K.S. School of Engineering & Management

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Department of Civil Engineering

FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY (BCV402)

IV Semester

Academic Year

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Laboratory Manual/Observation Book

Name of the Student :

Branch :

University Seat No :

Batch :

FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY

Subject Code: BCV402 | **IA Marks: 20**
Hours/Week: 03 | **Exam Hours: 03**
Total Hours: 50 | **Exam Marks: 80**

CONTENTS

K S SCHOOL OF ENGINEERING AND MANAGEMENT

Holiday Village Road, Vajarahalli Village, Mallasandra, off, Kanakapura Rd, Bengaluru, Karnataka 560109

VISION

To impart quality education in engineering and management to meet technological business and societal needs through holistic education and research.

MISSION

K. S. School of Engineering and Management shall,

- Establish state-of-art infrastructure to facilitate effective dissemination of technical and managerial knowledge.
- Provide comprehensive educational experience through a combination of curricular and experiential learning, strengthened by industry-institute interaction.
- Pursue socially relevant research and disseminate knowledge.
- Inculcate leadership skills and foster entrepreneurial spirit among students.

DEPARTMENT OF CIVIL ENGINEERING

VISION

- To emerge as one of the leading Civil Engineering Department by producing competent and quality ethical engineers with strong foot hold in the areas of Infrastructure development and research.

MISSION

- Provide industry oriented academic training with strong fundamentals and applied skills.
- Engage in research activities in Civil Engineering and allied fields and inculcate the desired perception and value system in the students.

Experiment 1: Verification of Bernoulli's equation

Aim: To verify Bernoulli's Theorem.

Theory

BERNOULLI'S THEOREM: In an ideal, incompressible, steady and continuous flow, the sum of pressure energy, potential energy, kinetic energy per unit weight of fluid is constant.

The energy per unit weight of fluid (N-m/N) has got a dimension of length (L) and can be expressed in meters of fluid column , commonly called as head .Thus according to the BERNOULLI'S theorem , the sum of pressure head $\left[\frac{P}{\gamma}\right]$,datum head (Z) and the velocity head $\left[\frac{V^2}{2g}\right]$ is constant .

i.e. $\frac{P}{\gamma} + Z + \frac{V^2}{2g} = Constant$

In cases of real fluids, because some energy is always lost in overcoming frictional resistance, the BERNOULLI'S theorem for real fluids is

$$\frac{P_1}{\gamma} + Z_1 + \frac{{V_1}^2}{2g} = \frac{P_2}{\gamma} + Z_2 + \frac{{V_2}^2}{2g} + H_{L2}$$

Where, $\mathbf{H_L}$ is loss of head from section 1 to 2

EXPERIMENTAL SETUP: The set-up consists of a horizontal converging-diverging duct having a varying width and varying depth. The conduit is made of transparent Perspex sheets. A number of piezometers are fitted on the conduit to indicate the piezometric levels at various sections.
The conduit is connected to a constant-head tank at one end. The supply tank is fitted with a piezometer to indicate the water depth. The overflow pipe discharges the excess water and thus keeps the water level constant.
The water is collected in the measuring tank for determination of the discharge.

Procedure

1. Allow the water into variable conduit by adjusting inlet gate valve such that flow is steady at the measured head.
2. Measure the water level in the piezometer tubes and their distance from the inlet of conduit.
3. Measure the time required to collect water in the collecting tank under steady flow condition.
4. Calculate the cross sectional area of conduit at various piezometric connection points.

5. Calculate the actual discharge of flow at constant head at supply tank.
6. Calculate the pressure head and velocity head various piezometric connection point in the conduit.
7. Calculate sum of pressure head, velocity head and datum head at each section of conduit and verify bernoullis equation.
8. Assume the central axis of conduit as datum line and datum head becomes zero.
9. Repeat the steps for different head in the water supply tank.

Observations and Calculations

I. Specimen details

Diameter of the conduit d = 40mm, 35mm, 30mm, 25mm, 20mm

Length of the collecting tank L = 300mm

Width of collecting tank B = 300mm

Area of cross-section A = L x B =

Rise in water level R =

Time required for collection of water t =

Constant head in the supply tank h_1=

II. Specimen Calculations

Volume of water collected in the collecting tank V = A X R

Actual discharge $Q_{act} = \frac{AxR}{T}$

Area of conduit at any section $a = \frac{\pi d^2}{4}$

Velocity of flow at any section of conduit $V = \frac{Q_{act}}{A}$

Velocity head $\frac{V^2}{2g} =$

Datum head Z = 0

Total head $\frac{P}{\gamma} + Z + \frac{V^2}{2g} = Constant$

Tabular Column

Piezometric connection points	**Area cross section of conduit**	**Time required for collection of 100 ml of water**	**Actual discharge Q_{act}**	**Velocity $V = \frac{Q_{act}}{A}$**	**Velocity head $\frac{V^2}{2g}$**	**Pressure head $\left[\frac{P}{\gamma}\right]$**	**Total head H**	**Loss of head H_L**

Discussion:

Reference:

EXPERIMENT NO – 2 Determination of Cd for Venturimeter /Orifice meter

INTRODUCTION:

A Venturi Meter is a device that is used for measuring the rate of flow of fluid through a pipeline. The basic principle on which a Venturi Meter works is that by reducing the cross – sectional area of the flow passage, a pressure difference is created between the inlet and throat & the measurement of the pressure difference enables the determination of the discharge through the pipe.

A Venturi Meter consists of,

- An inlet section followed by a convergent cone,
- A cylindrical throat,
- A gradually divergent cone.

The convergent cone is a short pipe, which tapers from the original size of the pipe to smaller section of the venturimeter known as the throat. The convergent cone has a sharp angle of about 20^0, while the divergent cone has a relatively flat angle of about 5^0 to 7^0.This results in the convergent cone of the venturimeter being smaller than its diverging cone. The throat is a short parallel-sided pipe, which is the smallest section of the venturimeter. In order to avoid the phenomenon of cavitations to occur, the diameter of the throat section can be reduced only unto a certain limited value. In general the diameter of the throat section may vary from 1/3 to 3/4 of the pipe diameter and more commonly it is kept equal to 1/2 of the pipe diameter. The diverging cone of the venturimeter is a gradually diverging pipe with cross-sectional area increasing from that of the throat section back to the original size of the pipe.

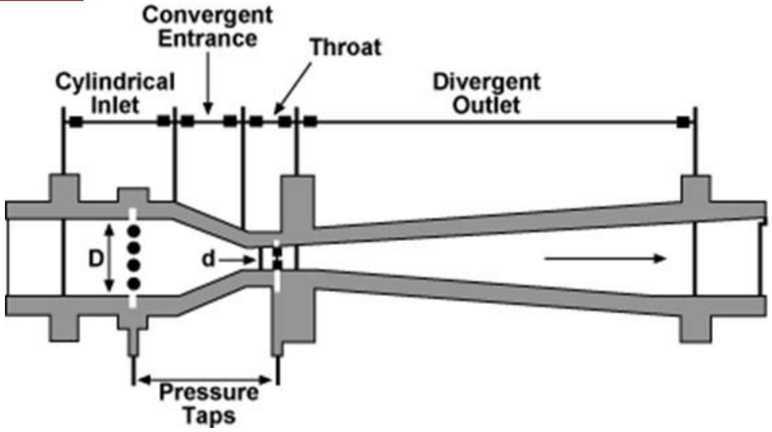


Fig: venturimeter

An ORIFICE METER is a simple device used for measuring the discharge through pipes. The basic principle on which an Orifice meter works is that by reducing the cross – sectional area of the flow passage, a pressure difference between the two sections before and after Orifice is developed and the measure of the pressure difference enables the determination of the discharge through the pipe. However an Orifice meter is a cheaper arrangement for discharge measurement through pipes and its installation requires a smaller length as compared with Venturi Meter. As such where the space is limited, the Orifice meter may be used for the measurement of discharge through pipes.

