Application of Bernoulli's Equation.

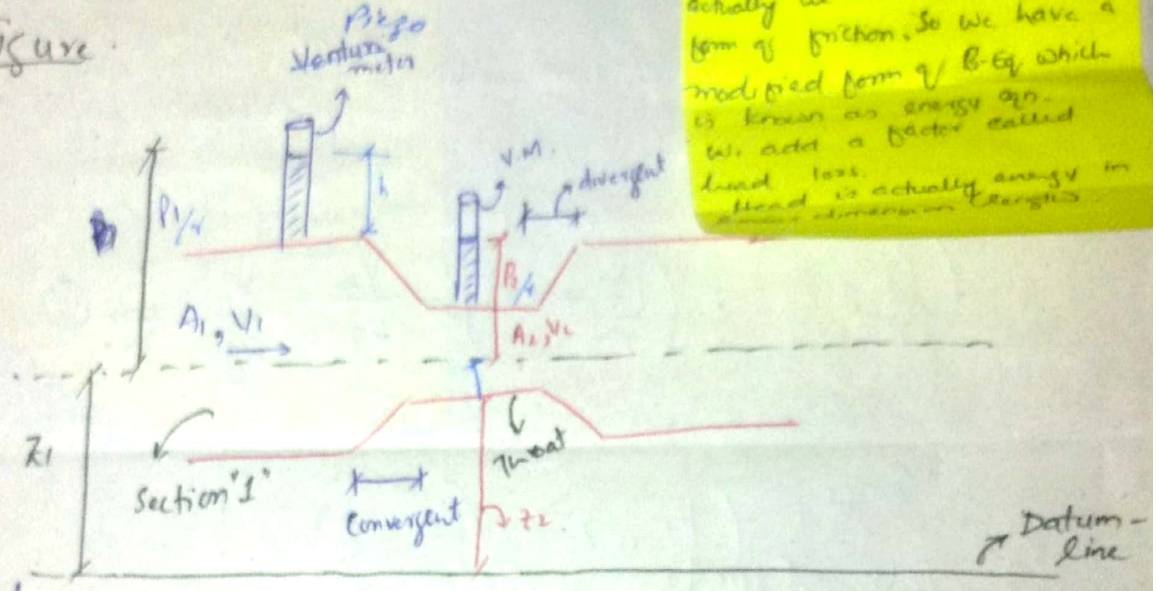
i. Venturimeter
ii. Pitot tube
iii. Orifice

i. Venturi meter :-

It is a device which is used to measure the flow of fluid (speed)

As Bernoulli's Eqn was for ideal (frictionless fluid). But actually we have energy loss in form of friction. So we have a modified form of B-Eq which is known as energy eqn. We add a factor called head loss. Head is actually energy in dimensional terms.

Figure.



Important to note :-

Section "1"-"1" we take from where fluid starts flow.

- At section "1-1" there is no energy loss.
- The head loss is the energy loss by fluid when the fluid pass through pipe or any other dimensional things.
- We add this energy head loss to right because no energy loss at start but other section there is loss in energy.
- Head loss is commulative loss in energy.

Since from Bernoulli's Equation.

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g} \longrightarrow (A)$$

where $\frac{P_1}{\gamma}$ = ~~Potential~~ Pressure head.

z_1 = Potential head.

$\frac{V_1^2}{2g}$ = Kinetic head.

- The value of z for pressure flow & gravity flow is different.
- In venturimeter, we consider pressure flow.
- If we consider centre line as datum line then $z_1 = 0$.

