A Few unsteady Flow Phenomena

Q1. Choose the correct answer

(i) Unsteady form of Bernoulli's equation is given by

(a) $\frac{p_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2} + gz_2$

(b) $\frac{p_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2} + gz_2 + \int_1^2 \frac{\partial V}{\partial s} dt$

(c) $\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + \int_1^2 \frac{\partial V}{\partial t} ds$

(d) $\frac{p_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2} + gz_2 + \int_1^2 \frac{\partial V}{\partial t} ds$

[*Ans.(*d)]

(ii) The propagation velocity of a pressure wave in a rigid pipe carrying a fluid of density ρ and viscosity μ varies as

(a) ρ

(b) $\sqrt{\rho}$

(c) $\sqrt{1/\rho}$

(d) ρ/μ

[*Ans.(*c)]

(iii) A surge tank is provided in a hydroelectric power station to

(a) increase the net head across the turbine

(b) reduce water hammer problem in the penstock

(c) reduce frictional losses in the system

[*Ans.(*b)]

Q2.

A straight pipe 600 m in length, and 1 m in diameter, with a constant friction factor *f*= 0.025, and a sharp inlet, leads from a reservoir where a constant level is maintained at 25 m above the pipe outlet which is initially closed by a glove valve (*K*=10). If the valve is suddenly opened, find the time required to attain 90% of steady-state discharge.

Solution

From the consideration of establishment of steady flow in a pipe, the expression for time required for the same is

$$t = \frac{LV_0}{2g(H+h)} \ln \frac{V_0 + V}{V_0 - V}$$

Steady state velocity V_0 is found out by the application of Bernoulli's equation, at steady state, between a point on the free surface of water in the reservoir and a point on the discharge plane after the valve, as

$$25 = \frac{V_0^2}{2g}\left(0.5 + \frac{0.025\times 600}{1} + 10 + 1\right)$$

or $$V_0 = \left[\frac{2 \times 9.81 \times 25}{26.5} \right]^{1/2}$$

Substituting this value of $V_0 = \left[\frac{2 \times 9.81 \times 25}{26.5} \right]^{1/2}$ in the above equation, we obtain

$$t = \frac{600}{\left(2 \times 9.81 \times 25 \times 26.5\right)^{1/2}} \ln \frac{1.9}{0.1} = 15.5 \text{ s}$$