HEAD LOSS
Friction | FIND h_f | EX. 10.4

Water (temp = 20°C) flows at a rate of 0.05 m^3/sec in a 20-cm Ø asphalted cast-iron pipe.

What is the head loss per kilometer of pipe

Compute Velocity

$$Vel = \frac{Q}{AREA} = \frac{0.05\ m^3/sec}{\pi (0.10\ m)^2} = 1.59\ m/sec$$

Compute Reynold's # & k_s/D

$$N_R = \frac{VD}{\gamma} = \frac{(1.59\ m/sec)(0.20\ m)}{1.00 * 10^{-6}\ m^2/sec} = 3.18 * 10^5$$

(γ Table A.5)

$k_s = 0.12\ mm = 0.00012\ m$ (Table 10.2)

$\frac{k_s}{D} = \frac{0.00012\ m}{.20\ m} = 6 * 10^{-4}$

Calculated book example use Fig. 10.9

Find f using N_R & k_s/D

$f = 0.019$ Figure 10.8

Use Darcy-Weisbach to find h_f

$$h_f = f \frac{L}{D} \frac{V^2}{2g} = (0.019)\left(\frac{1000\ m}{0.20\ m}\right)\left(\frac{(1.59\ m/sec)^2}{(2)(9.81\ m/sec^2)}\right)$$

$$\boxed{h_f = 12.2\ m \text{ per km of pipe}}$$

The head loss per kilometer of 20-cm asphalted cast-iron pipe is 12.2 m. What is the discharge of water?

Can't compute N_R so compute $Re\, f^{1/2}$

$$= \frac{D^{3/2}\left(\sqrt{2g\, h_f/L}\right)}{\nu}$$ (See discussion on pg. 367)

$$Re\, f^{1/2} = \frac{(0.2\,m)^{1.5}\left[(2)(9.81\,m/sec^2)(12.2\,m/1000\,m)\right]^{1/2}}{1\times10^{-6}\,m^2/sec}$$

$$Re\, f^{1/2} = \frac{(0.0894\,m^{1.5})(0.4892\,m^{0.5}/sec)}{1\times10^{-6}}$$

$$Re\, f^{1/2} = 4.4\times10^4$$

$$\frac{k_s}{D} = \frac{0.00012\,m}{0.20\,m} = 0.0006$$

Find f using $Re\, f^{1/2}$ & k_s/D

$f = 0.019$ Figure 10.8

Solve for V using Darcy-Weisbach equation

$$h_f = f\,\frac{L}{D}\,\frac{V^2}{2g}$$ Area $= \pi(0.1)^2 = 0.0314\,m^2$

$$V^2 = \left(\frac{h_f}{f}\right)\left(\frac{D}{L}\right)(2g)$$

$$V^2 = \left(\frac{12.2\,m}{0.019}\right)\left(\frac{0.2\,m}{1000\,m}\right)(2)(9.81\,m/sec^2)$$

$V = 1.59\,m/sec$

$Q = V\cdot A = (1.59\,m/sec)(0.0314\,m^2) = \boxed{0.05\,m^3/sec = Q}$