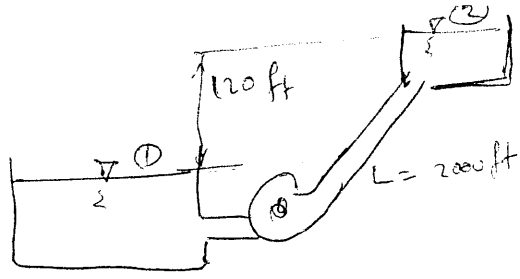
6.62)



$Q = 3\ ft^3/s$ $\rho = 1.94\ slug/ft^3$

$d = 6$ in and cast iron $\mu = 2.09 \times 10^{-5}\ \frac{slug}{ft\cdot s}$

$\eta = 75\%$ $P = ?$ $\varepsilon = 0.00085$

$\frac{\varepsilon}{d} = \frac{0.00085}{6/12} = 0.001$

$$V = \frac{Q}{A} = \frac{3}{\frac{\pi}{4}(6/12)^2} = 15.3\ ft/s$$

$$Re = \frac{\rho V d}{\mu} = \frac{1.94 \times 15.3 \times 6/12}{2.09 \times 10^{-5}} = 709000 \qquad \varepsilon/d = 0.0017 \Rightarrow f_{moody} = 0.0227$$

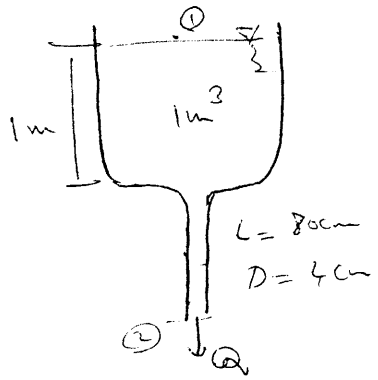
Energy Eqn: $\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_p + h_f$

$$h_{pump} = \Delta z + f\frac{L}{d}\frac{V^2}{2g} = 120 + 0.0227\ \frac{2000}{6/12}\ \frac{15.3^2}{2(32.2)} = 120 + 330 = 450\ ft$$

Power: $P_{ideal} = \rho g Q h_p = 1.94 \times 32.2 \times 3 \times 450 =$

$$P = \frac{P}{\eta} = \frac{P_{ideal}}{0.75} = 112400\ ft\cdot lbf/s = \frac{112400}{550} = 204\ hp$$

6.63)



$Q = ?$

$T = 20^{\circ}C$ $\rho = 998\ kg/m^3$ $\mu = 0.001\ kg/m.s$ Table 6-1: drawn tubing $\varepsilon = 0.0015$

$$\frac{\varepsilon}{d} = \frac{0.0015}{40} = 0.0000375$$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_f$$

$$\Rightarrow \Delta z = \frac{V^2}{2g} + f\frac{L}{d}\frac{V^2}{2g} \Rightarrow 1.8 = \frac{V^2}{2g}\left(1 + \frac{0.8}{0.04} f\right) \Rightarrow$$

$$V^2 = \frac{35.32}{1+20f}$$

guess $f = 0.015$ $\quad V = \left[\frac{35.32}{1+20\times 0.015}\right]^{1/2} = 5.21\ m/s$

$$Re = \frac{998 \times 5.21 \times 0.04}{0.001} = 208000$$

$Re = 208000$, $\varepsilon/d = 0.0000375 \rightarrow f = 0.0158 \rightarrow V = 5.18\ m/s$

$Re = 207000$

It is good enough. $V = 5.18\ m/s$ $\quad Q = \frac{\pi}{4} \times 0.04^2 \times 5.18 = 0.00651\ m^3/s$

$= 23.4\ m^3/h$

6.09 $P_{pump} = 80\ hp$

$Q = 3\ ft^3/s$

$$h_{pump} = \Delta z + f\frac{L}{d}\frac{V^2}{2g} = 120 + f\frac{2000}{d}\frac{\left[4\times 3/\pi d^2\right]^2}{2\times 32.2} = 120 + 453\frac{f}{d^5}$$

$$h_{pump} = \frac{P}{\rho g Q} = \frac{80\times 550}{62.4\times 3} = 235$$

$$\Rightarrow 235 = 120 + 453\ f/d^5 \Rightarrow d^5 = 3.94f$$

$f = 0.02 \quad d = [3.94\times 0.02]^{1/5} = 0.602\ ft \quad Re = \frac{\rho V d}{\mu} = \frac{\rho\frac{4Q}{\pi d^2}d}{\nu}$

$$= \frac{4\rho Q}{\pi\mu d} = 589080$$

$Re = 589000, \quad \frac{\varepsilon}{d} = \frac{0.00085}{0.602} = 0.00141 \longrightarrow f_{moody} = 0.0218$