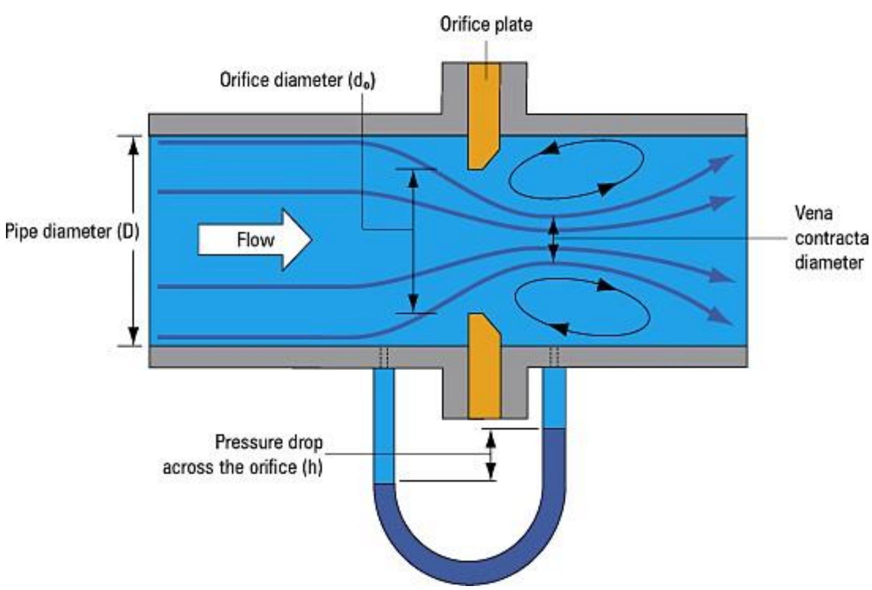


Fig: Orifice meter

DESCRIPTION OF THE APPARATUS:

1. The apparatus consists of an Orifice meter and a Venturi meter made of clear ACRYLIC fitted to specially made separate pipelines which are interchangeable.
2. Tappings with Ball Valves are provided at appropriate positions which are connected to a Manometer.
3. ACRYLIC Piezo-meter is provided to measure the height of the water collected in the measuring tank.
4. Mercury filled Manometer made of Acrylic is provided to measure the pressure difference.
5. Butterfly valve is provided in the measuring tank for instant close and release.
6. Overflow arrangement is also provided to the tanks.
7. A supply pump (Kirloskar/Sharp make) with starter is provided for supplying the water and a supply tank is provided to store the water.
8. Vinyl sticker scale is provided for both Manometer and Piezometer for better readability.
9. The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS angle with all the provisions for holding the tanks and accessories.

AIM: The experiment is conducted to,

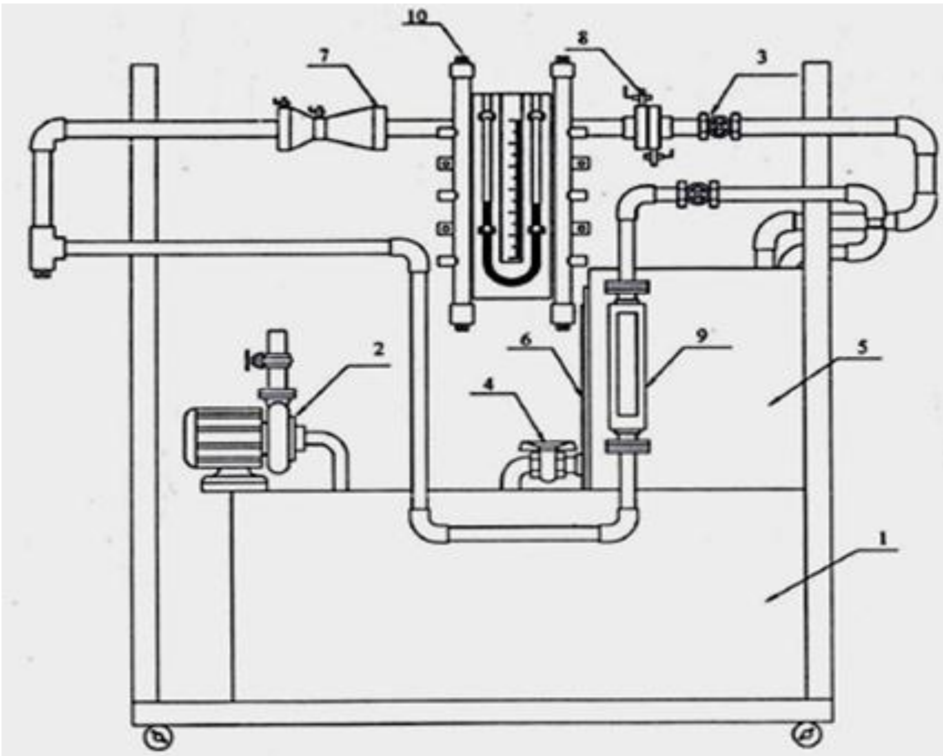
- Calibration of Venturimeter and Orifice meter at different flow rate.
- Determination of Co-efficient of Discharge through Venturimeter and Orifice meter.

PROCEDURE:

1. Fill in the sump tank with clean water.
2. Keep the delivery valve closed and manometer valve at open position.
3. Connect the power cable to 1Ph, 220V, 10 Amps with earth connection.
4. Switch on the pump & open the delivery valve.
5. Open the corresponding Ball valve of the Venturi or Orifice meter pipeline.
6. Adjust the flow through the control valve of the pump.
7. Open the corresponding Ball valves fitted to Venturi or Orifice tappings.

8. Note down the differential head reading in the Manometer. (Expel if any air, by opening the drain cocks provided with the Manometer.)
9. Operate the Butterfly valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken.
10. Change the flow rate and repeat the experiment.

EXPERIMENTAL SETUP:



1. Sump tank
2. Supply Pump
3. Flow control valve
4. Drain valve
5. Collecting tank
6. Gauge glass
7. Venturimeter
8. Orifice meter
9. Rota meter.
10. Manometer

Fig: Venturimeter and Orifice meter experimental set

TABULAR COLUMNS:

Sl. No	Type	Manometer Reading			T, sec	H = h×12.6, m of H_2O	Q_A m^3/sec	Q_T m^3/sec	C_D	Average „C_D"
		h_1, mm of Hg	h_2, mm of Hg	h = (h_1- h_2), mm of Hg						
1	Venturi Meter									
2										
3										
1	Orifice Meter									
2										
3										

CALCULATIONS:

1. Pressure Head, H

$$H = (h_1 - h_2) \times 12.6 \text{ m of water}$$

Where,

- h_1 = Manometric head in first limb
- h_2 = Manometric head in second limb
- s_m = Specific gravity of Manometric liquid, (i.e.) Liquid mercury Hg = 13.6
- s_1 = Specific gravity of flowing liquid water = 1
- 12.6 = conversion factor from mercury to water head

Basic Constants

1) Area of the measuring tank (A) =
2) Acceleration due to gravity (g) =
3) Diameter of inlet (D_1) =
4) Diameter of throat (D_2) =
5) Area of inlet (a_1) =
6) Area of throat (a_2) =
7) Specific gravity of manometer liquid (G_1) =
8) Specific gravity of water (G_2) =

Tabular Column

Trial No.	Monometer readings			Differential head	Measuring tank readings				Qa m^3/s	Qth m^3/s	(Cd)	Average of Cd
	X1 (mm)	**X2 (mm)**	**X (mm)**	**(H) m of water**	**FR**	**IR**	**R (m)**	Time (s)				
1												
2												
3												

Loss of head (H) = $x\left[\frac{G_1}{G_2}-1\right]$ = -------- m of water

Actual discharge (Q_a) = $\frac{A\,X\,R}{T}$ = -------- m^3/s

Theoretical discharge (Q_{th}) = $\frac{a_1 a_2\sqrt{2gH}}{\sqrt{{a_1}^2-{a_2}^2}}$= ------- m^3/s

Coefficient of discharge (C_d) = $\frac{Q_a}{Q_{th}}$

- d_1 = diameter of the pipe =.025m
- d_2 = throat/orifice diameter=.0125m
- g = Acceleration due to gravity = 9.81 m/s^2
- H = Total head.

Result: The average value of coefficient of discharge for a given venturimeter is =

The average value of coefficient of discharge for a given orifice meter is=

Discussion:

Reference:

Experiment 3: Determination of Hydraulic coefficients of a vertical orifice

Aim: To determine the hydraulic coefficients such as Cd, Cv and Cc of a given vertical orifice.

Apparatus: 1) Tank with controlled inflow from top and circular opening on side wall, 2) Orifice, 3) Measuring tank with a piezometer, 4) Stopwatch.

Theory: An orifice is an opening in the wall of tank or in a plate which may be fitted in a pipe such that the plate is normal to the pipe axis.

Usually an orifice has a sharp edge. Orifice and mouthpiece are used for the discharge measurement. The jet approaching the orifice or mouthpiece continues to converge beyond the entrance till the stream lines are parallel. This section of the jet is then, a section of minimum cross sectional area and is known as vena- contracta. Discharge is the function of the height of water above the center of the opening and cross sectional area of flow.

Procedure

1. Note down the diameter of orifice.
2. Admit the water into the head tank by opening the gate valves and wait till the steady conditions occurs and water head becomes constant.
3. Measure the head of water above the central line of the orifice (Piezometer reading).
4. Node down the horizontal and vertical coordinates using horizontal and vertical scales i.e., x and y co-ordinates at various points of the jet.
5. Note down the time required to fill particular height of water in the measuring tank.
6. Tabulate the readings and repeat the experiment for varying diameters of the orifice.
7. Calculate the hydraulic coefficients (C_d, C_v, and C_c).

