SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF AGRICULTURE ENGINEERING

III SEMESTER

1902305 - FLUID MECHANICS LABORATORY

Regulation – 2019

Academic Year 2021 – 22

Prepared by

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PREFACE

This instruction manual has been prepared by the department of civil engineering to facilitate instructions during practical classes and further to be used as a reference manual by the agricultural engineering students of this college. This manual covers explanation of experiments included in the latest syllabus of autonomous regulation in fluid mechanics laboratory for the B.E degree course. Any suggestions for the improvement of the manual will be gratefully received.

Mrs.E.Maheswari,

1902305 FLUID MECHANICS LAB

L T P C

OBJECTIVES: **0 0 2 1**

- To have a knowledge on flow measurements using various devices.
- To give hands on experience on the flow through different types of notches.
- To gain experimental knowledge on computation of major losses in pipes.
- To train students on determination of minor losses in pipes.
- To study the characteristics of various pumps.

LIST OF EXPERIMENTS

1. FLOW MEASUREMENT

- Calibration of Rotameter
- Flow through Venturimeter
- Flow through a circular Orifice
- Determination of mean velocity by Pitot tube
- Flow through a Triangular Notch
- Flow through a Rectangular Notch

2. LOSSES IN PIPES

- Determination of friction coefficient in pipes
- Determination of losses due to bends, fittings and elbows

3. PUMPS

- Characteristics of Centrifugal pump
- Characteristics of Submersible pump
- Characteristics of Reciprocating pump

OUTCOMES:

1. The students will be able to measure flow through pipes.
2. The students will be able to measure flow in open channel.
3. The students will be able to compute the major and minor losses in pipes.
4. The students will be able to study the characteristics of pumps.
5. The students will be able to analyse the performance of pumps.

TOTAL: 30 PERIODS

REFERENCE BOOKS:

1. "Hydraulic Laboratory Manual", Centre for Water Resources,

   Anna University, 2004.
2. Modi P.N. and Seth S.M., "Hydraulics and Fluid Mechanics",

   Standard Book House, New Delhi, 2000.
3. Subramanya, K., "Flow in Open Channels", Tata McGraw - Hill Pub. Co.1992.
4. Subramanya, K., "Fluid Mechanics", Tata McGraw- Hill Pub. Co., New Delhi, 1992.

LIST OF EQUIPMENTS REQUIRED

- Rotameter – 1 no.
- Venturimeter – 1 no.
- Orifice meter – 1 no.
- Pitot tube – 1 no.
- Bernoulli" s theorem apparatus – 1 no.
- Triangular notch and Rectangular notch – 1 each (with a lined open channel setup)
- Coefficient of friction apparatus
- Pipe setup with bends, fittings and elbows for estimating minor losses
- Centrifugal pump, Reciprocating pump, Submersible pump, Jet pump – 1 each
- Collecting tank, Stop watch – 1 no. for each experiment.

LABORATORY SAFETY PROCEDURE

Safety

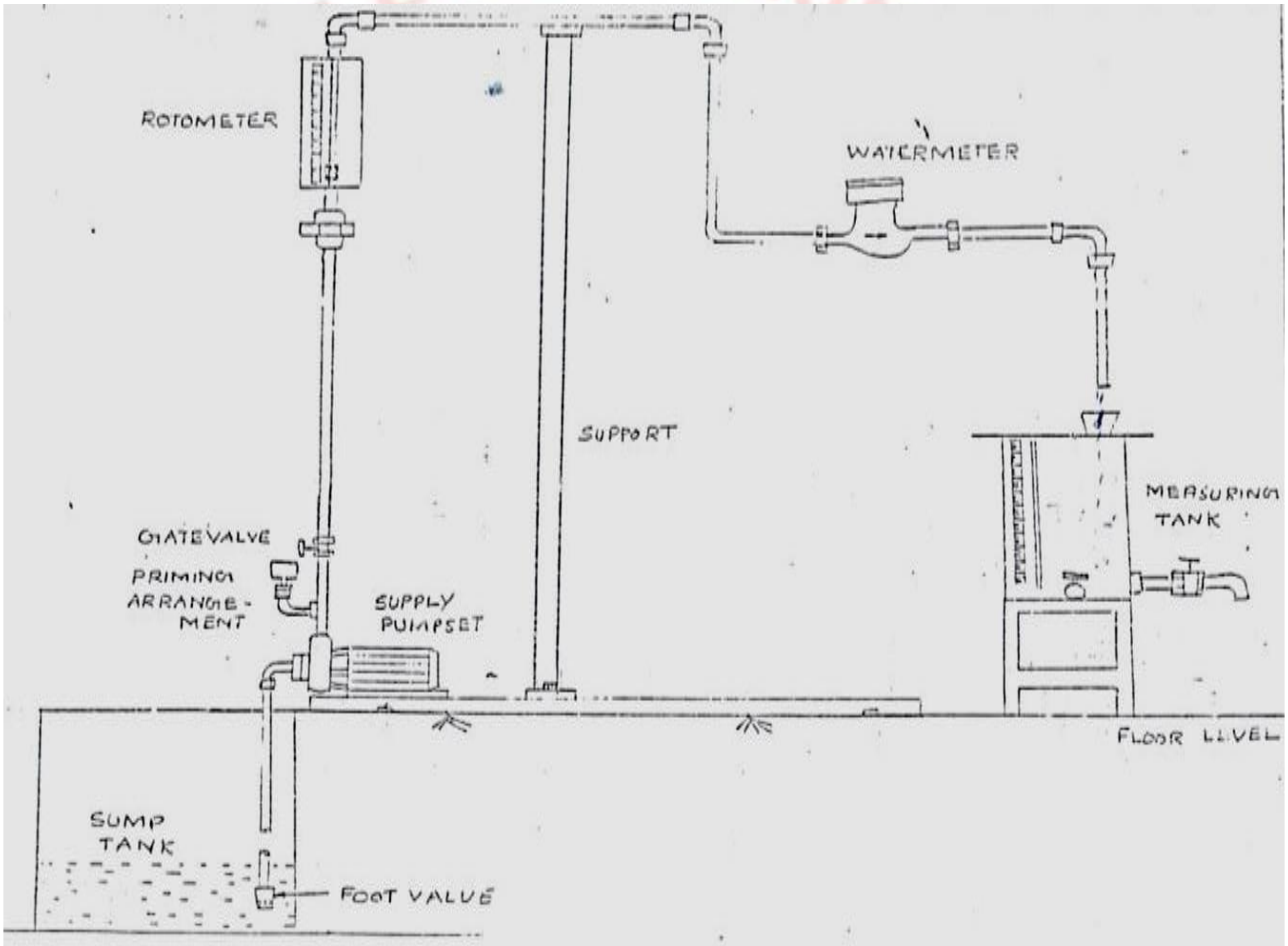
Safety is our prime concern at all times and you will be asked to leave the lab if your conduct is deemed to compromise safety regulations. Do not perform unauthorized experiments by yourself. Never leave unattended an experiment that is in progress. The students are strictly advised to wear shoes when they come to the laboratory as a measure of safety.

Do's

1. Bring observation note books, lab manuals and other necessary things for the class.
2. Check the instruments for proper working conditions while taking and returning the same.
3. Thoroughly clean your laboratory work space at the end of the laboratory session.
4. Maintain silence and clean environment in the lab

Dont's

1. Do not operate the machines without the permission of the staff
2. Do not put hands or head while equipment is in running condition.
3. Do not fix or remove the test specimen while the main is switch on.



Rotameter setup

EX.NO:…1…….   **DATE**:………

CALIBRATION OF ROTAMETER

AIM:

To determine the Co-efficient of discharge of the Rotameter and to obtain the calibration error.

APPARATUS REQUIRED:

- Rotameter fitted with pipe line setup
- Stop watch
- Measuring scale & Tape

THEORY:

The Rotameter is the most popular flow meter. It consists essentially of a plummet or float which is free to move up or down in a vertical slightly tapered tube having its small end down. The fluid enters the lower end of the tube and causes the float to rise until the annular area between the tube and the float is such that the pressure drop across this construction is just sufficient to support the float. Typically, the tapered tube is of glass and caries etched upon it a nearly linear scale on which the position of the float may be usually noted as an indication of the flow.

Rotameter have proved satisfactory both for gasses and for liquids at high and low pressures. Rotameter required straight runs of pipe before or after the point of installation. Pressure losses are substantially constant over the whole flow rang. In experimental work, for greatest precision, a Rotameter should be calibrated with the fluid which is to be entered. However, most modern Rota meters are precision-mode such that their performance closely corresponds to a mater calibration plate for the type in question.

FORMULA:

Co-efficient of discharge

$$C_d = \frac{\text{Actual discharge}}{\text{Theoretical discharge}} = \frac{Q_a}{Q_t}$$

OBSERVATION:

Internal plan dimensions of the collecting tank

Length of collecting tank (L) = …… cm

Breadth of collecting tank (B) = …… cm

Sl.No	Rotameter Reading *Kg/cm²*	Time For 5 CM raise of water (t) *sec.*	Actual Discharge (Q_{act}) *m³/sec.*	Actual Discharge (Q_{theo}) *m³/sec*	Co-efficient of Discharge (Cd)	Calibration error

Actual discharge ,

$$Q_a = \frac{A*h}{t} \ m^3/s$$

Where,

A - Area of the measuring tank m^2.

H - Rise of water level meters (say 5 cm)

t - Time in seconds for rise of water level (say 5 cm)

Theoretical discharge, Q_t = Rotameter reading × 1000 x60 m^3/s

Calibration error = $\frac{Qt-Qa}{Qt}$

MODEL CALCULATIONS:

1. Actual discharge

$$Q_a = \frac{A*h}{t} \ m^3/s$$

= ....m^3/s

2. Theoretical discharge

Q_t = Rotameter reading × 1000 x60 m^3/s

= ....m^3/s

3. Co-efficient of discharge

$C_d = Q_a/Q_t$

= …………..

4. Calibration error

$$= \frac{Qt-Qa}{Qt}$$

= ………..

PROCEDURE:

- Note the cross section area of collecting tank.
- Slowly open the delivery valve of Rotameter.
- The actual discharge is measured with the help of Rotameter.
- Note down the value of Rotameter.
- The theoretical discharge is measured with the help of the Rotameter.
- Refitted the above procedure for different values of Rotameter.

GRAPH:

- Actual Qa Vs Co-efficient of discharge.
- Actual Qa Vs calibration of an error

RESULT:

- Average co-efficient of discharge (Cd) = ___________________
- Average calibration error = ___________________

Thus the given Rotameter was calibration and connected at parameter.

VIVA VOCE QUESTIONS ROTAMETER

1. Define Rotameter

The rotameter is an industrial flowmeter used to measure the flowrate of liquids and gases.

2. What are the Advantages of rotameter?

A rotameter requires no external power or fuel, it uses only the inherent properties of the fluid, along with gravity, to measure flow rate, A rotameter is also a relatively simple device that can be mass manufactured out of cheap materials, allowing for its widespread use.

3. What are the Dis-advantages of rotameter?

Rotameters are not easily adapted for reading by machine; although magnetic floats that drive a follower outside the tube are available and Rotameters are not generally manufactured in sizes greater than 6 inches/150 mm, but bypass designs are sometimes used on very large pipes.

4. What is steady flow?

Flow doesn‟t vary with time. In steady flow, velocity of fluid is constant on every point at a specific time.

5. What is the application of Pitot-Static tubes

Pitot-Static tubes measures velocity at a point of fluid in a stream.

6. A magnetic flow meter will not properly measure?

It is used to measure the flow rate of oil.

7. What is ROTAMETER?

The rotameter is an industrial flowmeter used to measure the flowrate of liquids and gases. The rotameter consists of a tube and float. The float response to flowrate changes is linear, and a 10-to-1 flow range or turndown is standard

8. What is the source of error in Rotameter?

The major source of error in rotameter is due to the variation of density of the fluid. Besides, the presence of viscous force may also provide an additional force to the float.

9. What is the working principle of Rotameter ?

Rotameter works as a constant pressure drop variable area meter.

10. Write the disadvantage of Rotameter

Rotameter can be only be used in a vertical pipeline.

EX. NO:2 **DATE: …………**

DETERMINATION OF COEFFICIENT OF DISCHARGE OF VENTURIMETER

OBJECTIVE:

To determine the coefficient of discharge for the venturimeter

APPARATUS REQUIRED:

- A venturimeter with known diameters at the mouth and throat fitted with stopcocks at the mouth and throat.
- A U-tube manometer containing mercury.
- Water measuring tank.
- A stopwatch.

Theoretical discharge

THEORY:

Venturimeter is a device, which works on the principle of Bernoulli's equation. It is used for measuring the rate of flow of fluid through a pipe. It consists of these parts.

- A short converging part.
- Throat
- Diverging part

A U-tube manometer is connected to the pipe and through which shows the head difference between them. There will not be any datum head H the water is horizontal. Hence, the pressure head is equal to the velocity head. The main principle involved is that the pressure at throat has maximum due to decreasing cross section, which is measured by using manometer. Thus, we measure discharge as well as co-efficient.

FORMULA:

Co-efficient of discharge, $(C_d) = \frac{Q_a}{Q_t}$

Theoretical Discharge, $Q_t = \frac{Cd*A1*A2\sqrt{2gH}}{\sqrt{(A1^2 - A2^2)}}$ m^3/s

A1 - cross sectional area of pipe, m^2
A2 - cross sectional area of throat, m^2
d1 - diameter of the pipe
d2 - throat/orifice diameter

g - Acceleration due to gravity = 9.81 m/s^2
H - Total head = h*12.6

Co-efficient of discharge of venturimeter

S.No	Manometer Reading in (cm)			Total Head (cm)	Time taken 10cm rise of water level (Seconds)	Discharge (Q) m^{3}/sec		Co-efficient of discharge (Cd)
	h1	h2	H			Actual discharge (Q_a)	Theoretical discharge (Q_t)	

MODEL CALCULATIONS:

1. Total head ,

$$H = (h_1 - h_2) * 12.6$$

= ……… cm

2. Theoretical Discharge,

$$Q_t = \frac{Cd * A1 * A2\sqrt{2gH}}{\sqrt{(A1^2 - A2^2)}}$$

= ....m^3/s

3. Actual Discharge,

$$Q_a = \frac{A * R}{t * 100}$$

= ....m^3/s

4. Co-efficient of discharge,

$$(C_d) = \frac{Q_a}{Q_t}$$

= …………

Actual Discharge, $Q_a = \frac{A*R}{t*100}$ m^3/s

Where,A - Area of collecting tank (m^2)

R - Rise in water level of the collecting tank (cm)

t - Time for 'R' cm rise of water (sec)

PROCEDURE:

1. Check whether all the joints are leak proof and watertight.
2. Close all the pipes with cocks in the pressure feed pipes and manometer to prevent damage and over loading of the manometer.
3. Open the inlet value of the pipe. Switch on the pump and adjust and the control value to allow the meter to flow through Venturimeter.
4. Open the downstream and upstream cocks that connect the manometer to the Venturimeter for which the co-efficient of discharge is to be calculated.
5. Prime the manometer properly. Adjust the control value to maintain the flow and for the deserved rate of flow.
6. Measure the manometer head to find the venture discharge. Measure the time taken for 10mm rise in the collecting tank to find the actual discharge.
7. Calculate the co-efficient of discharge and repeat the procedure for the different flow rates.

