# SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

## DEPARTMENT OF CIVIL ENGINEERING

**IV SEMESTER**

**1903411 - HYDRAULIC ENGINEERING LABORATORY**

**Regulation – 2019**

**Academic Year 2021 – 22**

*Prepared by*

**Ms. K.SUGANYA DEVI, Assistant Professor/ CIVIL**

# PREFACE

This instruction manual has been prepared by the department of Civil Engineering to facilitate instructions doing practical classes and further to be used as a reference manual by the fourth semester Civil Engineering students of this college. This manual covers explanation of experiments included in the syllabus according to Regulation 2019 - 1903411 Hydraulic Engineering Laboratory for the B.E Civil Engineering degree course.

**Ms.K.Suganya Devi**

Assistant Professor

## Specific Rules and Hazards Associated with this Lab Include

**Capacity**-Normal Occupancy during teaching labs is 30

- Students should enter the lab with proper uniform and ID card.
- Always keep work areas clean and tidy.
- Observe safety alerts in the laboratory.
- Always wear shoes that completely cover your feet. No sandals or opened toed shoes are allowed.
- Follow all written and verbal instructions carefully.
- Observe the safety alerts in the laboratory.
- Don’t forget to bring Lab manual, Record, observation, calculator, graph sheet and other accessories when you come to lab.
- In the absence of Instructor no student shall be allowed to work in the laboratory.
- Don’t use mobile phones during lab hours.
- Place tools and equipment in proper place after use.
- Turn off the power switches of weighing balance and equipments after used.
- Report to the staff if any injuries.
- Dont try to repair any faulty instruments.
- Follow the COVID precautionary measures while inside the lab.

## 1903411 HYDRAULIC ENGINEERING LABORATORY

**L T P C**
**0 0 4 2**

**OBJECTIVE:**

• Students should be able to verify the principles studied in theory by performing the experiments in lab.
• Reinforcing the fundamentals of fluid mechanics and machinery by hands on experiment.
• hands on experiments in calibration of flow meters
• Performance characteristics of pumps
• Performance characteristics of turbines

**LIST OF EXPERIMENTS**

**A. Flow Measurement**

1. Calibration of Rotameter
2. Calibration of Venturimeter / Orificemeter
3. Bernoulli's Experiment

**B.Losses in Pipes**

4.Determination of friction factor in pipes
5. Determination of minor losses

**C. Pumps**

6. Characteristics of Centrifugal pumps
7. Characteristics of Gear pump
8. Characteristics of Submersible pump
9. Characteristics of Multistage Centrifugal pumps
10. Characteristics of Reciprocating pump

**D. Turbines**

11. Characteristics of Pelton wheel turbine
12. Characteristics of Francis turbine/Kaplan turbine

**E. Determination of Metacentric height**

13. Determination of Metacentric height of floating bodies

**TOTAL: 60 PERIODS**

**OUTCOMES:**

- The students will be able to measure flow in pipes and
- The students will be able to determine frictional losses
- The students will be able to develop characteristics of pumps
- The students will be able to develop characteristics of turbines
- The students will have through knowledge on floating bodies