Observations and calculations

Basic constants

Area of measuring tank = A= 0.054m^2

Diameter of the orifice =

Head of water = H =

Specimen calculations

Cross sectional area of jet = a= $\frac{\pi d^2}{4}$

Theoretical velocity = v_{th}=$\sqrt{2gh}$

Theoretical discharge = $Q_{th} = V_{th} X\ a$

Actual velocity = $V_a = \sqrt{\frac{gx^2}{2y}}$

Actual discharge = $Q_a = \frac{A\ X\ R}{T}$

Coefficient of discharge= $c_d = \frac{Q_a}{Q_{th}}$

Coefficient of velocity = $c_v = \frac{V_a}{V_{th}} = \frac{x}{\sqrt{2gh}}$

Coefficient of contraction = $c_c = \frac{C_d}{C_v}$

Tabular column

Diameter of orifice	Head of orifice	Measuring tank reading		Actual discharge	Theoretical discharge	Coefficient of discharge	Jet measurement with gauge		Actual velocity	Theoretical velocity	Coefficient of velocity	Coefficient of contraction
		Rise	Time									
(d) m	(H) m	(R) m	(T) s	(Q_a) m^3/s	(Q_{th}) m^3/s	C_d	(x) m	(y) m	(V_a) m/s	(V_{th}) m/s	C_v	C_c

Result: The average values of

1) Coefficient of discharge (C_d) =
2) Coefficient of velocity (C_v) =
3) Coefficient of contraction (C_c) =

Discussion:

Reference:

Experiment 4: Calibration of triangular notch (V-notch)

Aim: Conduct the experiment to calibrate the given V-Notch.

Apparatus: V-notch (90^o) fitted at the end of the approach channel, collecting tank, stop clock, Point gauge.

Theory: A notch is a device used for measuring the rate of flow of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening.

Procedure

1. Fix a V-notch at the end of approach channel with the sharp edge on the upstream side.
2. Fill the channel with water up to crest level and adjust the hook gauge reading to zero.
3. Adjust the flow by control valve till the head (H) over the sill of the notch remains constant. Note down the final gauge reading with respect to water level.
4. The difference between two gauge readings gives head of water (H).
5. Collect the water flowing over the notch in a measuring tank.
6. Record the time (T) for a known rise (R) of water in the measuring tank.
7. Vary the water level in the approach channel in stages and record the series of readings in each trial.

Observations and Calculations

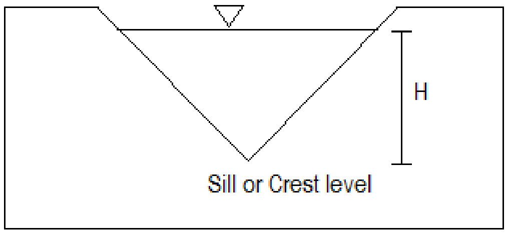


Fig: V- Notch

I. Basic Constants

Area of measuring tank (A) = 0.075m^2

Notch angle (θ) = 90^{o}

Acceleration due to gravity (g) = 9.81 m/s^2

II. Tabular Column

Sl No.	Point Gauge Reading (m)			Measuring Tank Reading (m)			Time (s)	Q_{th} m^3/s	Q_a m^3/s	Coefficient of discharge	Notch Constant	$\log Q_a$	$\log H$	$\log K$	Index Value
	IR	FR	H	IR	FR	R	T			C_d	(K)				n
1															
2															
3															

III. Specimen Calculations: Trial 1

1. Head of water over the sill level (H) = FR- IR= -------- m
2. Theoretical discharge

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

3. Rise of water in the measuring tank (R) = ------ m
4. Time taken for rise of water (T) = ------- s
5. Actual discharge

   $$Q_a = \frac{A\ X\ R}{T}\ \text{m}^3/\text{s}$$

6. Coefficient of discharge $C_d = \frac{Q_a}{Q_{th}}$
7. Notch constant $K = C_d\,\frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2}$
8. Index value (η)

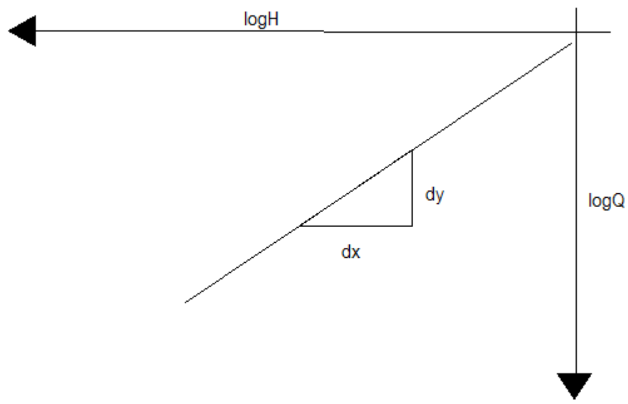
   $Q=KH^n$

   LogQ = LogK + nLogH

$$n = \frac{\log Q_a - \log K}{\log H}$$

Nature of Graph

When the Graph of log H v/s log Q_{th} is drawn it would be a straight line



Result

The Average value of coefficient of discharge obtained by i) Theoretical method (C_d) =

ii) graphical method (C_d) =

The Average value of Index value obtained by i) theoretical method (n) =

ii) graphical method (n) =

Discussion:

Reference:

Experiment 5: Determination of Cd for Cipolletti notch

Aim: To determine the co-efficient of discharge (C_d), notch constant (K) and index value (n) of discharge equation for the given rectangular and cipolletti notch.

Apparatus: Rectangular notch plate, cipolletti notch plate fitted at the end of the approach channel, collecting tank, stop clock, Point gauge, Caliper or a scale.

Theory: A notch is a device used for measuring the rate of flow of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening.

Procedure

1. Fix a rectangular or cipolletti notch at the end of approach channel with the sharp edge on the upstream side.
2. Fill the channel with water up to crest level and adjust the hook gauge reading to zero.
3. Adjust the flow by control valve till the head (H) over the sill of the notch remains constant. Note down the final gauge reading with respect to water level.
4. The difference between two gauge readings gives head of water (H).
5. Collect the water flowing over the notch in a measuring tank.
6. Record the time (T) for a known rise (R) of water in the measuring tank.
7. Vary the water level in the approach channel in stages and record the series of readings in each trial.

Observations and Calculations

1. **Rectangular Notch**

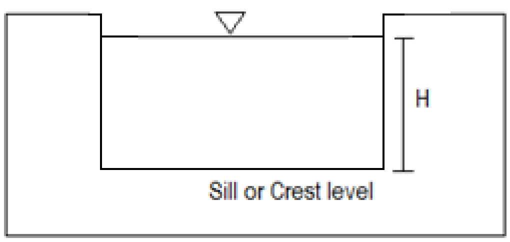


Fig: Rectangular Notch

I. **Basic Constants**

Area of measuring tank (A) = 0.075m^2

Crest length (L) = 0.07m

Acceleration due to gravity (g) = 9.81 m/s^2

II. Tabular Column

Sl No.	Point Gauge Reading (m)			Measuring Tank Reading (m)			Time (s)	Q_{th}	Q_a	Coefficient of discharge	Notch Constant	$\log Q_a$	$\log H$	$\log K$	Index Value
	IR	FR	H	IR	FR	H	T	m^3/s	m^3/s	C_d	(K)				n
1															
2															
3															

III. Specimen Calculations

1. Head of water over the sill level (H) = FR- IR= -------- m
2. Theoretical discharge

   $$Q_{th} = \frac{2}{3}\sqrt{2g}\, L\, H^{\frac{3}{2}}$$

3. Rise of water in the measuring tank (R) = ------ m
4. Time taken for rise of water (T) = ------- s
5. Actual discharge

   $$Q_a = \frac{A\ X\ R}{T}$$

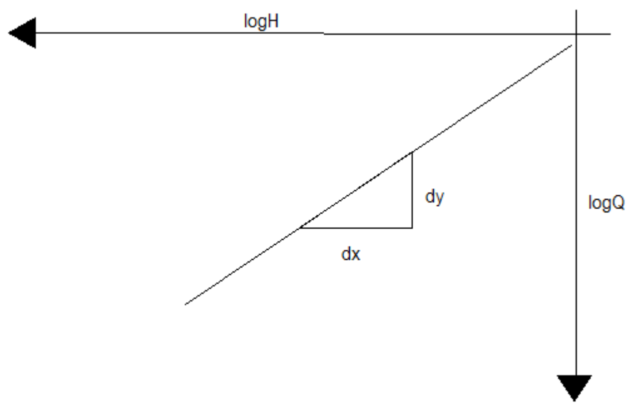
6. Coefficient of discharge $C_d = \frac{Q_a}{Q_{th}}$
7. Notch constant $K = C_d\ \frac{2}{3}\sqrt{2g}\ L$
8. Index value (η)

   $$\mathrm{n} = \frac{\log Q_a - \log K}{\log H}$$

Nature of Graph

When the Graph of log H v/s log Q_{th} is drawn it would be a straight line

$$\log Q = \log C_d + n \log H$$



Result

The Average value of coefficient of discharge obtained by theoretical method (C_d) =