GRAPH:

A graph is drawn between actual discharge Vs$\sqrt{h}$ by taking in X-axis and Q_a in Y-axis.

RESULT:

The co-efficient of discharge for the Venturimeter is found out and the necessary graph is plotted.

(i) From the table C_d =

(ii) From the graph C_d =

VIVA VOCE QUESTIONS VENTURIMETER

1. How the rate at which fluid flows through a closed pipe can be determined?
   Either by Determining the mass flow rate or Determining the volume flow rate

2. What are the devices used for flow obstruction?

Orifice plate, Venturi tube and Flow nozzle and dall flow tube

3. Venturimeter is based on integral form of Euler's equation.

4. Which device is used to measure the discharge?
   Venturimeter

5. The Size of a venturimeter is specified by **pipe diameter**

6. What happens Venturimeter is placed in a pipe?

   When a venturimeter is placed in a pipe carrying the fluid whose flow rate is to be measured, a pressure drop occurs between the entrance and throat of the venturimeter.

7. What an ideal flow of any fluid must satisfy ?

   It must satisfy continuity equation

8. Define Turbulent flow

   Turbulent flow, type of fluid (gas or liquid) flow in which the fluid undergoes irregular fluctuations, or mixing, in contrast to laminar flow, in which the fluid moves in smooth paths or layers.

9. Define laminar flow In fluid dynamics, laminar flow (or streamline flow) occurs when a fluid flows in parallel layers, with no disruption between the layers.

10. what is the coefficient of discharge of venture?

   Cd = 0.9 - 0.95

EX NO - 3 **DATE**

DETERMINATION OF COEFFICIENT OF DISCHARGE OF ORIFICE METER

AIM:

To determine the Coefficient of discharge (C_d) of the given Orificemeter.

APPARATUS REQUIRED:

1. Orificemeter with all accessories
2. Stop watch
3. Metre scale

THEORY:

Orificemeter is a device, used to measure the discharge of any liquid flowing through a pipeline. The pressure difference between the inlet and the orifice is recorded using a differential Manometer, and the time is recorded for a measured discharge.

$$\text{Theoretical discharge, } Q_t = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

Where, a_1 = Area of Inlet

a_2 = Area of Orifice

g = Acceleration due to gravity

h = Orifice head in terms of flowing liquid

$= [h_1 - h_2]$

h_1= Manometric head in one limb of the Manometer

h_2= Manometric head in other limb of the Manometer.

Actual Discharge, $Q_a = \frac{AH}{t}$

Where , A = Internal plan area of collecting tank

H = Rise of liquid

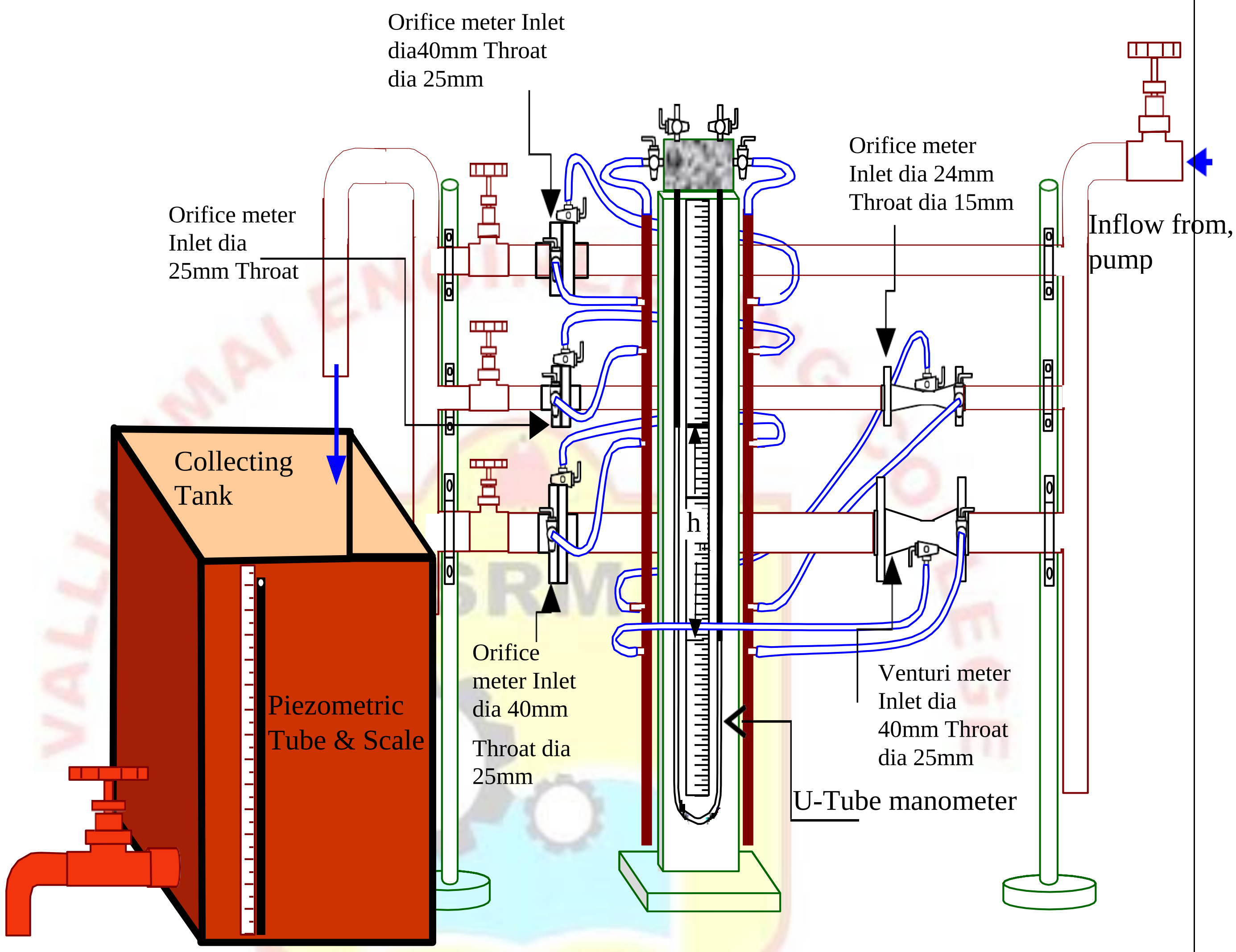
t = Time of collection

Coefficient of Orifice meter (C_d) is the ratio between the actual discharge (Q_a) and the theoretical discharge (Q_t)

i.e $C_d = \frac{Q_a}{Q_t}$

PROCEDURE:

1. The dimensions of the inlet and orifice are recorded and the internal plan dimensions of the collecting tank are measured.
2. Keeping the outlet valve closed, the inlet valve is opened fully.
3. The outlet valve is opened slightly and the manometric heads in both the limbs (h1 and h2) are noted.
4. The outlet valve of the collecting tank is closed tightly and the time t required for H rise of water in the collecting tank is observed using a stopwatch.
5. The above procedure is repeated by gradually increasing the flow and observing the required readings.
6. The observations are tabulated and the coefficient of Orificemeter (C_d) is computed.



Venturimeter and orifice meter setup

OBSERVATION:

Diameter of the Inlet, d_1 = mm

Diameter of the orifice, d_2= mm

Internal plan dimensions of collecting tank, Length, L = mm

Breadth, B= mm

Acceleration due to gravity, g = 9810 mm/sec^2

TABULATION:

Sl. No.	Manometric Readings			$\sqrt{h}$	Time for H = 100mm rise of water(t)	Actual Discharge Q_a = AH/t	Theoretical Dsicharge $Q_t = a_1 a_2\sqrt{(2gh)} / \sqrt{a_1^2 - a_2^2}$	Co efficient of Orificemeter $C_d = Q_a / Q_t$
	h_1	h_2	$h=h_1-h_2$					
	mm of water			mm$^{1/2}$	Sec	mm^3/s	mm^3/s	
1								
2								
3								
4								
5								
6								

MODEL CALCULATION:

1. Area of inlet, a_1 = $\pi d_1^2/4$

= mm²

2. Area of Orifice, a_2 = $\pi d_2^2/4$

= mm²

3. Internal plan area of collecting tank

= L x B

= mm²

4. Actual Discharge Qa = AH/t

= mm³/s

5. Theoretical Discharge $Q_t = a_1 a_2 \sqrt{(2gh)} / \sqrt{a_1^2 - a_2^2}$

= mm³/s

6. Co efficient of discharge = Q_a/Q_t

=

GRAPH:

A graph Q_a vs. $\sqrt{h}$ is drawn taking $\sqrt{h}$ on X axis.

RESULT:

Coefficient of discharge of the Orificemeter (C_d)

1. Theoretically =
2. Graphically =

Ex no : 4 **Date:**

Flow through a small orifice

Aim:-

1. To investigate the discharge characteristics of circular orifices subjected to a constant head.
2. To investigate the trajectory of a horizontal jet issuing from an orifice and hence determine the coefficient of velocity for the orifice.

Apparatus Required:-

1. Constant head inlet tank (Figure 1).
2. Circular orifices with different diameters.
3. Hook gauge and scale.
4. Hydraulic bench.

Theory:-

Consider a small orifice in the side of a vessel with the head of water above the orifice kept constant.

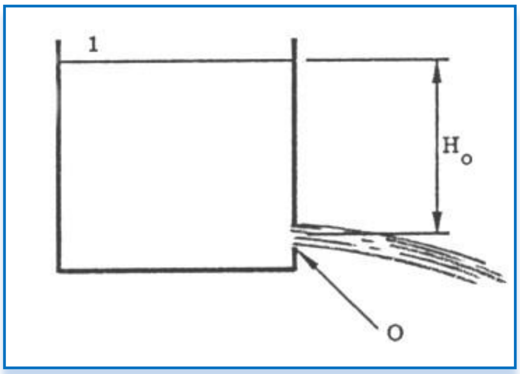


Figure 2: Discharge through an orifice

Applying Bernoulli's theorem between the surface of the water 1 and the orifice O yields

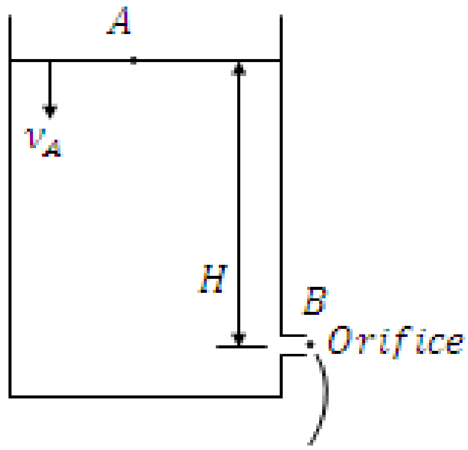
$$\text{H is constant} \Rightarrow v_A = 0$$

$$TH_A = TH_B + h_{L_{A-B}}$$

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

$$\Rightarrow \boxed{v_B = \sqrt{2gH}}$$

$$\therefore Q_{th} = A\sqrt{2gH}$$



Two

Firs $Q_{act} = \frac{volume}{time} = C_d A\sqrt{2gH}$

between point A and B.

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

C_v is the coefficient of velocity

Second: The stream line of the orifice contract reducing the area of flow. (Vena Contraction)

$$A_{actual} = C_c \cdot A$$

Where. C_c is the coefficient of contraction.

$$Q_{actual} = Cv . C_c . A\sqrt{2gh}$$

$$Q_{actual} = Cd\, A\sqrt{2gh}$$

C_d in the range [0.6-0.65]

Consider the trajectory of a jet formed by the discharge of water through an orifice mounted in the side of a tank. The jet will be subjected to a downward acceleration of g due to gravity. Taking the origin of co-ordinates at the vena-contracta and applying the laws of motion in the horizontal and vertical planes then ignoring any effect of air resistance on the jet.

$$v = v_o + at$$

$$v^2 = v_o^2 + 2ax$$

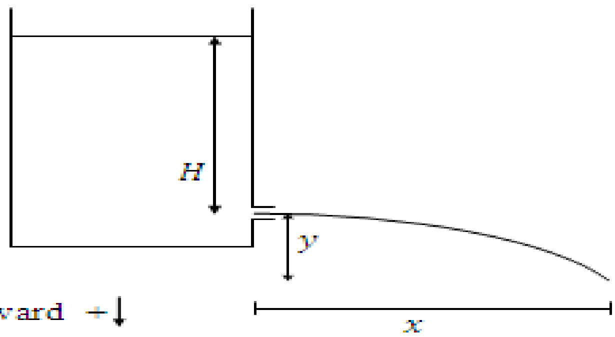
$$x = v_o t + \frac{1}{2}at^2$$

In x-direction:

$$x = vt \Rightarrow t = \frac{x}{v}$$

In y-direction:

$$y = v_{oy}t + \frac{1}{2}gt^2, \text{ assuing positive is downward } +\downarrow$$



$$y = \frac{1}{2}gt^2$$

$$y = \frac{1}{2}g\left(\frac{x}{v}\right)^2 = \frac{1}{2}g\frac{x^2}{v^2}$$

$$v = \sqrt{\frac{1}{2}g\frac{x^2}{y}} \Rightarrow \boxed{v_{act} = \sqrt{\frac{gx^2}{2y}}} = \frac{x}{\sqrt{\frac{2y}{g}}}$$

Procedures:

1. Fit the 5mm diameter orifice into the side of the inlet head tank. Remove the overflow extension pipe. Start the pump and set up an inlet head of 25cm.
2. Measure the trajectory of the jet using the hook gauge. Record the horizontal and

vertical distances.

3. Replace the overflow extension tube and establish an inlet head of 500mm. Measure the trajectory of the jet
4. Repeat the experiment using the 8mm diameter orifice.

