NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF MECHANICAL ENGINEERING

REPORT

TITLE Caliberation of V-notch

Name PRINCE MAURYA

Semester 4th Roll No. 21ME8011

Section A Year 2022-23

Signature Prince

Date of Experiment 17th Jan 2023

Objective :-

1. To determine the V-notch constant (K & N) from plotting of Q_a Vs H on a log-log graph paper.
2. To determine coefficient of discharge C_d of the V-notch

Theory :-

In laboratory, experiments, where amount of flow is relatively small, discharge is generally measured by V-notch. Without considering the approach velocity, theoretical discharge through V-notch is given by -

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

where θ is the angle of notch & H is the height of water surface from crest-level. But depending on shape of the notch and its friction actual discharge Q_a is smaller than Q_t and is given by $Q_a = C_d \times Q_t$, where discharge coefficient C_d is always lesser than unity.

For practical use,

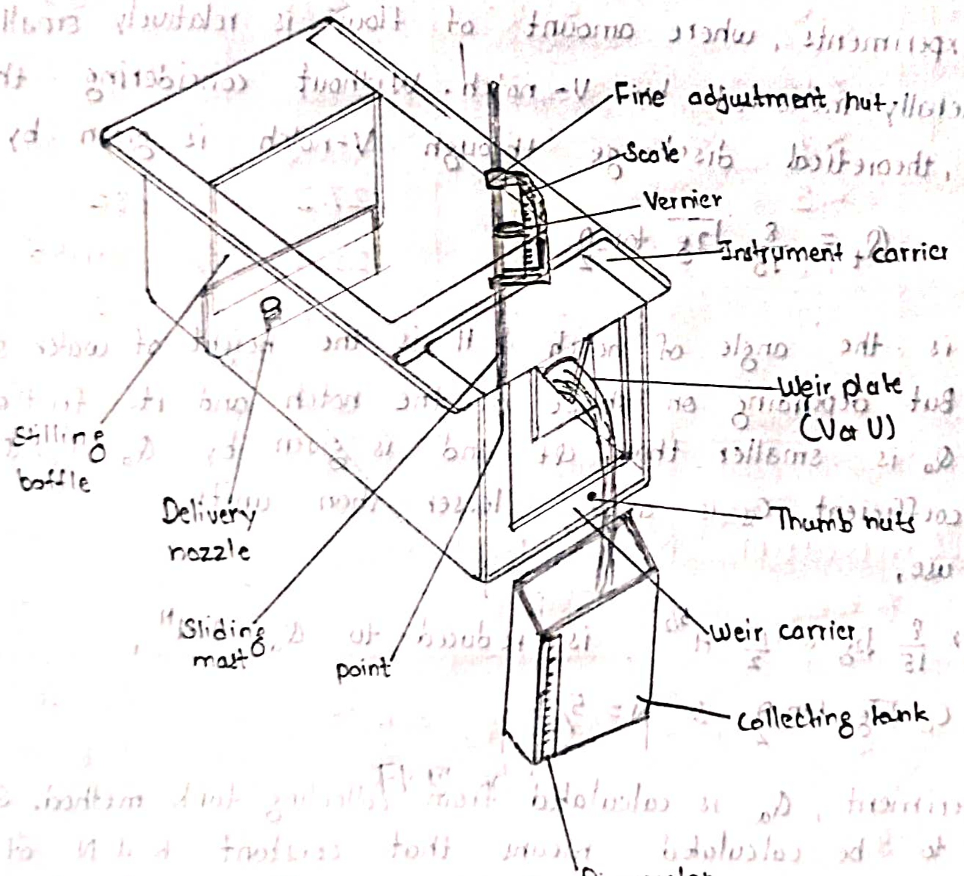
$$Q_a = C_d \times \frac{8}{15}\sqrt{2g}\,\tan\frac{\theta}{2}\,H^{5/2} \text{ is reduced to } Q_a = KH^N,$$

where $K = \frac{8}{15} C_d \sqrt{2g}\,\tan\frac{\theta}{2}$ & $N = 5/2$

In the experiment, Q_a is calculated from collecting tank method. So the V-notch is to be calculated means that constant K & N of the notch are to be ~~maintained~~ determined experimentally. In its logarithm the V-notch ~~da~~ discharge equation, $Q_a = KH^N$ takes the form of $\log Q_a = N\log H + \log K$. When plotted Q_a Vs H represents a straight line on a log-log graph and values of K & N may be determined from the graph.

Apparatus Required :-

Pipeline assembly with water supply by electrical pump and motor, Collecting tank, V-notch, pointer gauge.


Fine adjustment nut
Scale
Vernier
Instrument carrier
Weir plate (V or U)
Thumb nuts
Weir carrier
Collecting tank
Pizo meter
Stilling baffle
Delivery nozzle
Sliding mast
point

V-notch

Procedure :-

Delivery value was fully opened. For for the first set of observations, the control value was so regulated that maximum flow was allowed in the channel and level difference 'H' reached maximum. The final pointer gauge reading h_f at free water surface in the channel were noted. Initial & Final reading of reading of pizometer also noted. For the next set, flow in channel was decreased by the control value and the corresponding reading were noted. The proceduce was repeated for obtaining at least six set of observations. At last, initial pointer gauge reading h_i (common for all sets) was noted when the water surface touched the crest of the V-notch.

Calculations :-

Area of the collecting tank (A) = $L \times B$

$= 38 \times 20 = 760 \text{ cm}^2$

Pizometer level difference = $h = b - a$

$= 28.25 - 80$

$= 20.25$

volume of water collected $Q_a = \frac{Ah}{t} = \frac{760 \times 20.25}{33.447} = 460.13$

Head of water (H) = $h_i - h_f = 4.9$ cm

V-notch $Q_f = \frac{8}{15} \sqrt{2g} \tan \frac{\theta}{2} H^{5/2} = \frac{8}{15} \times \sqrt{2 \times 980} \times \tan 30° \times 4.9^{5/2}$

$= 724.52$

value of $C_d = \frac{Q_a}{Q_f} = \frac{724.52}{460.13}$

$= 0.635$

Average value of $C_d = 0.655$

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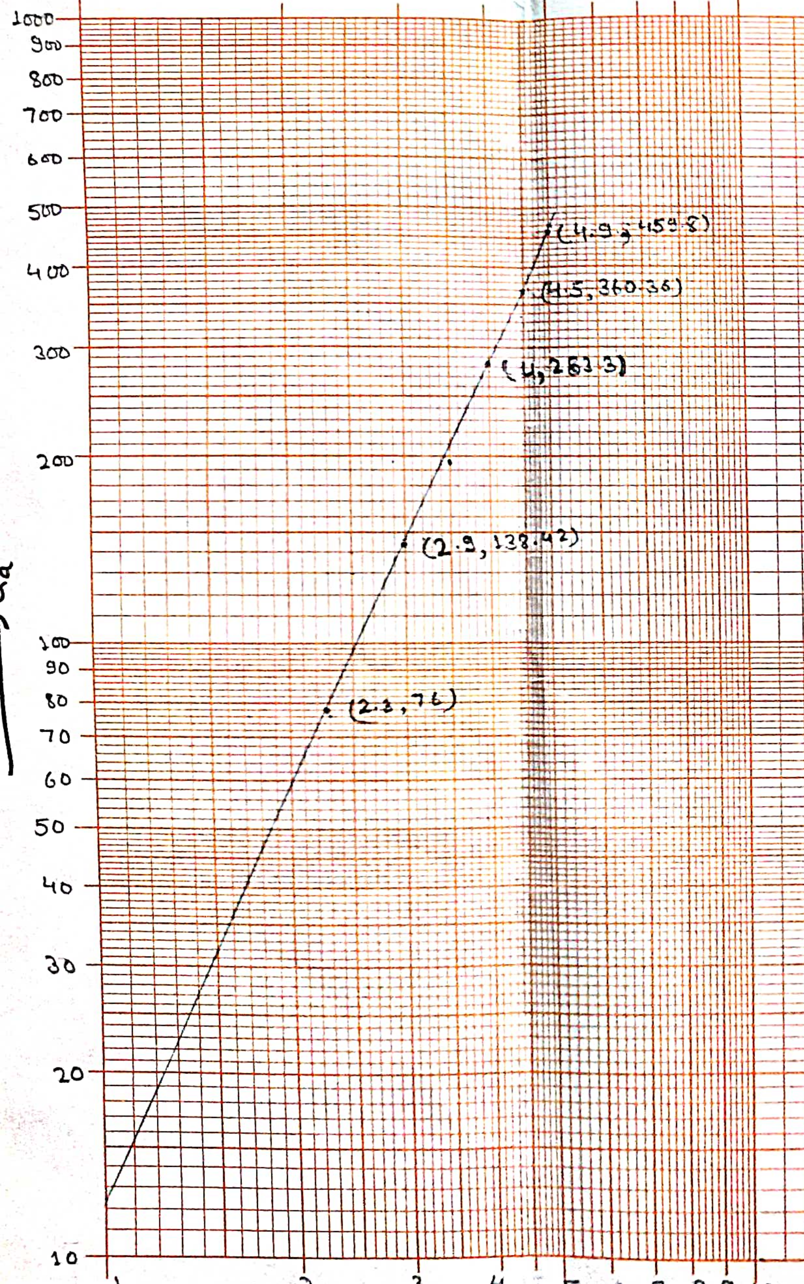

Scale :

x-axis = $10^0 \rightarrow 10$ unit (1st cycle)

y-axis = $10^0 \rightarrow 10^2$ unit (1st cycle)

$10^2 \rightarrow 10^3$ unit (2nd cycle)

slope :- $\dfrac{\log (y_2/y_1)}{\log (x_2/x_1)}$

$= \dfrac{\log\left(\frac{138.02}{76}\right)}{\log\left(\frac{2.9}{2.3}\right)}$

$\boxed{n = 2.586}$

From graph : K = 12.5

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Observation :

Collecting tank Area = 38 X 20 = 760 cm^2

Obs. No.	Pointer guage reading		Pizometer reading		Water collection time in second
	Initial (h_i)	Final (h_f)	Initial (a)	Final (b)	
1.		6.5	8.0	28.25	33.47
2.		6.1	6.5	27.7	44.71
3.	1.6	5.6	5.5	26.0	54.99
4.		5.1	6.3	27.2	1.80
5.		4.5	6.0	21.4	84.55
6.		3.9	21.4	29.6	82

Result Sheet :-

V-notch angle, $\theta = 60°$

Set No.	Pizometer Level Diff. $h = b - a$	$Q_a = \frac{Ah}{t}$	$H = H_i - H_f$	$Q_t = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2}H^{5/2}$	$C_d = \frac{Q_a}{Q_t}$	Average (C_d)
1.	20.25	459.8	4.9	724.41	0.634	
2.	21.2	360.36	4.5	585.5	0.61	
3.	20.5	283.32	4	436.16	0.65	0.655
4.	20.9	198.55	3.5	312.36	0.63	
5	15.4	139.42	2.9	195.2	0.709	
6.	8.2	76	2.3	109.34	0.7	

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Precautions :-

1. Do not start pump if the supply is less than 300 V.
2. Do not forget to give electrical earth and neutral connections correctly. Frequently, at least once in three months, grease all visual moving parts.
3. Fill the tank with clean water free from foreign material.
4. Atleast every ~~wk~~ week, operate the unit for five minutes to prevent any clogging of the moving parts.

Date .... Signature ....

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DEPARTMENT OF MECHANICAL ENGINEERING

REPORT

TITLE To study the impact of jet on a hemispherical vane

Name Prince Maurya

Semester 4th Roll No. 21ME8011

Section A Year 2022-23

Signature Prince

Date of Experiment 24 Jan 2023

Experiment - 2

Objective – To study the impact of jet on a hemispherical vane.

Theory – When a jet of water emerging from a nozzle strikes a plate, it exerts forces on the plate due to change in the jet momentum, to calculate the magnitude of this force, theoritically we use control volume analysis.

The jet is considered to strike the vane as a perfect cylindrical column. The hemispherical film together with the cylindrical column are considered to be control volume. The angle of deriuation of jet is considered to be 'θ'.

Assumptions – i> Steady flow
ii> Incompressible flow
iii> Inviscous flow
iv> Uniform flow at a section
v> Frictionless and Symmetric vane.

