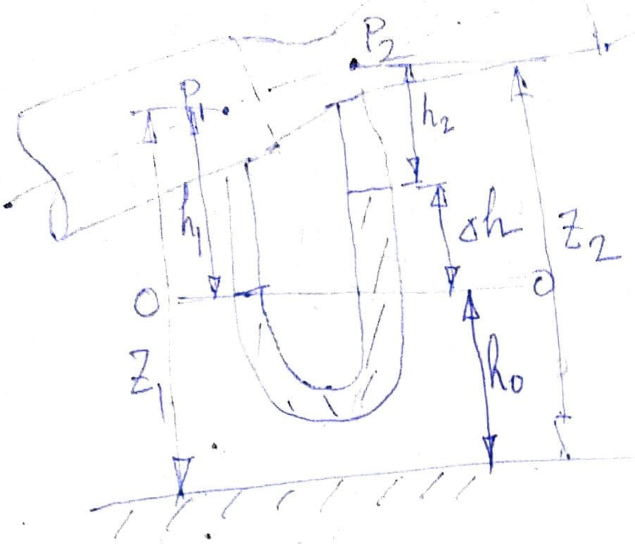
Venturi Meter



$P_0 = P_1 + \cancel{Z_1 \rho_{wf} g} + \rho_{wf} g h_1$
$= P_2 + \rho_w g h_2 + Z_2 \rho_w g + \rho_{Hg} g \Delta h.$

$A_1 V_1 = A_2 V_2$

$V_2 = \dfrac{A_1 V_1}{A_2}$

$$\frac{P_1}{\rho_{wf} g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho_{wf} g} + \frac{V_2^2}{2g} + Z_2$$

$$2g\left\{\left(\frac{P_1}{\rho_{wf} g} + Z_1\right) - \left(\frac{P_2}{\rho_{wf} g} + Z_2\right)\right\} = \left(V_2^2 - V_1^2\right)$$

$$= \left(\frac{A_1^2 V_1^2}{A_2^2} - V_1^2\right)$$

$$= A_1^2 V_1^2 \left(\frac{1}{A_2^2} - \frac{1}{A_1^2}\right)$$

$$= (A_1 V_1)^2 \left(\frac{A_1^2 - A_2^2}{(A_1 A_2)^2}\right)$$

$$= \left(Q \frac{\sqrt{A_1^2 - A_2^2}}{A_1 A_2}\right)^2$$

$P_0 = P_1 + \rho g (Z_1 - h_0) = P_2 + \rho g (Z_2 - h_0 - \Delta h) + \rho_{Hg} g \Delta h$

$\frac{P_1}{\rho g} + Z_1 - \cancel{h_0} = \frac{P_2}{\rho g} + Z_2 - \cancel{h_0} - \Delta h + \frac{\rho_{Hg}}{\rho} \Delta h$

$\left(\frac{P_1}{\rho g} + Z_1\right) - \left(\frac{P_2}{\rho g} + Z_2\right) = \left(\frac{\rho_{Hg}}{\rho} - 1\right)\Delta h$

$= \left(\frac{S_{Hg}}{S} - 1\right)\Delta h$

$$\therefore Q_{th} = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g\left\{\left(\frac{P_1}{\rho_{wf} g} + Z_1\right) - \left(\frac{P_2}{\rho_{wf} g} + Z_2\right)\right\}}$$

$$= \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g(\Delta h)\left(\frac{S_{Hg}}{S_{wf}} - 1\right)}.$$

$Q_{act} = C_d Q_{th}$ ✓ C_d = coefficient of discharge.

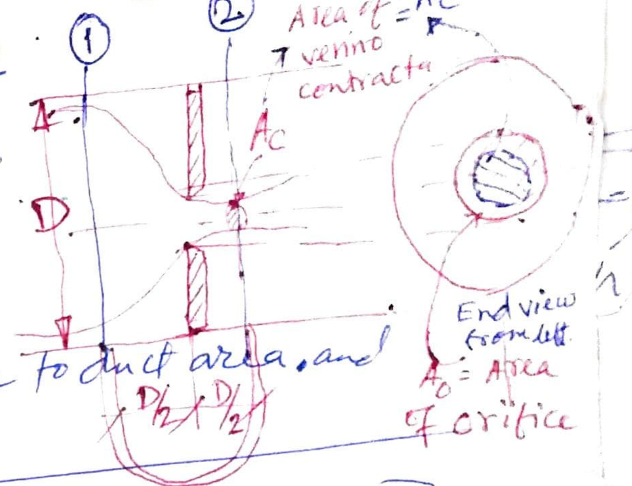
Orifice Meter

$A_1 V_1 = A_c V_c$ $\qquad C_c = \frac{A_c}{A_0}$ $\qquad$ D = Dia of pipe.