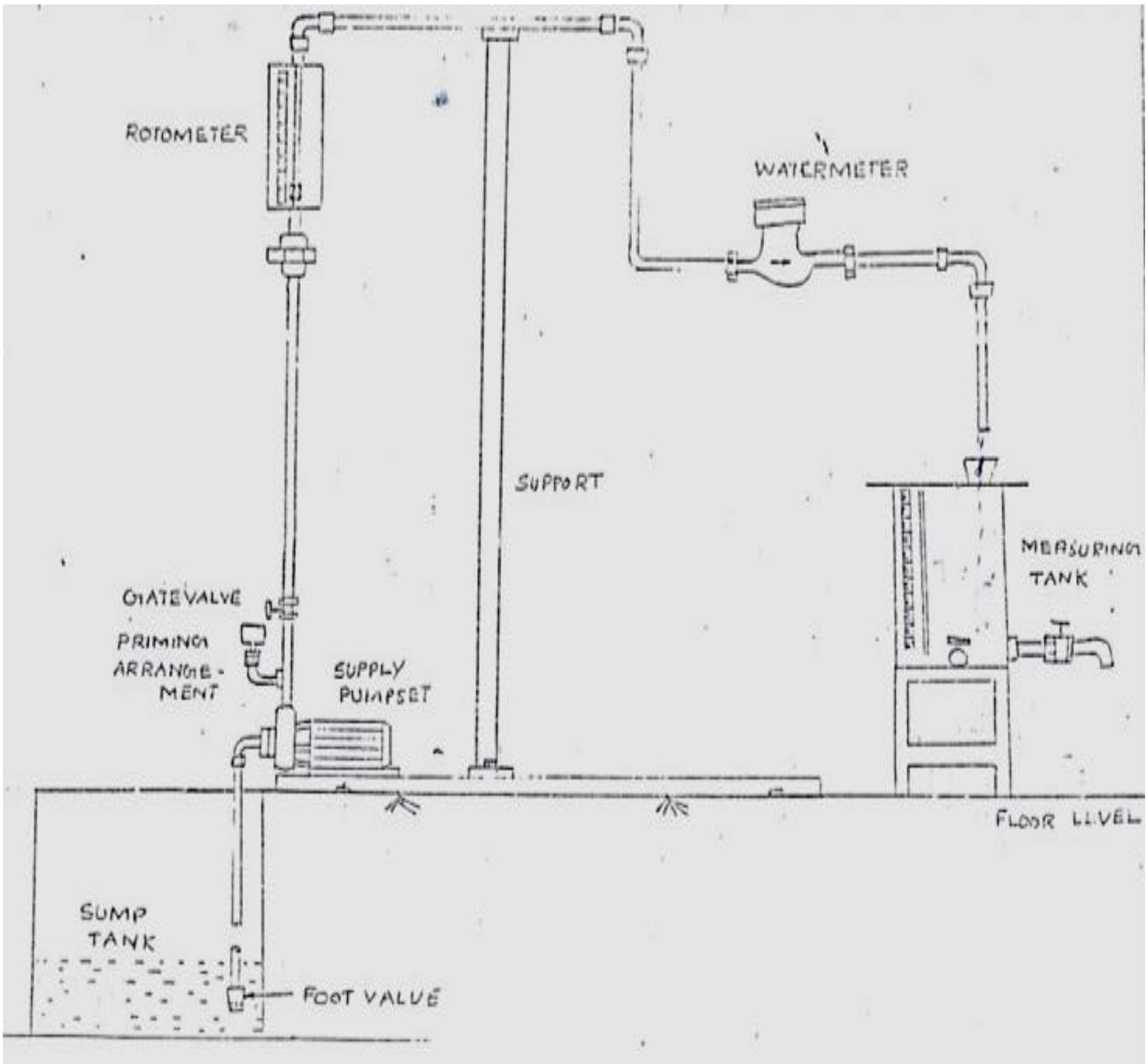
**REFERENCES:**


1. Sarbjit Singh. "Experiments in Fluid Mechanics", Prentice Hall of India Pvt. Ltd, Learning Private Limited, Delhi, 2009.
2. "Hydraulic Laboratory Manual", Centre for Water Resources, Anna University, 2004.
3. Modi P.N. and Seth S.M., "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi, 2000.
4. Subramanya K. "Flow in open channels", Tata McGraw Hill Publishing. Company, 2001.

**LIST OF EQUIPMENTS**

1. One set up of Rotometer
2. One set up of Venturimeter/Orifice meter
3. One Bernoulli's Experiment set up
4. One set up of Centrifugal Pump
5. One set up of Gear Pump
6. One set up of Submersible pump
7. One set up of Reciprocating Pump
8. One set up of Pelton Wheel turbine
9. One set up of Francis turbines/one set of kaplon turbine
10. One set up of equipment for determination of Metacentric height of floating bodies
11. One set up for determination of friction factor in pipes
12. One set up for determination of minor losses

