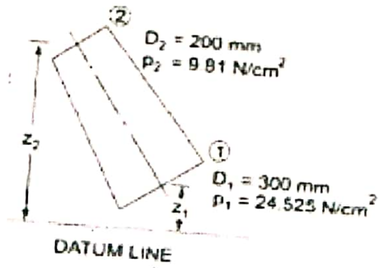
the difference in datum head ($Z_2 - Z_1$), if the rate of volume flow through pipe is 0.04 m^3 / s. (the flow is ideal)

Solution:



$$Q = A_1 V_1$$

$$V_1 = \frac{0.04}{\frac{\pi \times 0.3^2}{4}} = 0.565 \text{ m/s}$$

$$V_2 = \frac{0.04}{\frac{\pi \times 0.2^2}{4}} = 1.274 \text{ m/s}$$

Applying Bernoulli equation between section 1 & section 2 , we get :

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$

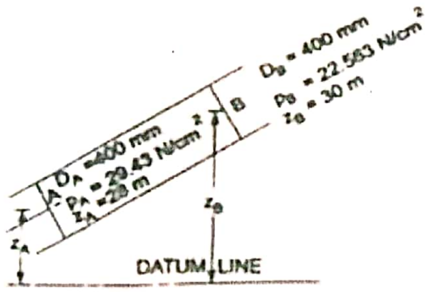
$$\frac{24.525 \times 10^4}{1000 \times 9.81} + \frac{(0.566)^2}{2 \times 9.81} + Z_1 = \frac{9.81 \times 10^4}{1000 \times 9.81} + \frac{(1.274)^2}{2 \times 9.81} + Z_2$$

$$Z_2 - Z_1 = 13.7 \text{ m}$$

Problem 5.3 /

A pipe of diameter 400 mm carries water at a velocity of 25 m/s. The pressure at the points A and B are given as 29.43 × 10^4 N/m² & 22.563 × 10^4 respectively while the datum head at A & B are 28 m and 30 m respectively . Find the loss of head between A & B (H_L).

Solution:



Applying Bernoulli equation between section A & section B , we get :

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + H_L$$

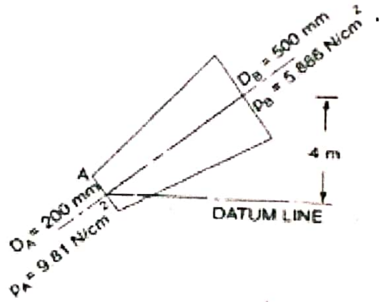
$$\frac{29.43 \times 10^4}{1000 \times 9.81} + \frac{(25)^2}{2 \times 9.81} + 28 = \frac{22.563 \times 10^4}{1000 \times 9.81} + \frac{(25)^2}{2 \times 9.81} + 30 + H_L$$

$H_L = 5$ m

Problem 5.4 /

A pipeline carrying oil of specific gravity (S = 0.87) , changes in diameter from 200 mm diameter at a position A to 500 mm diameter at a position B which is 4 meter at a higher level . If the pressure at A and B are 9.81×10^4 N/ m² and 5.886×10^4 N/ m² respectively and the discharge is 200 L /s, determine the loss of head (H_L) and direction of flow? the flow is real (actual).

Solution:



$$V_A = \frac{Q}{A_A} = \frac{200 \times 10^{-3}}{\frac{\pi \times 0.2^2}{4}} = 6.369 \text{ m/s}$$

$$V_B = \frac{Q}{A_B} = \frac{200 \times 10^{-3}}{\frac{\pi \times 0.5^2}{4}} = 1.018 \text{ m/s}$$

Applying Bernoulli's equation between section A & section B , we get :

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + H_L$$

$$\frac{9.81 \times 10^4}{870 \times 9.81} + \frac{6.369^2}{2 \times 9.81} + 0 = \frac{5.886 \times 10^4}{870 \times 9.81} + \frac{1.018^2}{2 \times 9.81} + 4 + H_L$$

$H_L = 2.609$ m

Problem 5.5 /

A horizontal venturimeter with inlet and throat diameter 30 cm and 15 cm respectively is used to measure the flow of water. The reading of differential manometer connected to the inlet and the throat is 20 cm of mercury. Determine the rate of flow. Take $C_d = 0.98$.

Solution:

$x = 20$ cm

$$h = x\left[\frac{S_h}{S_o} - 1\right] = 20\left[\frac{13.6}{1} - 1\right] = 252 \text{ cm of water .}$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(0.3)^2 = 0.0706 \text{ m}^2$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(0.15)^2 = 0.0176 \text{ m}^2$$

$$Q = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2gh}$$

$$Q = 0.98 \times \frac{0.0706 \times 0.0176}{\sqrt{(0.0706)^2 - (0.0176)^2}} \times \sqrt{2 \times 9.81 \times 0.252}$$

$Q = 0.125756$ m³ /s

Problem 5. 6 /

An oil of sp.gr. 0.8 is flowing through a venturimeter having inlet diameter 20 cm and throat diameter 10 cm. The oil – mercury differential manometer shows a reading of 25 cm. Calculate the discharge of oil through the horizontal venture meter. Take $C_d = 0.98$.

