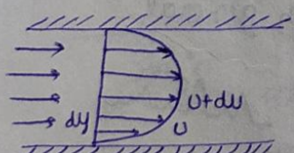
lecture 13
8| 04| 19

[FLOW through Pipes
⑦ Chapter GATE]

Pipe FLOW :- (Imp. topic for gate) It is closed conduit generally having circular cross-section. Note the cross-section may be of different other shape such as □ △ ▭ e.t.c.

Note: For other shape cross-section of closed conduit, terminology like duct is used.

Pipe Flow:- When the flow completely fill the cross-section of pipe and the flows are considered as pipe flow.



τ = exist

$F_{vis.} = \tau.A$

$Re = \frac{F_{inertia}}{F_{viscous}}$

$Re = \frac{\rho.V.L}{\mu}$

L = characteristic dimension

Characteristic Dimension ⇒ hydraulic Diameter (D_{TH})

$Re = \frac{\rho . V D_{TH}}{\mu}$

$$\boxed{D_{TH} = \frac{4A}{P}}$$

P = Wetted Perimeter

For circular,

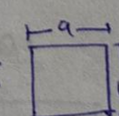
$D_{th} = \frac{4A}{P}$

$= \frac{4 \times \frac{\pi}{4} \times D^2}{\pi D}$

$$\boxed{D_{th} = D}$$

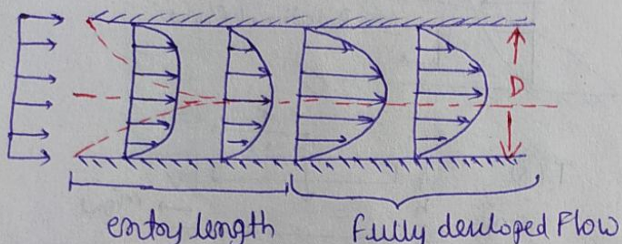
$$\boxed{Re = \frac{\rho.V.D}{\mu}}$$

Ex:

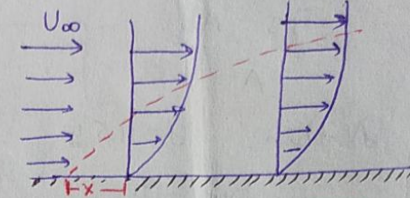


FLOW physics (characteristic Dimension)

Pipe Flow



Flow over Flate Plate:

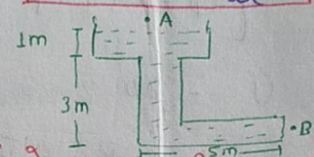


$$\boxed{(Re)_x = \frac{\rho U_\infty x}{\mu}}$$

Head losses:-

→ Major head losses

→ Minor head losses



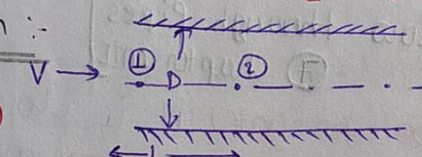
L = जहाँ से Pressure निकालना और जहाँ तक निकालना उसकी distance है।

L = 1+3+5 = 9 m

Major Head losses

① Darcy weisbach eqn :-

(It is used for only closed channel)



V → mean velocity of pipe flow

$$\boxed{h_f = \frac{f \cdot L \cdot V^2}{2gD}}$$

$$V = \frac{Q}{\frac{\pi}{4}D^2}$$

$$h_f = \frac{fL}{2gD}\left[\frac{Q}{\frac{\pi}{4}D^2}\right]^2 = \boxed{\frac{8Q^2}{\pi^2 g} \cdot \frac{f.L}{D^5}}$$

① F = friction factor

② $\boxed{F = 4F'}$

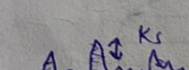
③ F' = [coefficient of friction]

② For pipe flow (circular c/s)

Re < 2000 [laminar]

Re > 4000 [turbulant]