## TABLE OF CONTENTS




**Fig(1). Rotameter**

**Ex. no: 1** **Date:**

## CALIBRATION OF ROTAMETER (FLOW METER)

**AIM:**

To calibrate the Rotameter (Flow meter)

**APPARATUS REQUIRED:**

1. Rota meter with all accessories
2. Stop-watch

**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:**

The actual volume flow rate is found from dividing the selected volume of water by the time required to accumulate that volume,

$$Q_{act} = \frac{V}{t} = \frac{A*h}{t} \text{x } 60{,}000 \text{ lpm}$$

Where,

$V$ is the volume of the water output accumulated in the storage tank, $m^3$.
$t$ is the time it takes to fill the selected volume, sec.
$A$ is the cross-section area of the storage tank, $m^2$
$h$ is the height of water in the storage tank, m.

The theoretical volume flow rate is found by,

$$Q_t = \frac{n}{t}\, x\, \frac{60}{10} \text{ mm}^3\text{/s}$$

**OBSERVATION AND CALCULATIONS:**

Length of the collecting tank, L = m

Breadth of the collecting tank, B = m

Area of collecting tank, A = $m^2$

**TABULATION :**

| Sl.No | Rotameter Readings $Q_{tr}$(lpm) | Time for 20 div in water '$t_w$' (ms) | Theoretical discharge $Q_t$(lpm) | Time for 10cm raise in collecting tank 't' (sec) | Actual discharge $Q_a$(lpm) | Co-efficient of discharge $C_d = Q_a/Q_t$ |
|---|---|---|---|---|---|---|
| | | | | | | |

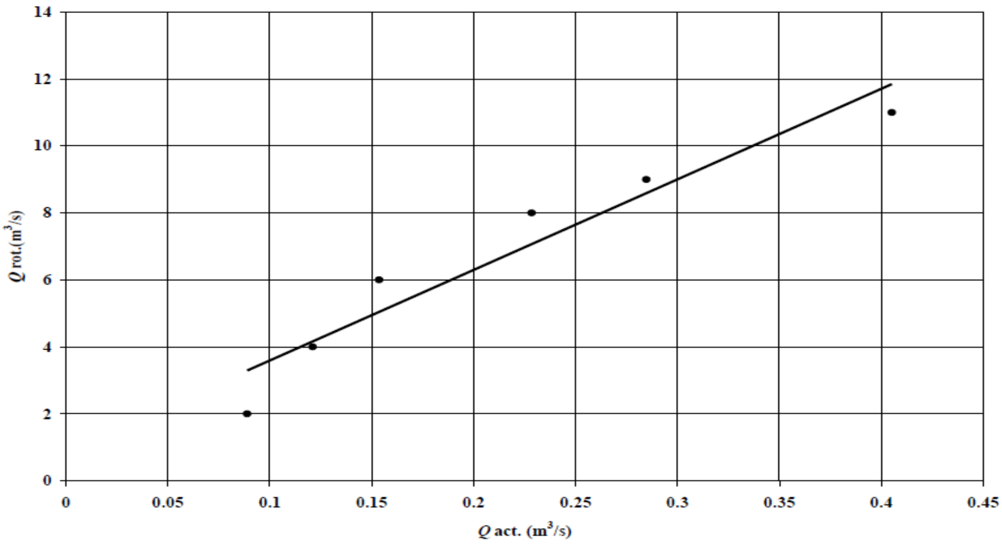



**Fig. (2).** Calibration curve for rotameter.

n – Number of division (take 20 division)

Co-efficient of discharge

$$C_d = \frac{Q_{act}}{Q_t}$$ (the value varies from 0.9 – 1.01)

**PROCEDURE:**

1. Select a rate of fluid flow through the rotameter.

2. Opening the inlet valve till the float reaches the selected flow rate.

3. estimating the time required to fill a fixed volume of output water.

4. The rotameter reading indicates the rotameter flow rate ($Q_{rot.}$) in (L/min); while the volume selected divided by the time measured indicates the actual flow rate ($Q_{act.}$) in (lit/sec).