Model Calculation

1. $X = c_v \sqrt{y} 2\sqrt{H}$

   = -------------- m

2. $c_c = \frac{c_d}{c_v}$

   = ------------

Results:

1. Record the results on a copy of the result sheet for discharge characteristics.
2. For each result calculate the flowrate
3. Plot a graph of square root of the head against the flow rate for each orifice diameter, the results should lie on a straight line passing through the origin to confirm that:

$$Q \alpha \sqrt{H}$$

Measure the slope of the line and hence calculate the coefficient of velocity from:

$$Q = \frac{slope}{A\sqrt{2g}}$$

Table 1 Collecting tank Value

D (mm)				
H (cm)				
$\sqrt{H}$**(m**				
V (L)				
T (sec)				
Q (m^3/s)				

Table 2: Trajectory of horizontal jet

D (mm)				
H (cm)				
x (cm)	**Vertical distance below orifice center line y (cm)**			
Slope of graph				

Ex No : 5 **Date :**

Determination of mean velocity by Pitot-Tube

AIM

To determine co-efficient of discharge of the Pitot tube.

APPARATUS

1 Pitot tube
2 Pipe
3 Manometer
4 Stop watch
5 Collecting tank fitted with a valve

Theory

The pitot tube can be used to measure the velocity of water in an open channel as well as in a closed pipe. For an open channel, a simple pitot tube will serve the purpose. However for a closed pipe in which the water is flowing under pressure, it is necessary to measure the static pressure also. Then the velocity head will be equal to the total Pitot-tube reading minus the static pressure. The static pressure is measured by inserting another L-shaped tube with its end pointing towards the flow downstream. The water will be drawn in this tube by means of suction. If, now, the tubes are connected by an inverted U-tube manometer, the difference of water height 'h' will give the velocity head. Such an arrangement is known as ''Pitot-meter". The static pressure can also be measured by inserting the other end of inverted U-tube to the pipes.

A Pitot tube is fixed inside a pipe connected to a supply water tank. The Pitot tube is connected to an inverted water manometer. The flow rate in the pipe is measured from given collecting tank. The flow rate is varied by adjusting the delivery valve.

The following formulae are employed to find the theoretical velocity and Pitot tube coefficient

Theoretical velocity, $V_a = \sqrt{2gh}$

Actual discharge, $Q_a = AH/T$

A = Internal plan area of collecting tank H

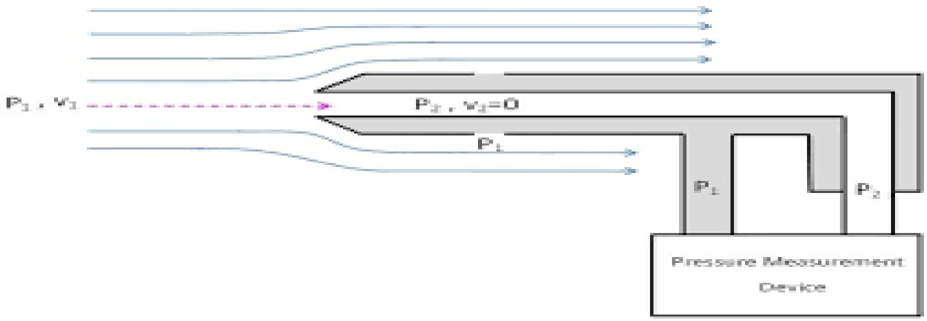
= Rise of liquid in collecting tank

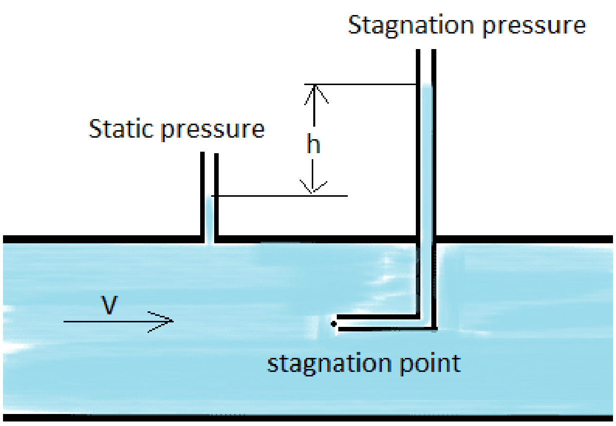
T = Time taken to collect liquid in the collecting tank

Actual velocity, $V_a = Q_a/a$

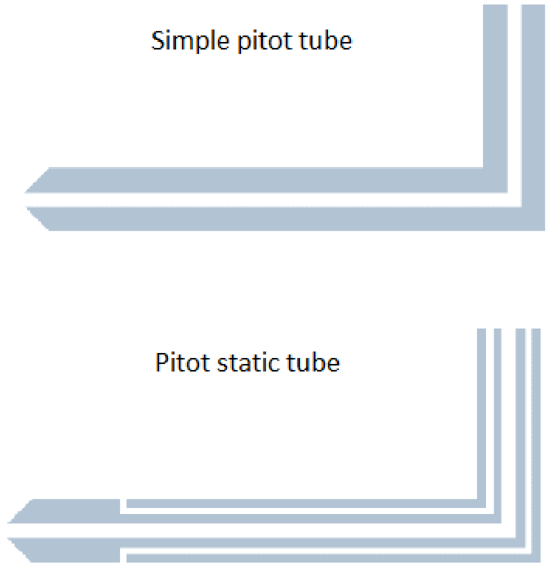
Error of the Pitot tube, $\Phi = V_a / V_{th}$

It is a device used for measuring the velocity of flow at any point in a pipe or a channel. It is based on the principle that if the velocity of flow at a point becomes zero, the pressure there is increased due to the conversion of the kinetic energy into pressure energy. In its simplest form, the Pitot-tube consists of a glass tube, bent at right angle as shown in figure below.





Simple pitot tube



The lower end, which is bent through 90 is directed in the upstream direction as shown in Figure. The liquid rises up in the tube to the conversion of kinetic energy in to pressure energy. The velocity is determined by measuring the raise of liquid in the tube.
Consider two points (1) and (2) at the same level in such a way that (2) is just at the inlet of the Pitot-tube and point (1) is far away from the tube.

Let
P1= intensity of pressure at point (1)
v1 = velocity of flow at (1)
P2= pressure at section (2)
V2 = velocity at point (1), which is zero
H= depth of tube in the liquid
h= rise of liquid in the tube above the free surface.

Applying Bernoulli's equations at point (1) and (2), we get

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

But $Z_1 = Z_2$ as points (1) and (2) are on the same line and V2 =0.

$\frac{P1}{g}$ = pressure head at (1) = H and $\frac{P2}{g}$ = pressure head at (2) = (h+H)

Substituting these values, we get

$$H + (V_1^2/2g) = (h+H)$$

This is theoretical velocity. Actual velocity is given by $(v1)act = Cv\sqrt{2gh}$,

Where Cv = Co-efficient of Pitot-tube

Velocity of flow in a pipe by Pitot-tube

For finding the velocity at any point in a pipe by Pitot-tube, the following arrangements are adopted:

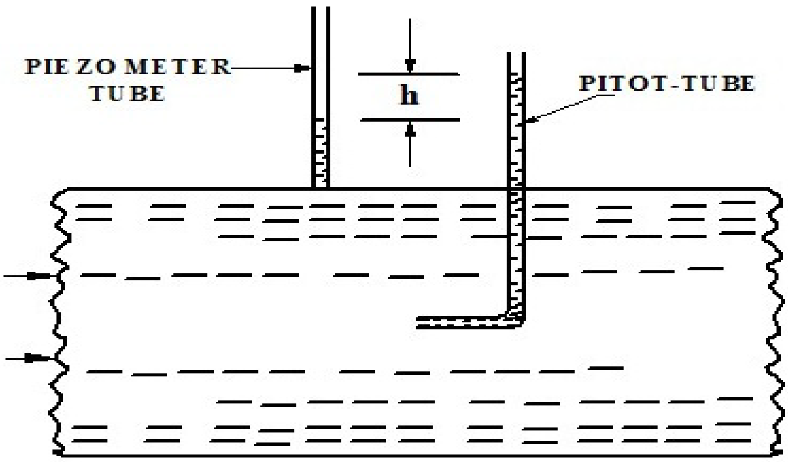


Fig. (b)

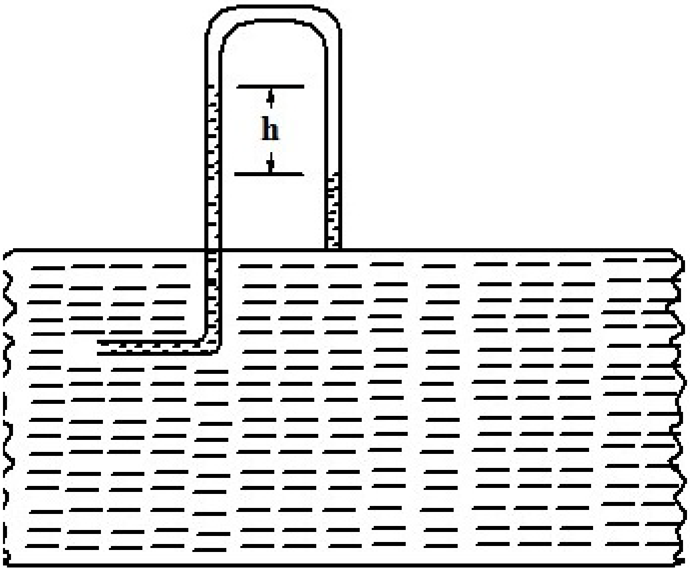


Fig. (c)

1. Pitot-tube along with a vertical piezometer tube as shown in Fig. (b).
2. Pitot-tube connected with piezometer tube as shown in Fig. (c).
3. Pitot-tube and vertical piezometer tube connected with a different U-tube manometer as shown in Fig. (d).

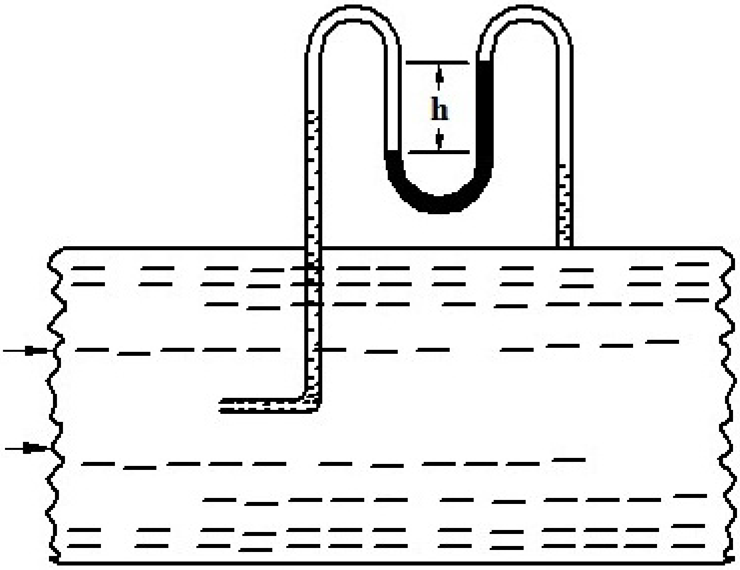


Fig. (d)

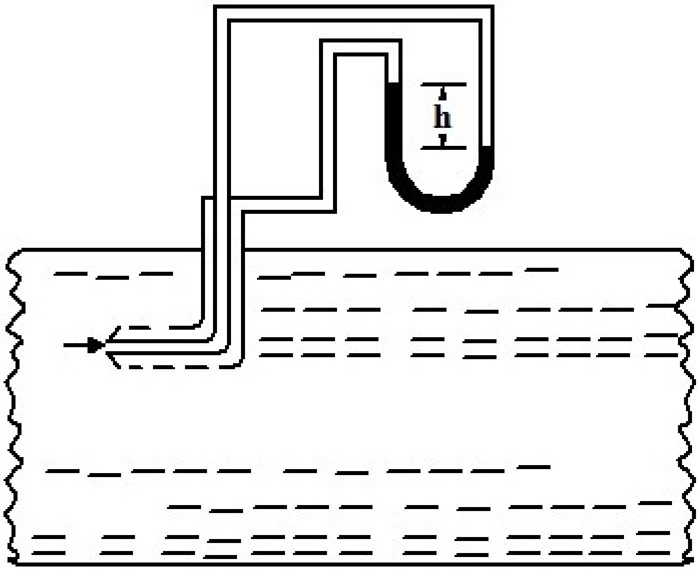


Fig. (e)

4. Pitot-static tube, which consists of two circular concentric tubes one the other with some annular space in between as shown in Fig. (e).
5. The outlet of these two tubes are connected to the different manometer where the difference of pressure head ‘h’ is measured by knowing the Difference of the levels of the manometer liquid say x. then

$h = x\,(\frac{Sg}{So} - 1)$

PROCEDURE

1. The diameter of the orifice and the internal plan dimensions of the collecting tank are measured.
2. The supply valve of the orifice tank is regulated and water is allowed to fill the orifice tank to a constant head (h)
3. The out let valve of the collecting tank is closed tightly and the time taken for “H ” rise of water in the collecting tank is noted.
4. The above procedure is repeated for different heads and the readings are tabulated.

MODEL CALCULATIONS

1. Head calculation

$h = x\,(\frac{Sg}{So} - 1)$

= -----------------

$X = h_1 - h_2$ = -----------

2. Velocity calculation

v = $\sqrt{2gh}$ = ----------

3. Discharge calculation

   $Q_a = \frac{AH}{T}$ = -----------------

4. Velocity calculation

   $V_a = \frac{Qa}{A}$ = -----------------

5. Error in pitot tube

   $\Phi = \frac{V_a}{V}$ = ------------------

GRAPHS

The following graph is drawn by taking Va on y – axis and $\sqrt{h}$
Va vs $\sqrt{h}$

RESULT

Error of the pitot tube, Φ = -------------------
(From experiment)
Error of the pitot tube, Φ = ---------------------
(From Va vs graph)

OBSERVATIONS AND CALCULATIONS

Table 1. Results of flow through Prandtl Pitot tube

S.No.	Manometer reading, cm			$V = \sqrt{2gh}$	Time for 10 cm rise of water, T sec	$Q_a = \frac{AH}{T}$	$V_a = \frac{Q_a}{a}$	$\phi = \frac{V_a}{V}$
	h_1	h_2	$h = (h_1 \sim h_2)\left(\frac{S_m}{s} - 1\right)$					
1								
2								
3								
4								
5								

EX.NO: 6. **DATE**:………

FLOW THROUGH NOTCHES

OBJECTIVE:

To determine the coefficients of discharge of the rectangular, triangular and trapezoidal notches.