The Coefficient of discharge obtained by graphical method (C_d) =

The Average value of Index value obtained by theoretical method (n) =

The Index value obtained by graphical method (n) =

2. Cipolletti Notch

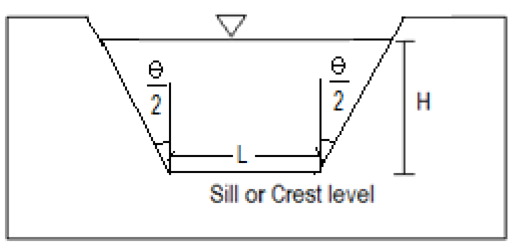


Fig: Cipolletti Notch

I. Basic Constants

Area of measuring tank (A) = $0.075 m^2$

Crest length (L) = 0.07m

Notch angle (θ) = 30^o

II. Tabular Column

Sl No.	Point Gauge Reading (m)			Measuring Tank Reading (m)			Time (s)	Q_{th}	Q_a	Coefficient of discharge	Notch Constant	$\log Q_a$	$\log H$	$\log K$	Index Value
	IR	FR	H	IR	FR	H	T	m^3/s	m^3/s	C_d	(K)				n
1															
2															
3															

III. Specimen Calculations

1. Head of water over the sill level (H) = FR- IR= -------- m
2. Theoretical discharge

$$Q_{th} = \sqrt{2g}\, H^{\frac{3}{2}} \left[\frac{8}{15} \tan\frac{\theta}{2} H + \frac{2}{3} L\right]$$

3. Rise of water in the measuring tank (R) = ------ m
4. Time taken for rise of water (T) = ------- s
5. Actual discharge

$$Q_a = \frac{A\ X\ R}{T}$$

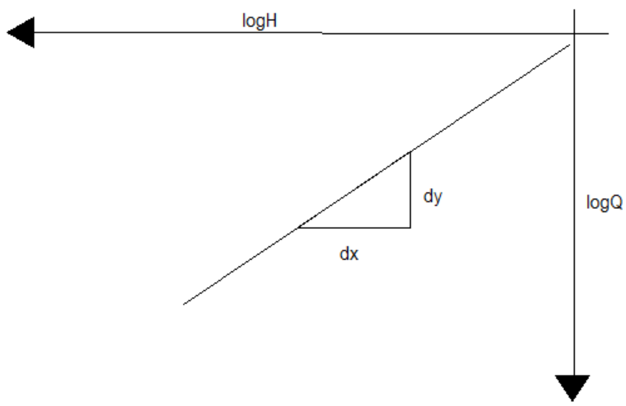
6. Coefficient of discharge $C_d = \frac{Q_a}{Q_{th}}$
7. Notch constant $K = C_d\sqrt{2g}\left[\frac{8}{15} \tan\frac{\theta}{2} H + \frac{2}{3} L\right]$
8. Index value (η)

$$\text{n} = \frac{\log Q_a - \log K}{\log H}$$

Nature of Graph

When the Graph of log H v/s log Q_{th} is drawn it would be a straight line

$$\log Q = \log C_d + n \log H$$



Result

The Average value of coefficient of discharge obtained by theoretical method (C_d) =

The Coefficient of discharge obtained by graphical method (C_d) =

The Average value of Index value obtained by theoretical method (n) =

The Index value obtained by graphical method (n) =

Discussion:

Reference:

EXPERIMENT NO – 06

DETERMINATION OF MAJOR LOSSES IN PIPES

INTRODUCTION:

A pipe may be of various diameters and may have bends, valves, etc. When a liquid is flowing through such pipes, the velocity of the liquid layer adjacent to the pipe wall is zero. The velocity of the liquid goes on increasing from the wall and hence shear stresses are produced in the liquid due to viscosity. This viscous action causes loss of energy, which is usually known as Frictional loss. Here, we are going to consider two important losses that occur during flow,

- Major Losses.
- Minor Losses.

Major losses occur due to friction. This friction may be due to viscosity or roughness in the pipe. Minor losses can be due to various reasons such as Inlet and Outlet of the pipe, bends, gates, sudden expansions and contractions.

The apparatus is designed to study the friction losses that appear in long pipes and the obstructions that are encountered in the way of flow by various types of fittings.

Friction is the resistance to motion which is set up when two moving surfaces come in contact with each other or a moving surface come in contact with a stationary surface. A pipe may be defined as a closed conduit (i.e. a conductor) or a long hollow cylinder (tube) for conveying liquids. A pipe is usually made from wrought steel, wrought iron, cast iron, alloys, seamless steel, copper, brass, plastic or cement. Liquids flowing through pipes are encountered with resistance resulting in loss of head or energy of liquids. The resistance is of two types, viz., viscous resistance which is due to the viscosity of the fluid and resistance due to the shear forces between fluid particles and pipe surface. However this frictional resistance depends on the type of flow namely laminar and turbulent.

Laws of fluid friction for laminar flow: The frictional resistance is

- Proportional to the velocity of flow
- Proportional to the area surface in contact

- Affected by variation of temperature
- Independent of pressure and nature of surface in contact.

Laws of fluid friction for turbulent flow: The frictional resistance is

- Proportional to V^n ($n \cong 2$)
- Proportional to density
- Proportional to area of surface in contact
- Independent of pressure.

DESCRIPTION OF THE APPARATUS:

1. The apparatus has 4 different specially made pipelines comprising of
    - 1" G.I (0.0254m)
    - 3/4" G.I(0.0192m)
    - 1/2" G.I(0.0127m)
    - 1" PVC(0.00254m)

2. All these are mounted on interchangeable lines for operation with necessary Pressure tappings at appropriate positions and Ball valves which is connected to a Manometer.
3. A measuring tank is provided to measure the flow rate.
4. Piezometer is provided to measure the height of the water collected in the measuring tank.
5. Mercury filled Manometer made of Acrylic is provided to measure the pressure difference.
6. Butterfly valve is provided in the measuring tank for instant close and release.
7. Overflow arrangement is also provided to the tanks.

A supply pump (Kirloskar/Sharp make) with starter is provided for supplying the water

8. A supply tank is provided to store the water.
9. Vinyl sticker scale is provided for both Manometer and Piezometer for betterreadability.
10. The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS angle with all the provisions for holding the tanks and accessories.

AIM: The experiment is conducted to determine:

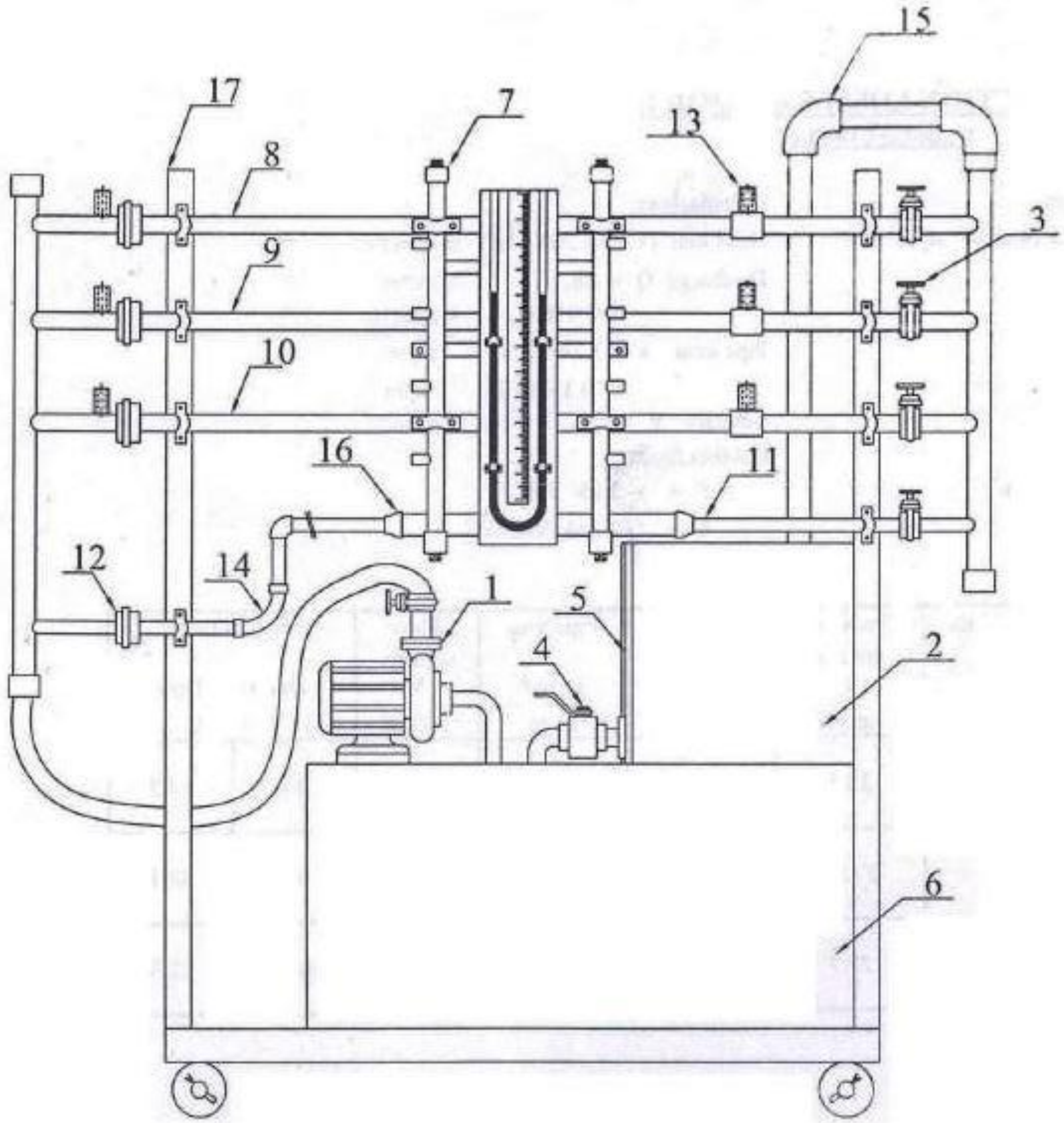
- Determination of Pressure drop and friction co-efficient across different pipes.
- Comparative analysis of different type of pipes.