5. Repeating the procedures from 1 to 3 for other selecting flow rate.

**Calculation and Results:**

Record the selected value of rotameter and estimated value of actual flow rate in a table as shown in table below.

Calculating correction factor ($C_f$), which is the ratio between the rotameter reading ($Q_{rot.}$) divided by the actual volume flow rate ($Q_{act.}$), for each reading, and then finding the average value of the correction factor.

Draw the calibration curve, the reading of the rotameter (on y-axis) against the measured actual volume flow rate (on x-axis). Also, find the average correction factor fromFig. (2) shown below, by finding the slope of the line.

**Discussion:**

Discuss the relation between actual volume flow rate and rotameter reading. Also, compare between the average correction factor obtained from table and that obtain from the figure.



**RESULT:**

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

(i) From the table $C_d$ =

(ii) From the graph $C_d$ =

## VIVA VOCE QUESTIONS
## ROTOMETER

1.Define Rotameter

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

2.The Advantages of rotometer are

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, Since the area of the flow passage increases as the float moves up the tube, the scale is approximately linear and Clear glass is used which is highly resistant to thermal shock and chemical action.

3. The Dis-advantages of rotometer are

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?

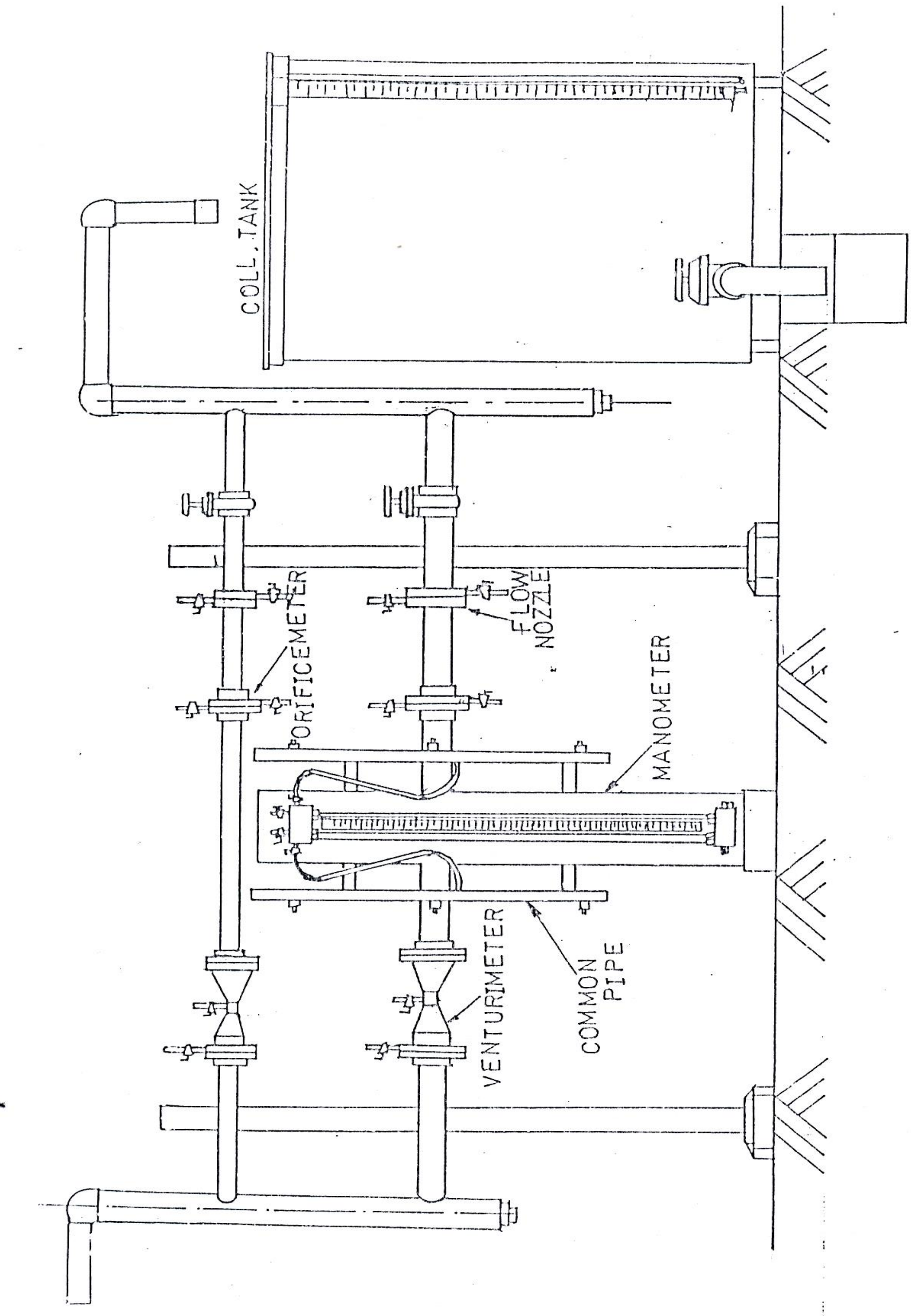
The major source of error in rotameter is due to the variation of density of the fluid. Besides, the presence of viscous force may also provide an additional force to the float.