APPARATUS REQUIRED:

- Hydraulic bench
  Notches – Rectangular, triangular, trapezoidal shape.
- Hook and point gauge
- Calibrated collecting tank Stop watch

THEORY:

A notch is a sharp-edged device used for the measurement of discharge in free surface flows. A notch can be of different shapes – rectangular, triangular, trapezoidal etc. A triangular notch is particularly suited for measurement of small discharges. The discharge over a notch mainly depends on the head H, relative to the crest of the notch, measured upstream at a distance about 3 to 4 times H from the crest. General formula can be obtained for a symmetrical trapezoidal notch which is a combined shape of rectangular and triangular notches. By applying the Bernoulli Equation (conservation of energy equation) to a simplified flow model of a symmetric trapezoidal notch, theoretical discharge Q_{th} is obtained as:

$$Q_{th} = \frac{8}{15}\sqrt{2g}\ H^{5/2}\tan\frac{\theta}{2} + \frac{2}{3}\sqrt{2g}\ B\,H^{3/2} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where ‘H’ is the water head measured above the crest, ‘θ’ is the angle between the side edges and ‘B’ is the bottom width of the notch.

When θ=0, this equation is reduced and applicable for rectangular notch or when B=0 (no bottom width) it is applicable for triangular notch. Hence the same equation (1) can be also used for both rectangular and triangular notches by substituting corresponding values (ie θ=0 or B=0).

If Q_{act} actual discharge is known then coefficient of discharge Cd of the notch can be expressed as

$Cd = Q_{act}/Q_{th}$.

DESCRIPTION

In open channel hydraulics, weirs are commonly used to either regulate or to measure the volumetric flow rate. They are of particular use in large scale situations such as irrigation schemes, canals and rivers. For small scale applications, weirs are often referred to as notches and invariablyare sharp edged and manufactured from thin plate material. Water enters the stilling baffles which calms the flow. Then, the flow passes into the channel and flows over a sharp-edged notch set at the other end of the channel. Water comes of the channel in the form of a nappe is then directed into the calibrated collection tank. The volumetric flow rate is measured by recording the time taken to collect a known volume of water in the tank.

A vertical hook and point gauge, mounted over the channel is used to measure the head of the flow above the crest of the notch as shown in Fig. 2.1. Hook gauge can be moved vertically to measure vertical movements.

FORMULA:

Coefficient of discharge , $C_d = \frac{Q_{act}}{Q_{th}}$

a) RECTANGULAR NOTCH

$$Q_{act} = \frac{\text{Volume Collected}}{\text{Time Taken}}$$

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

b) TRIANGULAR NOTCH

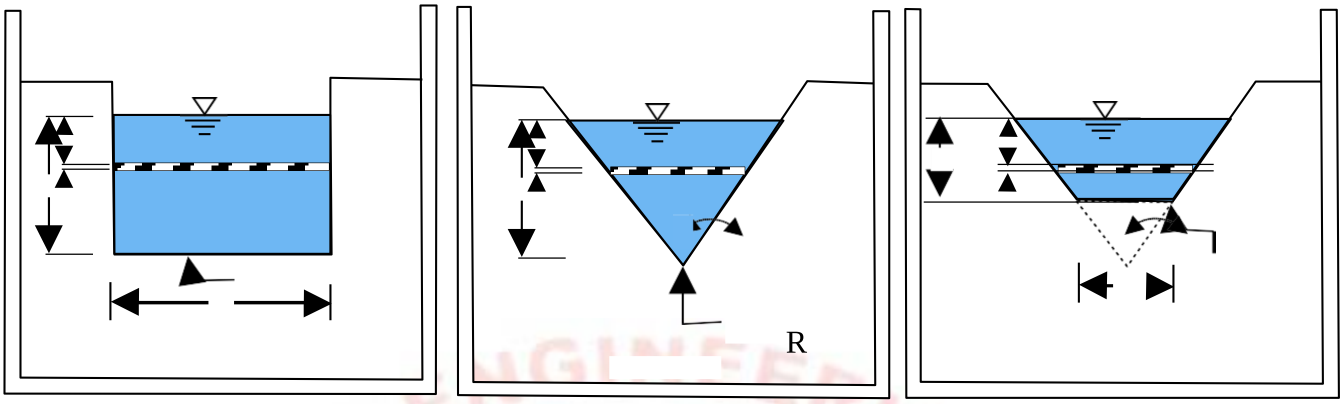
$$Q_{act} = \frac{\text{Volume Collected}}{\text{Time Taken}}$$

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

c) TRAPEZOIDAL NOTCH

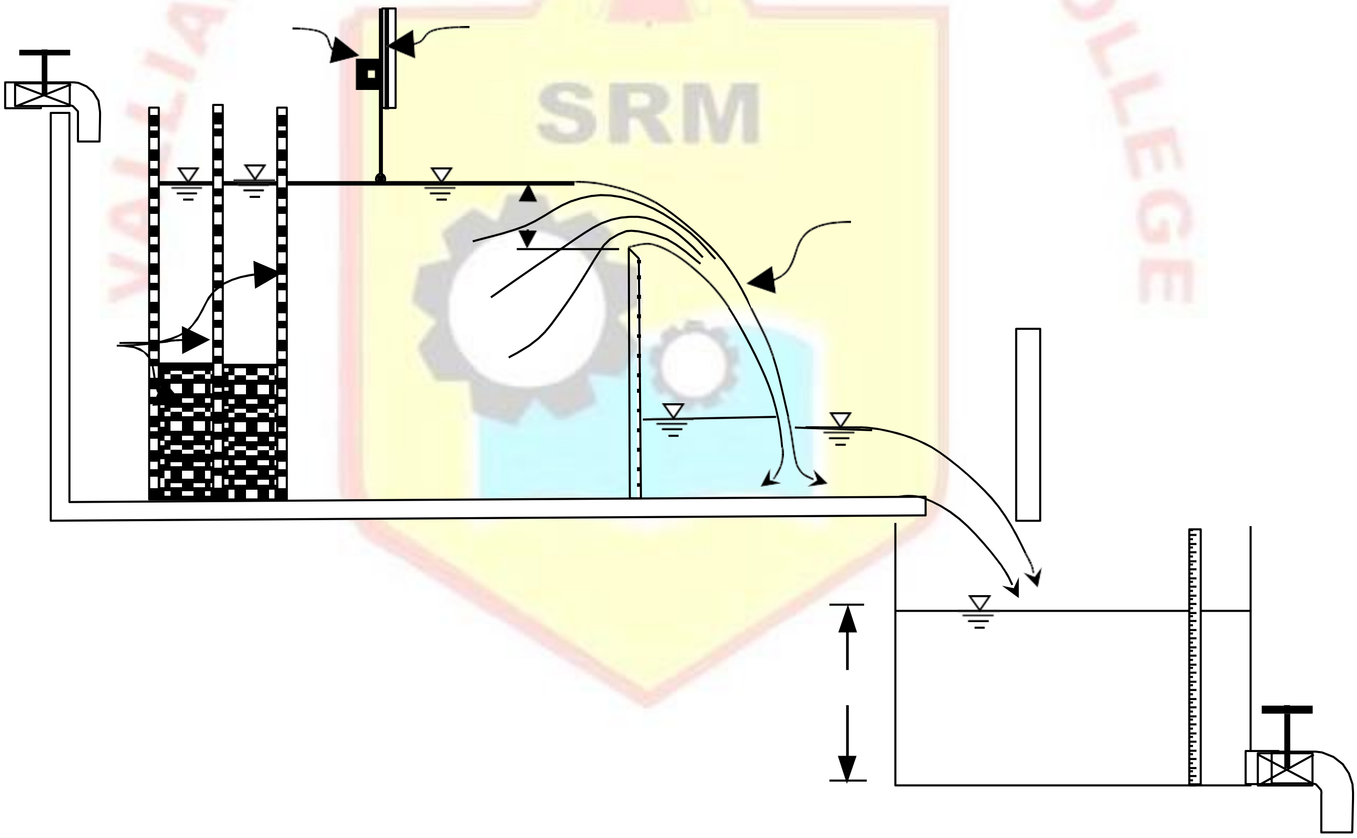
$$Q_{th} = \frac{8}{15}\sqrt{2g}\ H^{5/2}\tan\frac{\theta}{2} + \frac{2}{3}\sqrt{2g}\ B\,H^{3/2}$$

$$Q_{act} = \frac{\text{Volume Collected}}{\text{Time Taken}}$$



Collecting Tank

Longitudinal section of Experimental setup for notches



OBSERVATION AND COMPUTATIONS – I

A) For Rectangular notch

Notch width 'B'

= m

Initial reading of hook and point gauge h_0=

No.	*Theoretical Discharge Measurement*			*Actual Discharge Measurement*				*Cd*
	h1 (m)	H (m)	Theoretical Discharge, $Q_{th} = \frac{2}{3}\sqrt{2g}\,B\,H^{3/2}$	Water Rise in Collecting Tank R (m)	Time Taken 'T' (sec)	Volume of water collected (m3)ct	Discharge, **Q**act	**Qact** **Qth**
1								
2								
3								
4								
5								
6								

Area of collecting Tank A_{ct} = m^2

Tabulation 2.1 – Determination of Cd of rectangular notch.

Rectangular notch : Average Value of Cd = ……………...….

OBSERVATION AND COMPUTATIONS -II

A) For Triangular notch

Notch angle 'θ' = 90° or

60°

Initial reading of hook and point gauge h_0=

Area of collecting Tank A_{ct} = m^2

Tabulation 2.2 – Determination of Cd of triangular notch.

No.	*Theoretical Discharge Measurement*			*Actual Discharge Measurement*				*Cd*
	h1 (m)	H (m)	Theoretical Discharge, $Q_{th} = \frac{8}{15}\sqrt{2g}\ H^{5/2}\ \tan\frac{\theta}{2}$	Water Rise in Collecting Tank R (m)	Time Taken 'T' (sec)	Volume of water collected $(m^3)_{ct}$	Discharge, **Q**act	**Qact** **Qth**
1								
2								
3								
4								
5								
6								

Triangular notch: Average Value of Cd = ……………...….

OBSERVATION AND COMPUTATIONS - III

For Trapezoidal notch

Notch Bottom Width 'B' = m Notch angle 'θ' = °

Initial reading of hook and point gauge h_0= Area of collecting Tank A_{ct}= m^2

S.No	*Theoretical Discharge Measurement*			*Actual Discharge Measurement*				*Cd*
	h1 (m)	H (m)	Theoretical Discharge, $Q_{th} = \frac{8}{15}\sqrt{2g}\ H^{5/2} \tan\frac{\theta}{2} + \frac{2}{3}\sqrt{2g}$]	Water Rise in Collecting Tank R (m)	Time Taken 'T' (sec)	Volume of water collected (m^3)ct	Discharge, **Q**act	**Qact Qth**
1								
2								
3								
4								
5								
6								

Tabulation – Determination of Cd of trapezoidal notch.
Trapezoidal notch: Average Value of Cd = …………….

MODEL CALCULATIONS:

Actual discharge,

$$Q_{act} = \frac{\text{Volume Collected}}{\text{Time Taken}}$$

= ....m^3/s

Theoretical discharge,

$$Q_{th} = \frac{2}{3}\sqrt{2g}\ B\ H^{3/2}$$

= ……….. m^3/s - For rectangular notch

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

= ……….. m^3/s - For triangular notch

Coefficient of discharge , $C_d = \frac{Q_{act}}{Q_t}$

h

= ………….

PROCEDURE

Preparation for experiment:

1. Insert the given notch into the hydraulic bench and fit tightly by using bolts in order to prevent leakage.
2. Open the water supply and allow water till over flows over the notch. Stop water supply, let excess water drain through notch and note the initial reading of the water level ‘h_0’using the hook and point gauge. Let water drain from collecting tank and shut the valve of collecting tank after emptying the collecting tank.

Experiment steps:

3. After initial preparation, open regulating valve to increase the flow and maintain water level over notch. Wait until flow is steady.
4. Move hook and point gauge vertically and measure the current water level ‘h_1’ to find the water head ‘H’ above the crest of the notch.
5. Note the piezometric reading ‘z_0’ in the collecting tank while switch on the stopwatch.
6. Record the time taken ‘T’ and the piezometric reading ‘z_1’ in the collecting tank after allowing sufficient water quantity of water in the collecting tank.

7. Repeat step 3 to step 6 by using different flow rate of water, which can be done by adjusting the water supply. Measure and record the H, the time and piezometric reading in the collecting tank until 5 sets of data have been taken. If collecting tank is full, just empty it before the step no 3.
8. To determine the coefficient of discharge for the other notch, repeat from step

After entering the readings in the Tabulation 2.1 and Tabulation 2.2, compute the necessary values

RESULTS

1. The coefficient of discharge of rectangular notch = …………
2. The coefficient of discharge of triangular notch = …………
3. The coefficient of discharge of trapezoidal notch = ………….

VIVA VOCE QUESTIONS NOTCHES.

1. What are the types of notches?

Types Of Notches

- Rectangular notch.
- Triangular notch.
- Trapezoidal notch.
- Stepped notch.

2. How are notches classified?

A notch is usually made of metal plate whereas a weir is made of masonry or concrete. The bottom edge over which the water flows is called the sill or the crest of water the notch. ... They can be classified as rectangular, triangular and trapezoidal weirs based on the geometry of flow section

3. What is notch and Weir?

A notch is an opening in the side of a measuring tank or reservoir extending above the free surface. A weir is a notch on a large scale, used, for example, to measure the flow of a river, and may be sharp edged or have a substantial breadth in the direction of flow.

4. Which notch is more efficient?

In conclusion, V-notch has a higher discharge coefficient than rectangular notch. V-notch is moreefficient compared to rectangular notch.

5. What are the applications of notches?

There are many uses of notches, Mill ponds are created by notch impounding water then flows over the structure. Notches are commonly used to control the flow rates of the rivers during periods of high discharge. Sluice gates can be altered to increase or decrease the volume of water flowing downstream

6. Why V notch is used?

V-notch is generally used to measure flow rate in an open channel flow….. In real life applications it is used for seepage measurement of dam in foundation, inspection and top galleries and toe-drains in reservoirs. It has limited use in waste water and laboratories. It is a conventional device.

7. How do you cut pattern notches?

Simply cut outwards in a v shape. If the notch on your pattern points in, then just cut out from it. If you have a double sewing notch you can cut 2 separate v notches or cut across making it one piece. As long as you are consistent in the method you use, your pieces will match up

8. What is a notch radius?

For all notch types, a key parameter in governing stress concentration and failure in notched materials is the notch tip curvature or radius This notch is also often referred to as C-notch, and is the most widely form of introduced notch, due to the repeatability of results obtained from notch specimens.

1. What are the advantages of V notch over rectangular notch?

Well a V-score gives better exact outcomes when contrasted with rectangular indent. A traingular indent gives more precise outcomes for low releases than a rectangular score. The same triangular score can gauge an extensive variety of streams precisely.