$A_c V_c =$

$$\frac{P_1}{\rho_{wf} g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho_{wf}} + \frac{V_c^2}{2g} + Z_2$$

$$\left(\frac{P_1}{\rho_{wf} g} + Z_1\right) - \left(\frac{P_2}{\rho_{wf} g} + Z_2\right) = \frac{V_c^2}{2g} - \frac{V_1^2}{2g}$$



C = depends on the ratio of orifice to duct area, and the flow Reynolds no.

By Bernoullie's theorem :-

$$2g\left[\left(\frac{P_1}{\rho g} + Z_1\right) - \left(\frac{P_2}{\rho_{wf} g} + Z_2\right)\right] = (A_c V_c)^2 \left[\frac{A_1^2 - A_2^2}{(A_1 A_2)^2}\right]$$

or, $$A_c V_c = \sqrt{\frac{(A_1 A_2)^2}{A_1^2 - A_2^2}} \sqrt{2g\left[\left(\frac{P_1}{\rho_{wf} g} + Z_1\right) - \left(\frac{P_2}{\rho_{wf} g} + Z_2\right)\right]}$$

$\boxed{C_c = \frac{A_c}{A_0} \text{ orifice meter}, \quad A_c \equiv A_2 \text{ in}}$

$$= \sqrt{\frac{(A_1 \cdot A_c)^2}{A_1^2 - A_c^2}} \sqrt{2g\left[\left(\frac{P_1}{\rho_{wf} g} + Z_1\right) - \left(\frac{P_2}{\rho_{wf} g} + Z_2\right)\right]}$$

$$= \frac{A_1 C_c A_0}{\sqrt{A_1^2 - C_c^2 \cdot A_0^2}} \sqrt{2g(\Delta h)\left(\frac{S_{Hg}}{S_{wf}} - 1\right)}$$

$$= \cancel{\left(2g\,\Delta h\left(\frac{S_{Hg}}{S_{wf}} - 1\right)\right)}$$

or, $$\cancel{A_0 C_c \cdot V_0 \cdot C_v = \frac{A_0 C_c}{\sqrt{1 - C_c^2 \left(\frac{A_0}{A_1}\right)^2}}}$$

or, $$\cancel{A_0 V_0 = \frac{A_0 C_c}{C_c}}$$

$$V_c = \sqrt{\frac{2g\left(\frac{S_{Hg}}{S_{wf}} - 1\right)\Delta h}{\left(1 - C_c^2 A_0^2 / A_1^2\right)}}$$

where, K, the flow coeff.

$$C_d = \frac{\quad}{\sqrt{1 - C_c^2 \frac{A_0^2}{A_1^2}}}$$

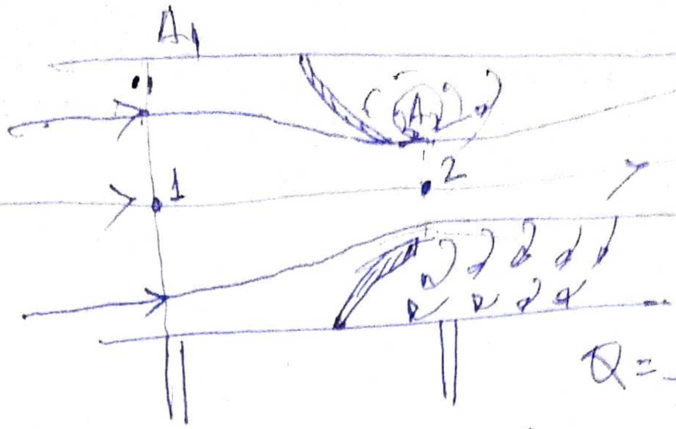
$$Q_{act} = A_c \cdot V_{c(actual)} = A_0 C_c \cdot C_v V_c$$

Flow unit $(A_0 C_d)$

$$= A_0 C_d \sqrt{\frac{2g\left(\frac{S_{Hg}}{S_{wf}} - 1\right)\Delta h}{\quad}}$$