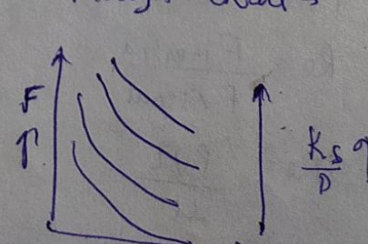
In general



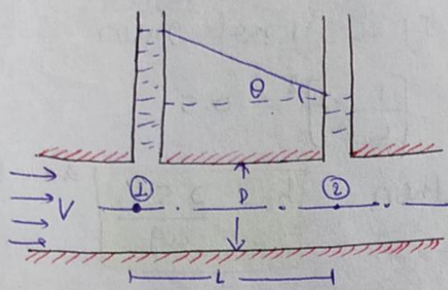
K_s = surface Roughness

laminar	turbulant
$\boxed{F' = \frac{16}{Re}}$	$\boxed{F' = \frac{0.079}{Re^{\frac{1}{4}}}}$
and	and
$\boxed{F = \frac{64}{Re}}$	$\boxed{F = \frac{0.316}{Re^{\frac{1}{4}}}}$

Mody's chart →



Chezy's Formula :- (It is used for open as well as close channel)



v = mean velocity of pipe flow

$$V = C\sqrt{mi}$$

$\left[m = \text{hydraulic mean depth} \right.$

$$V = C\sqrt{\frac{D}{4}\cdot\frac{h_f}{L}}$$

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

$$V^2 = C^2 \cdot \frac{D}{4}\cdot\frac{h_f}{L}$$

$$\left[i = \tan\theta = \frac{h_f}{L} \right]$$

$$\left[h_f = \frac{4 L V^2}{C^2 D} \right]$$

Pb - ①
$$\frac{f L V^2}{2gD} = \frac{4 \cdot L \cdot V^2}{D}$$

$$\boxed{C = \sqrt{\frac{8g}{f}}}$$

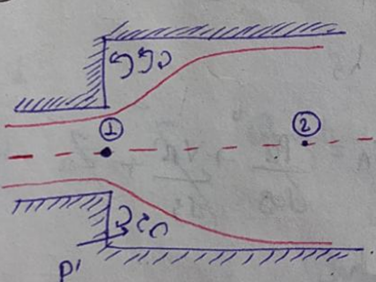
chezy's coefficient (C) is related to Darcy weisbach friction factor (f)

* ESE 2002

Minor head losses :-

1. Due to sudden expansion.
2. At the exit of pipe
3. Due to sudden contraction.
4. At the entrance of pipe.
5. Due to pipe bend.

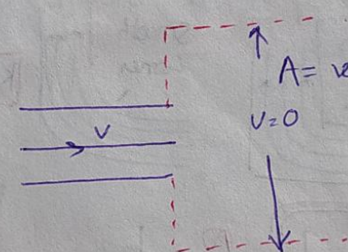
① Due to sudden expansion :-



(experiment)
$P' \simeq P_1$ ***

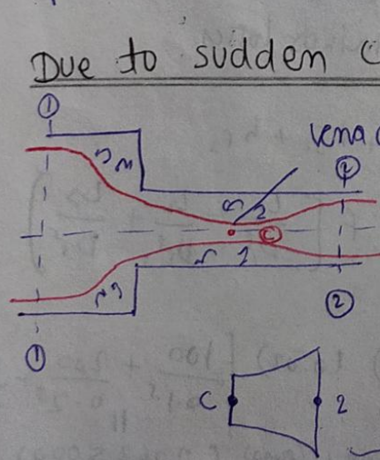
$$\boxed{h_L = \frac{(V_1 - V_2)^2}{2g}}$$

② At the exit point of pipe



$$h_L = \frac{(V-0)^2}{2g} = \boxed{\frac{V^2}{2g}}$$

③ Due to sudden contraction :-



$$h_L = \frac{(V_C - V_2)^2}{2g}$$

Apply continuity →

$$A_C V_C = A_2 V_2$$

$$\{ A_C = C_C A_2)$$

$$(C_C \cancel{A_2}) V_C = \cancel{A_2} V_2 \Rightarrow \boxed{V_C = \frac{V_2}{C_C}}$$

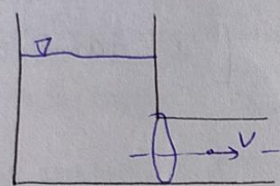
$$h_L = \frac{\left[\frac{V_2}{C_c} - V_2\right]^2}{2g} = h_L = \left(\frac{1}{C_c} - 1\right)^2 \frac{V_2^2}{2g}$$

