crude oil → Mixing all oils

UNIT - V

rate of flow (Q) = AV.

Measurement of flow of fluid — pipelines

Necessity of fluid pressure

↓

To measure the fluid flow

↓

We are using some instruments

↓

pitot tube, orifice meter, Venturi-meter

pitot tube:-

pitot tube is one of the tube of device ~~velocity~~ which measure velocity fluid pipe lines with help of kinetic energy into ~~(or)~~ ~~potential~~ pressure energy

inital velocity $V_1 = V$

finial velocity $V_2 = 0$

- pitot tube is a glass tube
- one end is open to atmosphere
- The other end is connected to a small tube
- it is an right angled triangle
- Next we have to keep the pilot tube in the tube

① potential energy

② position having some energy is called kinetic energy

By using Bernoulis EQ.

$$\frac{p}{\rho g} + z + \frac{v^2}{2g} = \text{constant}$$

$$\frac{p_1}{\rho g} + \cancel{z_1} + \frac{(v_1)^2}{2g} = \frac{p_2}{\rho g} + \cancel{z_2} + \frac{v_2^2}{2g}$$

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} \qquad \boxed{\frac{v_2^2}{2g} = 0}$$

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} \qquad \boxed{\begin{array}{l} v_1 = v \\ v_2 = 0 \end{array}}$$

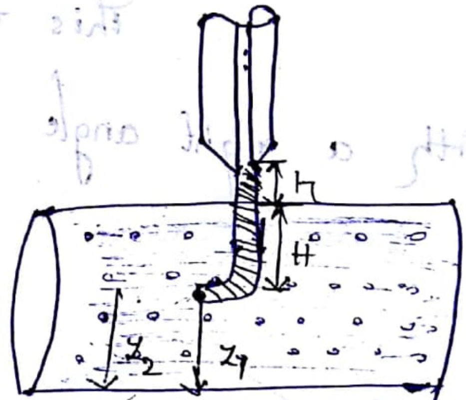
$$H + \frac{v_1^2}{2g} = h + H$$

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

$$v^2 = 2g \times h \Rightarrow \sqrt{2gh}$$

$$\boxed{v_{therotical} = \sqrt{2g \times h}.}$$

$$\boxed{v_{actual} = c_v \sqrt{2gh}}$$



$v = \sqrt{2gh}$

$v_{theotical} = \sqrt{2gh}$

$v_{actual} = c_v\sqrt{2gh}.$

p_1 = pressure at point ①

p_2 = pressure at point ②

v_2 = velocity at point ②

v_1 = velocity at point ①

H = depth of the tube in the liquid

h = rise of the liquid in the tube

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The objective of these chaphter is to measure flow of fluid passing through a pipe line the pititot tube is one of the device to measure the flow of fluid

Pitot tube :-

It is a device used for measuring the velocity of flow at any point in pipe or channel it is based on the principle of the velocity of the flow at a point become's zero the pressure their is increasing due to the conservation of kinetic energy in to pressure energy.

This tube consists of glass tube with a right angle bend

Orifice Meter → velocity & pressure

(Suddenly pressure drop appear than. orifice will be ...)

is a device which is used measure the flow of fluid and measure to convert the Energy

→ It will have some cross-Sectional area.

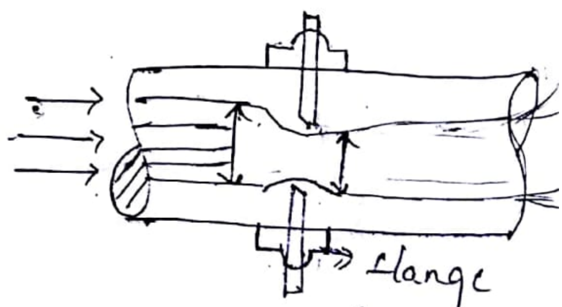
→ fluid particles are move in these area

→ upper section and lower section to orifice gates, phase place cheysanu, → they will have circular tubes → sharp end.

→ fluid flow will be directions will be change

will be inside of the tube

orifice
↓
Here we are also find flow and sudden pressure ~~decreas~~ drop will low So we find discharge (Q)



problem

1. A pilot statastic tube placed in the Centre of 300 mm pipe line. has one orifice pointing upstream and other point perpendicular to it. the mean velocity of the pipe is 0.80 of the Central velocity find the discharge through the pipe if the pressure difference b/w two orifice 60 mm water take the co-efficient of pilot tube is 0.98.