$2\left(\frac{S_{Hg}}{\quad}\right.$

Flow nozzle



$$Q = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g\left(\frac{S_m}{S}-1\right)\delta h}$$

$$H = \left(\frac{S_m}{S} - 1\right)\delta h.$$

$$Q_{Act} = C_d \cdot Q$$

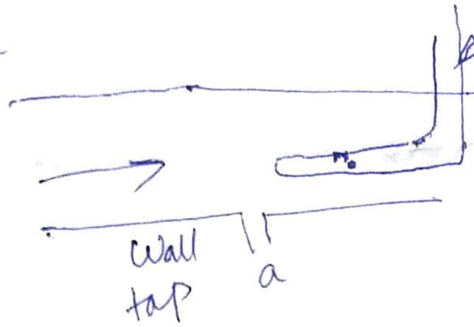
$$Q_{act} = K \cdot H^N$$

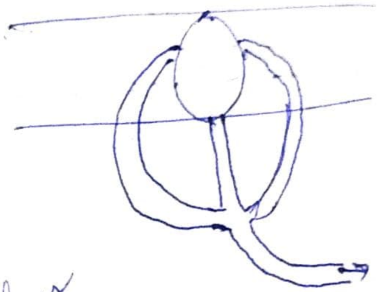
Pitot Tube :-

static & stagnation press
application static pitot tube

static

static probe.



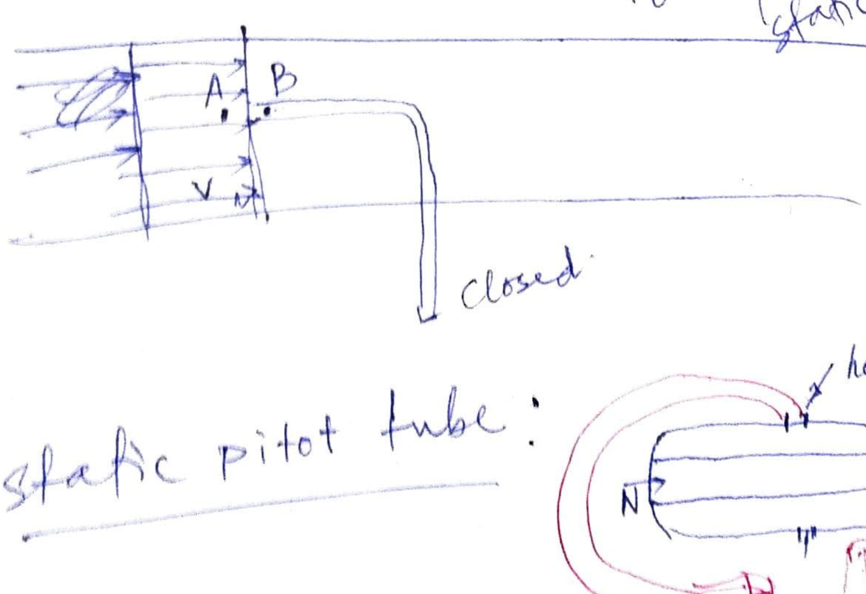


stagnation pressure :

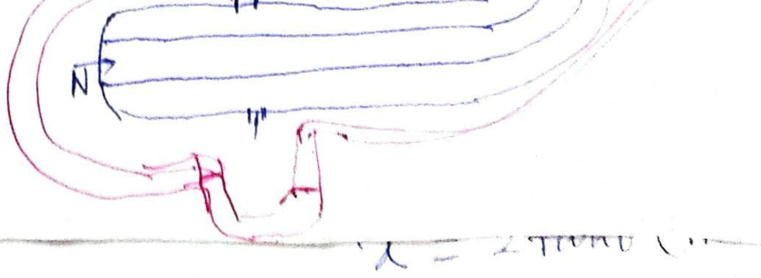
$$\underset{\text{stagnation}}{P_0} = \underset{\text{static}}{P_A} + \underset{\text{dynamic press}}{\frac{\rho V_A^2}{2}}$$

$$V = \sqrt{2(P_0 - P)/\rho}$$

$$V_{act} = C_v \sqrt{2(P_0 - P)/\rho}$$

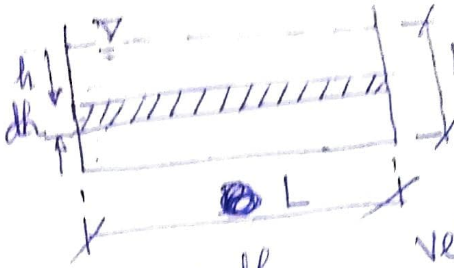


static pitot tube :



diff. from Soln

Flow measurement by Rectangular Weir



H = height over the crest by which water is flowing.