Reynold's ~~Tar~~ Transport Theorem :-

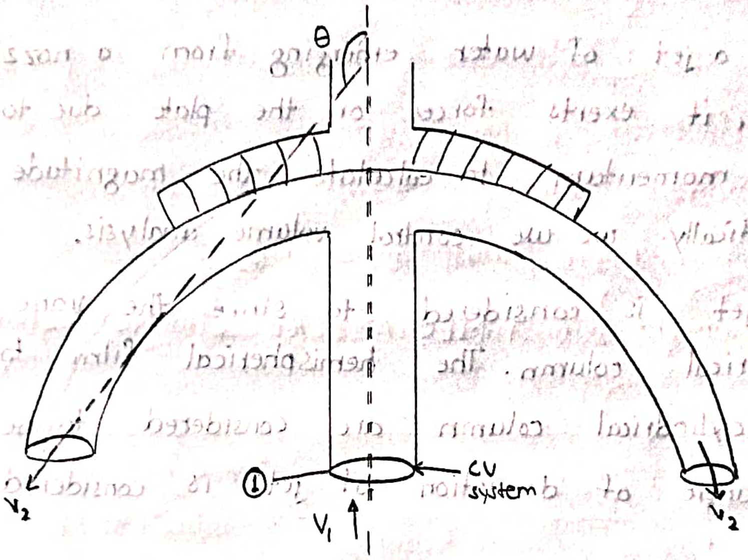
$$\frac{dN_s}{dt} = \frac{\partial}{\partial t}\int_{cv} \rho\eta\, dA + \int_{cs} \rho\eta\, \vec{V}.\vec{dA}$$

where,

$N_s \Rightarrow$ linear momentum $= m\vec{v}$, $\eta = \frac{N_s}{m} = \vec{V}$

and,

$$\frac{dN_s}{dt} = \frac{d}{dt}(m\vec{v}) = \vec{F} \quad \text{(Net External force on the system)}$$



Jet deflection angle

$$\vec{F} = \frac{\partial}{\partial t}\int_{cv} \rho\vec{v}\, d\forall + \int \rho\vec{v}\,(\vec{V}\, d\vec{A})$$

Applying Bernouli's Equation b/w section 1 and 2 :-

$$\frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g} \quad \left(\because \begin{array}{c} Z_1 = Z_2 \\ P_1 = P_2 = P_{atm} \end{array} \right)$$

$$\Rightarrow \quad V_1 \approx V_2 = V \quad (\text{discharge } Q = A_1V_1 = A_2V_2)$$

Linear momentum eqn in vertical direction -

$$F_v = \rho \int_{cs_1} V_1\,(V_1 dA_1 \cos 180^\circ) + \rho \int_{cs_2} V_2 \cos\theta\,(V_2 dA_2 \cos 0^\circ)$$

$$= -\rho V_1^2 \int_{cs_2} dA_1 + \rho V_2^2 \cos\theta \int_{cs_2} dA_2$$

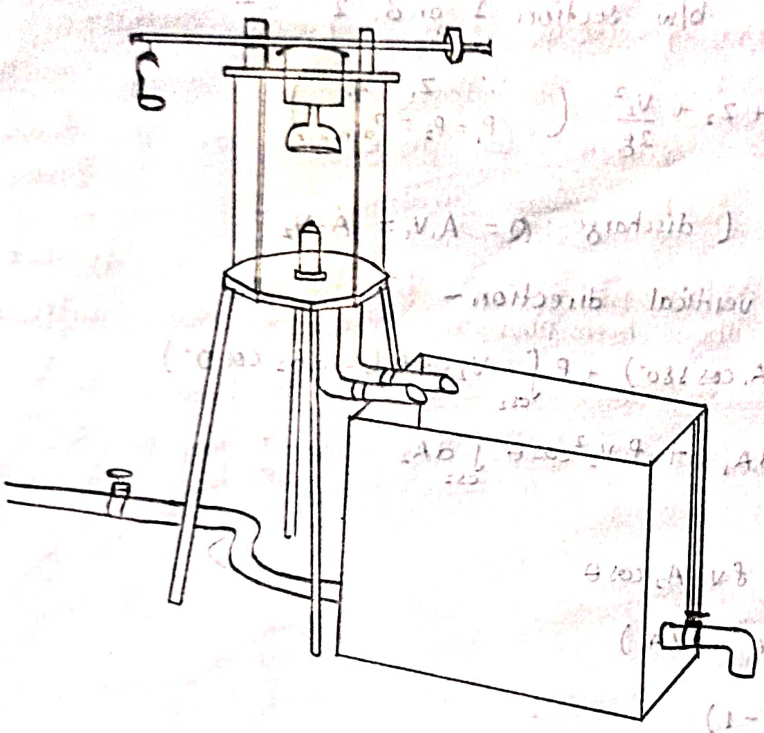
$$= -\rho V^2 A_1 + \rho V^2 A_2 \cos\theta$$

$$= \rho V\,(A V_2 \cos\theta - V A_1)$$

$$= \rho Q V\,(\cos\theta - 1)$$

Hence, force on the van by the system (jet) is,

$$F_j = -F_v = \rho Q V\,(1 - \cos\theta)$$



Impact of jet diagram

Observation Table :-

Length of collecting tank (L) = 38.3 cm

Width of collecting tank (B) = 19.9 cm

Diameter of the nozzle exit (d) = 0.01m

Angle of diffluction jet (θ) = 180°

Density of working fluid water = 1100 kg/m³

Weight of hemisphere / flat vane = 448

Weight of weight pan rod = 261 gm

Obs. No.	Pizometer Reading		Time of water collection (t)	Weight of the weight pan W (g)
	Initial Reading h_i (cm)	Final Reading h_f (cm)		
1.	5.2	25.65	20.32	1100
2.	7.8	27.3	20.3	1000
3.	7	26.6	20.29	900
4.	8	25.9	20.04	800
5.	10	27.3	20.28	700
6.	11.1	27.1	20.26	600
7.	11.9	26.8	20.38	500
8.	11.1	25.5	20.39	400
9.	11.5	24	20.28	300
10.	11.8	22	20.28	200
11.	11.8	22	20.34	100
12.	10.5	18.7	20.27	00

For 180° Deflection :

SL. No.	$H = h_f - h_i$ (in cm)	$Q = \frac{AH}{t}$ (in cm³/s)	$V = \frac{Q}{\frac{\pi D^2}{4}}$ (in m/s)	$F_{th} = \rho V Q(1-\cos 180°)$ $F_{th} = 2\rho V Q$	$F_{act} = W_v + W_p + W$	$C_j = \frac{F_{act}}{F_{th}}$
1.	20.45	767.04	9.68	16.34	13.769	0.842
2.	19.5	132.13	9.24	14.8	12.789	0.864
3.	19.6	736.25	9.29	15.04	11.809	0.785
4.	17.9	680.78	8.59	12.8	10.829	0.846
5.	17.3	650.17	8.21	11.7	9.849	0.841
6.	15.9	598.14	7.55	9.9	8.869	0.895
7.	14.9	557.23	7.03	8.6	7.889	0.917
8.	14.4	538.27	6.79	8.04	6.909	0.859
9.	12.5	469.78	5.93	6.1	5.929	0.971
10.	10.9	409.64	5.17	4.6	4.949	1.07
11.	10.2	382.209	4.82	4.05	3.969	0.98
12.	8.2	308.32	3.89	2.6	2.989	1.149

Sample Calculation :-

obs 1 :- Pizometer reading :-

Initial $h_i = 5.2$ cm

Final $h_f = 25.65$ cm

$$H = h_f - h_i$$
$$= 25.65 - 5.2$$
$$H = 20.45 \text{ cm}$$

Now, Discharg $Q = \frac{AH}{t} = \frac{762.17 \times 20.45}{20.32} = 767.04 \text{ cm}^3/\text{s}$

Jet Velocity $V (\text{m/s}) = \frac{Q}{\frac{\pi D^2}{4}} = \frac{767.04 \times 10^{-6}}{7.85 \times 10^{-5}} = 9.68 \text{ m/s}$

For 180° Deflection :-

Theoretical force $F_{th} = \rho v Q (1 - \cos 180°)$

$= 2 \rho v Q$

$= 16.34$ N

Actual force $F_{act} = (W_v + W_p + W) \times 10^{-3} \times 9.8$

$= 1405 \times 10^{-3} \times 9.8$

$= 13.769$ N

Coefficient of impact of jet $= \frac{F_{act}}{F_{th}} = \frac{13.769}{16.34} = 0.842$

Result :- The theoretical force is more than the actual force of the jet because there is losses. However C_j can be more than one if there is an energy gain during collision.

Sources of error :-

1> Error can occur if the water flow is non-steady & Uniform

2> Error can occur while taking reading on scale.

3> Weight can be put slowly by one otherwise error can occur.

4> Error can occur if after changing the value if flask is not closed tightly.

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DEPARTMENT OF MECHANICAL ENGINEERING

REPORT

TITLE Calibration of Venturimeter

Name Prince Maurya

Semester 4th Roll No. 21ME8011

Section A Year 2023

Signature Prince

Date of Experiment 31th Jan 2023

Objective

1. To determine the venturimeter constants (K & N) from plotting of Q_a v/s H_m on log - log graph paper.
2. To determine coefficient of discharge C_d of venturimeter and to plot C_d V/s Re on semi log graph paper.

Theory

A venturimeter is used to measure the flow - rate in a pipeline quite accurately. Theoretical discharge through a venturimeter is expressed as $Q_t = \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$, where A_1 and A_2 are cross - sectional areas of pipeline and venturimeter throat respectively and 'h' is differential head across section 1 & 2 in terms of flowing liquid. If head 'h' is measured by a differential manometer with a heavier liquid of sp. gr. S_m (than flow liquid of sp. gravity S.) then $h = H_m \left(\frac{S_m}{S} - 1 \right)$. But actual discharge Q_a is smaller than theoretical discharge Q_t and is given by $Q_a = C_d Q_t$ where discharge coefficient C_d depends on roughness etc. and is always lesser than unity. For all practical purposes expression $Q_a = \frac{C_d A_1 A_2 \sqrt{2g H_m \left(\frac{S_m}{S_w} - 1 \right)}}{\sqrt{A_1^2 - A_2^2}}$ is reduced to $Q_a = K H_m^N$, K & N are to be determined experimentally. Now, the discharge equation $Q_a = K H_m^N$ in its logorithm takes the form of $\log Q_a = N \log H_m + \log K$ when plotted Q_a V/s H_m represents a straight line on a log - log graph paper and K & N may be determined from it. Reynolds No. is given by $R_e = \frac{V_2 D_2}{\nu}$.

Apparatus & Instruments

Pipeline assembly with venturimeter fitted with mercury-manometer volumetric tank, stopwatch etc.

Procedure

Delivery valve was fully opened. For the first set of observations, control value was so regulated that maximum flow was allowed in the pipeline and level difference H_m in the venturimeter - manometer reached maximum, Manometer reading was noted. Water coming out of the pipe was stored in a collecting tank during some time interval 't' which was noted through a stop-watch. Height of the collected water H was noted through a piezometer tube fitted to the tank. The volume of collected water 'V' was then obtained from the product of 'H' multiplied by the area of the tank.

Actual discharge through the orifice Q_a could be calculated from the t, $Q_a = V/t$. For the next set flow in pipeline was decreased by constant value and corresponding reading at tank, stop watch and manometer were noted.

The procedure was repeated for obtaining at least 10 sets of observations.

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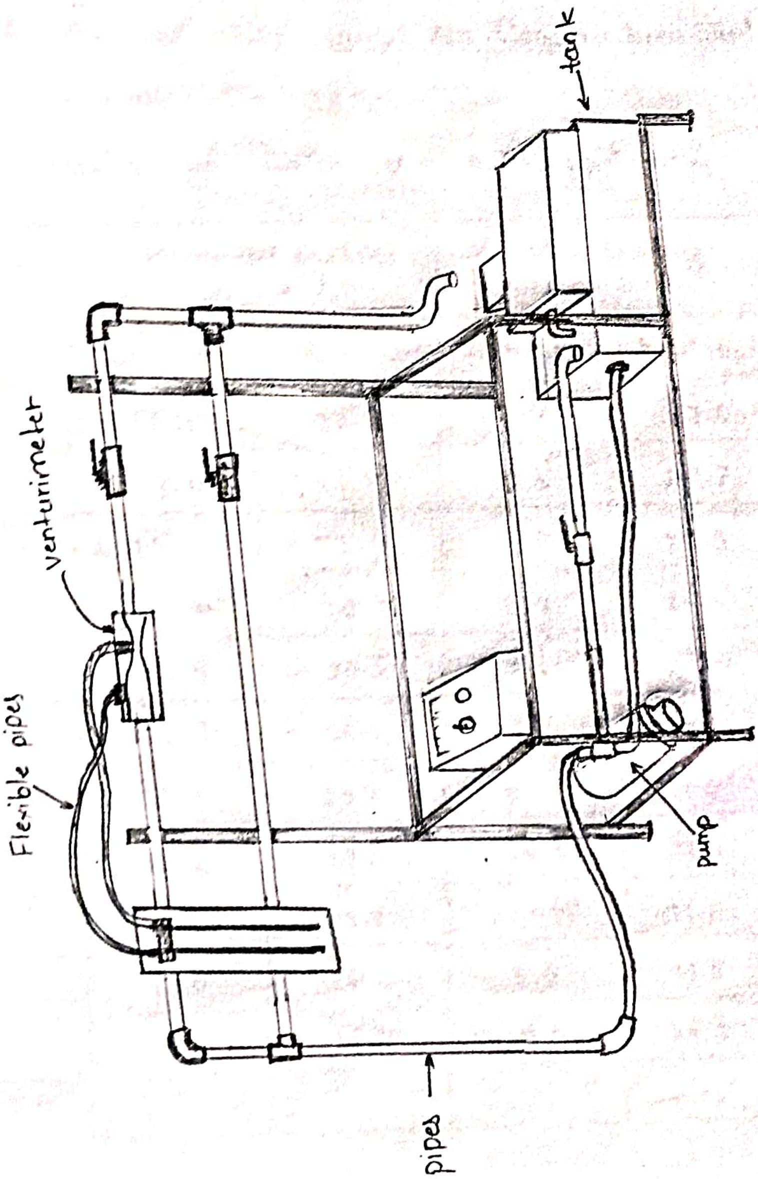