Sol:- given :-

Given data

diameter of the pipe line = 300 mm

= 0.3 m

~~Area of the pipe~~ $= \frac{\pi}{4}(d^2)$

$= \pi/4 \; (0.3)^2$

$\boxed{a = 0.0706 \, m^2}$

Mean velocity = 0.8 × Central velocity

$\bar{V} = 0.8 \times$ Central velocity

$\boxed{h = 0.06 \, m}$

$\boxed{C_v = 0.98}$

$Q = A \times V$

$$\boxed{V = C_v \sqrt{2gh}}$$

$V = 0.98 \sqrt{2 \times 0.98 \times 0.06}$

$$\boxed{V_{act} = 1.06 \text{ m/s}}$$

∴ Mean velocity

$\bar{v} = 0.8 \times 1.06$

$= 0.848 \text{ m/s}$

$Q = A \times \bar{v}$

$= 0.07065 \times 0.848 \text{ m/s}$

$$\boxed{Q = 0.059 \text{ m}^3/\text{s}}$$

(2.) Find the velocity of the flow of an oil through a pipe when the difference mercury level in differential U-tube Manometer connected to the two tappings of the pitot tube is 100mm. Take the co-efficient of pitot tube is 0.98 and Specific gravity of an oil 0.8

Sol:- given:-

mean of an differential u-tube manometer (x) = 100mm

$x = 0.1$

$C_v = 0.98$

Sp. gravity of oil $(S_o) = 0.8$

Sp. gravity mercury $(S_g) = 13.6$

$$\boxed{V = C_v \sqrt{2gh}}$$

$$h = x\left[\frac{S_g}{S_o} - 1\right]$$

$$h = 0.1\left[\frac{13.6}{0.8} - 1\right]$$

$$\boxed{h = 1.6\,m}$$

$$V = 0.98\sqrt{2 \times 9.81 \times 1.6}$$

$$\boxed{V = 5.49\,m/s}$$

③ A pitot Stastic tube is used to measure the velocity of water in a pipe the ~~Stan~~. Stagnation of pressure head is 6m and Stastic pressure head is 5m Calculate the velocity of flow Assume the co-efficient of cube is Equal to 0.98

Sol:- given :-

Stagnation of pressure head = 6m

Stastic pressure head = 5m

$C_v = 0.98$

$$V = C_v \sqrt{2gh}$$

$$V = 0.98 \sqrt{2 \times 9.81 \times 1}$$

$$\boxed{V = 4.340 \text{ m/s}}$$

Orifice Meter:- (or) orifice plate

It is a device used for measuring the rate flow of fluid through a pipe It is also work on the Same principle of the venturi meter.

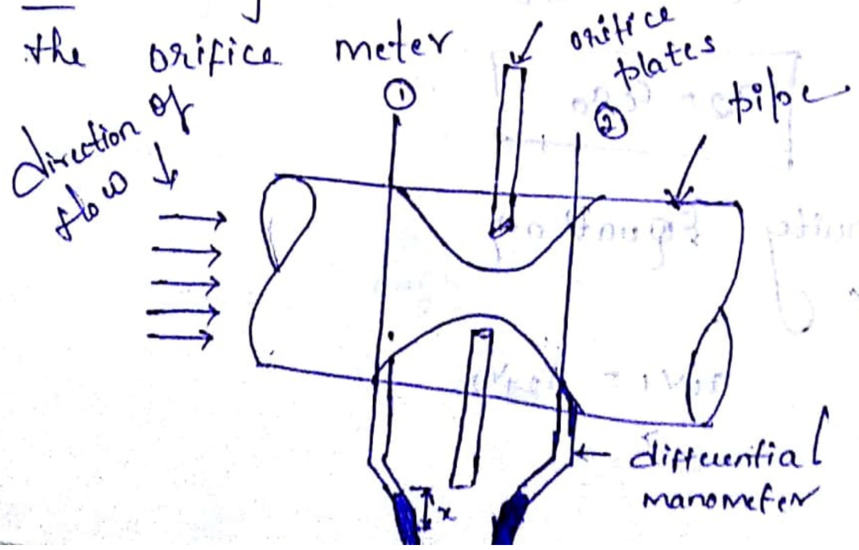
1. It consist flat circular plate, which has circular sharp edge hole it is called orifice

2. The orifice diameter is generally 0.5 times diameter of pipe

3. The flow is vary from 0.4 to 0.8 times of the diameter

4. The differential manometer is connected at sec ① which is at a distance about 1.5 to 2 times of the pipe diameter upstream from the orifice plate

5. At sec ② which is at a distance of half ($\frac{1}{2}$) the diameter of orifice from downstream sides from the orifice meter



Bernoulli's equation:

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$\left(\frac{p_1}{\rho g} + z_1\right) - \left(\frac{p_2}{\rho g} + z_2\right) = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

