### 5.21.2. Bernoulli's Equation for a Real Fluid

The Bernoulli's equation was derived on the assumption that fluid is non-viscous and therefore frictionless. But in actual practice, all fluids are real and offer some resistance to flow. Thus, there is always some loss of energy or head in fluid flow. The Bernoulli's equation is, therefore, modified as

$$\frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + z_2 + h_2$$

where $h_2$ is the loss of energy between entry and exit of fluid.

### 5.21.3. Practical Applications of Bernoulli's Equation

Bernoulli's equation can be applied in all practical situations or problems where incompressible fluid flow with energy considerations are involved. The main application of Bernoulli's equation is found in following measuring devices.

**1. Venturimeter.** A device used for measuring the rate of flow of a fluid flowing through a pipe. Rate of flow is calculated by

$$Q_{act} = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

Where $C_d$ = Coefficient of venturimeter and its value is less than 1.

**2. Orificemeter.** It is also used for measuring the rate of flow a fluid through a pipe. It is cheaper device as compared to venturimeter. Discharge can be found as follows :

$$Q = C_d \times \frac{a_0 \, a_1 \sqrt{2gh}}{\sqrt{a_1^2 - a_0^2}}$$

Where $C_d$ = Coefficient of discharge for orificemeter.

**3. Pitot tube.** It is a device used for measuring the velocity of flow at any point in a pipe or channel. The principle involved is that if the velocity of flow at point becomes zero, the pressure there increased due to the conversion of kinetic energy into pressure energy. Velocity at any point,

$$\boxed{V = C_v \sqrt{2gh}}$$

**Problem 12.** *A pipe 300 metre long has a slope of 1 in 100 and tapers from 1 m diameter at high end to 0.5 m at the low end. Quantity of water flowing is 5400 liters per minute. If the pressure at high end is 70 kPa. Find the pressure at the low end?* **[RGPV Dec., 2012]**

**Solution.** Given data :

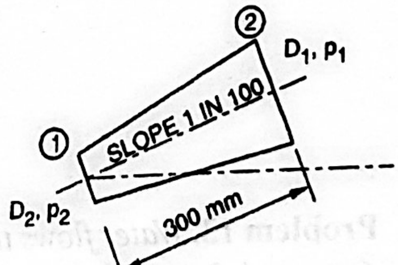


Fig. 5.16.

Length of pipe, $L = 300$ m

Diameter at high end, $D_1 = 1$ m

Area at high end, $A_1 = \frac{\pi}{4} D_1^2$

$A_1 = \frac{\pi}{4}(1)^2 = 0.785 \text{ m}^2$

Pressure at high end, $p_1 = 70 \text{ kPa} = 70 \times 10^3 \text{ N/m}^2$

Diameter at lower end, $D_2 = 0.5$ m

Area at lower end, $A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4}(0.5)^2$

$A_2 = 0.1963 \text{ m}^2$

Now, Rate of flow, $Q = 5400 \text{ litre/min} = 90 \text{ litre/sec}$

$$\boxed{Q = 0.09 \text{ m}^3/\text{s}}$$

Let the datum line passes through the centre of lower end.

Then $z_2 = 0.$

As slope is 1 in 100 means, $z_1 = \frac{1}{100} \times 300 = 3 \text{ m}$

As we know that, $Q = A_1 V_1 = A_2 V_2$

$$V_1 = \frac{Q}{A_1} = \frac{0.09}{0.785} = 0.1146 \text{ m/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.09}{0.1963} = 0.4584 \text{ m/s}$$

Applying Bernoulli's equation, we get

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

$$\frac{70 \times 10^3}{(10^3 \times 9.81)} + \frac{(0.1146)^2}{2 \times 9.81} + 3 = \frac{p_2}{\rho g} + \frac{0.4584^2}{2 \times 981} + 0$$

$$7.135 + 6.693 + 3 = \frac{p_2}{\rho g} + 0.01071$$

$$\frac{p_2}{\rho g} = 16.828 - 0.01071$$

$$\frac{p_2}{\rho g} = 16.8173$$

$$p_2 = 16.8173 \times 1000 \times 9.81$$

$$\boxed{p_2 = 164.97 \text{ kN/m}^2}$$ **Ans.**