Example 6.35. *A 300 mm × 150 mm venturimeter is provided in a vertical pipeline carrying oil of specific gravity 0.9, flow being upward. The difference in elevation of the throat section and entrance section of the venturimeter is 300 mm. The differential U-tube mercury manometer shows a gauge deflection of 250 mm. Calculate:*

(i) The discharge of oil, and

(ii) The pressure difference between the entrance section and the throat section.

Take the co-efficient of meter as 0.98 and specific gravity of mercury as 13.6. **[UPTU]**

Solution. Diameter at inlet, $D_1 = 300 \text{ mm} = 0.3 \text{ m}$

$\therefore$ Area of inlet, $A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07 \text{ m}^2$

Diameter at throat, $D_2 = 150 \text{ mm} = 0.15 \text{ m}$

$\therefore$ Area at throat, $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767 \text{ m}^2$

Specific gravity of heavy liquid (mercury) in U-tube manometer, $S_H = 13.6$

Specific gravity of liquid (oil) flowing through pipe, $S_p = 0.9$

Reading of differential manometer, $y = 250 \text{ mm} = 0.25 \text{ m}$

The differential 'h' is given by:

$$h = \left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right)$$

$$= y\left[\frac{S_H}{S_p} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right]$$

$$= 3.53 \text{ m of oil}$$

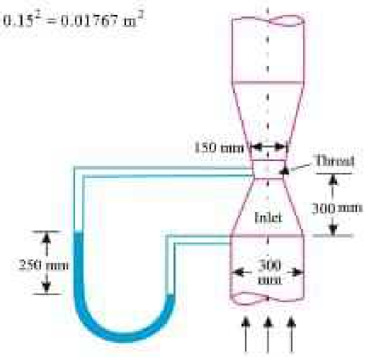

Fig. 6.31

(i) Discharge of oil, Q:

Using the relation,

$$Q = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}, \text{ we have:}$$

$$Q = 0.98 \times \frac{0.07 \times 0.01767}{\sqrt{0.07^2 - 0.01767^2}} \times \sqrt{2 \times 9.81 \times 3.53}$$

$$= \frac{0.001212}{0.0677} \times 8.32 = \mathbf{0.1489\ m^3/s.\ (Ans.)}$$

(ii) Pressure difference between entrance and throat sections, $p_1 - p_2$:

We know that, $$h = \left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right) = 3.53$$

or, $$\left(\frac{p_1}{w} - \frac{p_2}{w}\right) + (z_1 - z_2) = 3.53$$

But, $z_2 - z_1 = 300$ mm or 0.3 m ...(*Given*)

$\therefore$ $$\left(\frac{p_1}{w} - \frac{p_2}{w}\right) - 0.3 = 3.53 \quad \text{or} \quad \frac{p_1 - p_2}{w} = 3.83$$

or, $$p_1 - p_2 = (9.81 \times 0.9) \times 3.83 = \mathbf{33.8\ kN/m^2\ (Ans.)}$$

Example 6.36. *A vertical venturimeter carries a liquid of relative density 0.8 and has inlet and throat diameters of 150 mm and 75 mm respectively. The pressure connection at the throat is 150 mm above that at the inlet. If the actual rate of flow is 40 litres/sec and the $C_d = 0.96$, calculate the pressure difference between inlet and throat in N/m².* **(Anna University)**

Solution. *Given:* Sp. gravity = 0.8, D_1 = 150 mm = 0.15 m; D_2 = 75 mm = 0.075 m; $z_2 - z_1$ = 150 mm = 0.15 m, Q_{act} = 40 litres/sec. = 0.04 m³/s, C_d = 0.96.

Pressure difference $(p_1 - p_2)$:

$$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} \times 0.15^2 = 0.01767 \text{ m}^2$$

$$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} \times (0.075)^2 = 0.00442 \text{ m}^2$$

$$Q_{act} = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}, \text{ we get:}$$

$$0.04 = 0.96 \times \frac{0.01767 \times 0.00442}{\sqrt{0.01767^2 - 0.00442^2}} \times \sqrt{2 \times 9.81} \times \sqrt{h}$$

or, $$0.04 = 0.96 \times 0.004565 \times 4.429\sqrt{h}$$

$\therefore$ $$h = \left(\frac{0.04}{0.96 \times 0.004565 \times 4.429}\right)^2 = 4.247 \text{ m}$$

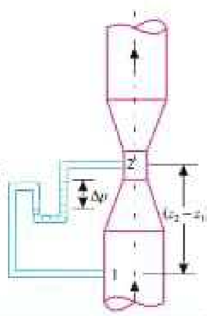

Fig. 6.32. Vertical venturimeter.

Also, $$h = \left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right)$$

or, $$4.247 = \left(\frac{p_1}{w} - \frac{p_2}{w}\right) + (z_1 - z_2)$$

$$= \left(\frac{p_1 - p_2}{\rho g}\right) - 0.15 \qquad (\because z_2 - z_1 = 0.15 \text{ m})$$

or, $(p_1 - p_2) = \rho g\,(4.247 + 0.15)$

$= (0.8 \times 1000 \times 9.81)\,(4.247 + 0.15)$ N/m²

= 34.51 kN/m² (Ans.)