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

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

$$2gh = v_2^2 - v_1^2$$

$$\boxed{v_2 = \sqrt{2gh + v_1^2}} \quad -①$$

Sec 2-2 is at the contraction and A_2 represe area of the vena contraction. If A_0 is the area of the orifice

co-efficient of contraction

Then $C_c = \frac{a_2}{a_0}$

$$\boxed{a_2 = C_c a_0}$$

Continuity Equation

$$a_1 v_1 = a_2 v_2$$

$$v_1 = \frac{a_2 v_2}{a_1}$$

$$v_1 = \frac{a_2}{a_1} v_2$$

$$\boxed{v_1 = \frac{C_c a_0}{a_1} v_2} \quad -(2)$$

Substitute (2) Eq in Eq (1)

$$v_2 = \sqrt{2gh + \frac{C_c^2 a_0^2}{a_1^2} v_2^2}$$

Squaring on B.S

$$v_2^2 = 2gh + \frac{C_c^2 a_0^2}{a_1^2} v_2^2$$

$$v_2^2 - \frac{C_c^2 a_0^2}{a_1^2} v_2^2 = 2gh$$

$$v_2^2 \left(1 - \frac{C_c^2 a_0^2}{a_1^2}\right) = 2gh$$

$$v_2^2 = \frac{2gh}{\left(1 - \frac{C_c^2 a_0^2}{a_1^2}\right)}$$

$$v_2 = \frac{\sqrt{2gh}}{\sqrt{1 - \frac{C_c^2 a_0^2}{a_1^2}}}$$

$$Q = a_2 v_2$$

$$Q = C_c a_0 \frac{\sqrt{2gh}}{\sqrt{1 - \frac{C_c^2 a_0^2}{a_1^2}}}$$

Formula

$$\boxed{C_d = C_d \times \frac{\sqrt{1 - \left(\frac{a_0}{a_1}\right)^2 C_c^2}}{\sqrt{1 - \left(\frac{a_0}{a_1}\right)^2}}}$$

$$Q = a_0 \cdot C_d \times \frac{\cancel{\sqrt{1 - \left(\frac{a_2}{a_1}\right)^2 C_c^2}}}{\sqrt{1 - \left(\frac{a_0}{a_1}\right)^2}} \times \frac{\sqrt{2gh}}{\cancel{\sqrt{1 - \frac{C_c^2 a_0^2}{a_1^2}}}}$$

$$\boxed{Q = a_0 \cdot C_d \frac{\sqrt{2gh}}{\sqrt{1 - \left(\frac{a_0}{a_1}\right)^2}}}$$

$$\boxed{Q = \frac{a_0 \cdot C_d \sqrt{2gh}}{\sqrt{1 - \left(\frac{a_0}{a_1}\right)^2}}}$$

$$Q = \frac{a_0 \cdot C_d \sqrt{2gh}}{\sqrt{\frac{a_1^2 - a_0^2}{a_1^2}}}$$

$$Q = \frac{\sqrt{a_1^2}\, a_0 \cdot C_d \sqrt{2gh}}{\sqrt{a_1^2 - a_0^2}}$$

$$\boxed{Q = \frac{a_1 a_0 \cdot C_d \sqrt{2gh}}{\sqrt{a_1^2 - a_0^2}}}$$

$\therefore$ C_d = co-Efficient of dilvery

a_0 = area of orifice

UNIT-5

Measurement of flow

Venturimeter:-

A Venturimeter is a device used for a measuring rate of flow of a fluid flowing through a pipe. It consists of three parts

i) A short converging part

ii) Throat and

iii) Diverging part. It is based on the principle of Bernoulli's Equation

Expression for Rate of flow through Venturimeter

Consider a Venturimeter fitted in a horizontal plane through which fluid is flowing

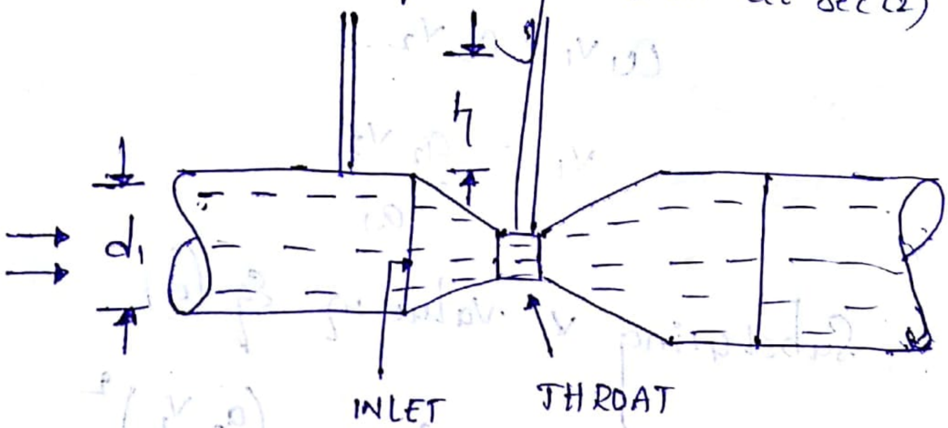
Let d_1 = diameter or inlet or at section (1)

p_1 = pressure at section (1)

v_1 = velocity of fluid at section (1)

a = area of section (1) $\frac{\pi}{4} d_1^2$

d_2, p_2, v_2, a_2 are corresponding values at sec (2)