2. What is calibration of notch?

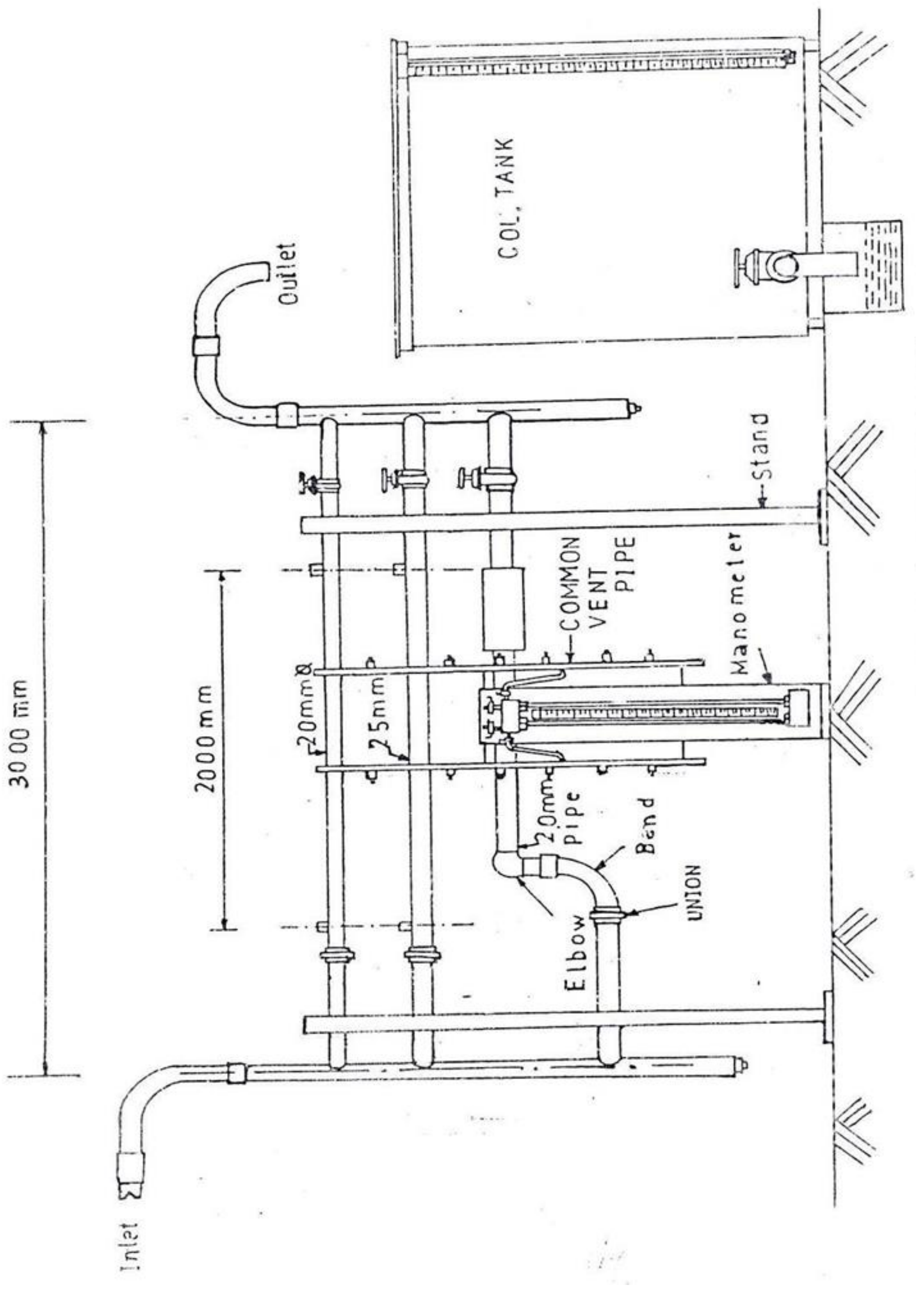
Notch is a flow meter used to measure the flowrate (). By calibrating the notch we are checking the flowrate shown by the notch is correct or not. Sometimes flowrate shown by the notch may be greater than (overrated) or less than (underrated) the actual flow rate of the material flowing.

3. Why does the V notch give more accurate flow measurement?

V-notch gives more accurate results for low discharge coefficient compared to rectangular notch. This is due to the space for the water to flow through the notch But, for triangular
notch the space of water will increase as the height of depth water increase related to the angle of notch.

4. What is notch sensitivity?

Notch Sensitivity. A measure of the reduction in strength of a metal caused by the presence of stress concentration.



LOSSES IN PIPE LINES (MINOR & MAJOR)

Ex. no: 7 **Date:**

STUDY OF FRICTION LOSSES IN PIPES

AIM:

To determine the coefficient of friction (f) of the given pipe material.

APPARATUS REQUIRED:

1. A pipe provided with inlet and outlet valves
2. U tube Manometer
3. Collecting tank
4. Stop watch
5. Metre scale

THEORY:

When liquid flows through a pipe line, it is subjected to frictional resistance. The frictional resistance depends upon the roughness of the inner surface of the pipe. The loss of head between a selected length of pipe is observed for a measured discharge. The coefficient of friction (f) is calculated by using the expression

$$h_f = 4fLv^2/ 2gd$$

Where,

h_f = loss of head due to friction = $h_1 - h_2$ mm

h_1 = Manometric head in one limb of the manometer mm

h_2 = Manometric head in other limb of the manometer mm

L = Length of pipe between pressure tapping cocks.	mm
V = Velocity of flow in the pipe = Q_a/a	mm/s
Q_a = Actual Discharge = AH/t	mm^3/s
A = Internal Plan area of the collecting tank	mm^2
H = Height of collection in the collecting tank	mm
T = time of collection	sec
a= cross sectional area of the pipe = $\pi d^2/4$	mm^2
d = diameter of pipe	mm
g = acceleration due to gravity = 9810	mm/s^2

PROCEDURE:

1. The diameter of the pipe, the internal plan dimensions of the collecting tank and the length of the pipe line between the pressure tapping cocks are measured,
2. Keeping the outlet valve fully closed, the inlet valve is opened completely.
3. The outlet valve of the collecting tank is closed tightly and the time t required for H rise of water in the collecting tank is observed using a stop watch.
4. The above procedure is repeated by gradually increasing the flow and observing the required readings.
5. The observations are tabulated and the coefficient of friction is computed.

OBSERVATIONS:

Diameter of the pipe d = mm

Length of the pipe L = mm

Internal plan dimensions of collecting tank, Length, L = mm

Breadth, B= mm

Acceleration due to gravity, g = 9810 mm/sec^2

TABULATION:

Sl. No.	Manometric Readings			Time for H = 100mm rise of water(t)	Actual Discharge $Q_a = AH/t$	Velocity = Q_a/a	V^2	Co-efficient of friction $f = 2gdh_f/4LV^2$
	h_1	h_2	$h_f=h_1-h_2$					
	mm of water			Sec	mm^3/s	mm/s	(mm/s)^2	
1								
2								
3								
4								
5								
6								

Mean Value of f =

MODEL CALCULATION:

1. Area of pipe, a = $\pi d^2 / 4$

= mm^2

2. Internal plan area of collecting tank

= L x B

= mm^2

3. Actual Discharge

$Q_a = AH/t$

= mm^3/ s

4. Velocity

$V = Q_a / a$

= mm/s

5. Coefficient of friction

$f = 2gdh_f/4Lv^2$

=

GRAPH:

A graph h_f vs. v^2 is drawn taking v^2 on X axis.

RESULT:

The Coefficient of friction of the given pipe (f)

1. Theoretically =
2. Graphically =

VIVA VOCE QUESTIONS

FRICTION LOSSES IN PIPES

1. What is meant by energy loss in a pipe?

When the fluid flows through a pipe, it looses some energy or head due to frictional resistance and other reasons. It is called energy loss. The losses are classified as; Major losses and Minor losses

2. Explain the major losses in a pipe.

The major energy losses in a pipe is mainly due to the frictional resistancecaused by the shear force between the fluid particles and boundary walls of the pipe and also due to viscosity of the fluid.

3. Explain minor losses in a pipe.

The loss of energy or head due to change of velocity of the flowing fluid in magnitude or direction is called minor losses. It includes: sudden expansion of the pipe, sudden contraction of the pipe, bend in a pipe, pipe fittings and obstruction in the pipe, etc.

4. What are the factors influencing the frictional loss in pipe flow?

Frictional resistance for the turbulent flow is,

i. Proportional to v^n where v varies from 1.5 to2.0.
ii. Proportional to the density of fluid.
iii. Proportional to the area of surface in contact.
iv. Independent of pressure.
v. Depend on the nature of the surface in contact.

5. Write the expression for loss of head due to sudden enlargement of the pipe.

$$h_{exp} = (V_1 - V_2)^2 / 2g$$

Where, h_{exp} = Loss of head due to sudden enlargement of pipe.
V_1 = Velocity of flow at pipe 1; V_2 = Velocity of flow at pipe 2.

6. Write the expression for loss of head due to sudden contraction.

$$h_{con} = 0.5\,V^2/2g$$

h_{con} = Loss of head due to sudden contraction. V = Velocity at outlet of pipe.

7. What is compound pipe or pipes in series?

When the pipes of different length and different diameters are connected end to end, then the pipes are called as compound pipes or pipes in series.

8. What is mean by parallel pipe and write the governing equations.

When the pipe divides into two or more branches and again join together downstream to form a single pipe then it is called as pipes in parallel. The governing equations are:Q = Q1+Q2

9. Define the terms a) Hydraulic gradient line [HGL] b) Total Energy line [TEL] Hydraulic gradient line:

It is defined as the line which gives the sum of pressure head and datum head of a flowing fluid in a pipe with respect the reference line. HGL = Sum of Pressure Head and Datum head Total energy line: Total energy line is defined as the line which gives the sum of pressure head, datum head and kinetic head of a flowing fluid in a pipe with respect to some reference line. TEL = Sum of Pressure Head, Datum head and Velocity head

10. What is meant by Moody‟s chart and what are the uses of Moody‟s chart?

The basic chart plotted against Darcy-Weisbach friction factor against Reynold‟s Number (Re) for the variety of relative roughness and flow regimes. The relative roughness is the ratio of the mean height of roughness of the pipe and its diameter (ε/D). Moody‟s diagram is accurate to about 15% for design calculations and used for a large number of applications. It can be used for non-circular conduits and also for open channels

Ex. no: 8 **Date:**

STUDY OF MINOR LOSSES IN PIPES

AIM:

To determine the co-efficient of minor loss of the given pipe.

APPARATUS REQUIRED:

1. Piping system
2. Measuring tank fitted with Piezometer
3. Differential U-tube manometer
4. Stop-watch

FORMULA:

Where there is any type of bend in pipe the velocity of flow changer, due to which the separation of the flow from the boundary and also formation of eddies takes place. Thus the energy is lost. The losses of head due to fittings in pipe

i.	Minor loss in bend	h_b	=	$KV_1^2 / 2g$
ii.	Minor loss in contraction	h_c	=	$KV_2^2 / 2g$
iii.	Minor loss in enlargement	h_e	=	$K(V_1-V_2)^2 / 2g$
iv.	Minor loss in elbow	h_d	=	$KV^2 / 2g$

Where, h_b = head loss due to bend
h_c = head loss due do contraction
he = head loss due to enlargement
h_d = head loss due to elbow
K = loss coefficient
V = velocity of fluid
V_1 = velocity of fluid in pipe of small diameter
V_2 = velocity of fluid in pipe of large diameter

2. Area of the collecting tank, L x B = cm^2

L - Length of the collecting tank (cm)

B - Breadth of the collecting tank (cm)

3. Discharge, Q = (A * y) / t cm^3 / s
A = Area of the collecting tank (cm^2)

y = Rise of water in the collecting tank (cm)

t = Time taken for 10 cm rise in the collecting tank (sec)

$a_1 = (\pi d_1^2) / 4$ (d_1 – diameter of the pipe in cm)

$a_2 = (\pi d_2^2) / 4$ (d_2 – diameter of the expanded pipe in cm)

4. Velocity, $V_1 = Q / a_1$

$V_2 = Q / a_2$

5. $h_e = (V_1 - V_2)^2 / 2g$

h_e - head lost due to sudden enlargement

g - Acceleration due to gravity (981 cm / s^2)

PROCEDURE:

1. Close all the valves provided
2. Fill the sump tank 75% with clean water and ensure that there are no foreign particles
3. Fill the manometer with measurement of mercury up to half of its level by opening the pipe from the fitting connected to the bottom most point of the manometer and connect the pipe back to its position
4. Open bypass valve
5. Ensure that ON/OFF switch given on the panel is at OFF position
6. Switch on the main power supply and switch on the pump
7. Open floe channel control valve of pipe for bend, sudden enlargement, sudden contraction and elbow fitting on ball valve and gate valve fitting
8. Open the pressure taps of manometer of related test section, very slowly to avoid the blow of water on manometer fluids
9. Now open the air release valve provided on the manometer, slowly to release the air in manometer
10. When there is no air in the manometer close the air release valves
11. Adjust water flow rate in desired section with the help of control valve for bypass valve
12. Record the manometer reading
13. Measure the flow of water, discharged through desired test section with using stop watch and measuring tank
14. Repeat the experiment for other fittings of selected pipe
15. When experiment is over for selected pipe open the control valve of other pipe
16. Repeat the experiment same procedure for different flow rate of water operating control valve and bypass valve

GRAPH :

A graph ,h_f Vs V_2^2 is drawn taking V_2^2 on X-axis

RESULT

1. The co-efficient of expansion of the given pipe C_e=

   i. Theoretically =

   ii. Graphically =

2. The co-efficient of contraction of the given pipe C_c =

   i. Theoretically =

   ii. Graphically = 3.The co-efficient of bend

of the given pipeC_b =

   i. Theoretically =

   ii. Graphically =

VIVA VOCE QUESTIONS MINOR

LOSSES

1. Where do major losses occur?

Major losses occur due to friction within a pipe.

2. Where do minor losses occur?

Minor losses occur at a change of section, valve, bend or other interruption.

3. What is the formula to calculate major losses h_f = (

f*L*V^2)/(D*2g)

4. What contributes to significant pressure loss.

A very sudden change to the flow path contributes to significant pressure loss.

5. Pressure loss is proportional to …..

L/D ratio and Velocity head.

6. What is the role of minor losses in pipe flow.

Minor losses are a major part in calculating the flow, pressure or energy reduction in piping systems.

7. What is the factor used to calculate configurational head loss.

Kinetic energy factor.

