

WORKED EXAMPLE 3

The diagram shows a horizontal nozzle discharging into the atmosphere. The inlet has a bore area of 600 mm^2 and the exit has a bore area of 200 mm^2 . Calculate the flow rate when the inlet pressure is 400 Pa . Assume there is no energy loss.

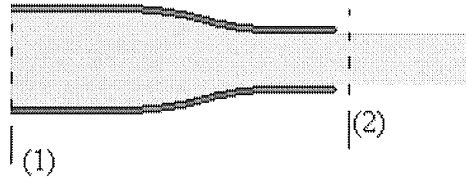


Fig. 1.4

SOLUTION

Apply Bernoulli between (1) and (2)

$$p_1 + \rho g z_1 + \frac{\rho u_1^2}{2} = p_2 + \rho g z_2 + \frac{\rho u_2^2}{2} + p_L$$

Using gauge pressure, $p_2 = 0$ and being horizontal the potential terms cancel. The loss term is zero so the equation simplifies to the following.

$$p_1 + \frac{\rho u_1^2}{2} = \frac{\rho u_2^2}{2}$$

From the continuity equation we have

$$u_1 = \frac{Q}{A_1} = \frac{Q}{600 \times 10^{-6}} = 1666.7Q$$

$$u_2 = \frac{Q}{A_2} = \frac{Q}{200 \times 10^{-6}} = 5000Q$$

Putting this into Bernoulli's equation we have the following.

$$400 + 1000 \times \frac{(1666.7Q)^2}{2} = 1000 \times \frac{(5000Q)^2}{2}$$

$$400 + 1.389 \times 10^9 Q^2 = 12.5 \times 10^9 Q^2$$

$$400 = 11.11 \times 10^9 Q^2$$

$$Q^2 = \frac{400}{11.11 \times 10^9} = 36 \times 10^{-9}$$

$$Q = 189.7 \times 10^{-6} \text{ m}^3/\text{s} \text{ or } 189.7 \text{ cm}^3/\text{s}$$