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Applied Fluid Mechanics Homework 03

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Applied Fluid Mechanics

Class Section 01

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Problem 8.68

8.68 A pipe of length 10^3 m and diameter 18cm is laid at a slope of 1 in 150. Oil is pumped at the rate of 25 L/s. The specific gravity of the oil is 1.1 and viscosity is 0.18 Ns · m^2. Determine the head lost due to friction and also calculate the power required to pump the oil.

Solution:

$$Re = \frac{\rho V D}{\mu} = \frac{\rho \frac{Q}{\frac{\pi D^2}{4}} D}{\mu} = \frac{4\rho Q}{\pi \mu D}$$
$$= \frac{4 \times 1.1 \times (1 \times 10^3\ \mathrm{kg/m^3}) \times (0.025\ \mathrm{m^3/s})}{\pi \times (0.18\ \mathrm{N \cdot s/m^2}) \times (0.18\ \mathrm{m})}$$
$$= 1080.681712 < 2300$$

$$f = \frac{64}{Re} = \frac{64}{1080.681712} = 0.0592$$

Therefore, the head lost due to friction is

$$h_l = f \frac{L}{D}\frac{\bar{V}^2}{2} = 0.0592 \times \frac{10^3\ \mathrm{m}}{0.18\ \mathrm{m}} \times \frac{\left[\frac{(0.025\ \mathrm{m^3/s})}{\frac{\pi \times (0.18\ \mathrm{m})^2}{4}}\right]^2}{2}$$
$$= 158.78\ \mathrm{kJ/kg}$$

$$h_{pump} = h_l + g z_2 = (158.78\ \mathrm{kJ/kg}) + (9.81\ \mathrm{m/s^2}) \times (10^3\ \mathrm{m}) \times \left(\frac{1}{150}\right) = 224.18\ \mathrm{kJ/kg}$$

$$W_{pump} = Q \rho h_{pump} = (0.025\ \mathrm{m^3/s}) \times 1.1 \times (1 \times 10^3\ \mathrm{kg/m^3}) \times (224.18\ \mathrm{kJ/kg}) = 6164.89\ \mathrm{W}$$

Problem 8.75

8.75 Water flows through a 50-mm diameter tube that suddenly contracts to 25 mm diameter. The pressure drop across the contraction is 3.45 kPa. Determine the volume flow rate.

Solution:

$$\begin{cases} \left(\frac{p_1}{\rho} + \frac{V_1^2}{2}\right) - \left(\frac{p_2}{\rho} + \frac{V_2^2}{2}\right) = K\frac{V_2^2}{2} \\ V_1 A_1 = V_2 A_2 \end{cases}$$

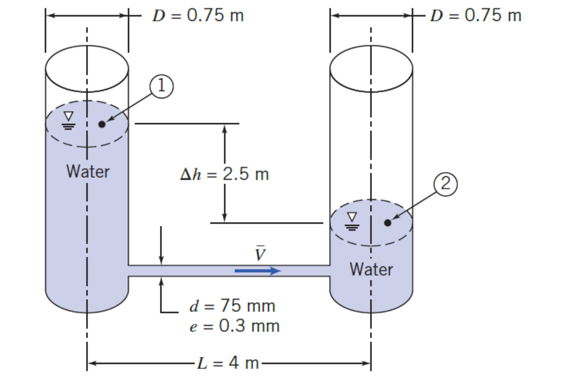
Therefore,

$$V_2 = \sqrt{\frac{2(p_1 - p_2)}{\rho\left(1 - \frac{D_2^4}{D_1^4} + K\right)}} = \sqrt{\frac{2 \times (3.45\ \mathrm{kPa})}{(1 \times 10^3\ \mathrm{kg/m^3}) \times \left(1 - \frac{(25\ \mathrm{mm})^4}{(50\ \mathrm{mm})^4} + (0.4)\right)}}$$
$$= 2.27\ \mathrm{m/s}$$

$$Q = V_2 A_2 = (2.27\ \mathrm{m/s}) \times \frac{\pi \times (25\ \mathrm{mm})^2}{4} = 1.11 \times 10^{-3}\ \mathrm{m^3/s}$$

Problem 8.108

8.108 Two open standpipes of equal diameter are connected by a straight tube, as shown. Water flows by gravity from one standpipe to the other. For the instant shown, estimate the rate of change of water level in the left standpipe.



P8.108

Solution:

$$\left(p_1+\frac{V_1^2}{2}+gz_1\right)-\left(p_2+\frac{V_2^2}{2}+gz_2\right)$$

$$=h_l+h_{lm}$$

$$=\left[f\frac{L-D}{d}-K_{ent}\right.$$

$$\left.+K_{exit}\right]\frac{V^2}{2}$$

Therefore,

$$g\Delta h=h_{lT}=\left[f\frac{L-D}{d}-K_{ent}+K_{exit}\right]\frac{V^2}{2}$$

$$\begin{cases}\dfrac{1}{\sqrt{f}}=-2.0\log\left(\dfrac{\frac{e}{D}}{3.7}+\dfrac{2.51}{Re\sqrt{f}}\right)\\ Re=\dfrac{VD}{v}\\ V=\sqrt{\dfrac{2g\Delta h}{f\dfrac{L-D}{d}-K_{ent}+K_{exit}}}\end{cases}$$

$$\Rightarrow V=0.0423\text{ m/s}$$

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