Applying Bernoulli's Equation

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1^2 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 \quad \text{—} (1)$$

$\therefore$ $z_1 = z_2$.

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} \quad \text{—} (2)$$

$$\frac{p_1 - p_2}{\rho g} = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} \quad \text{—} (3)$$

$\therefore$ Let $\frac{p_1 - p_2}{\rho g} = h$

Substuting 'h' value in Eq ③

$$h = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} \quad \text{—④}$$

Let continuity Equation

$$a_1 v_1 = a_2 v_2$$

$$v_1 = \frac{a_2 v_2}{a_1}$$

Substerting v_1 value in Eq ④

$$h = \frac{v_2^2}{2g} - \frac{\left(\frac{a_2 v_2}{a_1}\right)^2}{2g}$$

$$h = \frac{v_2^2}{2g}\left(1 - \frac{a_2^2}{a_1^2}\right)$$

$$h = \frac{v_2^2}{2g}\left[\frac{a_1^2 - a_2^2}{a_1^2}\right]$$

$$v_2^2 = 2gh\left[\frac{a_1^2}{a_1^2 - a_2^2}\right]$$

$$v_2 = \frac{a_1}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh}$$

let ∴ Discharge $Q = a_2 V_2$

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

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

∴ Discharge conditions is called theoretical discharge. Actual discharge will be less than theoretical discharge

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

∴ C_d is the co-efficient of venturimeter and its value less than 1

Value of 'h' given by differential U-tube Manometer:

Case: 1 Differential Manometer contains a liquid which is heavier than the liquid flowing through pipe. Let

S_h = Sp. gravity of heavier liquid

S_o = Sp. gravity of the liquid flowing through pipe

x = Difference of the heavier liquid column in U-tube

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

Case : 2

If the differential manometer contains a liquid which is lighter than the liquid flowing through a pipe, the value of h is given by

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

S_l = Sp. gravity of lighter liquid in U-tube

S_o = Sp. gr. of fluid through pipe

x = Difference of the lighter liquid columns in U-tube

Case 3 :- Both heavier liquid & Inclined Differential U-tube Manometer

$$h = \left(\frac{p_1}{\rho g} + z_1\right) - \left(\frac{p_2}{\rho g} + z_2\right) = x\left[\frac{S_h}{S_o} - 1\right]$$

Case 4 :-

from lighter liquid

$$h = \left[\frac{p_1}{\rho g} + z_1\right] - \left[\frac{p_2}{\rho g} + z_2\right] = x\left[1 - \frac{S_1}{S_0}\right]$$

Problem :-

① A horizontal Venturimeter with inlet and throat diameters 30cm and 15cm and respectively is used to measure the flow of water. The reading of differential manometer connected to the inlet and throat is 20cm of mercury. Determine the rate of flow Take $C_d = 0.98$

Sol :- given :-

$d_1 = 30cm$

$a_1 = \frac{\pi}{4}(d)^2 = \frac{\pi}{4} \times (30)^2 = 706.85 cm^2$

$d_2 = 15cm$

$a_2 = \frac{\pi}{4}(d)^2 = \frac{\pi}{4} \times (15)^2 = 176.7 cm^2$

$C_d = 0.98$

$\therefore x = 20$

$$h = x\left[\frac{S_H}{S_0} - 1\right] =$$

Sp. gravity of Mercury = 13.6
Sp. gravity of water = 1

$$h = 20\left[\frac{13.6}{1} - 1\right] = 252 cm$$

$$Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

$$= 0.98 \frac{(706.85)(176.7)}{\sqrt{(706.85)^2 - (176.7)^2}} \times \sqrt{2 \times 9.81 \times 252}$$

$$= 125.70 \ lit/sec$$

ORIFICE

. an opening (such as vent, mouth, or hole) through which something may pass an anatomical orifice

classification of orifices

- on the basis of
  - size
    - Small orifices
    - large orifices
  - shape
    - circular
    - Triangular.
    - Square
    - Rectangular.
  - shape of upstream edges
    - sharp edged orifice
    - Bottom Edged orifice
  - Discharge conditions
    - orifice discharged into free
    - Drowned or Sub-merged orifices

Flow through an orifice :-

Consider a tank fitted with a circular orifice in one of its sides as show in fig. Let H be the head of the liquid above the centre of the orifice. The liquid flowing through the orifice forms a jet of liquid whose area of cross-section is less than of orifice. The area of jet of fluid goes on decreasing at a section CC, the area is minimum. This section is approximately at a distance of half of diameter of the orifice. At this section, the stream lines are straight and parallel to each other and perpendicular to the plane of orifice. This section is called a Vena-Contracta Beyond Section.

