+1}$

$\lim_{W\to\infty} D_H = \frac{2H}{\frac{H}{W}+1} = 2H$ —

only a function of height

Turbulant $Re_{D_H} \gtrsim 2300$

Laminer $Re_{D_H} \lesssim 2300$

Use tables 8.1, 8.2, & 8.3 for fully developed laminar flow
Use recipes for Turbulant flow p. 536

Example 8.5 → premis of this example is ludacris

$T_{m_i} = 400°C \qquad \rho = 700\ \frac{kg}{m^3} \qquad c_p = 2590\ J/kg\cdot K \qquad D = 70\times10^{-3}\ m$

$T_{m_o} = 450°C \qquad k = 0.078\ \frac{W}{m\cdot k} \qquad \mu = 0.15\times10^{-3}\ \frac{N\cdot s}{m^2} \qquad \dot m = 2.5\ \frac{kg}{s}$

$q_s'' = 20{,}000\ \frac{W}{m^2}$

$\dot m = \rho V \frac{\pi D^2}{4} \rightarrow V = \frac{4\dot m}{\pi D^2 \rho}$

$Re_D = \frac{VD}{\nu} = \frac{\frac{4\dot m}{\pi D^2 \rho} D}{\mu/\rho} = \boxed{\frac{4\dot m}{\pi D \mu} = Re_D} \qquad Re_D = \frac{4(2.5\ \frac{kg}{s})}{\pi(.07\ m)(.15\times10^{-3}\ \frac{N\cdot s}{m^2})}\left(\frac{s^2 N}{m\ kg}\right) = 303{,}152$

→ clearly Turbulant

$Pr = \frac{\nu}{\alpha} = \frac{c_p \mu}{k} = \frac{(2590\ \frac{J}{kg\cdot K})(.15\times10^{-3}\ \frac{N\cdot s}{m^2})}{.078\ \frac{W}{m°C}} = 4.98$

(8.60) $Nu_D \cong 0.023\, Re_D^{4/5}\, Pr^n \longrightarrow 0.023\,(303{,}152)^{4/5}(4.98)^{.4} = 1062$

$n = <\begin{matrix} .3 \rightarrow \text{coolin} \\ .4 \rightarrow \text{heating} \end{matrix}$

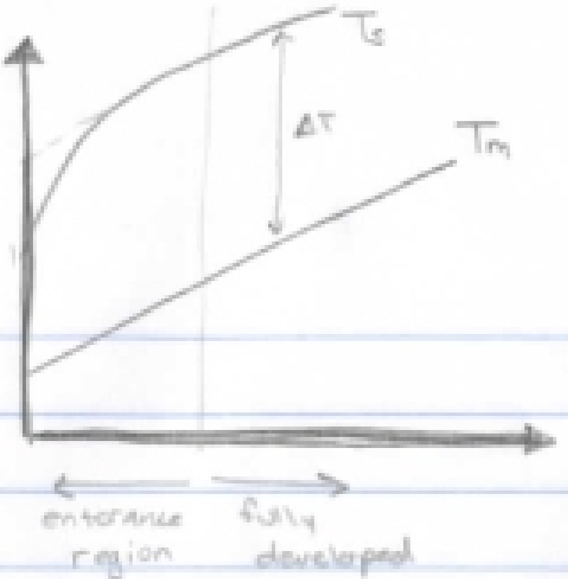
$h = \frac{Nu\,k}{D} = \frac{(1062)(0.078\ \frac{W}{m°C})}{70\times10^{-3}\ m} = 1182.9\ \frac{W}{m^2°C}$

$\dot E_{st} = \dot E_{in} - \dot E_{out} + \dot E_{gen} \longrightarrow \dot E_{in} = \dot E_{out} \longrightarrow$

$\dot m c\, T_{in} + q'' A = \dot m c\, T_{out} \longrightarrow q''A = \dot m c(T_{out} - T_{in}) \rightarrow A = \pi D L = \frac{\dot m c(T_{out} - T_{in})}{q''}$

$\boxed{L = \frac{\dot m c (T_{out} - T_{in})}{q'' \pi D}}$

continued →



constant
heat flux

$$q'' P \Delta x = h P \Delta x (T_s - T_m)$$

$$q'' \cancel{(P \Delta x)} = h \cancel{(P \Delta x)} \Delta T \rightarrow q'' = h \Delta T \rightarrow \Delta T = \frac{q''}{h} = \frac{20{,}000 \frac{W}{m^2}}{1180 \frac{W}{m^2 °C}} = \boxed{16.95 °C}$$