8. What is Kinetic energy factor of return bend.

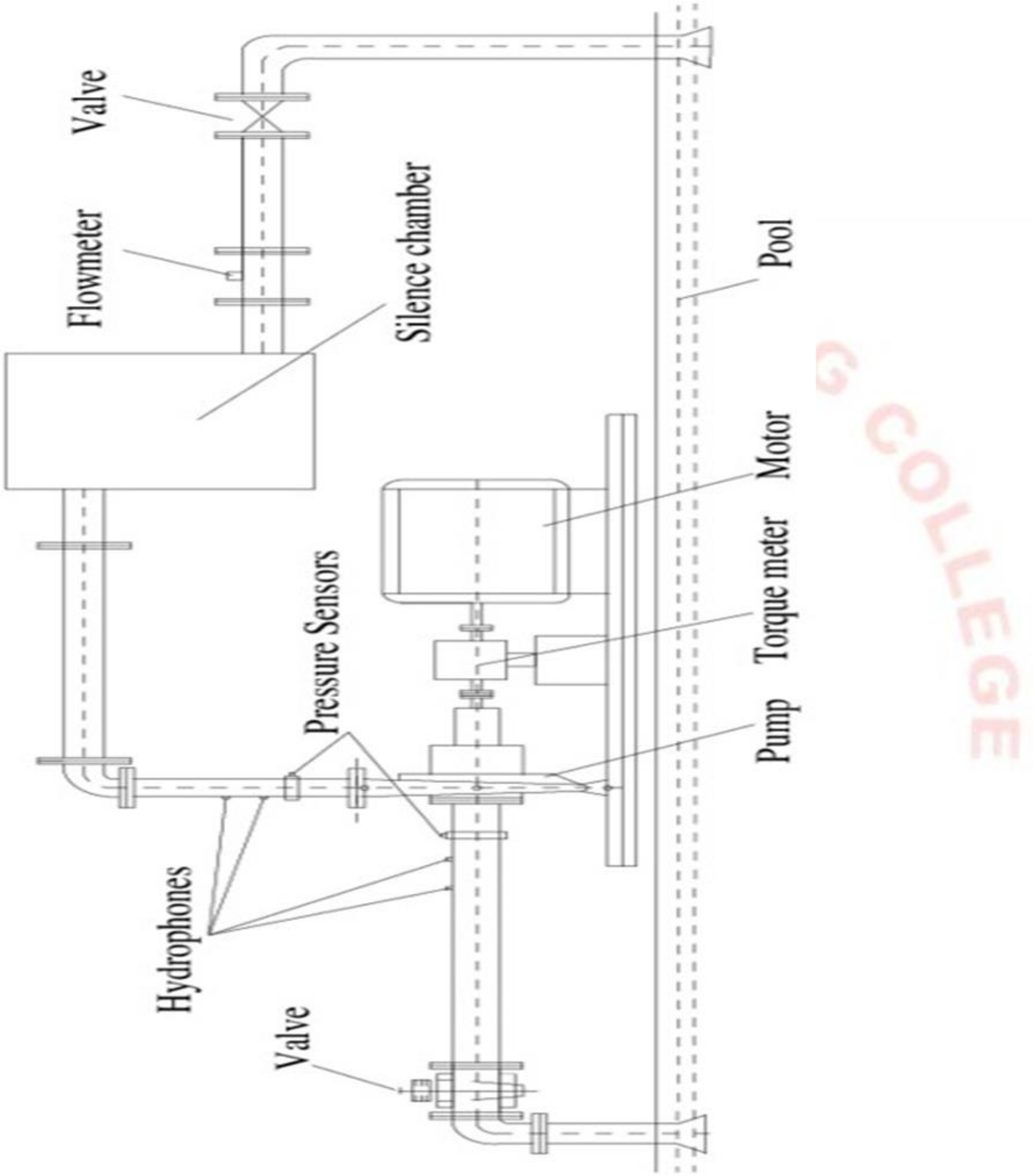
1.5

9. What is the formula to calculate minor losses h_f = (

k*$V^{2/}$2g)

10. What is the e_v value of check valve (ball).

70


Valve
Flowmeter
Silence chamber
Pool
Motor
Torque meter
Pump
Pressure Sensors
Hydrophones
Valve

Ex. no: 9 **Date:**

PERFORMANCE CHARACTERISTICS OF A CENTRIFUGAL PUMP

AIM:

To determine the best driving condition of the given centrifugal pump at constant speed and to drive the characteristic curves.

APPARATUS REQUIERED:

1. Centrifugal pump
2. Meter scale
3. Stop watch THEORY:

Centrifugal pumps are used to induce flow or raise a liquid from a low level to a high level. These pumps work on a very simple mechanism. A centrifugal pump converts rotational energy, often from a motor, to energy in a moving fluid.

The two main parts that are responsible for the conversion of energy are the impeller and the casing. The impeller is the rotating part of the pump and the casing is the airtight passage which surrounds the impeller. In a centrifugal pump, fluid enters into the casing, falls on the impeller blades at the eye of the impeller, and is whirled tangentially and radially outward until it leaves the impeller into the diffuser part of the casing. While passing through the impeller, the fluid is gaining both velocity and pressure.

Note:

Since the centrifugal pump is not self-priming, the pump must be filled with water before starting, for this reason water is not allowed to drain and a Foot valve is provided.

OBSERVATIONS:

Size of the tank	L=	m
	B=	m
Area of the Tank	A=	m^2
Correction head	X=	m
Energy meter constant	N_e=	rev/Kwh
Specific weight of water	w=	N/ m^2

TABULATION:

Sl.No		Pressure gauge reading	Pressure head G x 10	Vacuum gauge reading "V"	Vacuum head V x 0.0136	Total Head H = (G x 10) + (V x 0.0136)	Time for 10cm rise of rise of water in the tank "t"	Actual Discharge	Time for N_r = 10 revolutions in the energy meter "T"	Input Power P_i = 3600 x N_r / N_e x T	Output Power Po = wQH	Efficiency = (output power / input power)
ni	Kg/cm^2		'm' of water	'mm' of Hg	'm' of water	'm' of water	Seconds	m^3/sec	Seconds	KW	KW	%

1. Actual discharge $Q_a = AH/t$ (cumec)

Where:

A= area of the collecting tank in "m^2"

H= rise of water in the collecting tank in "m"

t = time taken for 10 cm rise in the collecting tank in "sec"

2. Total Head h= GX10 + V x 0.0136 + X (in m of water)
Where:

G= pressure gauge reading

V= vacuum gauge reading

X= correction head in m of water

3. Input power $P_i = 3600 \times N_r / N_e \times T$ (KW)
Where:

Nr= No of revolutions counted in energy meter disc.

Ne= Energy meter constant

T = Time taken for N_r revolutions in energy meter.

4. Output power po = WQH (KW)
Where:

w= specific weight of water (9.81 KN/m^3)

5. Efficiency = output power/ input power x 100 %

PROCEDURE:

1. The internal plan dimensions of the collecting tank are measured.
2. Correction head (The difference in level between the center of the pressure gauge and vacuum gauge) is measured.
3. The energy meter constant is noted down.
4. The motor is started and the following readings are noted down
   a) Pressure gauge and vacuum gauge reading
   b) Time 't' for 10 cm rise of water in the collecting tank
   c) Time 'T' for 10 revolutions in the energy meter
5. The above procedure is repeated for various pressure gauge reading.

MODEL CALCULATIONS:

1. Total Head(h)	=	Gx10 + Vx0.0136 + X	(in 'm' of water)
	=		
2. Actual discharge	=	Qa = Ah/t	(cumec)
	=		
3. Input power (P_i)	=	3600 x N_r / N_e x T	(KW)
	=		
4. Output power po	=	WQH	(KW)
	=		
5. Efficiency	=	output power/ input power x 100 %	
	=		

GRAPHS:

The following graphs are drawn taking discharge on X-axis

1. Discharge Vs Total Head
2. Discharge Vs Input power
3. Discharge Vs Efficiency

At the point of maximum efficiency of the graph, the corresponding value of discharge, head & Input power arrived from the graph

RESULT:

The characteristic curves are drawn from the point of maximum efficiency. The best driving conditions are found out and these conditions are obtained when,

1. The maximum efficiency =
2. Total head =
3. Discharge =
4. Input power =

VIVA VOCE QUESTIONS

CENTRIFUGAL PUMP

1. Why the Centrifugal Pump is called High Discharge pump?

Centrifugal pump is a kinetic device. The centrifugal pump uses the centrifugal force to push out the fluid. So the liquid entering the pump receives kinetic energy from the rotating impeller. The centrifugal action of the impeller accelerates the liquid to a high velocity, transferring mechanical (rotational) energy to the liquid. So it discharges the liquid in high rate. It is given in the following formula:

Centrifugal force F= (M*V2)/R.

Where,

M-Mass

V-

2. How Cavitation can be eliminated by Pump?

Cavitation means bubbles are forming in the liquid.

To avoid Cavitation, we have to increase the Pump size to One or Two Inch;

To increase the pressure of the Suction Head, or

Decrease the Pump Speed.

3. Why Cavitation will occur in Centrifugal Pump and not in Displacement Pump?

The formation of cavities (or bubbles) is induced by flow separation, or non-uniform flow velocities, inside a pump casing. In centrifugal pumps the eye of the pump impeller is smaller than the flow area of pipe. This decrease in flow area of pump results in increase in flow rate. So pressure drop happened between pump suction and the vanes of the impeller. Here air bubbles or cavities are formed because of liquid vapour due to increase in temperature in impeller. This air bubbles are transmitted to pump which forms cavitation.

4. Which Pump is more Efficient Centrifugal Pump or Reciprocating Pump? Centrifugal pump.Because flow rate is higher compared to reciprocating pump. Flow is smooth and it requires less space to install. Lower initial cost and lower maintenance cost.

5. Why Centrifugal Pump is not called as a Positive Displacement Type of Pump?

The centrifugal has varying flow depending on pressure or head, whereas the Positive Displacement pump has more or less constant flow regardless of pressure.Likewise viscosity is constant for positive displacement pump where centrifugal pump have up and down value because the higher viscosity liquids fill the clearances of the pump causing a higher volumetric efficiency. When there is a viscosity change in supply there is also greater loss in the system. This means change in pump flow affected by the pressure change.One more example is, positive displacement pump has more or less constant efficiency, where centrifugal pump has varying efficiency rate.

6. How Cavitation can be eliminated in a Pump?

Cavitation means bubbles are forming in the liquid.

· To avoid Cavitation, we have to increase the Pump size to One or Two Inch;

· To increase the pressure of the Suction Head, or

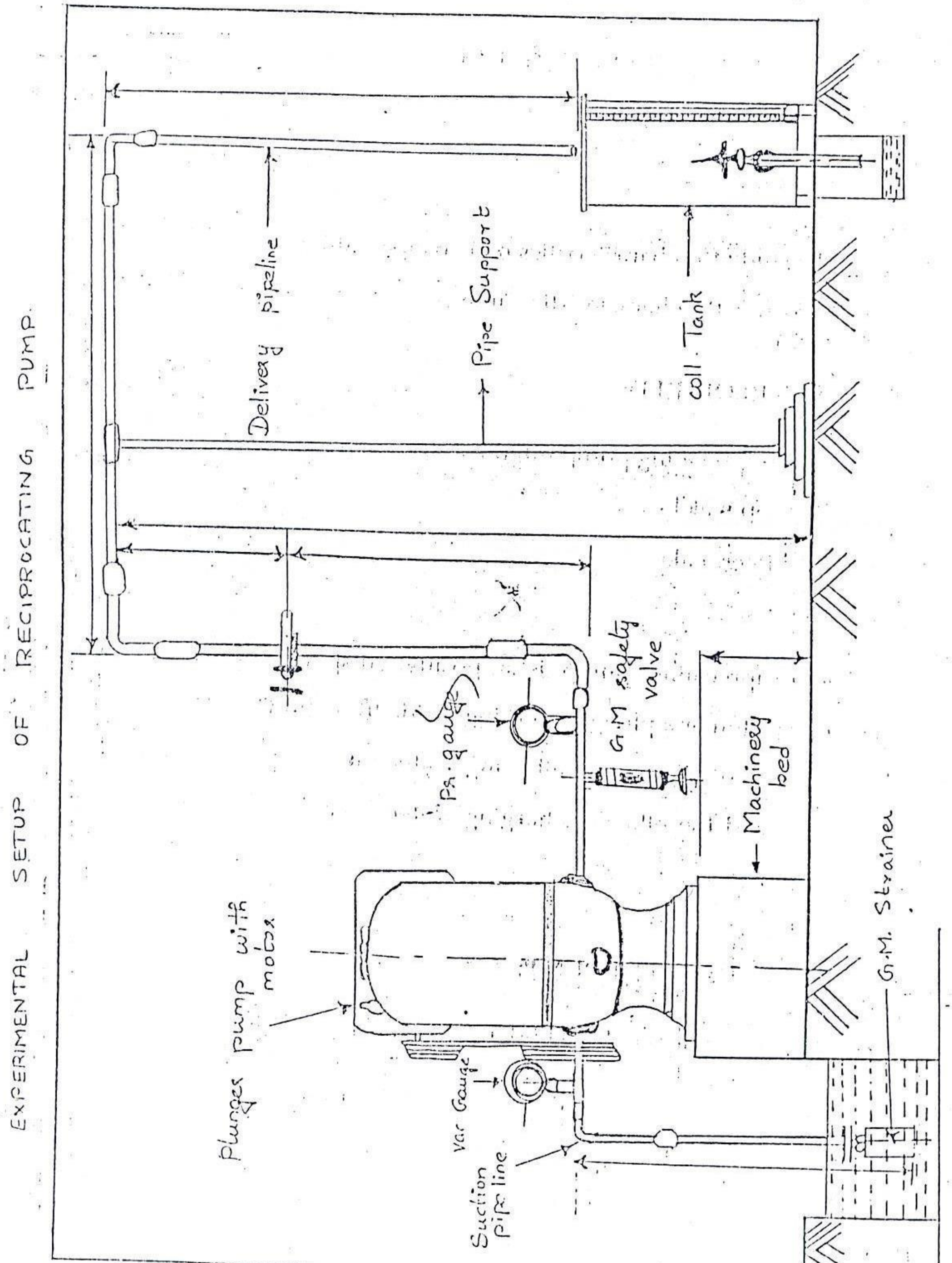
· Decrease the Pump Speed.

7. Which pump is more efficient Centrifugal pump or Reciprocating pump?
Centrifugal pump.
Because flow rate is higher compared to reciprocating pump. Flow is smooth and it requires less space to install. Lower initial cost and lower maintenance cost.

8. Why Centrifugal Pump is not called as a Positive Displacement Type of Pump?
The centrifugal has varying flow depending on pressure or head, whereas the Positive Displacement pump has more or less constant flow regardless of pressure.
Likewise viscosity is constant for positive displacement pump where centrifugal pump have up and down value because the higher viscosity liquids fill the clearances of the pump causing a higher volumetric efficiency. When there is a viscosity change in supply there is also greater loss in the system. This means change in pump flow affected by the pressure change.
One more example is, positive displacement pump has more or less constant efficiency, where centrifugal pump has varying efficiency rate.

9. What is a radial-flow turbine?
In a radial-flow turbine, steam flows outward from the shaft to the casing. The unit is usually a reaction unit, having both fixed and moving blades.