Consider two points 1 and 2 shown in fig. 7.1 point 1 is inside the tank and point 2 at the vena contracta. At the flow of steady and at a constant head H. Applying Bernoulli's Equation at points 1 and 2

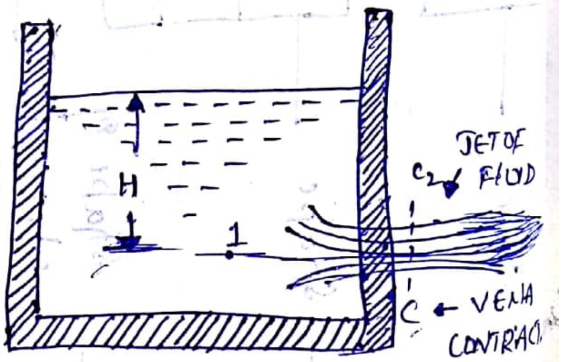


Fig. 7.1 Tank with an orifice

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$z_1 = z_2$$

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g}$$

$$\frac{p_1}{\rho g} = H$$

$$\frac{p_2}{\rho g} = 0 \text{ [atmospheric pressure]}$$

v_1 is very small in comprasion to v_2 as area of tank is very large as compared to the area of jet of liquid

$$\cancel{H+0+0}$$

$$H + 0 = 0 + \frac{v_2^2}{2g}$$

$$v_2 = \sqrt{2gH}$$

This is theoretical velocity. Actual velocity will be less than value

Discharge Through large Rectangular orifice:-

consider a large rectangular in one sider of tank discharging freely in to an atmosphere under a constant head, H as show in fig

H_1 = height of liquid above top edge of orifice

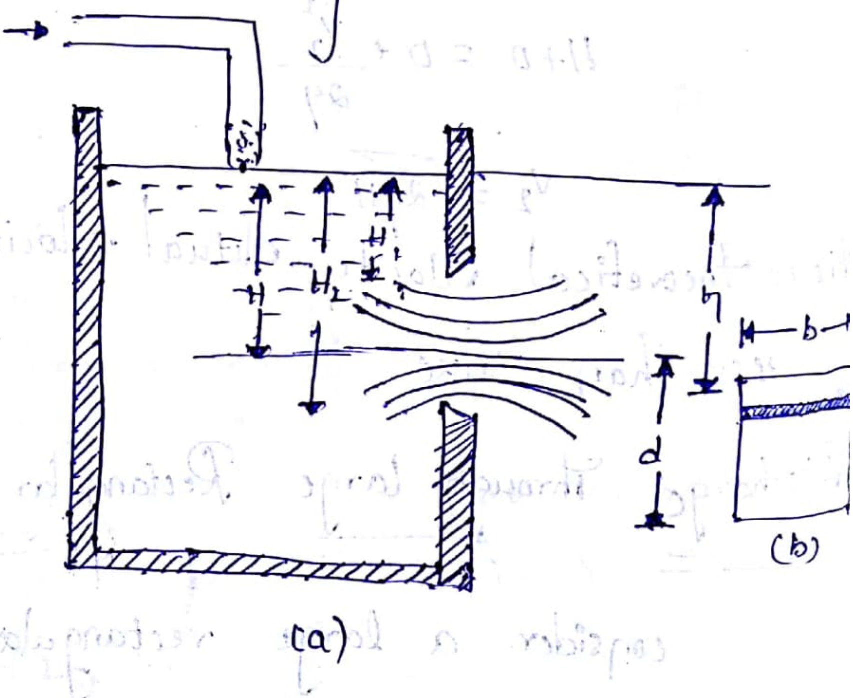
H_2 = Height of liquid above bottom edge of orifice

b = breadth of orifice

d = depth of orifice $= H_2 - H_1$

C_d = co-efficient of discharge

Consider an elementary horizontal strip of depth 'dh' at a depth of 'h' below the free surface of the liquid in the tank in fig



(a)