Re-arranging eq (A).

$$\left(\frac{P_1}{\gamma} + z_1\right) - \left(\frac{P_2}{\gamma} + z_2\right)$$

Since; $\left(\frac{P_1}{\gamma} + z_1\right) - \left(\frac{P_2}{\gamma} + z_2\right) = h.$

(static head)

where h = Venturi head.

$$h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g} \longrightarrow (C)$$

Note:-

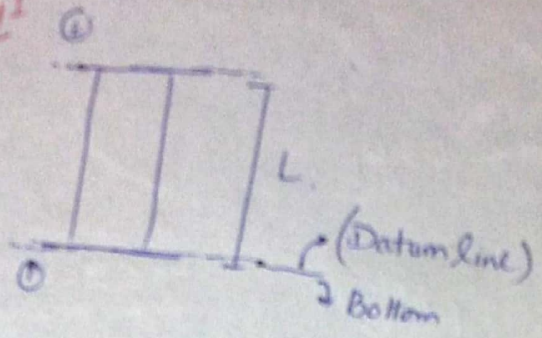
- z_1 is distance from datum line (entirely depend upon observer & always horizontal) upto centre line of pipe
- while P_1 (pressure head) is the distance

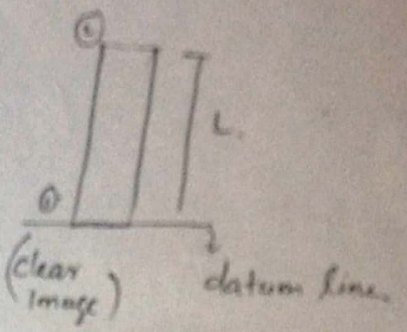
from Centre line to Vacuum meth (1) level
Pizometh

→ Piezometh always gives Static head.

(2) For velocity head we used pitot tube.

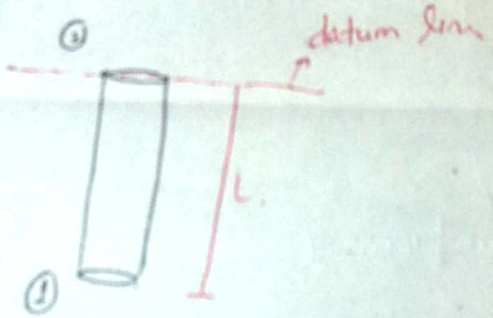
Example #1





- The value of z_1 along ① is zero where $z_2 = L$.

Example #02



$z_1 = -L$

& $z_2 = 0$.

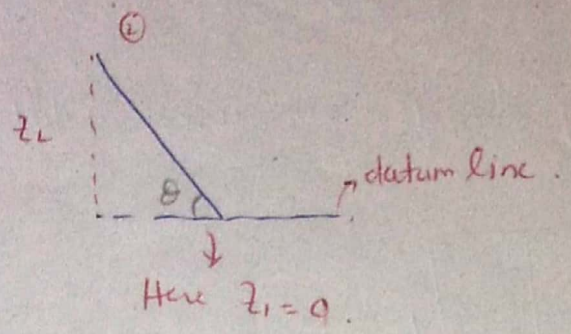
As datum line is reference line of we move above from that we will get +ve & if we move below from that reference line we get -ve.

As here we consider elevation so it can be -ve. Even after calculation we get same result by considering above or below datum line.

- Elevation depend upon if above so + & ↓ (below) -ve.

- By taking different position for datum line, the calculation should be same.

Consider datum line for Inclined section such that z_1 get zero.



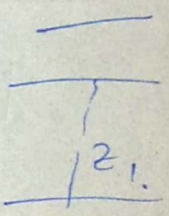
In case of pressure flow.

As pressure is max at centre. that y we take Pressure head at mid.

z = Distance from datum line to centre of channel line.

In case of open anded flow

z = Distance from datum line to bed of channel.



As from Equation of continuity.

$$A_1 V_1 = A_2 V_2.$$

A_1 & A_2 = Cross sectional area

V_1 & V_2 → Velocities

$$V_1 = \frac{A_2}{A_1} V_2.$$

Put in eq ②.

eq ② ⇒ $$h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}.$$

$$h = \frac{V_2^2}{2g} - \left(\frac{a_2 V_1}{2g}\right)^2 \Rightarrow \frac{V_2^2}{2g}\left(1 - \frac{a_2^2}{a_1^2}\right)$$

$$h \Rightarrow \frac{V_2^2}{2g}\left(\frac{a_1^2 - a_2^2}{a_1^2}\right)$$

$$V_2^2 = 2gh\left(\frac{a_1^2}{a_1^2 - a_2^2}\right)$$

$$V_2 = \sqrt{2gh}\ \frac{\sqrt{a_1^2}}{\sqrt{a_1^2 - a_2^2}}$$

$$V_2 = \frac{a_1}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh} \longrightarrow (1).$$

$A_1V_1 = A_2V_2 = C.$

$Q = AV.$

Now as $Q = A_2V_2$. or a_2V_2.

using eq (1) in above eq.