If C_c is not given

$$\left[\frac{1}{C_c} - 1\right]^2 = 0.5$$

then, $\boxed{h_L = \frac{0.5 V_2^2}{2g}}$ ★★★

④ At the entrance of pipe:



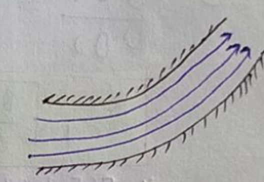
$$\boxed{h_L = \frac{0.5V^2}{2g}}$$

⑤ Due to pipe bend:

(Sharp) $\boxed{h_L = \frac{KV^2}{2g}}$

K = coefficient of Pipe bend

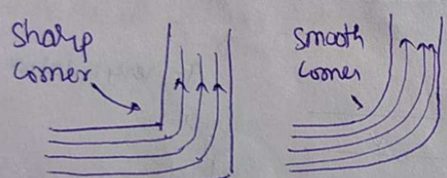
- Effect ★★★



$\boxed{K\uparrow}$

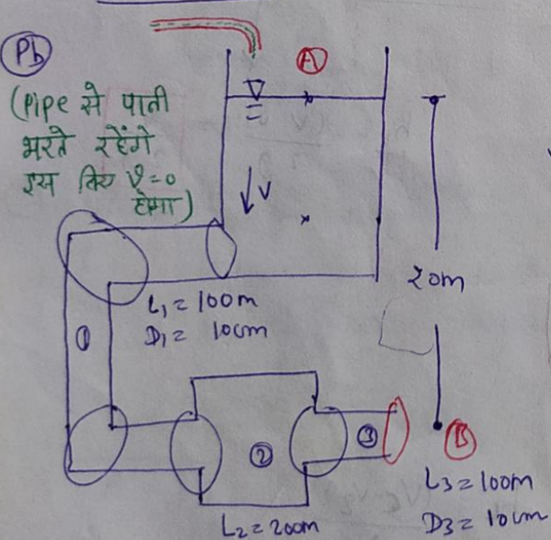
Effect ★★★

Radius of curvature:



$\boxed{K\downarrow}$

Pb



Given,

$K_{bend} = 1$

$f = 0.02$

Determine % error in discharge if minor head loss neglected.

Apply energy eqⁿ: b/w Ⓐ and Ⓑ

$$E_B = E_A + h_f$$

$$\frac{\cancel{P_A}}{\rho g} + \frac{\cancel{V_A^2}}{2g} + Z_A = \frac{\cancel{P_B}}{\rho g} + \frac{\cancel{V_B^2}}{2g} + \cancel{Z_B} + h_f$$

$$20 = h_f$$

Neglected minor losses.

$$20 = h_{f_1} + h_{f_2} + h_{f_3}$$

$$20 = \frac{8Q^2}{\pi^2 g} \cdot f\left[\frac{L_1}{D_1^5} + \frac{L_2}{D_2^5} + \frac{L_3}{D_3^5}\right]$$

$$20 = \frac{8Q^2}{\pi^2 g}(0.02)\left[\frac{100}{0.1^5} + \frac{200}{0.2^5} + \frac{100}{0.1^5}\right]$$

$$= 34118.16(\text{PWRA}) \quad (20625000)$$

~~773781.408~~

$12090.33 = Q^2(20625000)$

$$\boxed{Q = 24.22 \times 10^{-3}\ m^2/s}$$

Actual-

$$20 = h_{f_1} + h_{f_2} + h_{f_3} + 0.5\frac{V_1^2}{2g} + \frac{V_1^2}{2g} + \frac{V_1^2}{2g} + \frac{(V_1 - V_2)^2}{2g}$$

$$+ 0.5\frac{V_3^2}{2g} + \frac{V_3^2}{2g}$$

$$20 = \left(\frac{f_1 L_1 V_1^2}{2g D_1} + \frac{f_2 L_2 V_2^2}{2g D_2} + \frac{f_3 L_3 V_3^2}{2g D_3}\right) + \frac{2.5 V_1^2}{2g}$$

$$+ \frac{(V_1 - V_2)^2}{2g} + \frac{1.5 V_3^2}{2g}$$

$$20 = \frac{(0.02)\times 100}{0.1}\frac{V_1^2}{2g} + 20\frac{V_2^2}{2g} + 21.5\frac{V_3^2}{2g} + \frac{(V_1 - V_2)^2}{2g}$$

