

December 1, 2008

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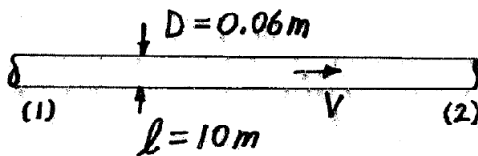
Fluids-ID _____

Quiz 9. Water flows through a horizontal 60-mm-diameter galvanized iron pipe at a rate of $0.02 \text{ m}^3/\text{s}$. Determine the pressure drop Δp between sections (1) and (2) shown below, if:

- the pipe is new with roughness $\epsilon = 0.15 \text{ mm}$
- the pipe is old with roughness $\epsilon = 0.30 \text{ mm}$

$$(\rho = 999 \text{ kg/m}^3, \nu = 1.12 \times 10^{-6} \text{ m}^2/\text{s})$$

You may use the formula for f given at the equation box or the Moody chart at the textbook pp.434.



Energy equation:

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + f \frac{l}{D} \frac{V^2}{2g}$$

Friction factor:

$$f = \frac{1.325}{\left\{ \ln \left[\left(\frac{1}{3.7} \frac{\epsilon}{D} \right) + \left(\frac{5.74}{Re^{0.9}} \right) \right] \right\}^2}$$

Solution

Continuity:

$$V = \frac{Q}{A} = \frac{0.02 \text{ m}^3/\text{s}}{\pi(0.06 \text{ m})^2/4} = 7.07 \text{ m/s} \quad (+1 \text{ point})$$

Reynolds number:

$$Re = \frac{VD}{\nu} = \frac{(7.07 \text{ m/s})(0.06 \text{ m})}{1.12 \times 10^{-6} \text{ m}^2/\text{s}} = 3.79 \times 10^5 \quad (+1 \text{ point})$$

Energy equation:

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + f \frac{l}{D} \frac{V^2}{2g} \quad (\because z_1 = z_2 \text{ and } V_1 = V_2) \quad \text{or}$$

$$\Delta p = p_1 - p_2 = \gamma \cdot f \frac{l}{D} \frac{V^2}{2g} = f \cdot \frac{l}{D} \cdot \frac{1}{2} \rho V^2 \quad (+4 \text{ points})$$

(a) New pipe

$$\frac{\epsilon}{D} = \frac{0.15 \text{ mm}}{60 \text{ mm}} = 2.5 \times 10^{-3} \quad \text{and} \quad f = 0.0254$$

$$\therefore \Delta p = (0.0254) \left(\frac{10 \text{ m}}{0.06 \text{ m}} \right) \left(\frac{1}{2} \right) \left(999 \frac{\text{Kg}}{\text{m}^3} \right) \left(7.07 \frac{\text{m}}{\text{s}} \right)^2 = \mathbf{106 \text{ kPa}} \quad (+2 \text{ points})$$

(b) Old pipe

$$\frac{\epsilon}{D} = \frac{0.30 \text{ mm}}{60 \text{ mm}} = 5.0 \times 10^{-3} \quad \text{and} \quad f = 0.0307$$

$$\therefore \Delta p = (0.0307) \left(\frac{10 \text{ m}}{0.06 \text{ m}} \right) \left(\frac{1}{2} \right) \left(999 \frac{\text{Kg}}{\text{m}^3} \right) \left(7.07 \frac{\text{m}}{\text{s}} \right)^2 = \mathbf{128 \text{ kPa}} \quad (+2 \text{ points})$$