PROCEDURE:

1. Fill in the sump tank with clean water.
2. Keep the delivery valve closed and manometer valve at open position.
3. Check and give necessary electrical connections to the system.
4. Switch on the pump & open the delivery valve.
5. Open the corresponding Ball valve of the pipeline.
6. Adjust the flow through the control valve of the pump.
7. Open the corresponding Ball valves of the Pipeline in study.(Make sure that all valves of other fittings to be in closed position)
8. Note down the differential head reading in the Manometer. (Expel if any air is the by opening the drain cocks provided with the Manometer.)
9. Operate the Butterfly valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken.
10. Change the flow rate and repeat the experiment.

Experimental set up:

Fig: Frictional losses test rig



1. Supply pump
2. Sump tank
3. Flow control valve
4. Drain valve
5. Gauge glass
6. Collecting tank
7. Manometer
8. Copper pipe
9. Aluminium pipe
10. Stainless Steel pipe
11. Minor losses pipe
12. M.S Union
13. M.S Coupling
14. Bend
15. Elbow
16. Reducer
17. Support Stand

OBSERVATIONS:

Sl. No	Diameter of the pipe in, m	Manometer Reading			$h_f = h \times 12.6$, m of H_2O	T, sec	Q, m^3/sec	V, m/sec	f	Re	Type of flow
		h_1, mm of Hg	h_2, mm of Hg	h = (h_1 - h_2), mm of Hg							
1	1/2" GI Pipe										
2											
3											
1	3/4" GI Pipe										
2											
3											
1	1" GI Pipe										
2											
3											
1	1" PVC Pipe										
2											
3											

CALCULATIONS:

1. **TOTAL HEAD**, h_f

Where, $h_f = (h_1 - h_2) \times 12.6$ m of water

12.6 = conversion factor from mercury to water head

2. DISCHARGE, Q

Where,
$$Q = \frac{A \times R}{T}$$

Q in m^3/s

- A = Area of collecting tank = 0.05 m^2.
- R = Rise in water level of the collecting tank, m.
- T = time for „R" cm rise of water, sec

3. VELOCITY, V=Q/A

V is in m/s

- a= area of the pipe in use = $\frac{\pi \times d^2}{4}$
- d= diameter of the pipe, m

4. **FRICTION FACTOR, F:**

$$f = \frac{2gh_f}{4LV^2}$$

Where,

- h_f= total head, m of water
- V = velocity of water flow in pipe, m
- g = acceleration due to gravity, 9.81m/s²
- L = Distance b/w tapping = 1.5m

5. **Reynolds Number,**

$$Re = \frac{\rho V d}{\mu}$$

- ρ = Mass density of water = 1000 kg/ m^3
- μ = dynamic viscosity of water = 1.0 x 10^{-3} N-S / m^2

RESULTS: The average frictional factor f for given pipe

- 1/2" pipe = ____________________
- 3/4" pipe = ____________________
- 1" pipe = ____________________

Experiment 7: Calibration of Cd for ogee / broad crested weir

Aim: To determine the co-efficient of discharge (C_d) for a given weir.

Apparatus: Broad crested, sharp crested and ogee weir are fitted at the end of the approach channel, collecting tank, stop clock, Hook gauge.

Theory: A notch is a hydraulic device used for measuring the rate of flow of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening. It is made of metallic plate. On the other hand weir is a hydraulic structure placed in an open channel over which flow occurs. It runs all the way across the channel in the form of a wall and has a sharp top edge. It is generally concrete or masonry structure. Weirs are classified as rectangular, triangular and trapezoidal weirs on the basis of openings. On the basis of shape of the crest weirs are classified as sharp crested weir (SCW), Broad crested weir (BCW), Ogee weir (OW).

Procedure

1. Fill in the sump with clean water.
2. Fix the weir on the weir tank.
3. Keep the delivery valve one fourth open and Switch on the pump.
4. Adjust the flow rate at required head.
5. Allow some time, so as water to stabilize (Constant head)
6. Note down the head at weir using hook gauge.
7. Operate butterfly valve to note down collecting tank reading against known time.
8. Change the flow rate and repeat the experiment for different heads of weir.

Observations and Calculations

I. Basic Constants

Area of measuring tank = $0.075 m^2$

1. <u>Broad Crested weir</u>

Width of the weir (w) = 60mm

Breadth of weir (B) = 120mm

Length of weir (L) = 147mm

2. <u>Sharp Crested weir</u>

Width of the weir (w) = 70mm

Breadth of weir (B) = 35mm

Length of weir (L) = 147mm

3. **Ogee weir**

Width of the weir (w) = 78mm

Breadth of weir (B) = 75mm

Length of weir (L) = 147mm

II. Specimen Calculation

Actual discharge $Q_a = \frac{A\ X\ R}{T}$

Theoretical discharge

For BCW, $Q_{th} = \frac{2}{3} L H^{\frac{3}{2}}$

For OW, $Q_{th} = \frac{2}{3} L \sqrt{2g} H^{\frac{3}{2}}$

For SCW, $Q_{th} = \frac{2}{3} L \sqrt{2g} H^{\frac{3}{2}}$

Trial No.	Type of weir	Measuring tank readings		Hook gauge readings			Qa m^3/s	Qth m^3/s	Coefficient of discharge (Cd)	Average of Cd
		Rise (R) m	**Time (T) s**	**FR**	**IR**	**H**				
1	Sharp crested weir									
2										
3										
4										
1	Broad crested weir									
2										
3										
4										
1	Ogee weir									
2										
3										
4										

RESULT

The average value of coefficient of discharge for sharp crested weir (Cd) =

The average value of coefficient of discharge for broad crested weir (Cd) =

The average value of coefficient of discharge for Ogee weir (Cd) =

Experiment 8: DETERMINATION OF EFFICIENCY OF A JET ON FLAT AND CURVED VANES

AIM: To determine the co-efficient of impact of jet by comparing the momentum in a fluid jet with the force generated when it strikes a fixed surface/ vane.

APPARATUS: Force analog indicator, rotometer, water supply [provision to hit the vane bottom]

THEORY: When the jet of water is directed to hit the vane, the force is exerted in the opposite direction of the jet. The amount of force exerted depends on diameter of jet, shape of vane, density of fluid, rate of supply. The vane can be stationary or movable. As far as this experiment is concerned, the vanes are stationary.

PROCEDURE

1. Fix the required diameter of the jet and required shape of the vane and adjust the force analog indicator to zero.
2. Close the delivery valve and switch off the system.
3. Tighten the transparent covers carefully.
4. Switch on and open the delivery valve.
5. Adjust the rate of flow and record as indicated by rotometer.
6. Record the force (Fa) as indicated by force analog indicator.
7. Note down the diameter of the jet, type of vane, rate of flow and force exerted and then tabulate.