<u>In terms of V_2</u>

$$20 = \left[22.5(4)^2 + 20 + 21.5(4)^2 + (4-1)^2\right]\frac{V_2^2}{2g}$$

$$V_2 = 0.7316\ m/s$$

Apply continuity

$$A_1 V_1 = A_2 V_2 = A_3 V_3$$

$$\frac{\pi}{4}(0.1)^2 V_1 = \frac{\pi}{4}(0.2)^2 V_2 = \frac{\pi}{4}(0.1)^2 V_3$$

$$(V_1 = 4V_2 = V_3)$$

$$Q_{actual} = A_2 V_2 = \frac{\pi}{4}\times(0.2)^2(0.7316)$$

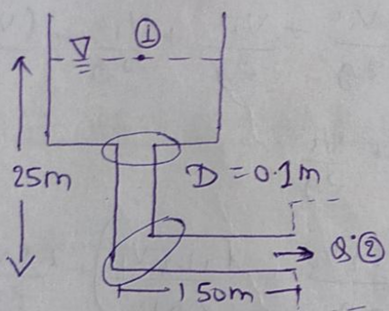
$$= 22.98 \times 10^{-3}\ m^3/s$$

$$\text{error}\ \% = \frac{Q - Q_{actual}}{Q_{actual}} \times 100$$

$$= \boxed{\frac{24.22 - 22.98}{22.98} \times 100}$$

$$= 5.39$$

Pb - 14 Grate



Apply energy eq b/w ① and ②

$$\cancel{\frac{P_1}{\rho g}} + \cancel{\frac{V_1^2}{2g}} + Z_1 = \cancel{\frac{P_2}{\rho g}} + \cancel{\frac{V_2^2}{2g}} + \cancel{Z_2} + h_f$$

$$25 = h_f$$

Neglect minor losses

$$25 = \frac{8Q^2}{\pi^2 g} \cdot \frac{fL}{D^5}$$

$$25 = \frac{8Q^2 (0.03)\boxed{(25+150)}}{\pi^2 g \, (0.1)^5}$$ ***

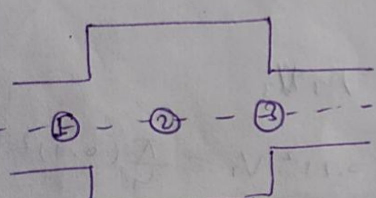
$$\boxed{Q = 24 \times 10^{-3}\ m^3/s}$$

Different connection -

Flow chart →

Parameter → Flow (Discharge) (Q)
→ Drop (Head loss) (h_f)

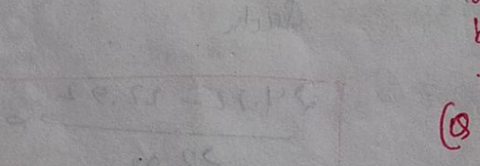
Series →



Q → same (Q remain same) (in series)

$h_f = h_{f_1} + h_{f_2} + h_{f_3}$

Parallel



$\boxed{Q = Q_1 + Q_2}$

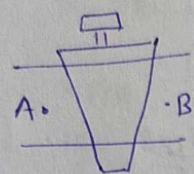
$\boxed{h_{f_1} = h_{f_2}}\boxed{= h_T}$ (h_T = total head loss)

[Q will remain same if diameter and velocity whatever]
but in parallel case and total loss will also equal]
(Q will be total)

(Pb) (10) [Inverted will not used in gas]

Flow Nozzle : having converging section as venturimeter
bt not diverging section
1, 2, 3 unit

Pb (31)



$$\frac{P_A}{\rho g} + \cancel{\frac{V_A^2}{2g}} + Z_A = \frac{P_B}{\rho g} + \cancel{\frac{V_B^2}{2g}} + Z_B + h_f$$

$$2.5 + 1.5 = \frac{P_B}{\rho g} + Z_B + 0.2$$

$$\frac{P_B}{\rho g} + Z_B = 4.8$$