Experimental Set up

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CALIBERATION OF VENTURIMETER

DEPARTMENT OF MECHANICAL ENGINEERING PAGE NO

Observations :-

Cross sectional area of flow in pipe, $A_1 = (\pi D_1^2)/4 = 6.15 \ cm^2$

Cross- sectional area of venturimeter throat, $A_2 = (\pi D_2^2)/4 = 1.53 \ cm^2$

Specific - gravity of manometric liquid, $S_m = 13.6$

Area of the collecting tank, A= (length x breadth) = $37.5 \times 20 = 750 \ cm^2$

Room temperature, T = 25°C

Kinetic viscosity of water, $\nu = 0.81 \times 10^{-6} \ m^2/s$

Observation No.	Manometer reading (in cm)		Tank Reading (in cm)		Time of collection, t (in (s))
	LHS (a)	RHS (a)	Initial (h_i)	Final (h_f)	
1.	13.0	22.2	7.5	27.6	20
2.	13.4	21.8	9.3	28.7	20
3.	13.8	21.4	9.8	27.9	20
4.	14.4	20.9	9.4	25.4	21
5.	14.9	20.5	9.6	25.4	20
6.	15.3	20.1	9.9	24.0	20
7.	15.8	19.7	8.5	21.0	20
8.	16.2	19.2	10.3	21.4	20
9.	16.6	18.8	21.11	31.1	20
10.	17.0	18.4	9.0	19.5	30
11.	17.4	18.0	19.5	25.5	30
~~12.~~					

Date 31 Jan 2023 31/01/2023 Signature Prince Maurya

21ME8011

Sample Calculation :— 3rd Observation.

Manometer reading :- LHS (a) = 13.8 cm

RHS (b) = 21.4 cm

Manometer deflection $(H_m) = (b-a)$

$= 21.4 - 13.8 = 7.6$ cm

Tank Reading :- $h_i = 9.8$ cm

$h_f = 27.9$ cm

$H = h_f - h_i = 18.1$ cm

$$Q_a = \frac{A \times H}{t} = \frac{750 \times 18.1}{20} = 6.79 \times 10^{-4} \ m^3/s$$

$$\cancel{Q_t} \ A_1 = \frac{\pi D_1^2}{4} = 6.15 \times 10^{-4} m^2$$

$$A_2 = \frac{\pi D_2^2}{4} = 1.53 \times 10^{-4} m^2$$

$$Q_t = \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} = \frac{6.15 \times 1.53 \times 10^{-8} \sqrt{2 \times 9.8 \times 7.6 \times 10^{-2} \times (13.6-1)}}{10^{-4} \sqrt{6.15^2 - 1.53^2}}$$

$$= 68.43 \times 10^{-5} \ m^3/s$$

$$= 6.85 \times 10^{-4} \ m^3/s$$

$$C_d = \frac{Q_a}{Q_t} = \frac{6.79 \times 10^{-4}}{6.85 \times 10^{-4}} = 0.991$$

$$Re = \frac{Q_a}{A_2} \times \frac{D_2}{\nu} = \frac{6.79 \times 10^{-4}}{1.53 \times 10^{-4}} \times \frac{0.014}{0.81 \times 10^{-6}} = 69121$$

Result sheet -

Set No.	Manometer deflection $H_m = a-b$ (in cm)	$H = h_f - h_i$ (in cm)	$Q_a = V/t = \frac{A \times H}{t}$ in (m^3/s)	$Q_t = A_1 A_2 \times \sqrt{2gh} / \sqrt{A_1^2 - A_2^2}$ (m^3/s)	$C_d = Q_a/Q_t$	$R_e = V_2 D_2 / v = (Q_a/A_2) \times (D_2/v)$
1.	9.6	22.2	7.67×10^{-4}	7.75×10^{-4}	0.990	69408
2.	8.6	21.1	6.86×10^{-4}	7.33×10^{-4}	0.936	62177
3.	7.6	18.1	6.79×10^{-4}	6.85×10^{-4}	0.991	69121
4.	6.5	16.0	6.00×10^{-4}	6.33×10^{-4}	0.947	60101
5.	4.6	17.2	4.99×10^{-4}	5.36×10^{-4}	0.930	45156
6.	4.8	14.1	5.29×10^{-4}	5.44×10^{-4}	0.971	53845
7.	3.9	12.5	4.69×10^{-4}	4.9×10^{-4}	0.955	47735
8.	3	11.1	4.16×10^{-4}	4.3×10^{-4}	0.967	42389
9.	2.2	9.7	3.64×10^{-4}	3.68×10^{-4}	0.987	37042
10.	1.4	10.5	2.63×10^{-4}	2.94×10^{-4}	0.893	26731
11.	0.6	6.0	1.50×10^{-4}	1.92×10^{-4}	0.779	15275

Result :

We know that $\log Q_a = N \log H_m + \log K$

From graph we get that

$K = 2.18 \times 10^{-4}$

$N = 0.554$

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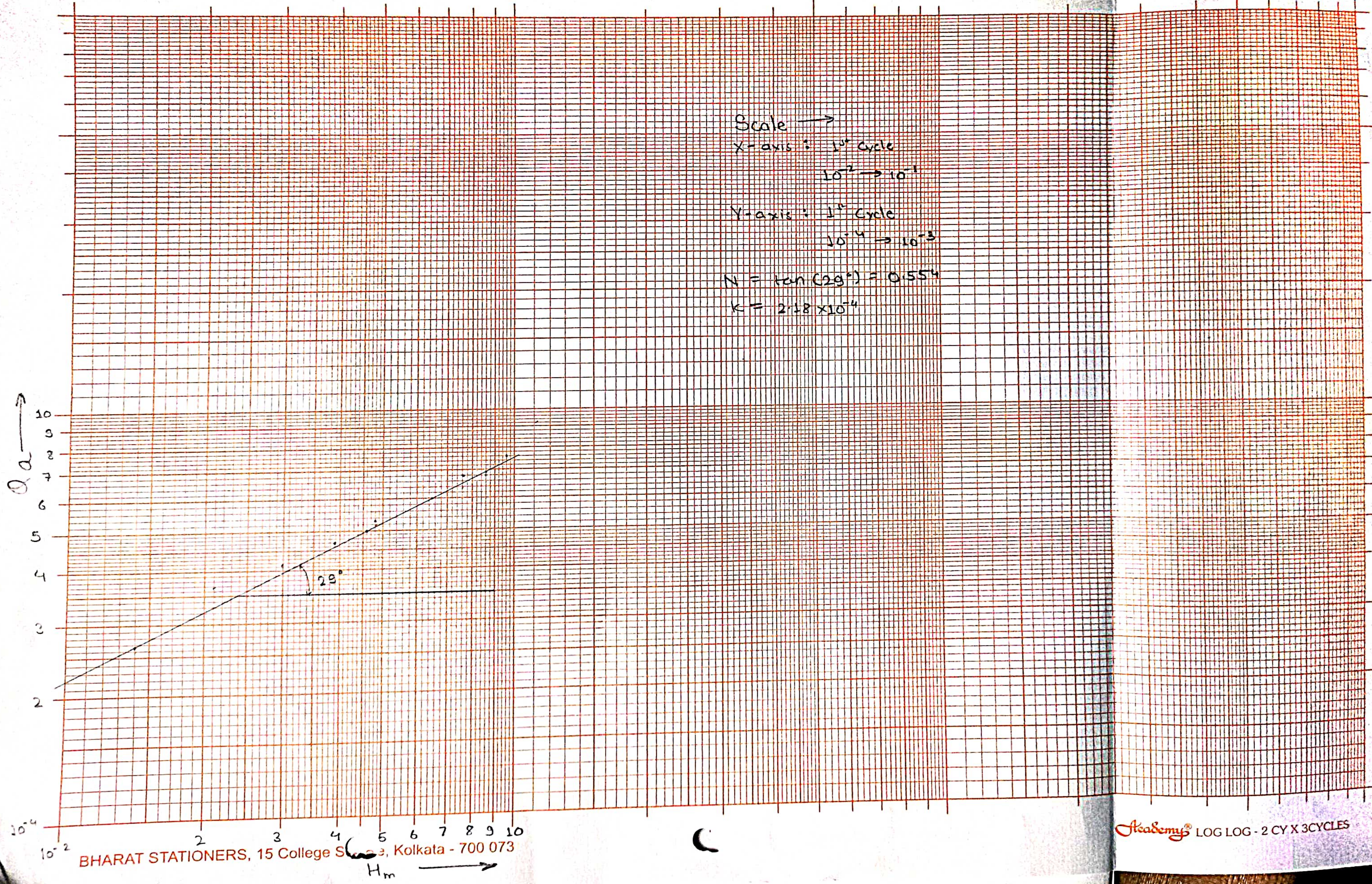
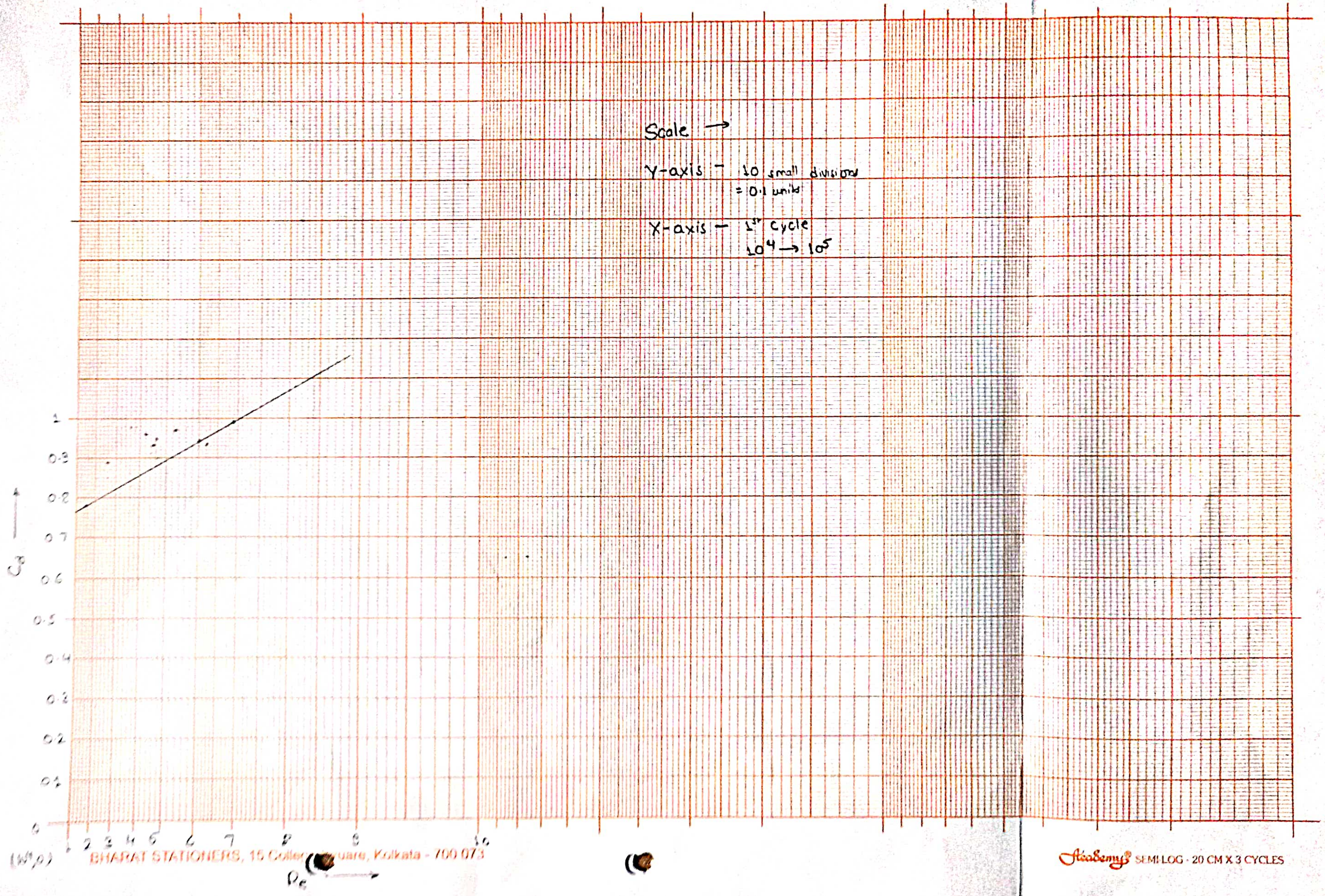

Scale →
X-axis : 1st Cycle
$10^{-2} \rightarrow 10^{-1}$
Y-axis : 1st Cycle
$10^{-4} \rightarrow 10^{-3}$
N = tan (29°) = 0.554
K = 2.18 × 10^{-4}
29°
Q_a →
H_m →


Scale →
Y-axis – 10 small divisions = 0.1 units
X-axis – 1st cycle
$10^4 \to 10^5$
C_d
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
$(10^4, 0)$
$Re \to$

Sources of Error

1> Keep the other valve closed while taking reading through the pipe, otherwise error can occur.

