November 22, 2013

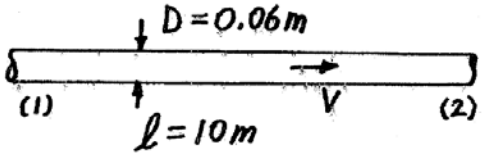
NAME

Fluids-ID

Quiz 12. Water flows through a horizontal 60-mm-diameter galvanized iron pipe at a rate of 0.02 m^3/s. Determine the pressure drop Δp between sections (1) and (2) shown below, if:

a) the pipe is new with roughness ϵ = 0.15 mm
b) the pipe is old with roughness ϵ = 0.30 mm

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



Energy equation:

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

Friction factor:

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

Note: Attendance (+2 points), format (+1 point)

Solution

Continuity:

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

Reynolds number:

$$Re=\frac{VD}{\nu}=\frac{(7.07\ \text{m/s})(0.06\ \text{m})}{1.12\times10^{-6}\ \text{m}^2/\text{s}}=3.79\times10^5$$ (+1 point)

Energy equation:

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

$$\Delta p=p_1-p_2=\gamma\cdot f\frac{\ell}{D}\frac{V^2}{2g}=f\cdot\frac{\ell}{D}\cdot\frac{1}{2}\rho V^2$$ (+3 points)

(a) New pipe

$$\frac{\epsilon}{D}=\frac{0.15\ \text{mm}}{60\ \text{mm}}=2.5\times10^{-3} \quad \text{and} \quad f=0.0254$$

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

(b) Old pipe

$$\frac{\epsilon}{D}=\frac{0.30\ \text{mm}}{60\ \text{mm}}=5.0\times10^{-3} \quad \text{and} \quad f=0.0307$$

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