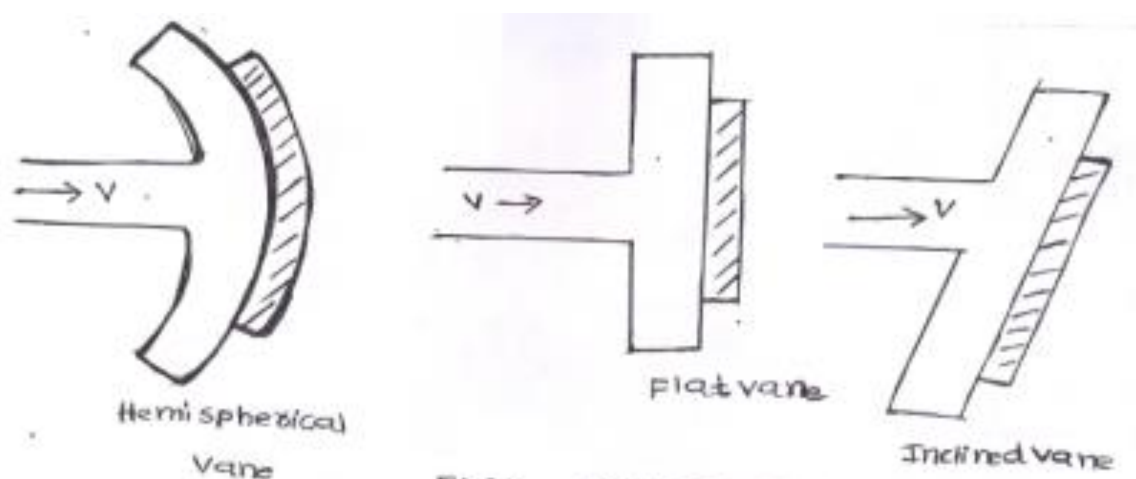


FIG: Impact of jet-on vanes.

OBSERVATION AND CALCULATION

BASIC CONSTANTS

1) Density of water (ρ) =
2) Diameter of the jet (d) =

3) Acceleration due to gravity (g) =
4) Angle between jet and vane (θ) =

SPECIMEN CALCULATION

I Flat vane

1) Cross sectional area of jet (A) =
2) Discharge = Q =
3) Velocity of jet = V = $\frac{Q}{A}$ =
4) Actual force as indicated by force analog indicator = Fa =
5) Theoretical force exerted by jet = F_{th} = $\rho A v^2$
6) Co-efficient of impact on jet vane combination = K = $\frac{F_a}{F_{th}}$

II Inclined vane

1) Cross sectional area of jet (A) =
2) Discharge = Q =
3) Velocity of jet = V = $\frac{Q}{A}$ =
4) Actual force as indicated by force analog indicator = Fa =
5) Theoretical force exerted by jet = F_{th} = $\rho A v^2 \sin^2\theta$
6) Co-efficient of impact on jet vane combination = K = $\frac{F_a}{F_{th}}$

III Curved vane

1) Cross sectional area of jet (A) =
2) Discharge = Q =
3) Velocity of jet = V = $\frac{Q}{A}$ =
4) Actual force as indicated by force analog indicator = Fa =
5) Theoretical force exerted by jet = F_{th} = $2\rho A v^2$
6) Co-efficient of impact on jet vane combination = K = $\frac{F_a}{F_{th}}$

TABULAR COLUMN

Type of vane	Dia of jet on vanes	Rate of flow (Q)		Gauge pressure	Actual Force (Fa)		Theoritical Force (F_{th})		Coefficient K = $\frac{F_a}{F_{th}}$	Average (K)
	(mm)	LPM	m^3/s	Kg/cm^2	Kg-F	N	Kg-F	N		
Flat										
Inclined										
Curved										

RESULT

The average values of co-efficient of impact of jet vane combination

i) Flat vane =

ii) Inclined vane =
iii) Curved vane =

Experiment 9: Determination of Cd of Venturiflume

Aim: Conduct the experiment to calibrate the given venturiflume

Apparatus: 1) Measuring tank to measure the flow rate, 2) A pipeline with venturimeter, 3) A constant steady supply of water with a means of varying the flow rate using monoblock pump, 4) Tapping with ball valve are provided at inlet and outlet of venturimeter, 5) Manometer, 6) stop watch.

Theory: A venturimeter is a device which is used to measure the rate of flow of fluid flowing through pipeline. Bernoulli's equation is applied in all problems of incompressible fluid flow. One of the measuring devices where Bernoulli's equation is applied is venturimeter.

The basic principle on which a venturimeter works is that by reducing the cross sectional area of flow passage, a pressure difference is created between the inlet and the throat and the measurement of pressure difference enables the determination of discharge through the pipe.

Procedure

1. Note down the diameter of the pipe at the inlet and throat.
2. Fill the sump with clean water.
3. Keep the delivery valve closed and Check the manometer connections.
4. Switch on the pump and open the delivery valve.
5. Open the corresponding ball valve of venturimeter.
6. Adjust the flow through controlling valve of pump.
7. Note down the manometer reading 'h'. expel air bubbles if any, using drain/air valve provided in the manometer.
8. Operate butterfly valve and using stop clock, note down the time in seconds, taken by water for known rise.
9. Change the flow rate and repeat the experiment

OBSERVATION AND CALCULATION

A venturimeter consists of

1) An inlet section followed by a convergent cone
2) A cylindrical throat
3) A gradually divergent cone

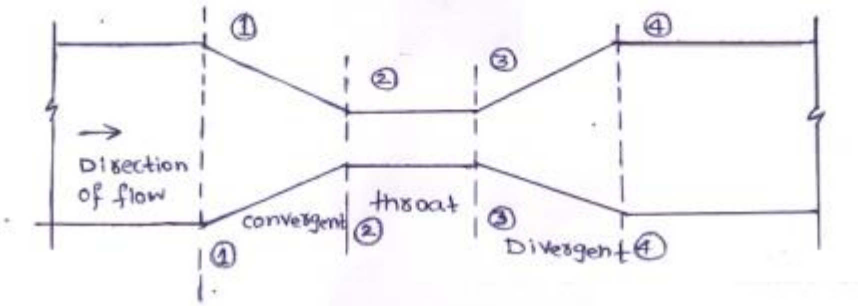


FIG: VENTURIMETER.

Basic Constants

9) Area of the measuring tank (A) =

10) Acceleration due to gravity (g) =

11) Diameter of inlet (D_1) =

12) Diameter of throat (D_2) =

13) Area of inlet (a_1) =

14) Area of throat (a_2) =

15) Specific gravity of manometer liquid (G_1) =

16) Specific gravity of water (G_2) =

Tabular Column
Specimen Calculation

Trial No.	Monometer readings			Differential head	Measuring tank readings				Qa m^3/s	Qth m^3/s	(Cd)	Average of Cd
	X1 (mm)	**X2 (mm)**	**X (mm)**	**(H) m of water**	**FR**	**IR**	**R (m)**	Time (s)				
1												
2												
3												

Loss of head (H) = $x\left[\frac{G_1}{G_2} - 1\right]$ = -------- m of water

Actual discharge (Q_a) = $\frac{A \, X \, R}{T}$ = -------- m^3/s

Theoretical discharge (Q_{th}) = $\frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1{}^2 - a_2{}^2}}$= ------- m^3/s

Coefficient of discharge (C_d) = $\frac{Q_a}{Q_{th}}$

Result: The average value of coefficient of discharge for a given venturimeter is =

Discussion:

Reference:

EXPERIMENT 10: DEMO DETERMINATION OF EFFICIENCY OF CENTRIFUGAL PUMP

AIM: To find the efficiency of the pump under different condition.

APPARATUS: Single stage centrifugal pump, measuring tank, stop clock etc.

THEORY: In general, pump may be defined as a mechanical device which when interposed in a pipeline converts the energy supply to it from external sources into hydraulic energy, thus resulting in the flow of liquid from lower to higher potential. The pumps are of major concern to most engineers and technicians. The type of pump varies in principle and design. The selection of pump for any particular type of applications is done by understanding their characteristics. The most commonly used pumps for domestic, industrial and agricultural purposes are centrifugal, pistons, axialflow, air jet, diaphragm and turbines. Most of these pumps fall into main class viz rotodynamic, reciprocating (air – operated pump).Centrifugal pump falls in to category of rotodynamic pumps. In this pump, liquid is made to rotate in closed chamber (volute casing) thus creating a centrifugal action which gradually builds pressure gradient towards output or input and results in continuous flow. These pumps when compared to reciprocating pumps are simple in construction and more suitable for handling viscous – turbid fluids. They are directly coupled to high speed electronic motors. They are easy to maintain, but their hydraulic load stage at low rate is not suitable for very high heads as compared to reciprocating pump. But in most of the cases, this is only the type of pump widely used for agricultural application because of its practical suitability. The present study is to understand or draw operation characteristics at various heads.

