The flow in a pipe is termed pipe flow only when the fluid completely fills the cross-section and there is no free surface of liquid.
The pipe running partially full is known as open channel flow.

Loss of energy :- when water flows in a pipe, it experiences some resistance to its motion, due to which its velocity and ultimately the head of water available is reduced. This loss of energy is classified as.

(a) Major loss — This loss is due to friction.
The losses due to friction are calculated by.

(1) Darcy - weisbach formula :-

$$h_f = \frac{4 f L V^2}{2 g \cdot d}$$

h_f → head loss due to friction.

f → Co-efficient of friction.

L → Length of pipe.

V → mean velocity of flow.

d → diameter of the pipe

(2) Chezy's formula :-

$$V = C\sqrt{m \cdot i}$$

C → Chezy's constant

m → hydraulic mean depth.

$$m = \frac{A}{P} = \frac{\frac{\pi}{4} D^2}{\pi D} = \frac{D}{4}.$$

i → slope $= \frac{h_f}{L}$ [loss of head per unit length]

Minor loss!- The minor loss of energy includes the following cases

(a) Loss of head due to sudden enlargement

(b) Loss of head due to sudden contraction

(c) Loss of head at the exit of pipe

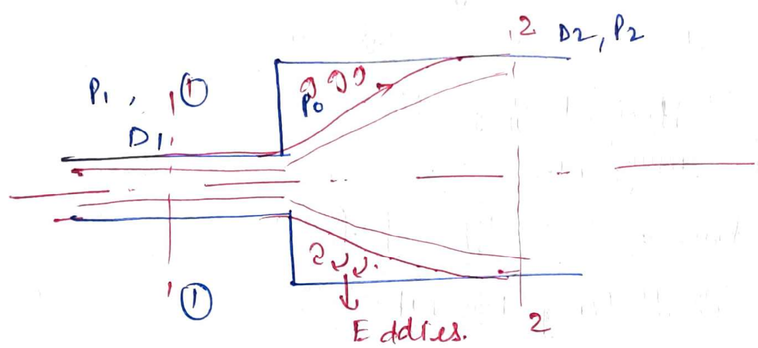
(d) Loss of head at the entrance of pipe

(e) Loss of head due to bend in pipe

(d) Loss of head due to an obstruction in the pipe

(f) Loss of head in various pipe fittings.

(a) Loss of head due to sudden enlargement!-



Applying bernoulli's eqn to section 1-1 & 2-2.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + \text{loss of head due to sudden enlargemt}$$

$Z_1 = Z_2$.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_e$$

$$h_e = \left(\frac{P_1 - P_2}{\rho g}\right) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right). \quad \text{———— (1)}$$

Force acting on liquid in the control volume

$F_x = P_1 A_1 - P_2 A_2 + P_0 (A_2 - A_1)$ { $P_0 = P_1$ experimental value; P_0 ↓ pressure due to eddies formation }

$F_x = P_1 A_2 - P_2 A_2 \Rightarrow (P_1 - P_2) A_2$ —— (II)

Momentum of liquid at section 1-1 & 2-2

at 1-1 section: $\rho A_1 V_1 \times V_1 = \rho . A V_1^2$

at sect 2-2 $= \rho A_2 V_2 \times V_2 = \rho A_2 V_2^2$

change of momentum liquid/sec.

$= \rho A_2 V_2^2 - \rho A_1 V_1^2$ —— (III)

$\rho = \frac{m}{V}$

Continuity eqn –

$A_1 V_1 = A_2 V_2$

$A_1 = \frac{A_2 V_2}{V_1}$ —— (IV)

put the value in eqn (III)

$= \rho A_2 V_2^2 - \rho \times \frac{A_2 V_2}{V_1} \times V_1^2$

$= \rho A_2 (V_2^2 - V_1 V_2)$ —— (V)

Net force = change in momentum.

$(P_1 - P_2) A_2 = \rho A_2 (V_2^2 - V_1 V_2)$

$\frac{P_1 - P_2}{\rho} = V_2^2 - V_1 V_2$

dividing both side by g

$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1 V_2}{g}$ ←—— (V)

put the value in eqn (I)

$h_e = \frac{V_2^2 - V_1 V_2}{g} + \frac{V_1^2}{2g} - \frac{V_2^2}{2g}$

(4)

$$= \frac{2v_2^2 - 2v_1v_2 + v_1^2 - v_2^2}{2g}$$

$$= \frac{v_1^2 + v_2^2 - 2v_1v_2}{2g}$$

(*)

$$h_e = \frac{(v_1 - v_2)^2}{2g}$$

Q.- At a sudden en

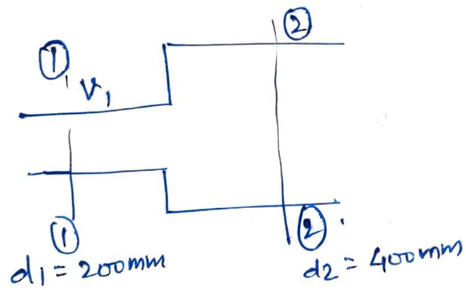
Q- The rate of flow through a horizontal pipe is 0.25 m³/s. The diameter of pipe which is 200mm is suddenly enlarged to 400mm. The pressure intensity in the smaller pipe is 11.772 N/cm². Determine.

(a) Loss of head due to sudden enlargement.

(b) pressure intensity in the large pipe.

(c) Power lost due to enlargement

Soln



$$h_e = \frac{(v_1 - v_2)^2}{2g}$$

$Q = 0.25\, m^3/s$.

$P_1 = 11.772\, N/cm^2 = 11.772 \times 10^4\, N/m^2$

$$v_1 = \frac{Q_1}{A_1} = \frac{0.25}{\frac{\pi}{4} \times (.2)^2} = 7.957\, m/s, \quad v_2 = \frac{0.25}{\frac{\pi}{4}(.4)^2} = 1.989\, m/s.$$

(a) $$h_e = \frac{(7.957 - 1.989)^2}{2 \times g} = 1.815\text{ meter.}$$

(b) Bernoulli's eqn → $$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + h_e \quad [z_1 = z_2].$$

$$\frac{11.772 \times 10^4}{1000 \times 9.81} + \frac{(7.959)^2}{2 \times 9.81} = \frac{P_2}{\rho g} + \frac{(1.989)^2}{2 \times 9.81} + 1.815$$

$P_2 = 12.96\, N/cm^2$.

(c) $P = \rho g Q h_{\text{loss of head}}$ ⇒ $P = 1000 \times 9.81 \times .25 \times 1.815 = 4451.28\, W$.