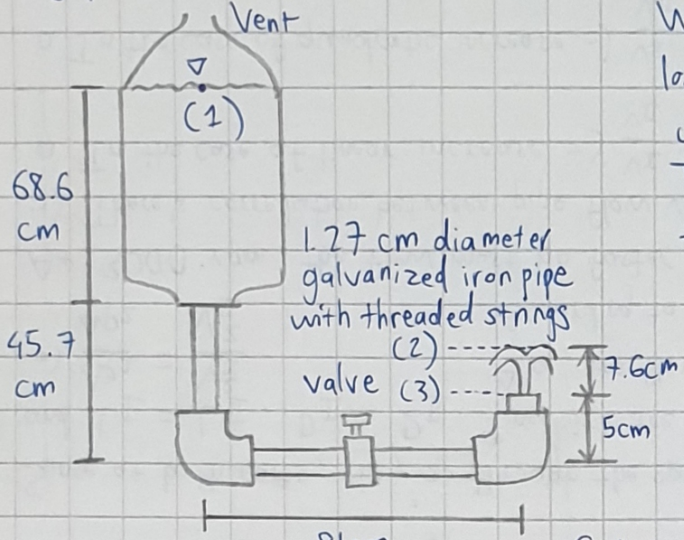
Nguyen Xuan Binh 887799 Round 6 Problem 1



Water flows from container like figure. Determine loss coefficient needed in the valve if water bubbles up 7.6cm from outlet pipe

There are three types of minor loss: the inlet, the valve and 90° regular elbows threaded

$\Rightarrow K_{L\,inlet} = 0.2$ (Since the inlet corner is rounded)

$K_{L\,elbow} = 1.5$, $\mu_{water} = 1.12 \times 10^{-3}$ kg/ms

$\Rightarrow$ find $K_{L\,valve}$? $\rho_{water} = 1000$ kg/m^3

$\Rightarrow \Sigma K_L = K_{L\,inlet} + 2 \cdot K_{L\,elbow} + K_{L\,valve}$

$= 0.2 + 2 \times 1.5 + K_{L\,valve} = K_{L\,valve} + 3.2$

Galvanized iron pipe $\Rightarrow \varepsilon = 1.5 \times 10^{-4}$ m

From point (1) to (2), we have extended Bernoulli equation:

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g z_1 - f\frac{L}{D}\frac{\rho V^2}{2} - \Sigma K_L \frac{\rho V^2}{2} = p_2 + \frac{1}{2}\rho v_2^2 + \rho g z_2$$

We have: $p_1 = p_2$ (atmospheric), $v_1 = v_2 = 0 \Rightarrow \rho g(z_1 - z_2) = f\frac{L}{D}\frac{\rho V^2}{2} + \Sigma K_L \frac{\rho V^2}{2}$ (1)

There's 3 unknowns: velocity in the pipe (V), f and Re

Pipe flow velocity can be determined right at the outlet (3). Because from (3) to (2), there's no pipe so there's no major nor minor losses $\Rightarrow$ normal Bernoulli can be applied. Let's call V as v_3

$p_2 + \frac{1}{2}\rho v_2^2 + \rho g z_2 = p_3 + \frac{1}{2}\rho v_3^2 + \rho g z_3$. We have $p_2 = p_3$ (atmospheric)

$\Rightarrow \rho g z_2 = \frac{1}{2}\rho v_3^2 + \rho g z_3$ $\qquad v_2 = 0$

$\Rightarrow v_3 = \sqrt{2g(z_2 - z_3)} = \sqrt{2 \cdot 9{,}81\,(7{,}6\text{cm})\,10^{-2}} = 1.22$ m/s $= V$

$\Rightarrow R_e = \frac{\rho V D}{\mu} = \frac{1000 \cdot 1.22 \cdot 1.27 \times 10^{-2}}{1.12 \times 10^{-3}\text{ kg/ms}} = 13833$, $\frac{\varepsilon}{D} = \frac{1.5 \times 10^{-4}}{1.27 \times 10^{-2}} = 0.0118$

According to Moody diagram $Re = 13833$, $\varepsilon/D = 0.0118 \Rightarrow f = 0.0437$

From equation 1: $z_1 - z_2 = f\frac{L}{D}\frac{V^2}{2g} + \Sigma K_L \frac{V^2}{2g}$ $\quad$ $K_{L\,valve} \approx 5.674$ (answer)

$$\Rightarrow (68.6 + 45.7 - 7.6 - 5) \cdot 10^{-2} = \left(0.0437\,\frac{45.7 + 81 + 5}{1.27} + K_{L\,valve} + 3.2\right)\frac{1.22^2}{2 \cdot 9{,}81}$$