PROCEDURE

1. Fill the sump with clean water.
2. Keep the delivery and suction valve closed. Open after initially priming of the pump.
3. Switch on the mains so that the ‘ON’ indicator glows.
4. Now, switch on the motor.
5. Set the speed using the drive provided.
6. Note down the pressure gauge, vacuum gauge, torque indicator and time for number of revolutions of energy meter disc (5).
7. Note down the speed using digital RPM indicator.
8. Operate the butterfly valve to note down the collecting tank readings for a known time.
9. Repeat the experiment for different discharges.
10. After the experiment tabulate the readings and calculate the results.
11. Plot the graph of discharge versus head.

OBSERVATION AND CALCULATION

I. BASIC CONSTANTS

1. 1HP = 745watts (N-m/s)
2. 1Kg/cm^2 = 760mm of Hg = 10m of water
3. Density of water (ρ) = 1000Kg/m^3
4. Energy meter constant = 1600 rev/kW – hr
5. Area of measuring tank (A) = 0.11m^2

II. SPECIMEN CALCULATION

1. Speed = ------- RPM
2. Delivery pressure (P) = --------- Kg/cm^2
3. Suction pressure (Pv) = -------- mm of Hg
4. Time taken for 5 blinks in energy meter (t) = ------- s
5. Actual discharge, $\boldsymbol{Q} = \frac{\boldsymbol{A\ x\ R}}{\boldsymbol{T}}$ = ------ m^3/s
6. Electrical power as indicated by energy meter

   $$\boldsymbol{HP_{ele}} = \frac{\boldsymbol{nx1000x60x60}}{\boldsymbol{1600x20x1000}} = \text{---------} \ kW$$

7. $HP_{shaft} = Hp_{ele}$ X 0.6 = -------- kW

   Where, n = number of blink in energymeter.

   t = Time taken by energymeter for n blinks in seconds

   0.6 = transmission efficiency

   1600 = energymeter constants

8. Total head (H) = [10 (Delivery pressure + vacuum pressure)] +x

   $$H = [10\left(\boldsymbol{P} + \frac{\boldsymbol{P_v}}{\boldsymbol{760}}\right) + x] = \text{----------} \ m$$

Where, P = Delivery pressure in Kg/cm^2

P_v = Vacuum pressure in mm of Hg.

X = 0.7

9. Hydraulic Power (Delivery by the pump)

   $$\boldsymbol{HP_{pump}} = \frac{\boldsymbol{WQH}}{\boldsymbol{1000}} = \text{--------} \ kW$$

10. Pump Efficiency (η)

$$\eta = \frac{HP_{pump}}{HP_{shaft}} \text{ X } 100 = \text{------ } \%$$

Belt Position	Speed in RPM	Delivery Pressure (P) in kg/cm^2	Suction pressure (Pv) in mm of Hg	Time taken for 5 blinks in energy meter (t) in seconds	Rise in water level (R) in m	Time taken for rise (T) in second	Discharge (Qa) in m^3/s	Power output HP_{pump} in (kW)	Power motor HP_{ele} in (kW)	Total Head (H) in m	HP_{shaft} (kW)	η (%)	average η (%)
1													
2													
3													

Graph: Discharge (x –axis) versus Head (y – axis)

Result: 1) The average value of efficiency of pump at belt position 1 = --------- %

2) The average value of efficiency of pump at belt position 2 = --------- %

3) The average value of efficiency of pump at belt position 3 = --------- %

Experiment 10: DEMO DETERMINATION EXPERIMENT ON KAPLAN TURBINE/FRANCIS TURBINE

Aim: To study the performance characteristics of the Kaplan turbine

Instrument used: Centrifugal pump, Turbine unit, Sump tank, Venturimeter, Energy meter, Digital RPM indicator, Pressure gauge.

Theory: Hydraulic turbines are the machines which are using the energy of water and convert it into mechanical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce electricity i.e., hydroelectric power.

The turbines are classified as impulse and reaction turbine. In impulse turbine the head of water is completely converted into a jet which impulses the force on the turbine. In reaction turbine it is the pressure of the flowing water, which rotates the runner of the turbine. Normally Pelton wheel (Impulse turbine) requires high head and low discharge, while Kaplan (reaction turbine) requires relatively low head and high discharge.

General Procedure (Operation Characteristics)

1. Keep the gate valve closed and switch ON the MCB.
2. Ensure that all the three indicators are glowing.
3. Keep the electrical load at zero by keeping all switches in OFF position.
4. Keep the blade for the required position by adjusting the wheel (1/4, ½, ¾ and full open).
5. Press the green button on the supply pump starter and then release.
6. Slowly open the gate so that the turbine rotor picks up the speed and attains the maximum at particular opening of the gate. Also ensure motor is running in correct direction.
7. Apply the load by switching ON each switch at a time (or in bunch).
8. Note down the venturimeter pressures, time for 5 blinks in energy meter, speed, pressure and vacuum on the motors at the control panel and tabulate results.
9. After completion of the experiment remove the load by switching off all the electrical switches.
10. Close the gate and then switch off the supply water pump set.
11. Follow the procedure described below for taking down the reading for evaluating the performance characteristics of the Kaplan turbine.

To Obtain Constant Speed Characteristics

1. Keep the propeller vane opening at maximum or any desired position.

2. For different electrical loads on the turbine/ generator; change the gate position so that the speed is held constant. See that the voltage does not exceed 230V to avoid excess voltage on heater.
3. The above readings will be utilized for drawing constant speed characteristics.

To obtain Constant head Characteristics

1. Select the blade angle position
2. Keep the gate closed and start the pump.
3. Slowly open the gate and set the pressure on gauge.
4. For different electrical loads, change the rotor pitch position and maintain the constant head and tabulate the results given in the table.

Observation and Calculation

I. Basic Constants

Diameter of venturimeter Inlet (d_1) = 0.15m

Diameter of venturimeter Outlet (d_2) = 0.075m

Coefficient of discharge (C_d) = 0.98

Transmission efficiency (η) = 0.7

II. Specimen Calculation

i. Electrical Power as indicated by energy meter

$$BP_{ele} = \frac{n\ X\ 1000\ X\ 60\ X\ 60}{1600\ X\ t}$$

Where, t = time taken by energy meter for n blinks in seconds

ii. $BP_{shaft} = \frac{BP_{ele}}{0.7}$

Where, n = no. of blinks of energy meter device

0.7 = Transmission efficiency

iii. Head on turbine (H) = $[10\left(P + \frac{P_v}{760}\right)]$ m of water

Where, P_1 = Venturi inlet pressure gauge reading (Kg/ cm^2)

Pv = Vacuum Pressure mm of Hg

iv. Flow rate of water through the turbine (Q_{th})

$$Q = \frac{C_d\ X\ a_1\ X\ a_2\ X\sqrt{2gH_v}}{\sqrt{a_1{}^2 - a_2{}^2}}\ m^3/s$$

H_v = 10 X h m of water

Where, h = (P_1 – P_2) Kg/ cm^2

P_1 = Inlet pressure in Kg/ cm^2

P_2 = Throat pressure in Kg/ cm^2

v. Hydraulic input to the turbine (P_{hyd})

$$P_{hyd} = \frac{wQH}{1000}\ kW$$

Where, w= Specific weight of water = 9810 N/m^3

Q = Discharge in m^3/s

H = head on the turbine in m of water

vi. Turbine Efficiency (η)

$$\eta = \frac{BP_{shaft}}{P_{hyd}}\ X\ 100$$

UNIT QUANTITIES – UNDER UNIT HEAD

vii) Unit speed $N_u = \frac{N}{\sqrt{H}}$ RPM

Where, N = speed in RPM

H = Head in m

viii) Unit Power $P_u = \frac{P}{H^{3/2}}$ kW

Where, P = Output Power (BP_{shaft}) Watts

H = Head in m

ix) Unit discharge $Q_u = \frac{Q}{\sqrt{H}}$ m^3/s

Where, Q = Discharge in m^3/s

H = Head in m

x) Specific Speed $N_u = \frac{N\sqrt{P}}{H^{5/4}}$

Where, N = speed in RPM

H = Head in m

P = Output Power (BP_{shaft}) Watts

xi) Percentage full load = $\frac{Part\ load\ BP}{Max\ load\ BP}\ X\ 100$

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Tabular Column: Constant Head Condition