2> The initial error in the manometer to be subtracted from final reading to avoid error.

3> Paradax error can occur.

4> constant discharge would not be maintained.

Precautions

1> Reading of the tank should be taken carefully.

2> Parallax error should be avoided.

3> Time should be noted carefully.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF Mechanical Engineering

REPORT

TITLE Friction Loss in flow through Pipes

Name Prince Maurya

Semester 4th Roll No. 21ME8011

Section A Year 2022-23

Signature

Date of Experiment 7th Feb 2023

Objectives :-

1) To determine the friction factor f and to plot f v/s Re on a log-log graph paper.

2) To find out absolute roughness of the pipe.

Theory :-

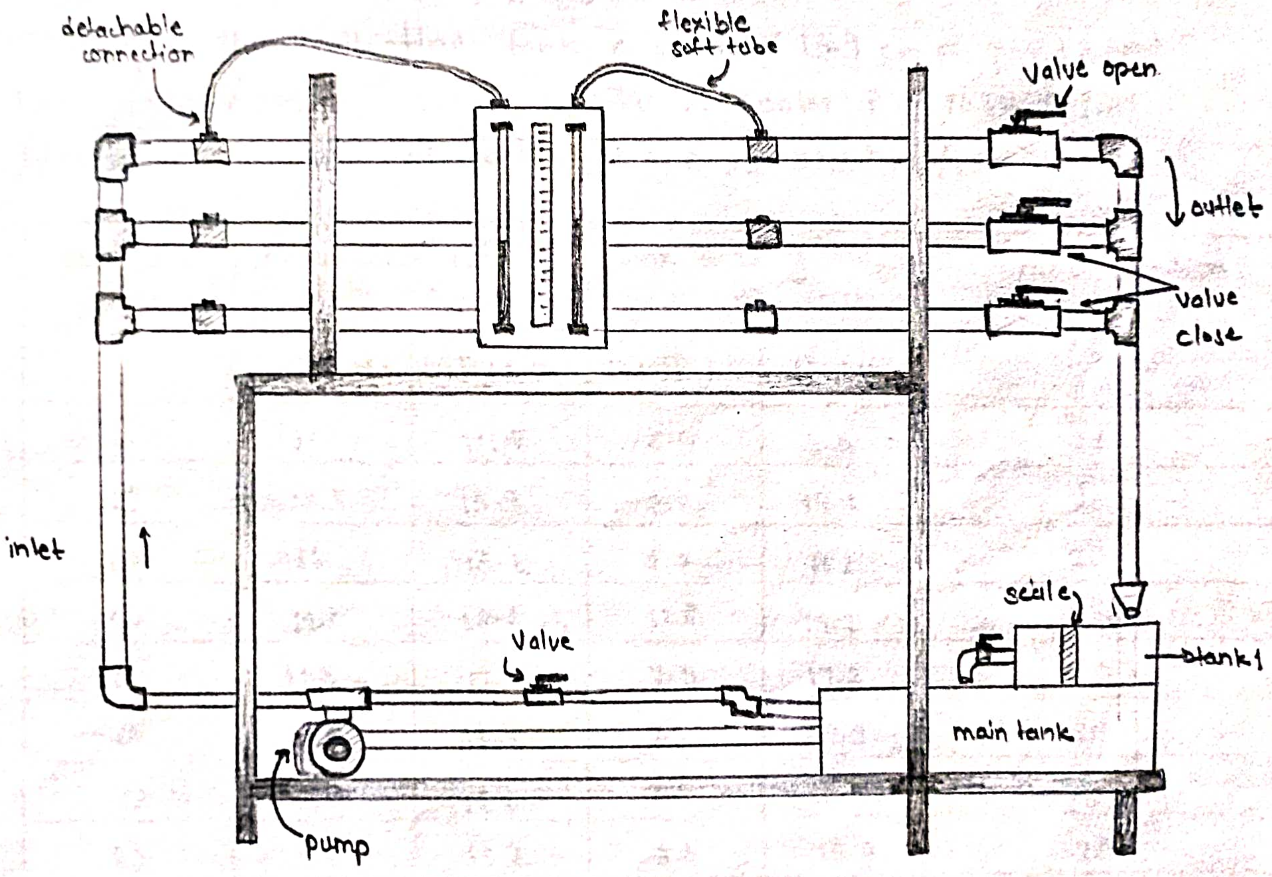
When liquid flows through a pipe a pressure drop occurs due to viscous shear on pipe wall. This head loss is quantitatively expressed by Darcy-Weisbach equation as $h_f = \frac{fLv^2}{2gD}$, where 'f' is friction factor, L is the length of pipe, v is the average velocity of the flow and D is the diameter of the pipe. Reynolds number for the flow is given by $Re = \frac{VD}{\nu}$, ν is the kinematic viscosity of the flowing fluid. Knowing the values of h_f and Q (i.e discharge), the value of f and Re can be calculated.

For laminar flow (i.e. for flow reynolds no. $f = \frac{64}{Re}$) therefore a plot of f v/s Re on log-log graph will show a straight line. But in turbulent flow f becomes function of Re and ε/D [i.e $f = f(Re, \varepsilon/D)$, where ε/D is the relative roughness and ε is the average height of pipe-wall roughness protrusions.

Apparatus and instruments :-

Pipe line assembly with supply system, volumetric tank, stopwatch etc.

Diagram :-



Experiment set up for measuring friction factor in pipes

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Roll no. - 21ME8011 Name - PRINCE MAURYA

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Observation :-

Length of straigh portion of pipe, L_s = 1m

Diameter of the pipe, D = 0.014 m

Area of the collecting tank, A = 38.1 × 19.9 cm = 758.19 cm^2

Room temperature, T = 25°C, Density of water ρ = 1050 Kg/m^3

Kinematic viscosity of water, ν = 0.897×10^{-6} m^2/sec

Observation No.	Manometer reading in		Tank Reading in		Time of collection t in
	LHS (a)	RHS (b)	(initial h_1)	final (h_2)	
1>	14	14.7	6.4	9.6	20
2>	13.5	15.2	9.6	14.1	20
3>	13	15.8	5.5	11.8	20
4>	12.4	16.5	11.8	19.2	20
5>	11.5	17.4	7.9	17.2	20
6>	10.8	18.1	7.5	17.9	20
7>	10.2	18.6	7.4	18.4	20
8>	9.6	19.2	8.5	18.9	20
9>	9.0	19.8	5.7	18.8	20
10>	8.1	20.7	6.5	20.3	20
11>	6.6	22.2	6.5	21.7	20

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Result Sheet :-

S. No.	$h_f = a-b$ (in cm)	$H = h_2 - h_1$ (in cm)	$Q = V/t = (A \times H)/t$ (in m^3/s)	$V = 4Q/\pi D^2$ (in m/s)	$f = \frac{2gDh_f}{LV^2}$ in -	$Re = UD/\nu$	ϵ/D from Moody's chart
1.	0.7	3.2	0.000121	0.788	0.0309	12299	0.0012
2.	1.7	4.5	0.000171	1.108	0.0380	17296	0.0078
3.	2.8	6.3	0.000239	1.557	0.0319	24214	0.0038
4.	4.1	7.4	0.000281	1.822	0.0339	28442	0.0055
5.	5.8	9.3	0.000353	2.290	0.0303	35745	0.0036
6.	7.3	10.4	0.000394	2.561	0.0305	39973	0.0038
7.	8.4	11	0.000417	2.708	0.0314	42279	0.0044
8.	9.6	11.4	0.000432	2.807	0.0334	43816	0.0057
9.	10.8	13.1	0.000497	3.226	0.0285	50351	0.0030
10.	12.6	13.8	0.000523	3.398	0.0299	53041	0.0038
11.	15.6	15.2	0.000578	3.743	0.0305	58422	0.0040

Sample calculation :-

Taking → Obs. No 3

$h_f = 15.8 - 13 = 2.8$ cm

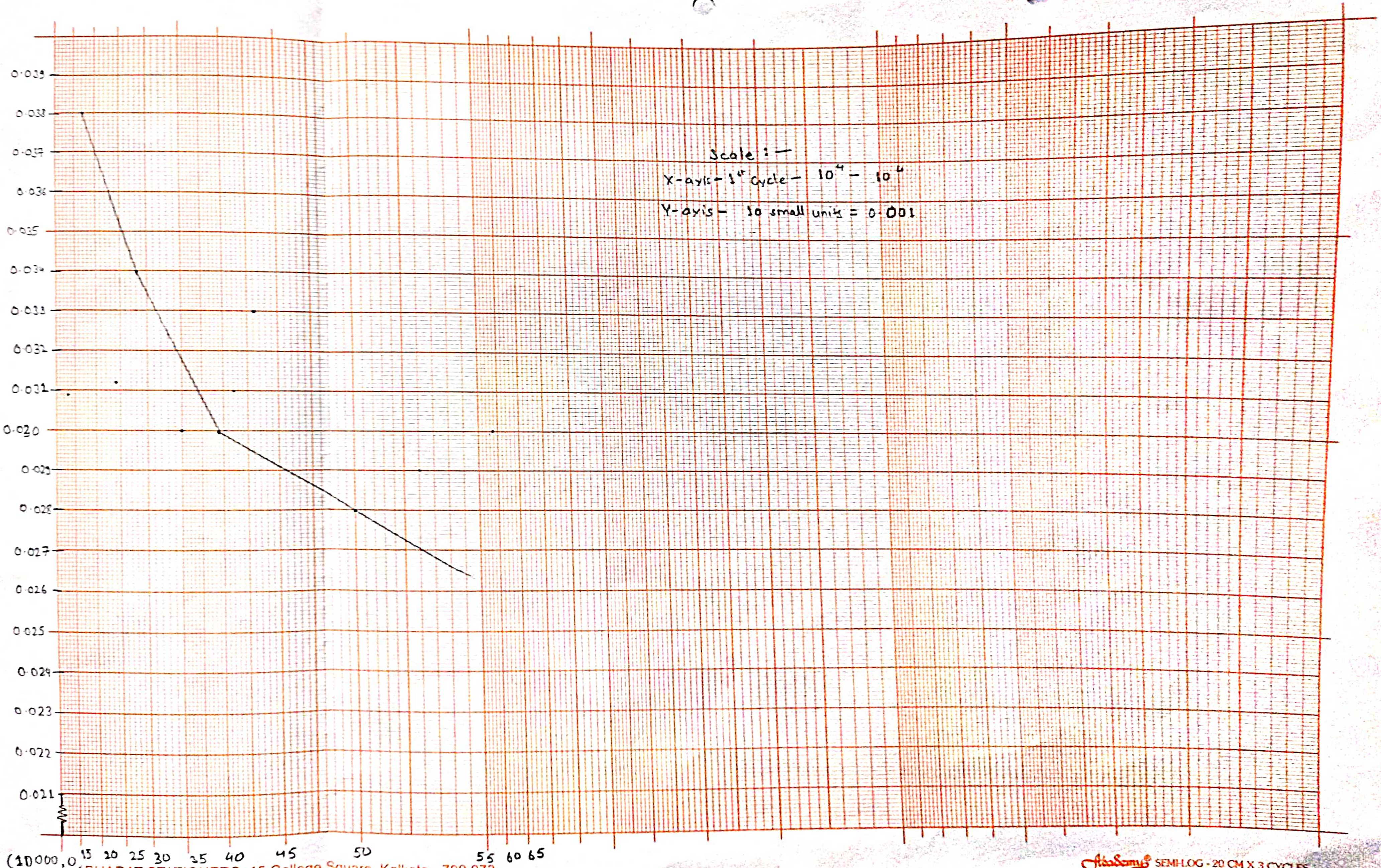
$H = 11.8 - 5.5 = 6.3$ cm

$t = 20$ sec

$$Q = \frac{A \times H}{t} = \frac{38.1 \times 19.9 \times 10^{-4} \times 6.3 \times 10^{-2}}{20} = 0.000239 \ m^3/s$$

$$V = \frac{4Q}{\pi D^2} = \frac{4 \times 0.000239}{\pi \times 14 \times 10^{-3}} = 1.557 \ m/s$$

$$f = \frac{2gDh_f}{LV^2} = \frac{2 \times 9.8 \times 14 \times 10^{-3} \times 2.8 \times 10^{-2}}{1 \times (1.557)^2} = 0.0319$$


Scale :—
X-axis— 1st cycle— 10^4 — 10^4
Y-axis— 10 small units = 0.001
0.039
0.038
0.037
0.036
0.035
0.034
0.033
0.032
0.031
0.030
0.029
0.028
0.027
0.026
0.025
0.024
0.023
0.022
0.021
(10000,0.
15 20 25 30 35 40 45 50 55 60 65

$$Re = \frac{VD}{\nu} = \frac{1.551 \times 14 \times 10^{-3}}{0.89 \times 10^{-6}} = 24214$$

$\varepsilon/D = 0.0038 \rightarrow$ from moody's chart

Avg. $\varepsilon/D = 0.00423$

Conclusion :-

The avg. absolute roughness ε of piple wall surface $= 0.00423 \times 14$
$= 0.05922$ mm

Sources of error :-

1) Error can occur due to the fluctuation of height when the fluid is flowing through the manometer tubes, we have to note the means.