Large rectangular orifice

$\therefore$ Area of Strip = $b \times dh$

and theoretical velocity of water through Strip = $\sqrt{2gh}$

$\therefore$ Discharge through Elementary strip is given

$$dQ = C_d \times \text{Area of strip} \times \text{velocity}.$$

$$= C_d \times b \times dh \times \sqrt{2gh} = C_d b \times \sqrt{2gh}\, dh$$

By integrating the above Equation b/w the limits H_1 and H_2 the total discharge through the whole orificed Obtained

$$Q = \int_{H_1}^{H_2} C_d \times b \times \sqrt{2gh}\, dh$$

$$= C_d \times b \times \sqrt{2g} \int_{H_1}^{H_2} \sqrt{h}\, dh = C_d \times b \times \sqrt{2g} \left[\frac{h^{3/2}}{3/2} \right]_{H_1}^{H_2}$$

$$Q = \frac{2}{3} C_d \times b \sqrt{2g} \left[H_2^{3/2} - H_1^{3/2} \right]$$

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Problem:-

(1.) A rectangular orifice 1.5 m wide and 1.0 m deep is discharging water from a tank. If the water level in the tank 3.0 m above the top Edge of the orifice, find the discharge through the orifice. Take the co-efficient of discharging of the orifice = 0

Sol:- given

Weight of orifice = (b) 1.5 m

Depth of orifice (d) = 1.0 m

$H_1 = 3.0$ m

$H_2 = H_1 + d$

$= 3.0 + 1.0$

$= 4.0$ m

Discharge Q is the given by the Equation

$$Q = 2/3 \times C_d \times b \times \sqrt{2g}\left[H_2^{3/2} - H_1^{3/2}\right]$$

$$= 2/3 \times 0.6 \times 1.5 \times \sqrt{2 \times 9.81}\left[(4.0)^{1.5} - (3.\right.$$

m

$$= 2.657\,[8.0 - 5.196]\ m^3/s$$

$$= 7.45\ m^3/s$$

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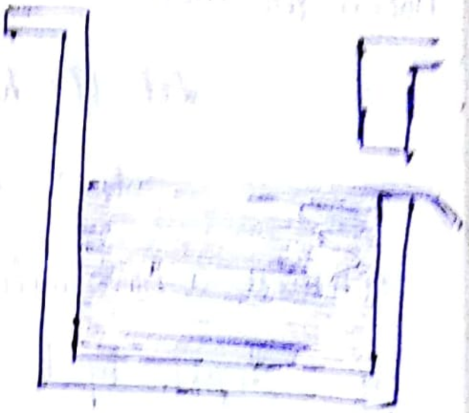
Notches

* A Notch may be defined as an opening provided in the side of a tank such that the liquid surface in the tank is below the top edge of the opening



* Notches made of metallic plates are also provided Narrow channels in order measure the rate of flow of liquid

* Such general notches are used for measuring the rate of flow of fluid from tank or in a channel

classification of Notches

* on the basis of
  * Shape
    * Rectangular notches
    * Stepped notches
    * Trapezoidal notches
    * Triangular notches
    * parabolic notches
  * Effects of sides on the nappe
    * Notch with end contraction
    * Notch without end contraction

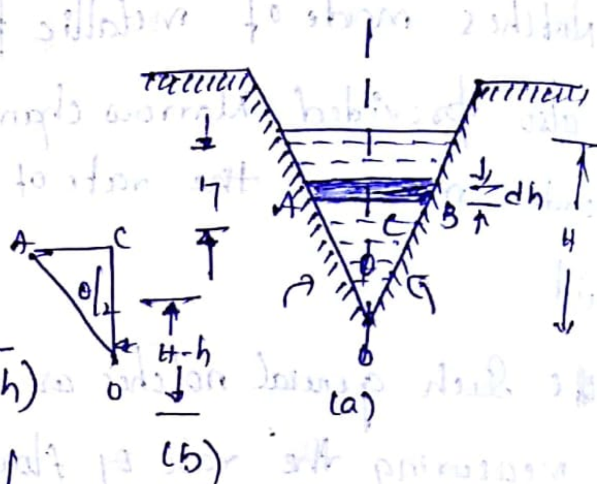
Discharge over a Triangular Notch or Weir :-

The Expression for the discharge over a triangular notch or weir is the same. It is derived as:

Let H = head of water above v-notch

θ = angle of notch

consider a horizontal strip of water of thickness 'dh' at a depth of h from the free surface of water.



