Fluid Mechanics

Asst. Lec. Safa Ali Hussein

Example

Brine of specific gravity 1.15 is draining from the bottom of a large open tank through a 80 mm pipe. The drain pipe ends at a point 10 m below the surface of the brine in the tank. Considering a streamline starting at the surface of the brine in the tank and passing through the centre of the drain line to the point of discharge and assuming the friction is negligible, calculate the velocity of flow along the streamline at the point of discharge from the pipe.

Solution. Refer Fig. 6.4

Section 1 – The surface of brine in the tank

Section 2 – The point of discharge.

Applying Bernoulli's equation between point 1 and 2, we get

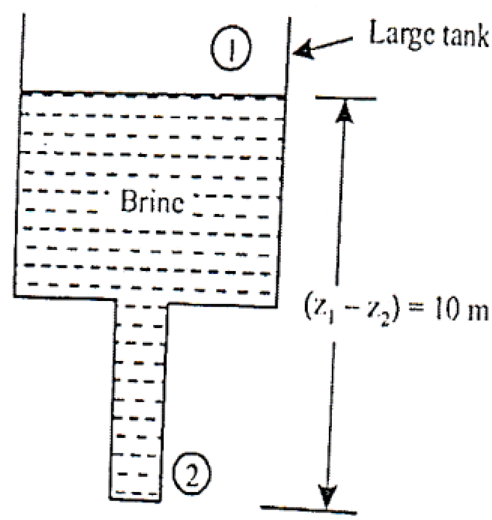
$$\frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + z_2$$

Here $p_1 = p_2 = p_{atm}$ (atmospheric pressure),

$V_1 = 0$ and $(z_1 - z_2) = 10$ m

$\therefore \quad V_2^2 = 2g\,(z_1 - z_2) = 2g \times 10 = 2 \times 9.81 \times 10 = 196.2$

or $\quad V_2 \simeq$ **14 m/s (Ans.)**



Example

A pipe 200 m long slopes down at 1 in 100 and tapers from 600 mm diameter at the higher end to 300 mm diameter at the lower end, and carries 100 litres/sec of oil (sp. gravity 0.8). If the pressure gauge at the higher end reads 60 kN/m², determine:

(i) Velocities at the two ends;

(ii) Pressure at the lower end.

Neglect all losses.

Solution. Length of the pipe, $l = 200$ m; diameter of the pipe at the higher end, $D_1 = 600$ mm = 0.6 m,

$\therefore$ Area, $A_1 = \frac{\pi}{4} \times 0.6^2 = 0.283\ m^2$

Diameter of the pipe at the lower end,

$D_2 = 300\ mm = 0.3\ m$

$\therefore$ Area, $A_2 = \frac{\pi}{4} \times 0.3^2 = 0.0707\ m^2$

Height of the higher end, above datum,

$z_1 = \frac{1}{100} \times 200 = 2\,m$

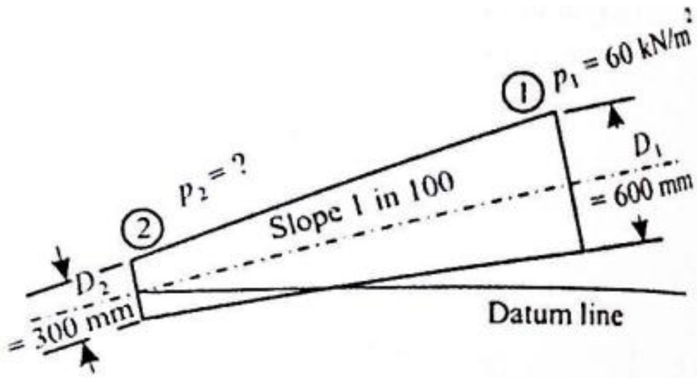


Fig. 6.9

Height of the lower end, above datum $z_2 = 0$

Rate of oil flow, $Q = 100$ litres/sec = 0.1 m³/s

Pressure at the higher end, $p_1 = 60\ kN/m^2$

(*i*) **Velocities, V_1, V_2:**

Now, $Q = A_1 V_1 = A_2 V_2$

Where, V_1 and V_2 are the velocities at the higher and lower ends respectively.

$$\therefore \quad V_1 = \frac{Q}{A_1} = \frac{0.1}{0.283} = \mathbf{0.353\,m/s\ (Ans.)}$$

$$\text{and} \quad V_2 = \frac{Q}{A_2} = \frac{0.1}{0.0707} = \mathbf{1.414\,m/s\ (Ans.)}$$

(*ii*) **Pressure at the lower end p_2:**

Using Bernoulli's equation for both ends of pipe, we have

$$\frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + z_2$$

$$\frac{60}{0.8 \times 9.81} + \frac{0.353^2}{2 \times 9.81} + 2$$

$$= \frac{p_2}{0.8 \times 9.81} + \frac{1.414^2}{2 \times 9.81} + 0$$

$$7.64 + 0.00635 + 2 = \frac{p_2}{0.8 \times 9.81} + 0.102$$

$$\therefore \quad \frac{p_2}{0.8 \times 9.81} = 9.54 \text{ m}$$

or $\quad p_2 = \mathbf{74.8\ kN/m^2\ (Ans.)}$