Valve Opening	No. of Bulbs ON	Speed	No. of blinks of energy meter	Time for n no. of blinks	Suction Pressure at inlet	Pressure at throat	Pressure at inlet	Input power	Power o/p	Head	Discharge	Hydraulic power	Efficiency	Unit Speed	Unit Power	Unit Discharge	Specific speed	% full load
		(N) in RPM	(n)	t (sec)	(Pv) in Kg/cm^2	(P_2) in Kg/cm^2	(P_1) in Kg/cm^2	(BPele) (Watts)	(BP_{shaft}) kW	(H) in m	(Q) in m^3/s	(P_{hyd}) kW	(η) in %	Nu	Pu	Qu	Ns	
Full open																		
3/4th open																		
½ open																		
1/4th open																		

Tabular Column: Constant Speed Condition

Valve Opening	No. of Bulbs ON	Speed	No. of blinks of energy meter	Time for n no. of blinks	Suction Pressure at inlet	Pressure at throat	Pressure at inlet	Input power	Power o/p	Head	Discharge	Hydraulic power	Efficiency	Unit Speed	Unit Power	Unit Discharge	Specific speed	% full load
		(N) in RPM	(n)	t (sec)	(Pv) in Kg/cm^2	(P_2) in Kg/cm^2	(P_1) in Kg/cm^2	(BPele) (Watts)	(BP_{shaft}) kW	(H) in m	(Q) in m^3/s	(P_{hyd}) kW	(η) in %	Nu	Pu	Qu	Ns	
Full open																		
3/4th open																		
½ open																		
1/4th open																		

Graph: i) For Constant head Condition: a) Unit speed versus Unit discharge

b) Turbine efficiency versus unit speed

ii) For Constant Speed Condition : a) Discharge versus Efficiency

b) Discharge versus BP

c) Full load versus efficiency

Result: Efficiency of Kaplan wheel

1) By Constant head method = -------- %
2) By Constant Speed method = --------- %

Experiment 11: DEMO EXPERIMENTAL DETERMINATION OF OPERATING CHARACTERISTICS OF PELTON WHEEL

Aim: To investigate the performance of the Pelton turbine and to obtain the main characteristic curves and operating characteristic curves

Equipment: Pelton wheel with accessories, Pump, Energy meter, venturimeter, Bulb bank.

Salient features: The experiment set-up consists of Multi stage Centrifugal Pump set. Turbine Unit, Sump Tank, Water circulating pipe system with venturimeter, The Centrifugal Pump set supplies the water from the Sump Tank to the Turbine through Control Valve, (which has venturimeter to the known quantity of water). The loading of the Turbine is achieved by Electrical loading. The provision for the measurement of Turbine Speed (Digital RPM Indicator), Head on Turbine (Pressure Gauge) are built-in on the Control Panel.

Principle: A Pelton wheel is an impulse, tangential flow, low specific speed and high head turbine which converts hydraulic energy into mechanical energy and then to electrical energy. The force exerted by a jet of water on the series of curved vanes (buckets) mounted on the wheel will induce the rotation of the runner.

Theory: In impulse turbine, the potential energy is converted into the kinetic energy by means of a convergence to a nozzle to create a free jet of water. Many a time multiple nozzles are used in the field.

Pelton wheel operates under a high head of water and hence requires a comparatively less quantity of water. Water is conveyed from the reservoir to the turbine through penstock. The penstock is connected to nozzle. A high velocity jet from the nozzle impinges on the buckets provided on the periphery of a wheel. A spear rod helps in varying the discharge by varying the flow area. In practice the buckets are usually spoon shaped, with a central ridge splitting the impinging jet into two halves which are deflected backwards after doing the work. The actual energy transferred by the jet to wheel is due to change of momentum of the flow. The water after imparting its energy to the turbine escapes into the tail race. As there is no pressure variation in flow, the fluid partly fills the buckets and the fluid remains in contact with the atmosphere.

Procedure

1. Keep the gate valve, sphere valve open and wheel valve closed (as the experiment is on the Pelton wheel turbine)
2. Keep the brakedrum loading at zero.

3. Press the green button of supply pump starter. Now the pump picks up the full speed and becomes operational.
4. Set the sphere valve to a required opening and also the gate valve in full open position so that the turbine rotor picks the speed and conduct experiment on constant speed and constant head.
5. Note down the speed, load and the pressure gauge readings.
6. Tabulate the readings.

A. For Constant Head Characteristics

1. Keep the sphere valve at particular position, gate valve at full open position and wheel valve in fully closed position.
2. For different brake load, note down the speed and the pressure gauge readings.
3. Tabulate the readings as per table given.
4. For different openings of the sphere valve repeat the experiment.

B. For Constant Speed Characteristics

1. Keep the sphere valve opening at required position ($1/4^{th}$,1/2 , $3/4^{th}$ and full opening).
2. For different brake drum loads on the turbine, change the wheel valve setting between maximum and minimum so that the speed is held constant.
3. Tabulate the readings as per the table given.
4. For different openings of the sphere valve conduct the experiment.

Observation and Calculation

I. Basic Constants

Diameter of venturimeter Inlet (d_1) = 0.049m

Diameter of venturimeter Outlet (d_2) = 0.0245m

Coefficient of discharge (C_d) = 0.98

Brake drum radius (r) = 0.15m

II. Specimen Calculation

i. Head on turbine (H) = 10 X P_1 m of water

Where, P_1 = Venturi inlet pressure gauge reading (Kg/ cm^2)

ii. Flow rate of water through the turbine (Q_{th})

$$Q = \frac{C_d \, X \, a_1 \, X \, a_2 \, X \sqrt{2gH_v}}{\sqrt{a_1{}^2 - a_2{}^2}} \text{ m}^3/\text{s}$$

H_v = 10 X h m of water

Where, h = (P_1 – P_2) Kg/ cm^2

P_1 = Inlet pressure in Kg/ cm^2

P_2 = Throat pressure in Kg/ cm^2

iii. Hydraulic input to the turbine (P_{hyd})

$$P_{hyd} = \frac{wQH}{1000}\ kW$$

Where, w= Specific weight of water = 9810 N/m^3

Q = Discharge in m^3/s

H = head on the turbine in m of water

iv. Brake power of the turbine (BP)

$$BP = \frac{2\pi NT}{60}\ \text{kW}$$

Where, N = speed in RPM

F_1 and F_2 = Loads in Kgf

T = (F_1 - F_2) X 9.81 X r

r = Brake drum radius = 0.15m

v. Turbine Efficiency (η)

$$\eta = \frac{BP}{P_{hyd}}\ X\ 100$$

UNIT QUANTITIES – UNDER UNIT HEAD

i) Unit speed $N_u = \frac{N}{\sqrt{H}}$ RPM

Where, N = speed in RPM

H = Head in m

ii) Unit Power $P_u = \frac{P}{H^{3/2}}$ kW

Where, P = Output Power (BP_{shaft}) Watts

H = Head in m

iii) Unit discharge $Q_u = \frac{Q}{\sqrt{H}}$ m^3/s

Where, Q = Discharge in m^3/s

H = Head in m

iv) Specific Speed $N_u = \frac{N\sqrt{P}}{H^{5/4}}$

Where, N = speed in RPM

H = Head in m

P = Output Power (BP_{shaft}) Watts

v) Percentage full load = $\frac{\boldsymbol{Part\ load\ BP}}{\boldsymbol{Max\ load\ BP}}\ \boldsymbol{X\ 100}$

Tabular Column: Constant Head Condition

Valve Opening	Spring balance Reading	Spring balance Reading	Speed	Pressure at throat	Pressure at inlet	h = $(P_1 - P_2)$	Head	Discharge	Power o/p	Hydraulic power	Efficiency	Unit Speed	Unit Power	Unit Discharge	Specific speed	% full load
	(F_1) in Kg	(F_2) in Kg	(N) in RPM	(P_2) in Kg/cm^2	(P_1) in Kg/cm^2	Kg/cm^2	(H) in m	(Q) in m^3/s	(BP_{shaft}) kW	(P_{hyd}) kW	(η) in %	Nu	Pu	Qu	Ns	
Full open																
3/4th open																
½ open																
1/4th open																

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Tabular Column: Constant Speed Condition

Valve Opening	Spring balance Reading	Spring balance Reading	Speed	Pressure at throat	Pressure at inlet	h = (P_1 - P_2)	Head	Discharge	Power o/p	Hydraulic power	Efficiency	Specific speed	% full load
	(F_1) in Kg	(F_2) in Kg	(N) in RPM	(P_2) in Kg/cm^2	(P_1) in Kg/cm^2	Kg/cm^2	(H) in m	(Q) in m^3/s	(BP_{shaft}) kW	(P_{hyd}) kW	(η) in %	Ns	
Full open													
3/4th open													
½ open													
1/4th open													

Graph: i) For Constant head Condition: Unit speed versus Unit discharge

ii) For Constant Speed Condition : a) Discharge versus Efficiency

b) Discharge versus BP

c) Efficiency versus full load

Result: Efficiency of Pelton wheel

1) By Constant head method = -------- %
2) By Constant Speed method = --------- %