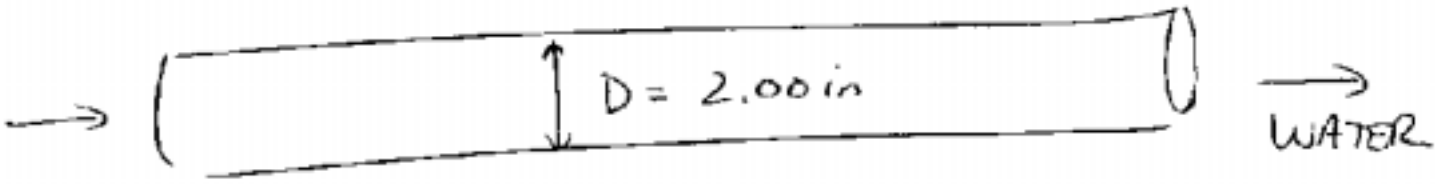
(Q from ΔP)

9-29-05

CALCULATE Q FROM GIVEN $\frac{\Delta P}{L}$



$\frac{\Delta P}{L} = 1.90 \times 10^{-2} \frac{lb_f}{ft \cdot in}$

$\rho = 62.4 \frac{lb_m}{ft^3}$

$\mu = 6.7197 \times 10^{-4} \frac{lb_m}{ft\ s}$

What is Q? SOLN DEPENDS ON WHETHER FLOW IS LAMINAR OR TURBULENT

- FOR LAMINAR FLOW:

  HAGEN POISEUILLE EQN

$$\langle V \rangle = \frac{Q}{\pi R^2} = \frac{\Delta P / L \; D^2}{32 \mu}$$

OR

$$f = \frac{16}{Re}$$

- FOR TURBULENT FLOW – SEE CHART McCABE et al p112

(Q from AP)

Since we can use the chart for either, we'll use $f(Re)$ method.

$$Re = \frac{\rho V D}{\mu}$$

(V: not known)

$$\text{☆}\quad f = \frac{\Delta P / L \; D/2}{\rho V^2}$$

(V: not known)

(see lecture 10 slides)

TRIAL + ERROR —

1. guess V
2. calculate Re
3. get f from chart
4. calc V from ☆
5. repeat w/ new guess if not the same.

OR

USE CORRELATIONS →

(Q from ΔP)

$$Re = \frac{\rho V D}{\mu}$$

$$f = .0014 + 0.125 Re^{-0.32}$$

this is an eqn that fits the chart data over this range

McCabe et al eqn 5.53

$$3000 < Re < 3 \times 10^6$$

need to check later to see if soln is in this range

From Defn of f:

$$V = \sqrt{\frac{\frac{\Delta P}{L} \frac{D}{2}}{\rho f}}$$

$$V = \sqrt{\frac{(\Delta P/L) D}{2\rho \left(.0014 + 0.125 \left(\frac{\rho V D}{\mu}\right)^{-.32}\right)}}$$

one eqn
one unknown, V

SOLN: $V = 19.8$ ft/s

(used Excel) $Re = 3.06 \times 10^5$ ← w/in range of correlation

TURBULENT

(Q from ΔP)

(b) What would $\Delta P/L$ be to make the flow laminar?

$$Re = 2100 = \frac{\rho V D}{\mu}$$

$$\Rightarrow V = 0.135682 \frac{ft}{s}$$

$$f = \frac{16}{Re} = 762 \times 10^{-3}$$

$$\frac{\Delta P}{L} = \frac{2 \rho V^2 f}{D}$$

$$= 0.105 \frac{lbm}{ft\ s^2} \cdot \frac{8\ lbf}{32.174\ lbm\ ft} \cdot \left(\frac{ft}{12\ in}\right)$$

$$\frac{\Delta P}{L} = 1.89 \times 10^{-6}\ lbf/in^2 \cdot in$$

LAMINAR