Solution:

$x = 0.25$ m

$$h = x\left[\frac{S_h}{S_o} - 1\right] = 0.25\left[\frac{13.6}{0.8} - 1\right] = 4 \text{ m of oil}$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \times (0.2)^2 = 0.0314 \text{ m}^2$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} \times (0.1)^2 = 0.00785 \text{ m}^2$$

$$Q = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

$$Q = 0.98 \times \frac{0.0314 \times 0.00785}{\sqrt{(0.0314)^2 - (0.00785)^2}} \times \sqrt{2 \times 9.81 \times 4}$$

$$Q = 0.0704 \quad m^3/s$$

Problem 5.7 :

A horizontal venturimeter with inlet diameter 20 cm and throat diameter 10 cm is used to measure the flow of oil of sp.gr.0.8. The discharge of oil through ventuimeter is 60 L/s. Find the reading of the oil – mercury differential manometer? Take $C_d = 0.98$.

Solution:

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \times (0.2)^2 = 0.0314 \text{ m}^2$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} \times (0.1)^2 = 0.00785 \text{ m}^2$$

$$Q = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

m³/s

$$60 \times 1000 = \frac{0.0314 \times 0.00785}{\sqrt{(0.0314)^2 - (0.00785)^2}} \times \sqrt{2 \times 9.81 \times h}$$

1000

h = 2.89 m of oil.

$$h = x \left[\frac{S_h}{S_o} - 1 \right]$$

$$2.89 = x \left[\frac{13.6}{0.8} - 1 \right]$$

x = 0.181 m = 18.1 cm

Problem 5.8 /

A horizontal venturimeter with inlet diameter 20 cm and throat diameter 10 cm is used to measure the flow of water. The pressure at inlet is 17.658×10^4 N/ m² and the vacuum pressure at the throat is 30 cm of mercury. Find the discharge of water through venturemeter? Take $C_d = 0.98$.

Solution :

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \times (0.2)^2 = 0.0314 \ m^2$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} \times (0.1)^2 = 0.0078 \ m^2$$

$$h = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} - (h_{Hg} \times S_{Hg})$$

$$h = 18 - (-0.3 \times 13.6) = 18 + 4.08 = 22.08 \text{ m of water}$$

$$Q = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

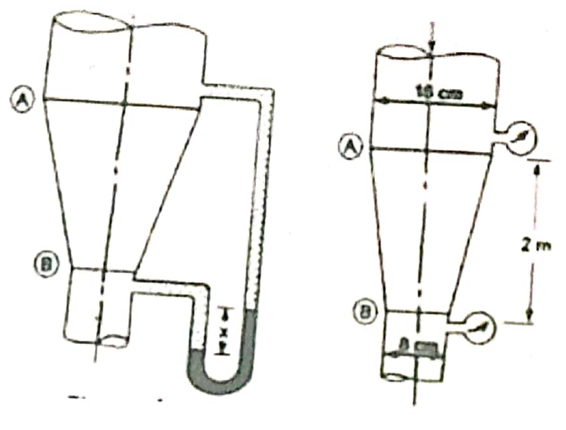
$$Q = 0.98 \times \frac{0.0314 \times 0.0078}{\sqrt{(0.0314^2 - 0.0078^2)}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$$Q = 165555 \ m^3/s.$$

Problem 5.9 :

In a vertical pipe conveying oil of sp. gr. 0.8, two pressure gages have been installed at A & B where the diameter are 16 cm and 8 cm respectively. A is 2 m above B . The pressure gauge readings have shown that the pressure at B is greater than at A by 9810 N/ m^2. Neglecting all losses, calculate the flow rate (Q) (discharge) , if the gauges at A & B are replaced by tubes filled with the same liquid and connected to a U – tube containing mercury , calculate the difference of level of mercury in the two legs of the U – tube (x) .

Solution: (Case 1):



(case 2) (case 1)

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} (0.16)^2 = 0.0201 \ m^2$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} (0.08)^2 = 0.00502 \ m^2$$

Applying Bernoulli's equation between A & B, and taking the reference line passing through section B, ($Z_B = 0$) , we get :

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B$$

$$\frac{P_A}{\rho g} - \frac{P_B}{\rho g} + Z_A = \frac{V_B^2}{2g} - \frac{V_A^2}{2g} + 0$$

$$\frac{P_A - P_B}{\rho g} + Z_A = \frac{V_B^2}{2g} - \frac{V_A^2}{2g}$$

Now applying Continuity equation at A & B , we get :

$$V_A A_1 = V_B A_2 \ , \quad V_B = \frac{V_A A_1}{A_2} = \frac{0.0201 V_A}{0.00502} = 4 V_A$$

$$\frac{9810}{0.8 \times 1000 \times 9.81} + 2 = \frac{16 V_A^2}{2g} - \frac{V_A^2}{2g}$$

$$0.75 = \frac{15 V_A^2}{2g}$$

$$V_A = \sqrt{\frac{0.75 \times 2 \times 9.81}{15}} = 0.99 \ m/s$$

$$Q = V_A A_1 = 0.99 \times 0.0201 = 0.01989 \ m^3/s$$

(Case 2):

Let, h – difference of mercury level.

$$h = \frac{P_A - P_B}{\rho g} + Z_A - Z_B$$

$$h = \frac{9810}{0.8 \times 1000 \times 9.81} + 2 - 0 = 0.75$$

$$h = X \left[\frac{S_g}{S_o} - 1 \right]$$

$$0.75 = X \left[\frac{13.6}{0.8} - 1 \right]$$

$$X = 0.0468 \ m = 4.68 \ cm$$