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Experiment 1 : Calibration of Venturimeter and Orifice Meter

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Aim - To calibrate Venturimeter and orifice Plate for a given fluid and study variation of coefficient of discharge C_d with Reynold's Number

Working and Calculations :

For venturimeter :

Given : $\beta = d/D = 0.697$

Supply pipe diameter = 21 mm

D(inlet) = 21.5 mm

d(throat) = 15 mm

$\rho_w = 1000\ kg/m^3$

$\mu = 0.0007975$ Pa s

$\rho_{Hg} = 13600\ kg/m^3$

$C_d(ISO) = 0.984$

Taking first row

$$Q_{act} = \frac{10 \times 10^{-3}}{17.3} = 5.78 \times 10^{-4}\ m^3/s$$

Reynold's number

$$Re_d = \frac{4 \rho_w Q_{act}}{\pi \times (\text{Supply Diameter}) \times \mu_w} = \frac{4 \times 1000 \times 5.78 \times 10^{-4}}{\pi \times 21 \times 10^{-3} \times 0.0007975} = \cancel{43959.8}\ 43945.5$$

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$h_w = \left(\frac{S_{Hg}}{S_w} - 1\right) h_{Hg}$

$= 12.6 \times 36 = \boxed{453.6\ mm}$

$Q_{th} = \frac{\pi d^2}{4}\sqrt{\frac{2\Delta p}{S_w(1-\beta^4)}} = \frac{\pi}{4} \times (15\times10^{-3})^2 \sqrt{\frac{2\times9.81\times1000\times453.6\times10^{-3}}{1000(1-0.697^4)}}$

$= 6.04\ m^3/s$

$C_d = \frac{Q_{act}}{Q_{th}} = \boxed{0.958}$

We can see that the results match with the excel sheet

For orifice :

Given $\beta = 0.7$

Supply pipe diameter = 21 mm

D(inlet) = 20 mm

d(throat) = 14 mm

$S_w = 1000\ kg/m^3$

$\mu_w = 0.0007975$ Pa s

$S_{Hg} = 13600\ kg/m^3$

Considering first row

$Q_{act} = \frac{10\times10^{-3}}{18} = 5.55\times10^{-4}\ m^3/s$

$Re = \frac{4 S_w Q_{act}}{\pi\times(\text{Supply Diameter})\times\mu_w} = \frac{4\times1000\times5.55\times10^{-4}}{\pi\times21\times10^{-3}\times0.0007975} = 42236.47$

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$$h_w = \left(\frac{S_{Hg}}{S_w} - 1\right) h_{Hg}$$

$$= 12.6 \times 105 = \boxed{1323 \text{ mm}}$$

$$Q_{th} = \frac{\pi d^2}{4} \sqrt{\frac{2 \Delta p}{\rho_w (1 - \beta^4)}}$$

$$= \frac{\pi}{4} \times (14 \times 10^{-3})^2 \sqrt{\frac{2 \times 1000 \times 9.81 \times 1323 \times 10^{-3}}{1000 (1 - 0.7^4)}}$$

$$= 8.9969 \times 10^{-4}$$

$$C_d(act) = \frac{Q_{act}}{Q_{th}} = \boxed{0.617}$$

$$C_d(ISO) = 0.5961 + 0.0261 \beta^2 - 0.216 \beta^6 + 0.000521 \left(\frac{10^6 \beta}{Re_d}\right)^{0.7} = \boxed{0.600156}$$

These match with values in the excel sheet

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Sources of error:

a) we calculate the volume flow as A×V, but this might be inaccurate as we consider velocity to be uniform over the cross section, which it isn't.

b) Eddies forming in the orifice meter cause flow separation causing energy dissipation.

c) The throat diameter d which we use to calculate β is larger than the actual diameter of the vena contracta where pressure is measured.

Questions

Q1) Venturimeter has a lower amount of flow separation and turbulence and hence the amount of energy dissipation is low. On the contrary, eddies form in orifice meter due to ~~causes~~ flow seperation. Also since, we used throat diameter instead of vena contracta, C_d gets affected

Q2) When fluid flows through the converging section of the venturimeter, it gains kinetic energy. This is converted back to pressure head in the diverging section. If the diverging angle is large, the pressure would increase rapidly ~~cau~~ causing flow separation from the wall of the venturimeter. This generates eddies and pressure losses due to friction of the fluid. Hence, the diverging angle is kept small to reduce the chances of flow ~~sepe~~ separation and keeping pressure efficiency as high as possible.