10. What are four types of turbine seals?
Carbon rings fitted in segments around the shaft and held together by garter or retainer springs.
Labyrinth mated with shaft serration‟s or shaft seal strips.
Water seals where a shaft runner acts as a pump to create a ring of water around the shaft. Use only treated water to avoid shaft pitting.Stuffing box using woven or soft packing rings that are compressed with a gland to prevent leakage along the shaft.


EXPERIMENTAL SETUP OF RECIPROCATING PUMP
Delivery pipeline
Pipe Support
coll. Tank
G.M safety valve
Pr. gauge
Machinery bed
Plunger pump with motor
Vac Gauge
Suction pipe line
G.M. Strainer

Ex. no: 10 **Date:**

PERFORMANCE CHARACTERISTICS OF A CENTRIFUGAL PUMP

AIM:

To determine the best driving condition of the given reciprocating pump at constant speed and to drive the characteristic curves.

APPARATUS REQUIERED:

1. Reciprocating pump
2. Meter scale
3. Stop watch THEORY

A **reciprocating pump** is a class of positive-displacement pumps that includes the piston pump, plunger pump, and diaphragm pump. Well maintained, reciprocating pumps can last for decades. Unmaintained, however, they can succumb to wear and tear.[1] It is often used

where a relatively small quantity of liquid is to be handled and where delivery pressure is quite large. In reciprocating pumps, the chamber that traps the liquid is a stationary cylinder that contains a piston or plunger. During the motion of piston from left to right(refer fig.) a partial vacuum created inside the cylinder. Because of this low pressure water will rise from well through suction tube and fill the cylinder by forcing to open the suction valve. This operation is known as suction stroke.(motion of piston from left to right). In this stroke crank rotates $\theta=0^\circ$ to $\theta=180^\circ$. Also delivery valve will be closed and suction valve will be open during this stroke. When the crank rotates from $\theta=180^\circ$ to $\theta=360^\circ$ piston moves inwardly from position right to left. Now piston exerts pressure on the liquid and due to which suction valve closes and delivery valve opens.the liquid is then foced up through delivery pipe. This stroke is known as delivery stroke. Now the pump has completed one cycle. The same cycle repeated as the crank rotates.

OBSERVATIONS:

Size of the tank	L=	m
	B=	m
Area of the Tank	A=	m^2
Correction head	X=	m
Energy meter constant	N_e=	rev/Kwh
Length of the stroke	l=	m
Speed of the pump	N=	rpm
Diameter of the cylinder	d=	m
Specific weight of water	w=	N/ m^2

TABULATION:

Sl.No	Pressure gauge reading G	Pressure head G x 10	Vacuum gauge reading "V"	Vacuum head V x 0.0136	Total Head H = (G x 10) + (V x 0.0136)	Time for 10cm rise of rise of water in the tank "t"	Actual Discharge Q= Ah/t	Time for Nr = 10 revolutions in the energy meter "T"	Input Power Pi = 3600 x Nr / Ne x T	Output Power Po = wQH	Efficiency = (output power / input power) * 100
Unit	Kg/cm2	'm' of water	'mm' of Hg	'm' of water	'm' of water	Seconds	m3/sec	Seconds	KW	KW	%
1											
2											
3											
4											
5											

1. Actual discharge Q_a = AH/t (cumec)
   Where:

A= area of the collecting tank in "m^2"

H= rise of water in the collecting tank in "m"

t = time taken for 10 cm rise in the collecting tank in "sec"

1. Total Head h= GX10 + V x 0.0136 + X (in m of water)
Where:

G= pressure gauge reading

V= vacuum gauge reading

X= correction head in m of water

2. Input power $P_i = 3600 \times N_r / N_e \times T$ (KW)
Where:

Nr= No of revolutions counted in energy meter disc.

Ne= Energy meter constant

T = Time taken for N_r revolutions in energy meter.

3. Output power po = WQH (KW)
Where:

w= specific weight of water (9.81 KN/m^3)

4. Theoretical discharge $Q_t = 2ALN/60$ Where:
A= Area of the cylinder L= Length of the stroke N= Speed of the Pump

5. % slip= $(Q_t - Q_a)/ Q_t * 100$

6. Efficiency = output power/ input power x 100 %

PROCEDURE:

1. The internal plan dimensions of the collecting tank are measured.
2. Correction head (The difference in level between the center of the pressure gauge and vacuum gauge) is measurement

The energy meter constant is noted down.

3. The motor is started and the following readings are noted down
   a) Pressure gauge and vacuum gauge reading
   b) Time 't' for 10 cm rise of water in the collecting tank
   c) Time 'T' for N_r revolutions in the energy meter
4. The above procedure is repeated for various pressure gauge reading.

MODEL CALCULATIONS:

1. Total Head(h) = Gx10 + Vx0.0136 + X (in ‘m’ of water)

   =

2. Actual discharge = $Q_a = Ah/t$ (cumec)

   =

3. Input power (P_i) = $3600 \times N_r / N_e \times T$ (KW)

   =

4. Output power po = WQH (KW)

   =

5. Theoretical discharge $Q_t = 2ALN/60$
6. % slip= $(Q_t - Q_a)/ Q_t * 100$

7. Efficiency = output power/ input power x 100 %

GRAPHS:

The following graphs are drawn taking discharge on X-axis

1. Discharge Vs Total Head
2. Discharge Vs Input power
3. Discharge Vs Efficiency

At the point of maximum efficiency of the graph, the corresponding value of discharge, head & Input power arrived from the graph

RESULT:

The characteristic curves of reciprocating pump are drawn from the point of maximum efficiency. The best driving conditions are found out and these conditions are obtained when,

1. The maximum efficiency =
2. Total head =
3. Discharge =
4. Input power =

VIVA VOCE QUESTIONS

RECIPROCATING PUMP

1. What are two types of clearance in a turbine?
Radial – clearance at the tips of the rotor and casing.
Axial – the fore-and-aft clearance, at the sides of the rotor and the casing.

2. What is the function of a thrust bearing?
Thrust bearings keep the rotor in its correct axial position.

3. What is a stage in a steam turbine?
In an impulse turbine, the stage is a set of moving blades behind the nozzle. In a reaction turbine, each row of blades is called a "stage." A single Curtis stage may consist of two or more rows of moving blades.

4. What is a diaphragm?
Partitions between pressure stages in a turbine‟s casing are called diaphragms. They hold the vane-shaped nozzles and seals between the stages. Usually labyrinth-type seals are used. One-half of the diaphragm is fitted into the top of the casing, the other half into the bottom.

5. What are the two basic types of steam turbines?
Impulse type.
Reaction type.

6. What are topping and superposed turbines?
Topping and superposed turbines arc high-pressure, non-condensing units that can be added to an older, moderate-pressure plant. Topping turbines receive high-pressure steam from new high-pressure boilers. The exhaust steam of the new turbine has the same pressure as the old boilers and is used to supply the old turbines.

7. What is a combination thrust and radial bearing?
This unit has the ends of the Babbitt bearing extended radically over the end of the shell. Collars on the rotor face these thrust pads, and the journal is supported in the bearing between the thrust collars.

8. How Cavitation can be eliminated in a Pump?
- Increase the Pump size to One or Two Inch,
- Increase the pressure of the Suction Head,
- Decrease the Pump Speed.

9. One litre =_________cm3 .
1000 cm3 .

10. Which Pump is more Efficient Centrifugal Pump or Reciprocating Pump?
Centrifugal pump.Because flow rate is higher compared to reciprocating pump. Flow is smooth and it requires less space to install. Lower initial cost and lower maintenance cost

Ex. no: 11 **Date:**

PERFORMANCE STUDY ON GEAR OIL PUMP

AIM:

To determine the best driving conditions of the giver gear oil pump at constant speed and to draw the characteristic curves.

APPARATUS REQUIRED:

1. Gear oil pump fitted with all accessories
2. Meter scale
3. Stop watch

FORMULA:

1. Actual Discharge (Q):

$Q = Ah/t$ cumec

2. Total head (H) m of water:

H = Pressure head+ Vaccum head + Correction head (m)

3. Input power:

$I/P = (3600n) / Ect_2$

Where,

N – no.of revolutions

Fc – Energy meter constant (rev/kwh)

T_2 – time for n revolutions(s)

4. Output power:

O/P = VWQH Watts

OBSERVATIONS:

Size of the tank	L=	m
	B=	m
Area of the Tank	A=	m^2
Correction head	X=	m
Energy meter constant	N_e=	rev/Kwh
Specific weight of water	w=	N/ m^2

TABULATION:

Sl.No	Pressure gauge reading G	Pressure head G x 10	Vacuum gauge reading "V"	Vacuum head V x 0.0136	Total Head H = (G x 10) + (V x 0.0136)	Time for 10cm rise of rise of water in the tank "t"	Actual Discharge Q= Ah/t	Time for Nr = 10 revolutions in the energy meter "T"	Input Power Pi = 3600 x Nr / Ne x T	Output Power Po = wQH	Efficiency = (output power / input power) * 100
Unit	Kg/cm2	'm' of water	'mm' of Hg	'm' of water	'm' of water	Seconds	m3/sec	Seconds	KW	KW	%
1											
2											
3											
4											
5											

5. Efficiency:

$$\eta = \{(O/P) / (I/P)\} X 100$$

PROCEDURE:

1. The internal dimensions of the collecting tank and the correction head are measured. The energy meter constant is noted.
2. The supply tank is filled with oil to the required height wsay ¾ of the tank.

3. The gate valve is opened in the delivery tube fully.
4. The motor is started and the following readings are noted.
    a. Pressure gauge & vacuum gauge readings
    b. Time for "h" m rise of oil in the tank.
    c. Time for "N_r" revolutions in the energy meter disc
    d. Take 4 or 5 sets of readings varying the delivery pressure.

GRAPH:

The following graph are drawn taking total "h" on X-axis.

1. Head VsDiscaharge
2. Head Vs Input power
3. Head Vs Efficiency

RESULT:

1. Maximum efficiency obtained =
2. Corresponding discharge =
3. Input power =
4. Corresponding total head of water =

VIVA VOCE QUESTIONS GEAR OIL PUMP

1. Define Pump?

Pump transfers the mechanical energy of a motor or of an engine into Pressure energy, kinetic energy or both of a fluid.

2. Define *Rotary displacement pumps*:

Positive displacement rotary pumps rely on fine clearances between moving parts for their efficient operation.

3. How the volume of oil discharge is calculate in aa gear pump?

The Volume of oil discharged per revolution = 2 x a x L x N m^3

4. Define horsepower?

Horsepower (hp) is a unit of measurement of *power* (the rate at which work is done).One horsepower is equal to 735 watts

5. What is the behavior of the pump with in-crease in pressure?

The flow rate in gear pump more or less remains constant with in-crease in pressure

6. Define Specific speed of pump

"The speed of an idealpump geometrically similar to the actual pump, which when running at this speed will raise a unit of volume, in a unit of time through a unit of head"

7. Write the principle for operation of pump ?

The principle of operation of pump is a partial vacuum is created at the pump inlet due to the internal operation of a pump. This allows atmospheric pressure to push the fluid out of the oil tank (reservoir) and into the pump intake. The pump then mechanically pushes fluid out ofthe discharge line.

8. Why Gear pumps cannot be used as a variable displacement pump?

In the gear pump, once the design parameters are finalized all the dimensions of gear pair is fixed and there is no way to vary the displacement.

9. What is the reasons for the popularity of external gear pump ?

The reasons for the popularity of external gear pump is Simple to design , Because gear pumps have only two moving parts, they are reliable, simple to operate, and easy to maintain and Low cost compared to other pumps

10. What is positive displacement pumps ?

The must positive displacement pumps are protected by relief valves because the Pumps are expensive items and if pressure shoots up do to some reason, then relief valve will allow the fluid to go back to the tank, if not pressure will rise to due to blockage of fluid and parts of pumps may fail. Relief valve thus limits the maximum pressure to which pump components can be subjected with.

EX.NO:12 DATE

PERFORMANCE TEST ON KAPLAN TURBINE

AIM:

To conduct load test on the Kaplan Turbine by keeping the speed as constant and to draw its characteristic curves.

APPARATUS REQUIRED:

- Kaplan turbine set up
- Sump tank
- Notch tank
- Centrifugal pump
- Collecting Tank

THEORY AND DESCRIPTION OF SET UP:

A Kaplan turbine is a type of propeller turbine which was developed by the Austrian engineer V. Kaplan (1876-1934). It is an axial flow turbine, which is suitable for relatively low heads, and hence requires a large quantity of water to develop large amount of power. It is also a reaction type of turbine and hence it operates in an entirely closed conduit from the headrace to the tailrace. The main components of Kaplan turbine are scroll casing, stay ring, arrangement of guide vanes, and the draft tube. Between the guide vanes and the runner the water in a Kaplan turbine turns through a right angle into the axial direction and then passes through the runner. The runner of a Kaplan turbine has four or six blades and it closely resembles a ship's propeller. The blades attached to a hub so shaped that water flows axially through the runner. Ordinarily the runner blades of a propeller turbine are fixed, but the Kaplan turbine runner blades can be turned about their own axis, so that their angle of inclination may be adjusted while the turbine is in motion. This adjustment of the runner blades is usually carried out automatically by means of a servomotor operating inside the hollow coupling of turbine and generator shaft.

The whole arrangement is attached to a rectangular notch provided. The whole arrangement is attached to a pump. The loading on the turbine is achieved with an electrical alternator connected to a lamp bank. Control panel on the turbine has digital units to display the turbine speed, head on turbine and electrical en

FORMULA:

1. **DISCHARGE** $\mathbf{Q = C_d A B^2 \sqrt{2gh / (1-B^4)}}$

   A = $\pi d^2/4$ where d_1 = 150mm

   B = 0.6

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

   h = (P_1-P_2) X 10 m of water

2. **INPUT POWER (P_i)**

$$\mathbf{Pi = \frac{\rho g \times Q_{act} \times H}{1000} \quad (Kw)}$$

Where,

ρ = Density of water (kg / m^3)

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

H = Total head of water (m)

3. **OUTPUT POWER(P_o)**

$\mathbf{P_o = \pi NDT/ 60000}$ **(Kw)**

D = Brake drum diameter

N = Turbine speed in RPM.