2) There can be parallax errors.

3) Some water can remain in the collecting tank which causes error.

4) Carefully we have to keep the same level of fluid in inlet and outlet supply.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF Mechanical Department

REPORT

TITLE Determination of coefficient of Bend loss in flow through pipes

Name Prince Maurya

Semester 4th Roll No. 21ME8011

Section A Year 2022-23

Signature Prince

Date of Experiment 28th Feb 2023

Title : Determination of coefficient of Bend loss in flow through pipes.

Objectives :

1> To determine pressure - drop coefficient for bend, K_b:

2> To plot variation of K_b with Reynolds number Re, on a semi-log graph paper.

Theory

When liquid flows through a pipe-bend, a pressure drop occurs due to the sudden change in its direction of flow. In the curved path, liquid experiences an inward (centripetal) acceleration and thus an increase in pressure occurs at the ~~at~~ outer wall of the bend starting at point A and reaching maximum value at point B. ~~See~~ On the other hand, a reduction in pressure occurs at point C of the inward wall with a subsequent rise from C to D. This pressure difference causes a back flow resulting in the formation of eddies and separation of flow. In general, head loss due to bend is expressed as $h_b = K_b V^2/2g$ where h_b is head loss due to bend, V is average velocity of flow through pipe and K_b is pressure drop coefficient for bend. Value of K_b depends on the angle of the bend θ (here $\theta = 90°$), relative radius of curvature R/D (where R is the radius of curvature at the centre line of bend and D is the pipe diameter) and Reynolds No. Re. In the experiment, average velocity V is calculated ~~as~~ from discharges Q_a obtained through a venturimeter connected in the pipe line; $Q_a = K(H_m)^N$, where H_m is level difference in the manometer connected to venturimeter, K and N being two constant of the calibrated venturimeter. Again, by Darcy-Weisbach equation, head loss due to friction in the pipe is expressed as $h_f = fLV^2/2gD$ where L is length of pipe and is friction factor. A pipe bend thus causes a loss of head in addition to what would occur if the pipe were of same total length but straight, and the total loss of head across a bend is given by, $h_t = h_b + h_f$

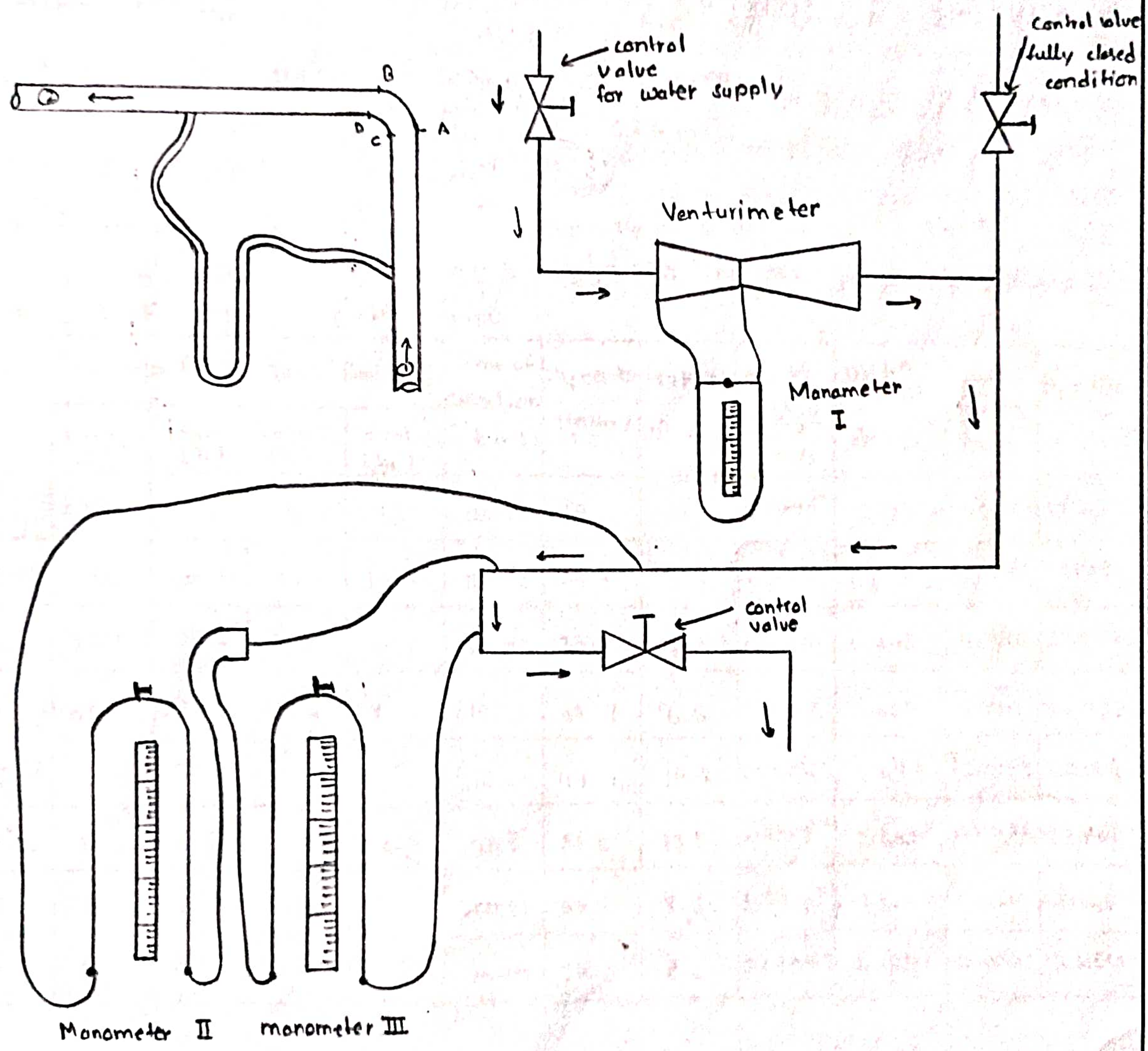
Apparatus & Instruments:

Pipeline assembly with supply system, venturimeter fitted in the pipe line.

Procedure:

Delivery valve was fully opened. For the first set of observations control valve in the pipeline was then opened to such an extent that maximum level differences occured in all the three manometers connected across venturimeter, straight portion L_s and bend portion L_b respectively. Readings in the manometer were noted. For the next set, flow-rate in the pipe-line was decreased by the control valve and corresponding manometer reading were noted.

The procedue was repeated for obtaining, at least six sets of of observations.



Line Diagram of the Experimental Set up to find the coefficient of Bend Loss in a pipeflow.

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Prince Maurya 21ME8011

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Observation :-

Diameter of the pipe, $D = 0.014$ m , Area of tank $A = 38 \times 20 = 0.076 m^2$

Length of straight portion of pipe, $L_s = 0.878$ m

Length of bend portion of pipe, $L_b = 0.575$ m

Venturimeter constant : $K = 730 \times 10^{-5}$

Room temperature, $T = 28°C$ Density of water $\rho = 1050$ Kg/m³

Kinematic viscosity of water $= \nu = 0.897 \times 10^{-6}$ m²/sec

Table - I : For straight portion pipe

Obs. No.	Manometer Reading		Tank Reading		Time of Collection 't' in(s)	$h_f = a-b$ (in cm)	$H = h_1 - h_2$ (in cm)	$Q = V/t = \frac{(A \times H)}{t}$ in m³/s	$V = \frac{4Q}{\pi D^2}$ in m/s	$f = \frac{2g D h_f}{L v^2}$	$Re = \frac{VD}{\nu}$	$f = 0.079 \times 4 \times Re^{-1/4}$
	LHS (a)	RHS (b)	Initial (h_1)	final (h_2)								
1.	45.7	28.7	9	13	20.22	17	4	1.5×10^{-4}	0.974	0.056	15201.7	0.028
2.	51.5	25.4	13	17.7	20.28	26.1	4.7	1.76×10^{-4}	1.144	0.0623	17855.0	0.0273
3.	55.4	25.3	7.9	13.6	19.48	30.1	5.7	2.22×10^{-4}	1.445	0.045	22558	0.0257
4.	61.1	22.4	13.6	20.2	19.75	38.7	6.6	2.54×10^{-4}	1.650	0.044	25763	0.0249
5.	67	19.6	3.2	18	20.02	47.4	14.8	2.55×10^{-4}	1.677	0.0529	26185	0.0248
6.	73.5	16.7	3.4	16.9	20.1	56.8	13.5	2.84×10^{-4}	1.843	0.0526	28766	0.0242
7.	79.6	13.4	8.6	16.9	20.21	66.2	8.3	3.12×10^{-4}	2.028	0.050	31661	0.0236
8.	86.2	11.2	8.4	17	20.00	75	8.6	3.27×10^{-4}	2.124	0.0523	33150	0.0234

Date 28/02/23

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Prince Maurya 21ME8011

Table II :- For Bend portion pipe

Obs. No.	Manometer Reading		Tank Reading		Time of collection (t in s)	$h_b = a-b$ in cm	$H = h_1 - h_2$ in cm	$Q = V/t = \frac{A \times H}{t}$	$V = \frac{4Q}{\pi D^2}$	$K = \frac{h_b \times 2g}{V^2}$	$Re = \frac{VD}{\nu}$
	LHS (a)	RHS (b)	Initial (h_1)	final (h_2)							
1.	37.7	31.1	8.5	12.6	20.06	6.6	4.1	1.55×10^{-4}	1.009	1.269	15757
2.	41.1	31.7	12.6	17.5	20.05	9.5	4.9	1.86×10^{-4}	1.207	1.264	18841
3.	46.1	32.4	8.9	14.4	20.17	13.7	5.5	2.07×10^{-4}	1.346	1.480	21022
4.	55.5	31.8	14.4	23.1	20.03	23.7	8.7	2.30×10^{-4}	2.145	1.009	33485
5.	59.2	31.6	7.3	15.9	20.11	27.6	8.6	3.25×10^{-4}	2.112	1.212	32969
6.	63.1	30.5	9.7	19.1	20.01	32.9	9.4	3.57×10^{-4}	2.320	1.186	36216
7.	67.2	30.2	8.8	28.7	20.14	37	19.9	3.74×10^{-4}	2.428	1.230	37896
8.	75.4	29.4	9.1	20.2	20.12	46	11.1	4.19×10^{-4}	2.725	1.214	42532

Sample calculation :

Taking obs. 1 for straight portion :-

Manometer reading :

LHS (a) = 45.7

RHS (b) = 28.7

$h_f = a - b = 17$ cm

Tank reading :

Initial Reading $h_1 = 9$

Final Reading $h_2 = 13$

$H = h_2 - h_1 = 4$ cm

Time of collection = 20.22 sec

Date .... 28/02/23 Signature ....

Now,

Rate of flow 'Q' $= \frac{V}{t} = \frac{A \times H}{t} = \frac{0.076 m^2 \times 4 \times 10^{-2}}{20.22}$

$Q = 1.5 \times 10^{-4}$ m^3/s

Now,

velocity of flow 'v' $= \frac{4Q}{\pi D^2} = \frac{4 \times 1.5 \times 10^{-4}}{\pi \times (0.014)^2}$

$V = 0.974$ m/s

friction factor $(f) = \frac{2g D h_f}{L v^2} = \frac{2 \times 9.8 \times 0.014 \times 17 \times 10^{-2}}{0.878 \times (0.974)^2}$

$f = 0.056$

Reynold's no. $(R_e) = \frac{VD}{\nu} = 15201.7$.