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

C_v = co-efficient of hydraulics.

$Q_{act} = Q_d$ = known as co-efficient of discharge which we add with Bernoulli equation in order to make it applicable for real situation fluid also.

→ The value of Cd should be less than 1 because due to friction its value gets decrease.

- Instead of piezometer sometimes we also used differential manometer.

When differential manometer is attached.

$$h = x\left(\frac{S_h}{S_o} - 1\right) \longrightarrow (1)$$

$$h = x\left(1 - \frac{S_l}{S_o}\right) \longrightarrow (2)$$

S_h & S_l is gauge liquid

S_o is for base liquid.

Eq (1) is used when gauge liquid is heavier than base liquid & eq (2) is used for vice versa. (i.e when $S_o > S_w$).

x is mercury level difference.

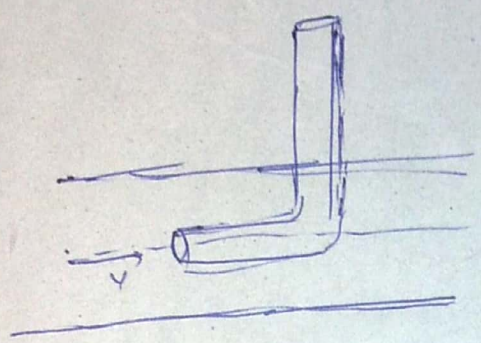
2. Pitot tube :-

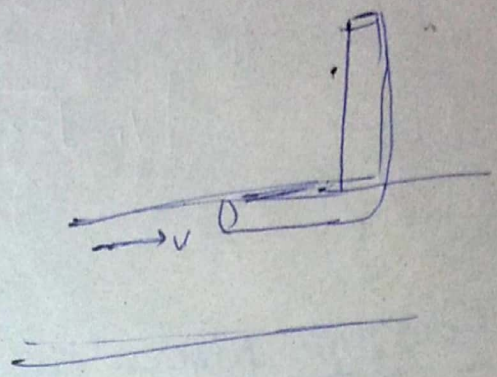
Combination of glasses which are at right angle and whose both are open.

It should be placed in such a way that its lower end is facing direction of flow.

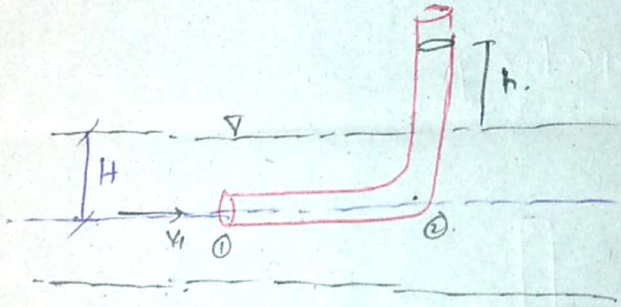
If placed in opposite direction we will even not find velocity head.

At what point we need velocity we should placed this point.





At mid of channel.



As from Bernoulli's equation.

$$P_1/\gamma + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g} \quad \rightarrow (A)$$

As from figure.

$P_1/\gamma = H$, $V_1 = ?$ $z_1 = z_2 = 0$.

$P_2/\gamma = h + H$, $V_2 = 0$.

By putting values in eq (A).

$$H + 0 + \frac{V_1^2}{2g} = h + H + 0 + 0$$

$$\frac{V_1^2}{2g} = h$$

$$V_1^2 = 2gh$$

$$\boxed{V_1 = \sqrt{2gh}}$$

For pipe flow:-

For pipe flow we need piezometer & pitot tube to measure pressure head & velocity head respectively.