$$\tan\theta/2 = \frac{AC}{OC} = \frac{AC}{(H-h)}$$

$$AC = (H-h)\tan\theta/2$$

Width of strip $= AB = 2AC = 2(H-h)\tan\theta/2$

$\therefore$ Area of strip $= 2(H-h)\tan\theta/2 \times dh$

The theoretical velocity of water through strip $= \sqrt{2gh}$

$\therefore$ Discharge, dQ, through the strip is

$dQ = C_d \times$ Area of strip $\times$ velocity (theoretical)

$$= C_d \times 2(H-h)\tan\theta/2 \times dh \times \sqrt{2gh}$$

$$= C_d \times 2(H-h)\tan\theta/2 \times dh \times \sqrt{2gh}$$

$= 2C_d(H-h)\tan\theta/2 \times \sqrt{2gh} \times dh$

Total discharge $Q = \int_0^H 2C_d(H-h)\tan\theta/2 \times \sqrt{2gh} \times dh$.

$= 2C_d \times \tan\theta/2 \times \sqrt{2g}\int_0^H (H-h)h^{1/2}\,dh$

$= 2\times C_d \times \tan\theta/2 \times \sqrt{2g}\int_0^H (Hh^{1/2} - h^{3/2})\,dh$

$= 2\times C_d \times \tan\theta/2 \times \sqrt{2g}\left[\frac{Hh^{3/2}}{3/2} - \frac{h^{5/2}}{5/2}\right]_0^H$

$= 2\times C_d \times \tan\theta/2 \times \sqrt{2g}\left[\frac{2}{3}H.H^{3/2} - \frac{2}{5}H^{5/2}\right]$

$= 2\times C_d \times \tan\theta/2 \times \sqrt{2g}\left[\frac{2}{3}H^{5/2} - \frac{2}{5}H^{5/2}\right]$ $[\because h = H]$

$= 2\times C_d \times \tan\theta/2 \times \sqrt{2g}\left[\frac{4}{15}H^{5/2}\right]$

$= \frac{8}{15}C_d \times \tan\theta/2 \times \sqrt{2g} \times H^{5/2}$

For right-angled v. notch if $C_d = 0.6$

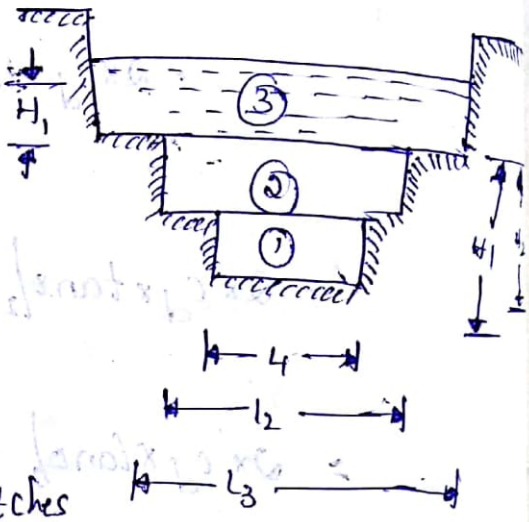
$\theta = 90^\circ$, $\therefore \tan\theta/2 = 1$

Discharge $Q = \frac{8}{15} \times 0.6 \times 1 \times \sqrt{2\times 9.81} \times H^{5/2}$

$= 1.417 H^{5/2}$

Discharge over a Stepped Notch :-

A stepped notch is a combination of rectangular notches. The discharge through stepped notch is Equal to the sum of the discharges through the different rectangular notches



H_1 = Height of Water above the crest of notch (1)

L_1 = Length of notch

H_2, L_2 and H_3, L_3 are corresponding notches

C_d = co-efficient of discharge value all notches

$\therefore$ Total discharge $Q = Q_1 + Q_2 + Q_3$

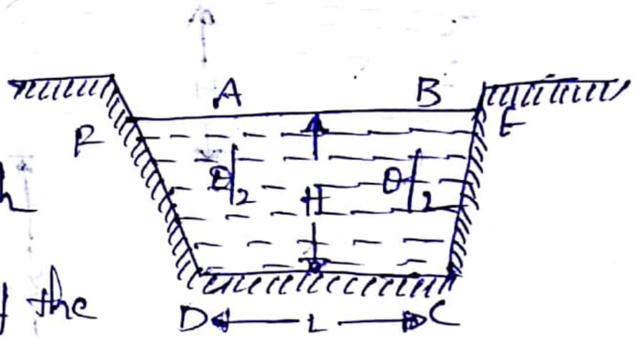
$$Q = \frac{2}{3} \times C_d \times L_1 \times \sqrt{2g}\left[H_1^{3/2} - H_2^{3/2}\right]$$

$$+ \frac{2}{3} C_d \times L_2 \times \sqrt{2g}\left[H_2^{3/2} - H_3^{3/2}\right] +$$

$$\frac{2}{3} C_d \times L_3 \times \sqrt{2g} \times H_3^{3/2}$$

Discharge over a Trapezoidal notch or Weir

A trapezoidal notch or weir is a combination of a rectangular and triangular notch or weir. Thus the total discharge will be equal to the sum of discharge through a rectangular.