Calculating friction factor from Blasius equation :

$f = 0.3164 \times Re^{-1/4}$

$= 0.3164 \times (15201.7)^{-1/4}$

$f = 0.028$

Taking obs. 1 for bend portion pipe :-

Manometer Reading :

LHS (a) = 37.7

RHS (b) = 31.1

$h_f = a - b = 6.6$ cm

Tank Reading :

Initial $h_1 = 8.5$

Final $h_2 = 12.6$

$H = h_1 - h_2 = 4.1$ cm

Time of collection in (s) = 20.06

Now,

Rate of flow $(Q) = \frac{A \times H}{t} = \frac{0.076 \times 4.1 \times 10^{-2}}{20.06} = 1.55 \times 10^{-4}\ m^3/s$

velocity of flow $(V) = \frac{4Q}{\pi D^2} = \frac{4 \times 1.55 \times 10^{-4}}{\pi \times (0.014)^2}$

$V = 1.009\ m/s$

pressure drop coefficient $(K_b) = \frac{h_b \times 2g}{V^2}$

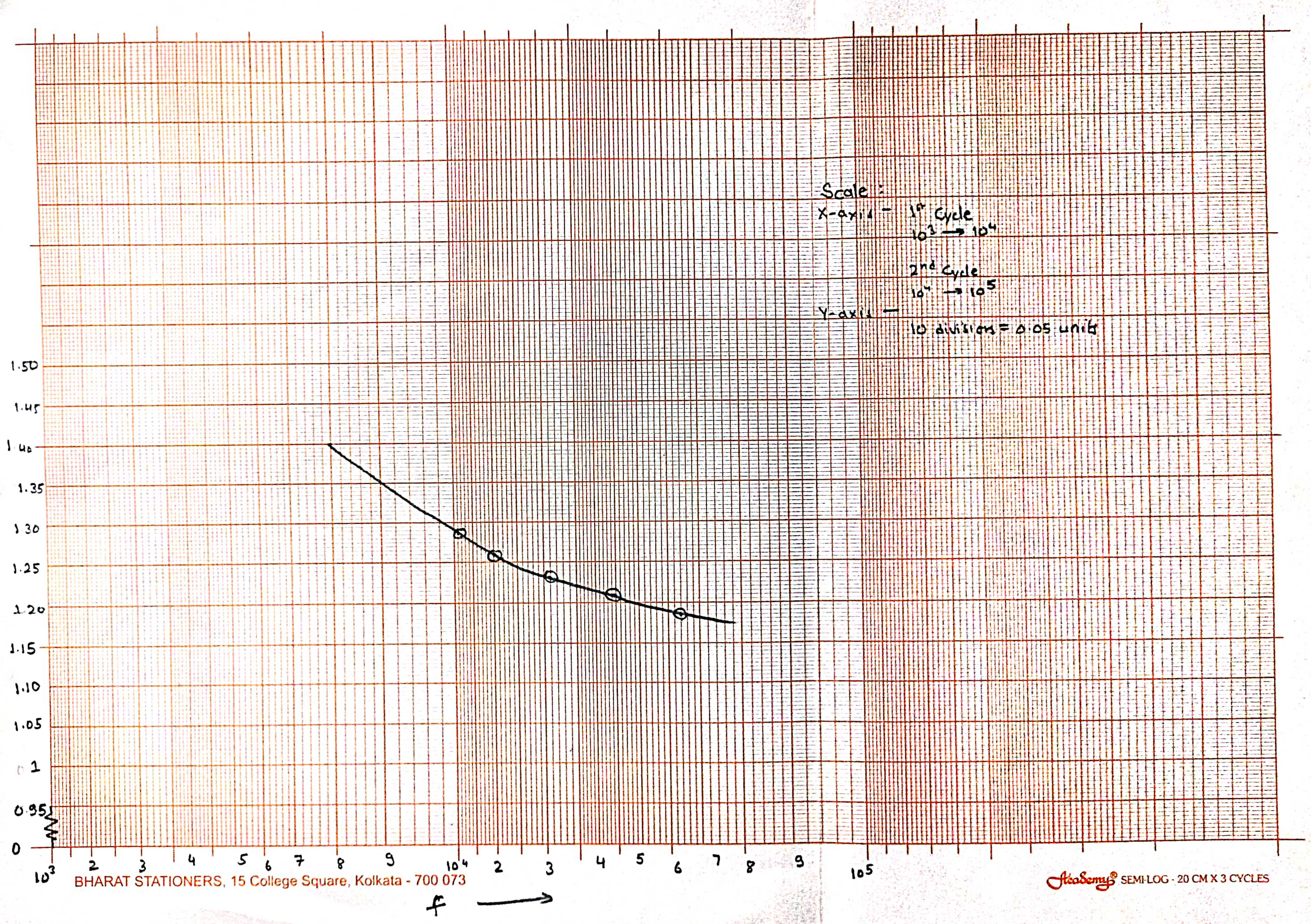
$K_b = \frac{6.6 \times 10^{-2} \times 2 \times 9.8}{(1.009)^2}$

$K_b = 1.269$

Now,

Reynold's no. $= \frac{VD}{\nu}$

$Re = 15757$



Scale :
X-axis — 1st Cycle
$10^3 \rightarrow 10^4$
2nd Cycle
$10^4 \rightarrow 10^5$
Y-axis — 10 divisions = 0.05 unit
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1
0.95
0
10^3 2 3 4 5 6 7 8 9 10^4 2 3 4 5 6 7 8 9 10^5
f
BHARAT STATIONERS, 15 College Square, Kolkata - 700 073
Academy® SEMI-LOG - 20 CM X 3 CYCLES

Sources of error -

1) Error can error due to the fluctuation of height when the fluid is flowing through the manometer tubes, we have to note means.

2) There can be parrallax errors.

3) some water can remain in the collecting tank which causes error.

4) Carefully we have to keep the same level of fluid in inlet and outlet supply.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF MECHANICAL ENGINEERING

REPORT

TITLE Calibration of Orificemeter

Name Prince Maurya

Semester 4th Roll No. 21ME8011

Section A Year 2022-23

Signature Prince

Date of Experiment 7th March 2023

Objective :

1) To determine the orificemeter - constants (K & N) from plotting of Q_a vs H_m on log-log graph paper.

2) To determine coefficient of discharge C_d of orificemeter and to plot C_d vs R_e on semi-log graph paper.

Theory :

An orificemeter is used to measure flow in a pipeline. Theoretic discharge through an orificemeter is expressed as $Q_t = A_1A_2\sqrt{2gh}/\sqrt{A_1^2 - A_2^2}$, where A_1 & A_2 are cross-sectional areas of flow in pipe and orifice respectively and 'h' is differential head across the orificemeter in terms of flowing liquid. If head h is measured by a differential manometer with heavier liquid of sp. gr. S_m (than flowing liquid of sp. gr. S) then $h = H_m(S_m/S - 1)$. However depending on the shape of orifice, reduction of flow-section at vena contracta and orifice friction, actual discharge Q_a is much smaller that than Q_t and is given by $Q_a = C_d \times Q_t$ where discharge coefficient $C_d < 1$. Therefore, practically the expression $Q_a = C_d A_1A_2\sqrt{2g(H_m(\frac{S_m}{S}-1))}/\sqrt{A_1^2-A_2^2}$ is reduced to $Q_a = K(H_m)^N$ where $K = C_d A_1A_2\sqrt{2g(\frac{S_m}{S}-1)}/\sqrt{A_1^2-A_2^2}$ and $n = \frac{1}{2}$. Thus the orifice meter is to be calibrated means its constants, i.e. K and N, are to be determined experimentally. Now, the discharge equation $Q_a = K(H_m)^N$ in its logarithmic form is given as $\log Q_a = N\log H_m + \log K$. When plotted, Q_a vs H_m represents a straight line on a log-log graph from which the values of K and N may be determined.

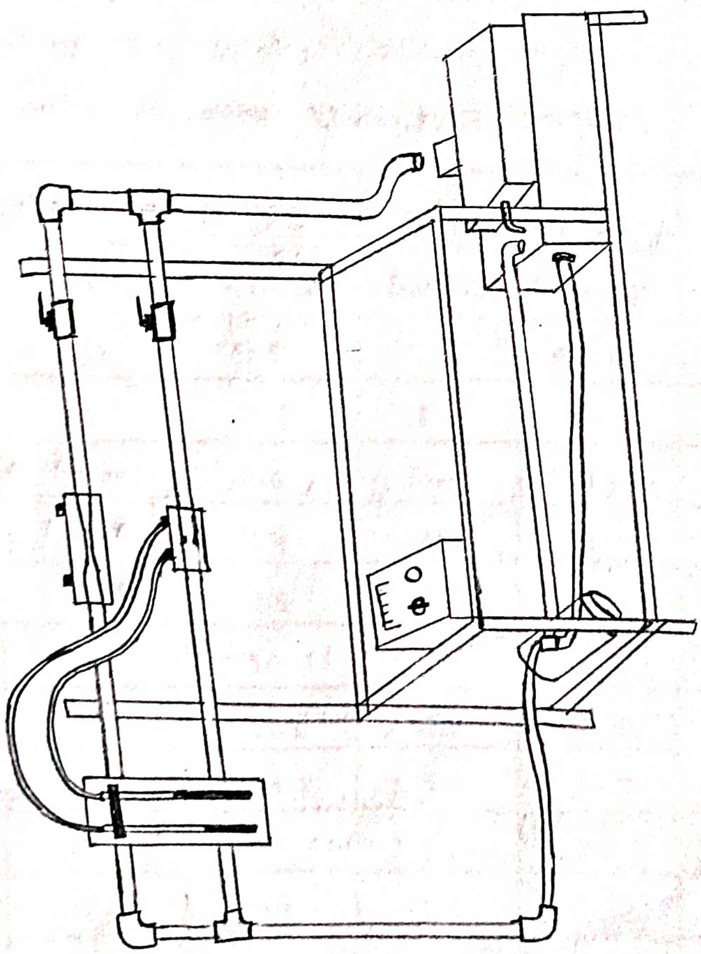
Reynolds No. is given by $R_e = \frac{V_2 D_2}{\nu}$, subscript 2 representing for orifice

Apparatus & Instruments :

Pipeline assembly with orifice meter fitted with mercury-manometer, volumetric tank, ~~spol~~ ~~sp.~~ stop watch etc.

Procedure :

Delivery valve was fully opened. For the first set of observations, control valve was so regulated that maximum flow was allowed in the pipeline and the level difference H_m in the orificemeter-manometer reached maximum. Manometer reading was noted. Water coming out of the pipe was stored in a collecting tank during some interval 't' which was noted through a stop-watch. Height of the collected water 'H' was noted through a piezometer tube fitted to the tank. The volume of collected water 'V' was then obtained from the product of 'H' multiplied by area of tank A. Actual discharge through the orifice Q_a could be then calculated from $Q_a = V/t$. For the next set, flow in pipeline was decreased by control-valve and corresponding reading at tank, stop watch and manometer were noted. The procedure was repeated for obtaining, at least, six sets of observations.



Experimental Setup.

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Name - Prince Maurya 21ME8011

DEPARTMENT OF Mechanical Engineering PAGE NO

Observations :

Cross section area of flow in pipe, $A_1 = (\pi D_1^2)/4 = 6.15 \ cm^2$

Cross sectional area of the orifice $A_2 = (\pi D_2^2)/4 = 1.53 \ cm^2$

Specific gravity of manometric liquid, $S_m = 13.6$

Area of the collecting tank $A = (\text{length} \times \text{breadth}) = 38.0 \times 20 = 760 \ cm^2$

Room temperature, $T = 30^\circ C$

Kinematic viscosity of water, $\nu = 0.81 \times 10^{-6} \ m^2/s$

Observation No.	Manometer reading		Tank Reading		Time of Collection t (in sec)
	LHS (a)	RHS (b)	Initial (h_i)	Final (h_f)	
1.	26.6	4.6	7.9	28.1	20.0
2.	26	5.6	8.3	27.6	20.0
3.	24.8	6.6	9.8	28.1	20.0
4.	23.5	7.7	9.2	26.2	20.0
5.	22.5	8.9	8.5	24	20.0
6.	21.1	10	8.8	23.3	20
7.	20	11.1	9.6	22.8	20
8.	19.4	11.8	9.5	21.8	20
9.	18.4	13	8.5	23	30
10.	17.2	14	8.3	19.7	30
11.	16.1	14.4	19.7	27	30

07.03.2023

Date 7 March 2023 Signature Prince

Sample calculation :-

Manometer reading :- LHS (a) = 26.6 cm

RHS (b) = 4.6 cm

manometer deflection :- $H_m = a - b$

$= 22$ cm

Tank reading :- $h_i = 7.9$ cm

$h_f = 28.1$ cm

$\Rightarrow H = h_f - h_i = 20.3$ cm

$$Q_a = \frac{A \times H}{t} = \frac{760 \times 20.3}{20} = 761.25 \text{ cm}^3/\text{s}$$

$A_1 = 6.15 \text{ cm}^2$

$A_2 = 1.53 \text{ cm}^2$

$$Q_t = \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} = \frac{6.15 \times 1.53 \times 10^{-8} \sqrt{2 \times 9.8 \times 22 \times 10^{-2} (13.6 - 1}}{10^{-4}\sqrt{6.15^2 - 1.53^2}}$$

$$= 11.641 \times 10^{-4} \text{ m}^3/\text{s}$$

$$= 1164.1 \text{ cm}^3/\text{s}$$

$$C_d = \frac{Q_a}{Q_t} = \frac{761.25}{1164.1} = 0.65$$

$$R_e = \frac{Q_a}{A_2} \times \frac{D_2}{\nu} = \frac{761.25}{1.53 \times 10^{-4}} \times \frac{0.014}{0.81 \times 10^{-6}} \times 10^{-4} = 7612.5$$