$f = 0.0217 \quad d = 0.612\ ft = 7.3\ in$

6.90)

$L = 90\,ft$ air at $20^{\circ}C$ and 1 atm $\rightarrow \rho = 0.00234\ slug/ft^3$ $\mu = 3.76 \times 10^{-7}\ slug/ft.s$

$P_{blower} = 1\,hp$ $Q = ?$

$$D_h = \frac{4A}{P} = \frac{4 \times \frac{1}{2} \times 9 \times 9 \sin 60}{3 \times 9} = 5.2'' = 0.433\,ft$$

$$h_f = f \frac{L}{D} \frac{v^2}{2g} = f \frac{90}{0.433} \frac{\left[\frac{Q}{0.5 \times (9/12)^2 \sin 60}\right]^2}{2 \times 32.2} = 54.4\, f Q^2$$

Sheet-steel: $\varepsilon = 0.00015\,ft$ $\varepsilon/D_h = 0.000346$

$$P = 1\,hp = 550\ \frac{ft.lbf}{s} = \rho g Q h_f = 0.00234 \times 32.2 \times Q \times 54.4\, f Q^2$$

$$\Rightarrow f Q^3 = 134$$

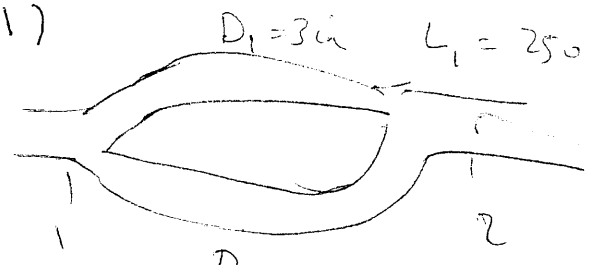
$f = 0.02$ $Q = \left(\frac{134}{0.02}\right)^{1/3} = 18.9\ ft^3/s$ $Re = \frac{\rho (Q/A) D_h}{\mu} = 209000$

$Re = 209000$, $\varepsilon/D_h = 0.000346 \Rightarrow f = 0.0179$ $Q = 19.6\ ft^3/s$

$Re = 216500$

$f = 0.01784$ $V = 80.4\ ft/s$ $Q = 19.6\ ft^3/s$

6.111)



Sae 10 oil at 20°C

$P_1 - P_2 = 3$ lbf/in^2

$\rho = 1.69$ slug/ft^3 $\quad \mu = 0.00217$ slug/ft.s $\quad \varepsilon = 0.00085$ ft cast iron

$\Delta P = 3$ psi $= 432$ psf

$$\Delta P_1 = \rho f_1 \frac{L_1}{d_1} \frac{v_1^2}{2g} = \frac{64\mu}{\rho v_1 d_1} \frac{L_1}{d_1} \frac{v_1^2}{2g}$$

$$= \frac{64\mu L_1}{\rho d_1^2 2g} \frac{Q_1}{\frac{\pi d_1^2}{4}} = \frac{128 \mu L_1 Q_1}{\rho \pi d_1^4}$$

$$\Rightarrow 432 = \frac{128 \times 0.00217 \times 250\, Q_1}{\pi (3/12)^4} \Rightarrow Q_1 = 0.0763 \text{ ft}^3/\text{s}$$

check: $Re_1 = 300$ ✓

$$\Delta P_2 = \frac{128 \mu L_2 Q_2}{\pi d_2^4} \Rightarrow 432 = \frac{128 \times 0.00217 \times 200\, Q_2}{\pi (2/12)^4} \Rightarrow Q_2 = 0.0188 \text{ ft}^3/\text{s}$$

check: $Re_2 = 112$ ✓

$$Q = Q_1 + Q_2 = 0.0763 + 0.0188 = 0.095 \text{ ft}^3/\text{s}$$