H = Height of water over the Notch

L = Length of the crest of the Notch

C_{d_1} = Co-efficient of discharge for rectangular portion ABCD

C_{d_2} = Co-efficient of discharge for triangular portion

$$Q = \frac{2}{3} \times C_{d_1} \times L \times \sqrt{2g} \times H^{3/2}$$

$$Q = \frac{8}{15} \times C_{d_2} \times \tan\theta/2 \times \sqrt{2g} \times H^{5/2}$$

$$Q_1 + Q_2$$

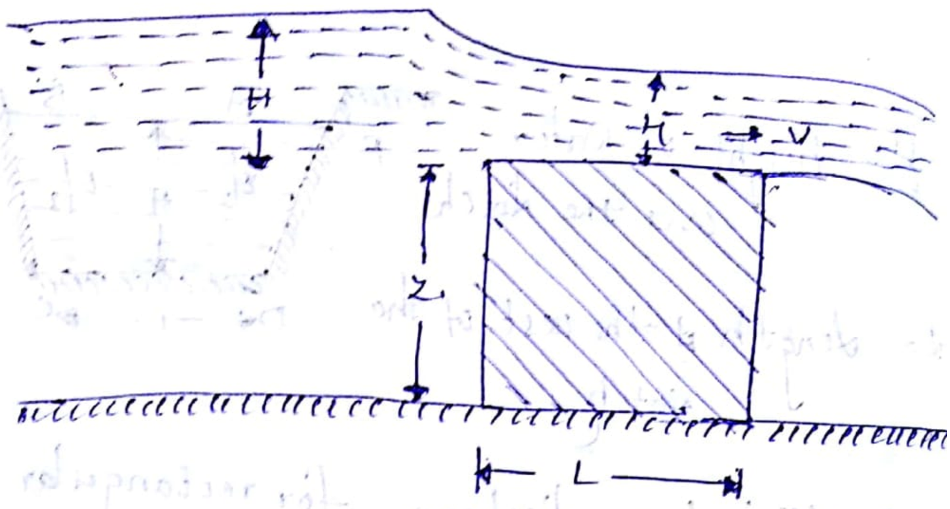
$$\frac{2}{3} \times C_{d_1} \times L \sqrt{2g} \times H^{3/2} + \frac{8}{15} C_{d_2} \times \tan\theta/2 \times \sqrt{2g} \times H^{5/2}$$

Discharge over a broad-crested weir :-

A weir having a wide crest is known as broad-crested weir.

H = height of water above the crest

L = length of the crest



If $2L > H$, the weir is called broad crested weir

If $2L > H$, the weir is called narrow crested weir

h = head of water at the middle of weir which is constant

v = velocity of flow over the weir

Bernoulli's EQ.

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

$$\frac{V^2}{2g} = H - h$$

$$V = \sqrt{2g(H-h)}$$

Discharge Q = $C_d \times$ Area of flow $\times$ velocity

$$= C_d \times L \times h \times \sqrt{2g(H-h)}$$

$$= C_d \times L \times \sqrt{2g(Hh^2 - h^3)}$$

The discharge will be maximum

if $(Hh^2 - h^2)$ is maximum

$$\frac{d}{dh}(Hh^2 - h^3) = 0 \text{ or } 2h \times H - 3h^3 = 0 \text{ or}$$

$$2H = 3H$$

$$h = \frac{2}{3} H$$

$$Q_{max} = C_d \times L \times \sqrt{2g\left[H \times \left[\frac{2}{3}H\right]^2 - \left[\frac{2}{3}H\right]^3\right]}$$

$$= C_d \times L \times \sqrt{2g} \sqrt{H \times \frac{4}{9}H^2 - \frac{8}{27}H^3}$$

$$= C_d \times L \times \sqrt{2g} \sqrt{\frac{4}{9}H^3 - \frac{8}{27}H^3}$$

$$= C_d \times L \times \sqrt{2g} \sqrt{\frac{(12-8)H^3}{27}}$$

$$= C_d \times L \times \sqrt{2g} \sqrt{\frac{4}{27}H^3}$$

$$= C_d \times L \times \sqrt{2g} \times 0.3849 \times H^{3/2}$$

$$= 0.3489 \times \sqrt{2 \times 9.81} \times C_d \times L \times H^{3/2}$$

$$= 1.7047 \times C_d \times L \times H^{3/2}$$

$$= 1.705 \times C_d \times L \times H^{3/2}$$