Prince Maurya 21ME8011

DEPARTMENT OF Mechanical Engineering

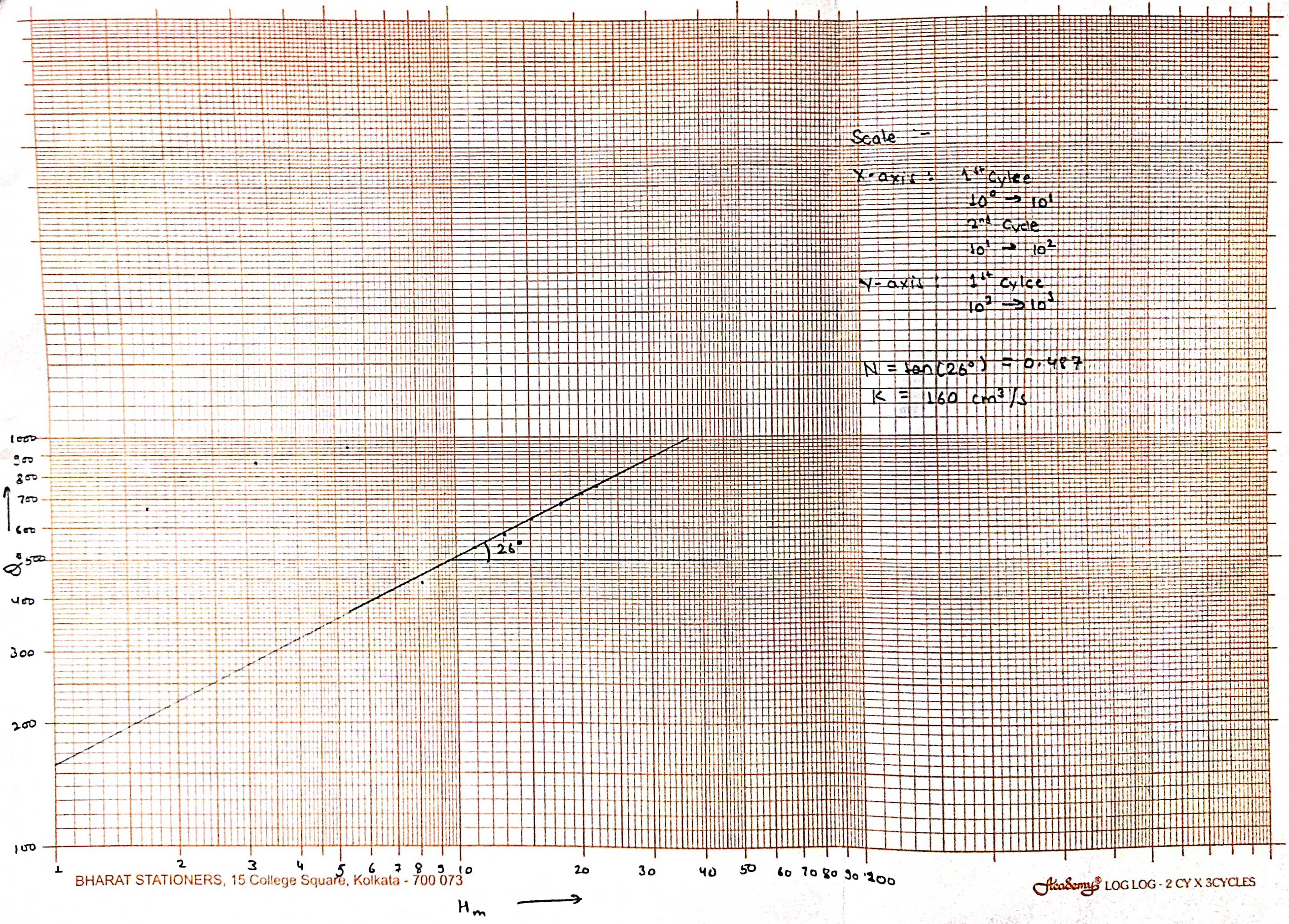
Result :-

Sl. No.	Manometer deflection $H_m = a-b$ in cm	$H = h_f - h_i$ in cm	$Q_a = \frac{A \times H}{t}$ in cm^3/s	$Q_t = \frac{A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$ in	$C_d = \frac{Q_a}{Q_t}$	$Re = V_2 D_2/\nu = \frac{Q_a \times D_2}{A_2 \nu}$
1.	22	20.3	761.25	1164.1	0.65	7612.5
2.	20.4	19.6	735	1121	0.65	7350
3.	18.2	18.3	686.25	1058.85	0.656	6862.5
4.	15.8	17	637.5	986.57	0.64	6375
5.	13.6	15.5	581.25	977.16	0.60	5812
6.	11.1	14.5	543.75	935.29	0.58	5437
7.	8.1	13.2	495	901.75	0.55	4950
8.	8.4	11.9	446.25	856.2	0.50	4425
9.	5.4	14.5	543.75	945.11	0.57	5437.5
10.	3.2	12.5	310	874	0.35	3100
11.	1.7	7.3	182.5	676	0.26	1825

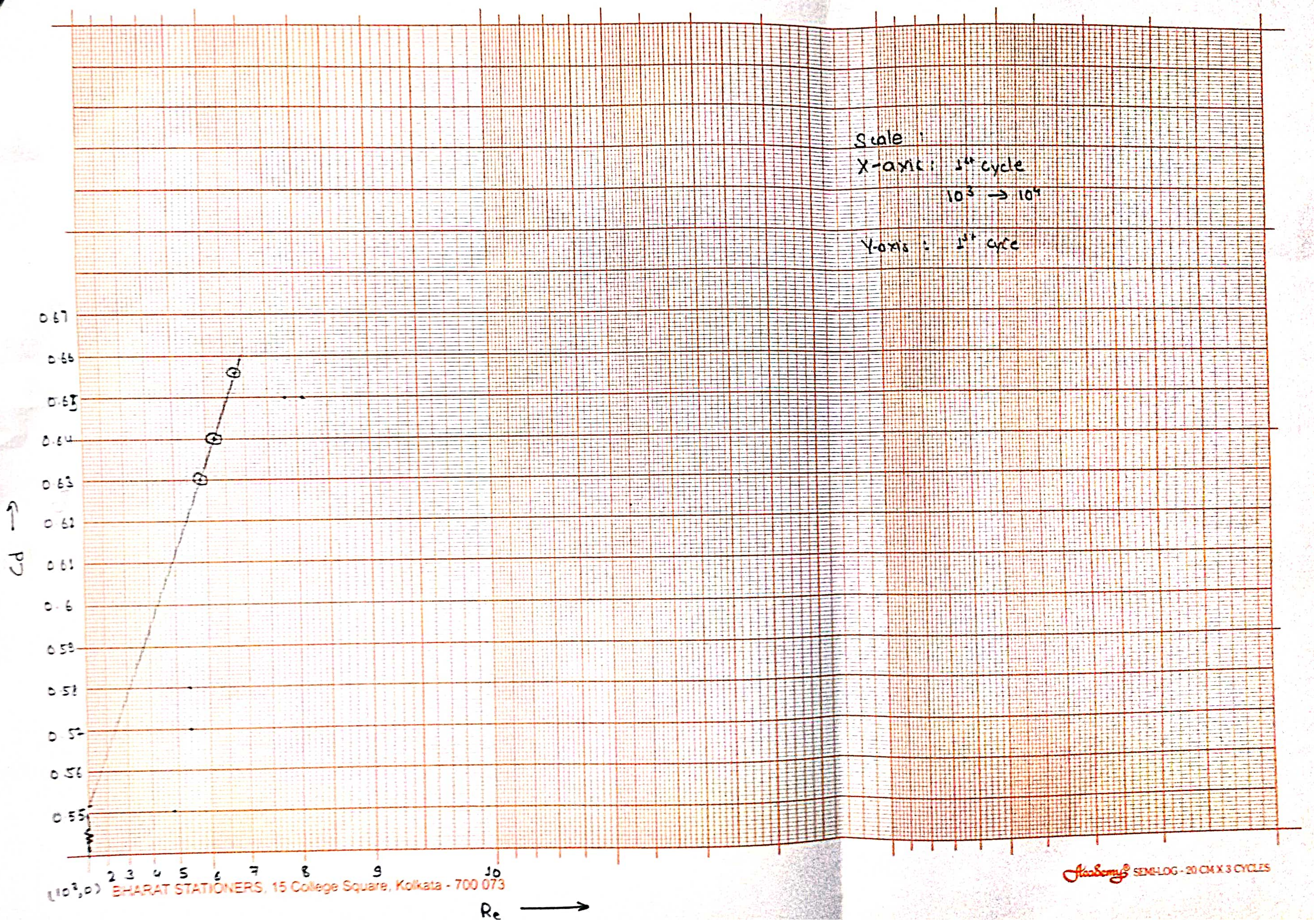
07-03-2023

Date 7 March 2023

Signature Prince



Scale :-
X-axis : 1st Cylce
$10^0 \rightarrow 10^1$
2nd Cycle
$10^1 \rightarrow 10^2$
Y-axis : 1st Cylce
$10^2 \rightarrow 10^3$
N = tan(26°) = 0.487
K = 160 cm³/s
26°
Q
Hm
1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100
100 200 300 400 500 600 700 800 900 1000


Scale :
X-axis : 1st cycle
$10^3 \rightarrow 10^4$
Y-axis : 1st cycle
Cd
Re
0.55
0.56
0.57
0.58
0.59
0.6
0.61
0.62
0.63
0.64
0.65
0.66
0.67
$(10^3, 0)$
2 3 4 5 6 7 8 9 10
BHARAT STATIONERS, 15 College Square, Kolkata - 700 073
Academy® SEMI-LOG - 20 CM X 3 CYCLES

Sources of Error

1) Keep the other value closed while taking reading through the pipe, otherwise error can occur.

2) The initial error in the manometer to be subtracted from final reading to avoid error.

3) Parallax error can occur.

4) constant discharge would ~~to~~ not be maintained.

Precautions :-

1) Reading of the tank should be taken carefully

2) Parallax error should be avoided.

3) Time should be noted carefully.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF Mechanical Engineering

REPORT

TITLE To verify Bernoulli's equation experimentally

Name Prince Maurya

Semester 4th Roll No. 21ME8011

Section A Year 2022-23

Signature Prince

Date of Experiment 14th March 2023

AIM : To verify Bernoulli's equation experimentally.

OBJECTIVE :

1. To calculate the total energy head ($\frac{P}{\rho g} + \frac{V^2}{2g} + z$) at different points of variable area duct.
2. To plot a graph between total energy head (E) v/s distance (s).

THEORY :

Bernoulli's Theorem states that for the continuous flow of ideal fluid, the total energy at any section of the flow will remain same, provided there is no subtraction or addition of energy at any point.

For steady and incompressible flow of ideal fluid the Bernoulli equation is :

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 = E$$

In word, sum of pressure energy head, kinetic energy head and potential energy head at different two locations along with the same stream line is constant. Energy head is defined as energy per unit weight.

Apparatus :

A variable area duct, an overhead tank for supply of constant head, a measuring tank to measure volume flow rate (Q), motor, pump and necessary pipe line assembly along with a by-pass value and a delivery value.

Experimental Procedure

Keeping all the values in the pipe line assembly closed fully open the by-pass value. partially Now switch on the pump by closing the by-pass value partially. In this condition run the pump until water over flow from the overhead tank. Now the delivery value provided at the end of the variable area duct is opened appropriately and collect the water for certain time which will help to calculate the volume flow rate Q at that opening of the delivery value And for this opening of delivery value, measure the pressure energy head ($h = \frac{P}{\rho g}$) at seven different points of the variable area duct by seven piezometer tubes respectively. Then slowly close the delivery value and repeat all the measurements as it is done in case of previous opening of the ~~dev.~~ delivery value.