T = Resultant Load = $((T_2-T_1) + T_o)$ Kg

4. **EFFICIENCY (η)** $\mathbf{\eta = \frac{Output\ power}{Input\ power} \times 100}$ **%**

OBSERVATION:

Diameter of the brake drum (D) = ____________

Diameter of the rope (d) =_____________

Weight of lad hanger and rope =_____________

Sl. No	**Inlet Pressure (P)** *Kg/cm²*	**Speed (N)** *RPM*	**Pressure gauge reading** *Kg/cm²*			**Discharge (Q)** m^3/s	**Load** *Kg*		**Net weight (T) (T2-T1 +T₀)** *Kg*	**Input power** *(Kw)*	**Output power** *(kW)*	**Efficiency** (%)
			P_1	**P_2**	**$h=P_1-P_2$**		**T_1**	**T_2**				
1												
2												
3												
4												
5												

RESULT:

The best driving conditions of the Kaplan turbine for maximum efficiency condition are:

a. Maximum efficiency =________________***%***

b. Maximum output power =________________***Kw***

c. Maximum Speed = ________________r

Viva voce – Kaplan Turbine

1. What type of turbine is Kaplan turbine?

The **Kaplan turbine** is a propeller-**type** water **turbine** which has adjustable blades. It was developed in 1913 by Austrian professor Viktor **Kaplan**, who combined automatically adjusted propeller blades with automatically adjusted wicket gates to achieve efficiency over a wide range of flow and water level.

2. How does a Kaplan turbine work?

Kaplan Turbine works on the principle of axial flow reaction. In axial flow turbines, the water flows through the runner along the direction parallel to the axis of rotation of the runner..... It is capable of **working** at low head and high flow rates very efficiently which is impossible with Francis **turbine**.

3. What is the difference between Francis and Kaplan turbines?

In **Kaplan turbine**, the water flows axially in and axially out while in **Francis turbine** it is radially in and axially out. The runner blades **in the Kaplan turbine** are less in number as the blades are twisted and covers a larger circumference.

4. Why Kaplan turbines are used for low heads?

Water flows both in and out of **Kaplan turbines** along its rotational axis (axial flow). ... The large area of **Kaplan turbines** make them most useful where large volumes of water flow, and can be **used** even in dams with relatively **low head**.

5. Where is Kaplan turbine used?

Kaplan turbines are widely **used** throughout the world for electrical power production. They cover the lowest head hydro sites and are especially suited for high flow conditions.

6. Why are the **twisted** shape of **blades** used in steam **turbines**?

The **Blade** design depends on theories of physics and aerodynamics......**Twisted blades** increase the velocity and thus makes it more efficient. The **twist** has to be around 0 to 20 degrees from the root to tip which makes the **blade** moves faster through the air.

7. What is the efficiency of Kaplan turbine?

The hydraulic **efficiency** of a **Kaplan turbine** is 95%, the mechanical **efficiency** is 93% and the volumetric **efficiency** is assumed to be 100%.

8. Which turbine is used for high head?

Pelton turbine or wheel is an impulsive turbine used mainly for high head hydroelectric schemes. The **Pelton wheel** is among the most efficient types of **water turbines**. The fluid power is converted into kinetic energy in the nozzles. The total pressure drop occurs in the nozzle.

EX.NO:13 **DATE: ………..**

CHARACTERISTICS CURVES OF FRANCIS TURBINE

AIM:

To conduct load test on Francis turbine and to study the characteristics of Francis turbine.

APPARATUS REQUIRED :

1. Francis wheel unit
2. Supply pump
3. Venturimeter
4. Brake drum
5. Dead Weight
6. Pressure gauge

THEORY AND DESCRIPTION OF THE SETUP:

A Francis turbine is an inward flow reaction turbine with mixed flow runner, in which water enters at high pressure. Around the runner, a set of stationary guide vanes direct the water into the moving vanes. The guide vanes also serve as gates. The gate openings can be adjusted by a handle. The guide vanes are surrounded by a chamber called 'spiral chamber'. On the discharge side, the water passes to the tailrace by a tube 'Draft tube'. The draft tube enables the turbine to be set at a higher level without sacrifice in head. Moreover, it entails regaining of pressure energy, thus increasing the efficiency of the turbines.

The input power supplied to the turbine is calculated from the net supply head on the turbine and the discharge through the turbine. The output power from the turbine is calculated from the readings taken on the rope brake drum and the speed of the shaft. A tachometer is used to measure the speed of the shaft. The efficiency of the turbine is computed from the output and the input.

FORMULA:

1. **DISCHARGE Q = Cd AB^2** $\overline{2gh/\,(\mathbf{1}-B^{4}}$

A = $\pi d^2/4$ where d_1 = 150mm

B = 0.6

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

h = P_1-P_2X 10 m of water

2. **INPUT POWER (P_I)**

$$Pi = \frac{\rho X g X Q_{act} X H}{1000} \quad (Kw)$$

Where,

ρ = Density of water *(kg / m³)*

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

= Total head of *water* *(m)*

3. **OUTPUT POWER(P_O)**

P_o = πDNT/60000 ***(Kw)***

D= Brake drum diameter (Effective diameter of brake drum = 0.315 m)

N = Turbine speed in RPM.

T = Resultant Load = ((T_2-T_1) +To) Kg

4. **EFFICIENCY (η) = Output power/ Input power X 100 %**

PROCEDURE:

1. The Francis turbine is started
2. All the weights in the hanger are removed
3. The pressure gauge reading is noted down and this is to be maintained constant for different loads
4. Pressure gauge reading is ascended down
5. The pressure gauge reading and speed of turbine are noted down
6. The experiment is repeated for different loads and the reading are tabulated

GRAPH;

The graph is drawn between speed along x-axis and output power and efficiency along y-axis. At the point of maximum efficiency output power and speed are noted from the graph and the specific speed is computed.

GRAPH TABLE;

Sl. No.	**X-axis**	**Y- axis**	
	Speed ***Rpm***	**Output power** ***kW***	**Efficiency** ***%***
1			
2			
3			
4			
5			

OBSERVATION:

Diameter of the brake drum (D) = ____________

Diameter of the rope (d) = _____________

Sl. No	Inlet Pressure (P) *Kg/cm²*	Speed (N) *RPM*	Pressure gauge reading *Kg/cm²*			Discharge (Q) m^3/s	Load *Kg*		Net weight (T) (T2-T1 +T_0) *Kg*	Input power *(Kw)*	Output power *(kW)*	Efficiency (%)
			P_1	P_2	$h=P_1-P_2$		T_1	T_2				
1												
2												
3												
4												
5												

RESULT:

The best driving conditions of the Francis turbine for maximum efficiency condition are:

1. Maximum efficiency =________________***%***
2. Maximum output power =________________***Watts***
3. Maximum Speed =_________________***rpm***

VIVA VOCE –FRANCIS TURBINE

1. How does a Francis turbine work?

Francis Turbine is a combination of both impulse and reaction turbine, where the blades rotate using both reaction and impulse force of water flowing through them producing electricity more efficiently.

2. Why is Francis turbine called a reaction turbine?

The Francis turbine is a reaction turbine, which means that the working fluid changes pressure as it moves through the turbine, giving up its energy.

3. Why is Francis turbine used?

Francis Turbine is a combination of both impulse and reaction turbine, where the blades rotate using both reaction and impulse force of water flowing through them producing electricity more efficiently.

4. Where is Francis turbine used?

Francis turbine is the most widely used turbine in hydro-power plants to generate electricity. Mixed flow turbine is also used in irrigation water pumping sets to pump water from ground for irrigation. It is efficient over a wide range of water head and flow rate.

5. What is the efficiency of Francis turbine?

The hydraulic efficiency of a Francis turbine is 90%, the mechanical efficiency is 95% and the volumetric efficiency is assumed to be 100

6. How many types of turbine are there?

There are 3 main types of impulse turbine in use: the Pelton, the Turgo, and the Crossflow turbine. The two main types of reaction turbine are the propeller turbine (with Kaplan variant) and the Francis turbine.

7. What is flow ratio in turbine?

The flow ratio of Francis turbine is defined as the ratio of the. A. Velocity of flow at inlet to the theoretical jet velocity. Theoretical velocity of jet to the velocity of flow at inlet. Velocity of runner at inlet to the velocity of flow at inlet.

8. What is specific speed of turbine?

Specific speed of a turbine is defined as the speed of a geometrically similar turbine which produce a unit power when working under a unit head

9. Which turbine is used in power plant?

There are 3 main types of impulse turbine in use: the Pelton, the Turgo, and the Crossflow turbine.

10. What is the most efficient water turbine? Pelton wheels

EX.NO: 14 **DATE: ………..**

HYDRAULIC JUMP (DEMONSTRATION)

THEORY

The title type hydraulic flume may be used for uniform flow through open channels(i.e A phenomenon of flow through open channels, in which the rate of flow, depth of flow, area of flow and slope of bed remains constant). The change in any of the above condition causes the flow to be non- uniform.

The specific energy may be defined as energy per unit weight with respect to the datum passing through the bottom of the channel $E= h+ v^2 /\sqrt{2}g$ where h= depth of liquid flow and v= velocity of the liquid.

Critical depth: The depth of water in a channel corresponding to the minimum specific energy is known as critical depth = $hc = q^2/g)^{1/3}$. the velocity of water at critical depth is known as critical velocity $v_c= q/h_c$

A hydraulic jump occurs in an open channel when the flow changes from the supercritical to subcritical. The water level abruptly rises at the hydraulic jump. A large number of roller of turbulent eddies are formed at hydraulic jump, which cause dissipation of energy.

The hydraulic jump is analyzed by applying the impulse momentum equation to a control volume.

EXPERIMENT SET-UP

The set-up consists of a rectangular tilting flume having at the inlet and exit. The water is supplied to the flume by a centrifugal pump. A sluice gate is provided in the middle portion of the flume to create supercritical flow condition on its down stream so that a hydraulic jump can form.

A pointer gauge trolley can move on the rails at the top of the walls for the measurement of the water depths.

An venturimeter is provided on the supply pipe for the measurement of actual discharge.

THEORY

The depth y1 before hydraulic jump and the depth y2 after the hydraulic jump The loss energy in the hydraulic jump is given by

$$dE = E_1 - E_2 = (Y_2 - Y_1)^3 / 4Y_1Y_2$$

PROCEDURE

- Measure the width of the flume. Take the pointer gauge at the bed of flume at suitable section upstream and downstream of the hydraulic of the hydraulic jump. H_0
- Open the supply value and adjust the inlet and exit gates so that the flow becomes uniform and steady.
- Gradually lower the sluice gate and adjust the exit gate so that a stable hydraulic jump is formed on the downstream of the sluice gate.
- Note the deflection h of manometer liquid in the u-tube manometer attached to the venturimeter on the supply line for computation of actual discharge

OBSERVATION AND CALCULATION

Width of flume L = 250 mm

Venturimeter dimension

D1 = 40mm ,

D2= 24 mm

Venturimeter coefficient

Cd = 0.95

s.no	VENTURIMETER		WATER DEPTH READING(cm)			Y1= H1''- H0''	Y2= H2''- H0''
	h1(cm)	h2(cm)	H1''	H2''	H0''		

RESULT

The loss energy in the hydraulic jump=

EXP NO :15 **DATE :**

BERNOULLI'S EXPERIMENT

AIM :

To verify the Bernoulli"s theorem.

APPARATUS USED:

1) A supply tank of water a tapered inclined pipe fitted with no.of piezometer tubes point,

2)measuring tank,

3)scale,

4) stop watch.

THEORY

Bernoulli"s theorem states that when there is a continues connection between the particle of flowing mass liquid, the total energy of any sector of flow will remain same provided there is no reduction or addition at any point.

FORMULA USED

$H1= Z1+ P1/w+V1^2/2g$ $H2= Z2+ P2/w + V2^2/2g$

PROCEDURE

1. Open the inlet valve slowly and allow the water to flow from the supply tank.

2.Now adjust the flow to get a constant head in the supply tank to make flow in and out flow equal.

3.Under this condition the pressure head will become constant in the piezometer tubes. 4.Note down the quantity of water collected in the measuring tank for a given interval of time.

5.Compute the area of cross-section under the piezometer tube. 6.Compute the area of cross-section under the tube.

7.Change the inlet and outletsupply and note the reading.

TABULATIONS:

Location	1	2	3	4	5	6	7	8	9	10	11
Discharge Of piezometer Tube from **inlet(cumec)**											
Area of Crosssection Under foot Of each point (m^2)											
Velocity Of water Under foot Of each point(m/sec)											
V^2/2g											
p/ ρ											
p/ ρ+ **V^2/2g**											

RESULTS:

Hence, Bernoulli"s theorem verified.

VIVA VOCE –BERNOULLIS EXPERIMENT

1. What is Bernoulli's principle example?
   An **example** of **Bernoulli's principle** is the wing of an airplane;

2. What is Bernoulli's Theorem and its application?
   Bernoulli's theorem and its applications. According to **Bernoulli's theorem**, the sum of pressure energy, kinetic energy, and potential energy per unit mass of an incompressible, non-viscous fluid in a streamlined flow remains a constant.

3. How do you verify Bernoulli's Theorem?
   Open the inlet valve and allow the water to flow from the supply tank to the receiving tank through a tapered inclined pipe.

   Adjust the flow using an outlet valve to make the head constant in the supply tank.

4. What is mean by Bernoulli's Theorem?
   In Fluid dynamics, the **Bernoulli's theorem** or the **Bernoulli's** Principle is the law or statement or expression that gives relation between energies of a flowing fluid. It states that " The sum of Kinetic Energy, Potential Energy and Pressure Energy of a fluid per unit weight at any point is always constant"

5. What are the four applications of Bernoulli's principle?
   List **four applications of Bernoulli's principle**. Airplane wings, atomizers, chimneys and flying discs

6. What is the V in Bernoulli's equation?
   v: velocity of the fluid. ρ: Density of the fluid. h: height of the container or the pipe here the fluid is flowing

7. What is the aim of Bernoulli's Theorem?
   Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy

8. Can Bernoulli's theorem apply on gases?
   Yes, bernaullis **theorem can** be **applied** to incompressible fluids (liquids) and compressible fluids (**gases**) in the range of low mach number (less than 0.3)

9. How is Bernoulli's principle related to airplanes?
   Bernoulli's principle helps explain that an **aircraft** can achieve lift because of the shape of its wings. They are shaped so that that air flows faster over the top of the wing and slower underneath..... The high air pressure underneath the wings will therefore push the **aircraft** up through the lower air pressure.

10. What is steady flow?

A **steady flow** is the one in which the quantity of liquid flowing per second through any section, is constant. This is the definition for the ideal case. True **steady flow** is present only in Laminar **flow**

11. How can you measure the flow in pipelines?

Pipe flow measurement is often done with a differential pressure **flow** meter like the orifice, **flow** nozzle, and ventruri meter; Venturi Meters are discussed in this article. For each type, a constriction in the **flow** path causes a pressure drop across the meter.

12. What is flow element in piping?

The measured flowrate is a function of the pressure drop. So the **flowmeter** consists of the **flow element** in the **piping**, as well as a nearby differential-pressure **meter**. Small tubes, called impulse lines, on either side of the **flow element** lead to the DP **meter** for measurement