$A = L\,dh$, velocity, $V = \sqrt{2gh}$

$$dQ = AV = L\,dh\sqrt{2gh}.$$

$$Q = \int_0^H L\sqrt{2gh}\,dh = L\sqrt{2g}\left[\frac{h^{\frac{1}{2}+1}}{\frac{1}{2}+1}\right]_0^H$$

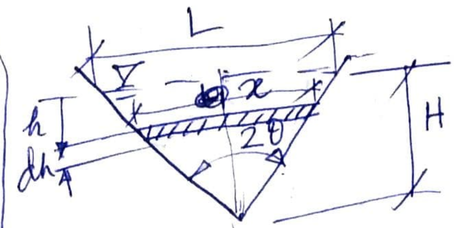
$$= \sqrt{2g}\cdot L\cdot\frac{2}{3}\cdot H^{3/2}$$

If we assume approach velocity, V_a, the corresponding initial head $= V_a^2/2g$.

$$\text{So,}\quad Q = \int_{V_a^2/2g}^{H+V_a^2/2g} L\sqrt{2gh}\,dh = \sqrt{2g}\cdot L\cdot\frac{2}{3}\left[h^{3/2}\right]_{V_a^2/2g}^{H+\frac{V_a^2}{2g}}$$

$$\therefore Q = \frac{2}{3}L\sqrt{2g}\left[\left(H+\frac{V_a^2}{2g}\right)^{3/2} - \left(\frac{V_a^2}{2g}\right)^{3/2}\right].$$

Flow measurement by V-notch



Area, A =

$\cancel{\tan 2\theta}$

$$\tan\theta = \frac{L/2}{H}$$

$L = 2H\tan\theta.$

By Similarity of two triangles, we get, $\dfrac{H}{H-h} = \dfrac{L/2}{x/2}$

$$\therefore x = \frac{L(H-h)}{H}$$

$$= \frac{2H\tan\theta\,(H-h)}{H}$$

$$x = 2\tan\theta\,(H-h)$$

$A = x\,dh = 2\tan\theta\,(H-h)\,dh$

$dQ = AV = 2\tan\theta\,(H-h)\,dh \cdot \sqrt{2gh}$

$= \sqrt{2g} \cdot 2\tan\theta \left[H \cdot h^{1/2} - h^{3/2}\right] dh.$

$$Q = \int_0^H \sqrt{2g} \cdot 2\tan\theta \left[H\,h^{1/2} - h^{3/2}\right] dh.$$

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

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

$$= \sqrt{2g} \cdot 2\tan\theta \, \frac{(10-6)}{15} H^{5/2}$$

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

Considering approach velocity, V_a ——— i.e. ~~[illegible]~~

replacing H by $H + V_a^2/2g$ we get.

$$Q = \frac{8}{15} \sqrt{2g} \tan\theta \left[\left(H + \frac{V_a^2}{2g}\right)^{5/2} - \left(\frac{V_a^2}{2g}\right)^{5/2} \right].$$

$2\tan\theta \left[\left(H + \frac{V_a^2}{2g}\right) h^{1/2} - h^{3/2}\right] dh.$

$$dQ = \sqrt{2g} \cdot 2\tan\theta \left[\left(H + \frac{V_a^2}{2g}\right) h^{1/2} - h^{3/2}\right] dh.$$

$$Q = \int_{V_a^2/2g}^{H + V_a^2/2g} \sqrt{2g} \cdot 2\tan\theta \left[\left(H + \frac{V_a^2}{2g}\right) h^{1/2} - h^{3/2}\right] dh$$

$$= \sqrt{2g}\; 2\tan\theta \left[\left(H + \frac{V_a^2}{2g}\right) \frac{h^{3/2}}{3/2} - \frac{h^{5/2}}{5/2} \right]_{V_a^2/2g}^{H + V_a^2/2g}$$

$$= \sqrt{2g} \cdot 2\tan\theta \left[\frac{2\left(H + \frac{V_a^2}{2g}\right)^{5/2}}{3} - \frac{2\left(H + \frac{V_a^2}{2g}\right)^{5/2}}{5} - \left(H + \frac{V_a^2}{2g}\right) \ldots \frac{2\left(V_a^2/2g\right)^{5/2}}{5} \right]$$

H now varies from $V_a^2/2g$ to $H + \frac{V_a^2}{2g}$.

$\frac{8}{15} \sqrt{2g} \cdot \tan\theta \left[\left(H + \frac{V_a^2}{2g}\right)^{5/2} - \left(\frac{V_a^2}{2g}\right)^{5/2}\right.$