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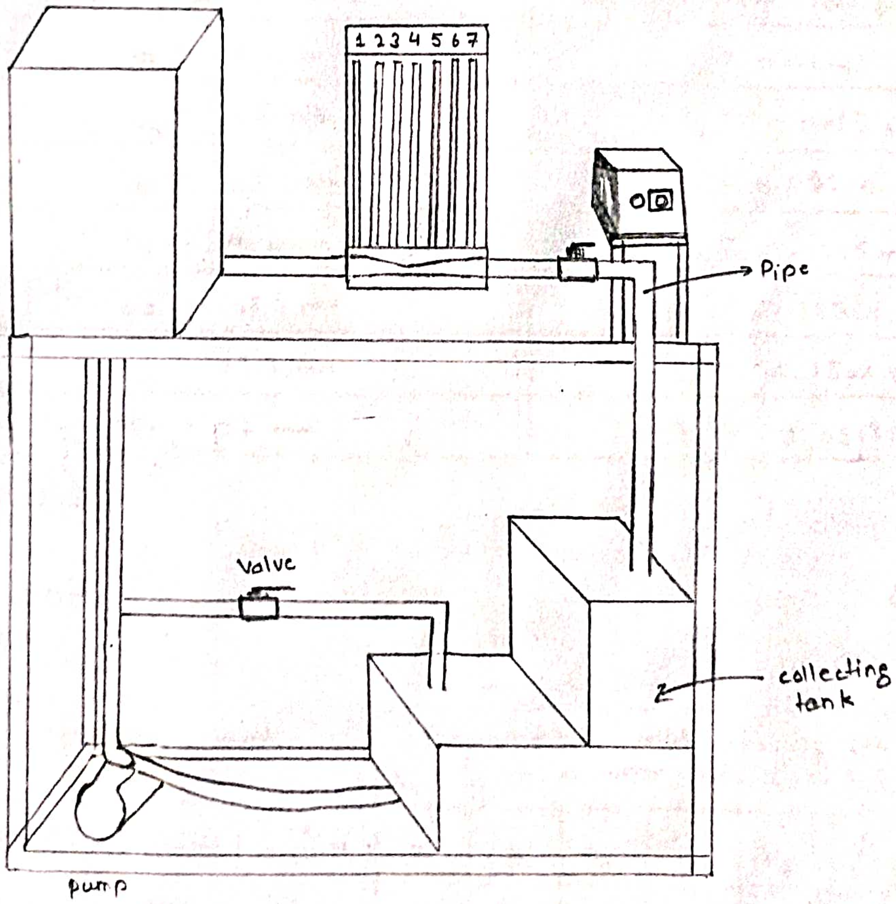
Experimental Setup :-



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Observations :

Given data :

Area of measuring tank = $0.076\ m^2$

$g = 9.81\ m/s^2$

Test Points	Diameter, d (mm)	Distance from ref. point S (m)
1.	d_1 = 28 mm	S_1 = 0.04 m
2.	d_2 = 23.5 mm	S_2 = 0.0785 m
3.	d_3 = 18.5 mm	S_3 = 0.092 m
4.	d_4 = 14 mm	S_4 = 0.1105 m
5.	d_5 = 18.5 mm	S_5 = 0.13585 m
6.	d_6 = 23.5 mm	S_6 = 0.1562 m
7.	d_7 = 28 mm	S_7 = 0.19155 m

Observation table :

Sl. No.	Measuring tank reading			Piezometric tube reading (cm). $h_i = \frac{P_i}{\rho g}$ cm of water head ($i = 1,2,3,4,5,6,7$)						
	h_i (initial)	h_f (final)	Time taken (t)	h_1	h_2	h_3	h_4	h_5	h_6	h_7
1.	6.6	11.6	30.36	32.2	31.4	29.5	20.8	25.5	27.5	28.6
2.	11.6	17.5	30.16	31.6	30.7	28.1	17.2	23.3	25.8	27.2
3.	17.5	24.5	30.46	31.1	30.4	26.9	14.5	21.8	24.7	26.5
4.	7.8	17.7	30.20	30	29.0	25.8	14.1	22.2	25	25.9
5.	7.2	19.1	30.18	29.1	28	24.2	10.4	20.4	23.5	25
6.	5.8	19.4	30.09	27.8	26.4	21.4	4.4	17.3	20.9	23

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Result Sheet :-

Sl. No.	$Q = \frac{AH}{t}$ (m^3/s)	$V_i = \frac{4Q}{\pi d_i^2}$ m/s ($\times 10^{-3}$ m) $\left(\frac{V_i^2}{2g}\right)$ m of water level where $i = 1, 2, 3, 4, 5, 6$ & 7							$E_i = \frac{V_i^2}{2g} + \frac{P_i}{\rho g} = \left(\frac{V_i^2}{2g} + \frac{h_i}{100}\right)$ m of water head where $i = 1, 2, 3, 4, 5, 6, 7$						
		$\frac{V_1^2}{2g}$	$\frac{V_2^2}{2g}$	$\frac{V_3^2}{2g}$	$\frac{V_4^2}{2g}$	$\frac{V_5^2}{2g}$	$\frac{V_6^2}{2g}$	$\frac{V_7^2}{2g}$	E_1	E_2	E_3	E_4	E_5	E_6	E_7
1.	1.86×10^{-4}	4.65	9.38	24	74	24	9.38	4.65	0.3266	0.3233	0.319	0.282	0.279	0.2843	0.290
2.	2.22×10^{-4}	6.63	13.36	34.8	106.11	34.8	13.36	6.63	0.322	0.320	0.315	0.278	0.267	0.271	0.278
3.	2.6×10^{-4}	9.09	18.33	47.73	145.54	47.73	18.33	9.09	0.32	0.322	0.316	0.29	0.265	0.265	0.274
4.	2.49×10^{-4}	8.34	16.81	43.78	133.49	43.78	16.81	8.34	0.308	0.306	0.301	0.274	0.265	0.266	0.267
5.	2.99×10^{-4}	12.03	24.24	63.12	192.48	63.12	24.24	12.03	0.303	0.304	0.305	0.296	0.267	0.259	0.262
6.	3.43×10^{-4}	15.83	31.90	83.07	253.3	83.07	31.90	15.83	0.293	0.295	0.297	0.297	0.256	0.24	0.245

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Sample Calculation :

Taking observation ①

Tank reading :

Initial h_i = 6.6 cm

Final h_f = 11.6 cm

$H = h_f - h_i = 5 cm$

Now,

Time take = 20.36 s

So, $Q = \frac{A \times H}{t} = \frac{0.076 \times 5 \times 10^{-2}}{20.36} = 1.86 \times 10^{-4}\ m^3/s$

Now, $V_i = \frac{4Q}{\pi d_i^2}$ (where i = 1, 2, 3, 4, 5, 6, 7)

$V_1 = \frac{4 \times 1.86 \times 10^{-4}}{\pi \times (0.028)^2} = 0.302\ m/s$

$\frac{V_1^2}{2g} = 4.653 \times 10^{-3}\ m$

Similarly,

$\frac{V_2^2}{2g} = \frac{16 \times Q^2}{\pi^2 \times 2g \times d_2^4} = \frac{16 \times (1.86 \times 10^{-4})^2}{\pi^2 \times 2 \times 9.8 \times (0.0235)^4} = 9.38 \times 10^{-3}\ m$

$\frac{V_3^2}{2g} = \frac{16 \times (1.86 \times 10^{-4})^2}{\pi^2 \times 2 \times 9.8 \times (0.0185)^4} = 24 \times 10^{-3}\ m$

$\frac{V_4^2}{2g} = \frac{16 \times (1.86 \times 10^{-4})^2}{\pi^2 \times 2 \times 9.8 \times (0.014)^4} = 74 \times 10^{-3}\ m$

$\frac{V_5^2}{2g} = \frac{16 \times (1.86 \times 10^{-4})^2}{\pi^2 \times 2 \times 9.8 \times (0.0185)^4} = 24.42 \times 10^{-3}\ m$

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$$\frac{V_6^2}{2g} = \frac{16 \times (1.86 \times 10^{-4})^2}{\pi^2 \times 2 \times 9.8 \times (0.0235)^4} = 9.38 \times 10^{-3} \text{ m}$$

$$\frac{V_7^2}{2g} = \frac{16 \times (1.86 \times 10^{-4})^2}{\pi^2 \times 2 \times 9.8 \times (0.028)^4} = 4.653 \times 10^{-3} \text{ m}$$

Now,

$$E_i = \left(\frac{V_i^2}{2g} + \frac{h_i}{100}\right) \text{m} \qquad (\text{where } i = 1,2,3,4,5,6,7)$$

$$E_1 = \frac{V_1^2}{2g} + \frac{h_1}{100} = 4.653 \times 10^{-3} + \frac{32.2}{100} = 0.3266 \text{ m}$$

Similarly,

$$E_2 = 9.38 \times 10^{-3} + \frac{31.4}{100} = 0.3233 \text{ m}$$

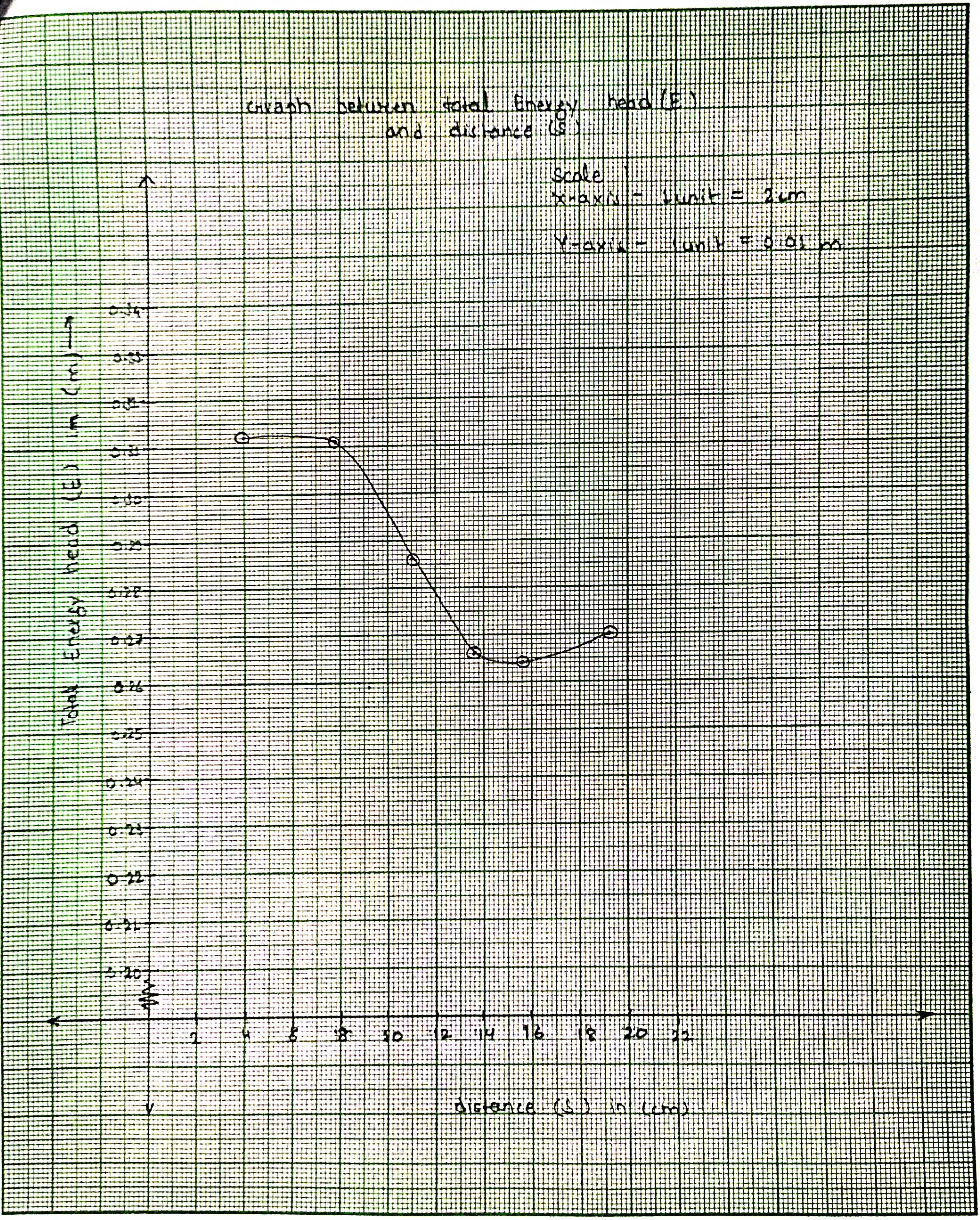
$$E_3 = 24 \times 10^{-3} + \frac{29.5}{100} = 0.3190 \text{ m}$$

$$E_4 = 74 \times 10^{-3} + \frac{20.8}{100} = 0.282 \text{ m}$$

$$E_5 = 24 \times 10^{-3} + \frac{25.5}{100} = 0.2790 \text{ m}$$

$$E_6 = 9.38 \times 10^{-3} + \frac{27.5}{100} = 0.2843 \text{ m}$$

$$E_7 = 4.653 \times 10^{-3} + \frac{28.6}{100} = 0.290 \text{ m}$$


Graph between total Energy head (E)
and distance (S)
Scale
X-axis - 1unit = 2cm
Y-axis - 1unit = 0.01 m
Total Energy head (E) in (m)
0.34
0.33
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
2
4
6
8
10
12
14
16
18
20
22
distance (S) in (cm)

Conclusion

According to bernoulli's theorem, total energy should remain conserved but, since it is a real fluid and not ideal so the ~~the~~ energy is decreasing as fluid flows due to dissipating action of friction and viscous force. Also there may be leakage

Precautions

1) Time should be noted carefully
2) All pipe should be tight to prevent any leakage.
3) Parallax error should be avoided.