Question 4

Q4) ~~Q3)~~ Vena-contracta is the point in the stream where diameter of the stream is the least and fluid velocity is maximum. Curvature in streamline causes velocity to vary a lot in a cross section. This happens due to centrifugal force. In the throat of orifice meter, there is a large curvature as the flow diverges from there. At the vena contracta, the velocity is almost uniform and the streamlines are almost parallel.

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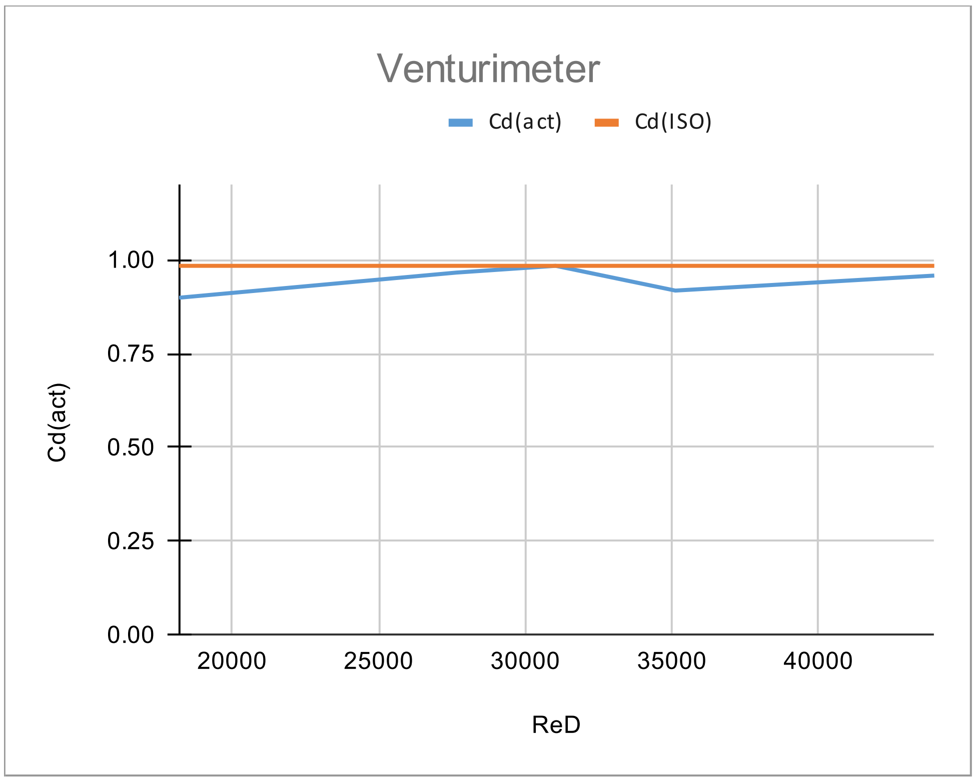
we can measure pressure accurately at the vena-contracta.

Q3) A low β ratio means that the plate has a smaller hole and a higher pressure drop. This would require a larger pump to operate and also more money. Higher β ratio means low differential pressure across the orifice which may be difficult to measure.

Venturi meter (β=d/D) = 0.697

Sr. No.	Volume V(Litres)	Time t (sec)	Qact (m3/s) *10-4	ReD	Manometer Reading hm (mm Hg)	Manometer Reading hw (mm water)	Qth (m3/s) *10-4	Cd (Expt)	Cd (ISO)
1	10	17.3	5.780346821	43945.46144	36	453.6	6.035748943	0.958	0.984
2	10	21.65	4.618937644	35115.77288	25	315	5.029790786	0.918	0.984
3	10	24.5	4.081632653	31030.87685	17	214.2	4.147671737	0.984	0.984
4	10	27.5	3.636363636	27645.69029	14	176.4	3.763950769	0.966	0.984
5	10	41.8	2.392344498	18187.95414	7	88.2	2.661515113	0.899	0.984



Orifice Plate (β=d/D) = 0.7

Sr. No.	Volume V(Litres)	Time t (sec)	Qact (m3/s)* 10-4	ReD	Manomet (mm Hg)	Manometer Reading hw (mm water)	Qth (m3/s) * 10-4	Cd (Expt)	Cd (ISO)
1	10	18	5.555555556	42236.47127	105	1323	8.996988266	0.617	0.6002
2	10	21.5	4.651162791	35360.76665	83	1045.8	7.999107821	0.581	0.6006
3	10	29.6	3.378378378	25684.34064	43	541.8	5.757536931	0.587	0.6017
4	10	37.41	2.673082064	20322.27968	21	264.6	4.023575471	0.664	0.6026
5	10	54.12	1.84774575	14047.60685	12	151.2	3.041537165	0.608	0.6045