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.


COLL. TANK
FLOW NOZZLE
ORIFICEMETER
MANOMETER
VENTURIMETER
COMMON PIPE

**Ex. no: 2** **Date:**

## DETERMINATION OF CO-EFFICIENT OF DISHCARGE FOR THE VENTURIMETER

**AIM:**

To determine the coefficient of discharge for the venturimeter

**APPARATUS REQUIRED:**

1. A venturimeter with known diameters at the mouth and throat fitted with stop cocks at the mouth and throat.
2. A U-tube manometer containing mercury.
3. Water measuring tank.
4. A stop-watch.

**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.

1. A short converging part.
2. Throat
3. 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:**

1. Drop in head across meter:

$$H = (h_1 - h_2)\ \{(s_m - s_w) / s_w\} \quad \text{(cm)}$$

Where,

$H_1, H_2$ – manometer readings (m)

$S_m$ – Specific gravity of mercury (13.6)

$S_w$ – Specific gravity of water (1)

2. Theroitical discharge ($Q_{th}$):

$$Q_{th} = (a_1 a_2 \sqrt{2gH}) / (\sqrt{a_1^2 - a_2^2}) \quad (cm^3/s)$$

Where,

$A_1$ – Cross sectional area of pipe $(cm^2)$

$A_2$ – Cross sectional are of throat $(cm^2)$

**OBSERVATION AND CALCULATIONS:**

Diameter of the inlet , $D_1$ = m

Diameter of the throat, $D_2$ = m

Length of the collecting tank, L = m

Breadth of the collecting tank, B = m

Area of collecting tank, A = $m^2$

**TABULATION :**

| Sl.No | Manometer Reading | | | √H | Time for 10cm raise in collecting tank 't' (sec) | Discharge $(m^3/s)$ | | Co-efficient of discharge $C_d = Q_a/Q_t$ |
|---|---|---|---|---|---|---|---|---|
| | $h_1$(m) | $h_2$(m) | H (m) | | | Actual Discharge $(Q_a)(m^3/s)$ | Theoritical discharge $(Q_t)(m^3/s)$ | |
| | | | | | | | | |

$D_1$ and $D_2$ – Diameter of pipe and throat (m)
H – Drop in head across meter (m)

3. Actual discharge ($Q_{act}$):

$$Q_{act} = (l*b*h) / t \quad (m^3/s)$$

Where,

l – Length of collecting tank (m)
b – Breadth of collecting tank (m)
h – Rise of water level in tank (m)
t – Time for 'h' m rise in tank (s)

4. Co-efficient of Discharge:

$$C_d = Q_{act} / Q_{th}$$

Where,

$Q_{act}$ – Actual discharge ($m^3/s$)
$Q_{th}$ – Theoretical discharge ($m^3/s$)

**PROCEDURE:**

1. Check whether all the joints are leak proof and water tight.
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 Qa 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.The rate at which fluid flows through a closed pipe can be determined by?

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**

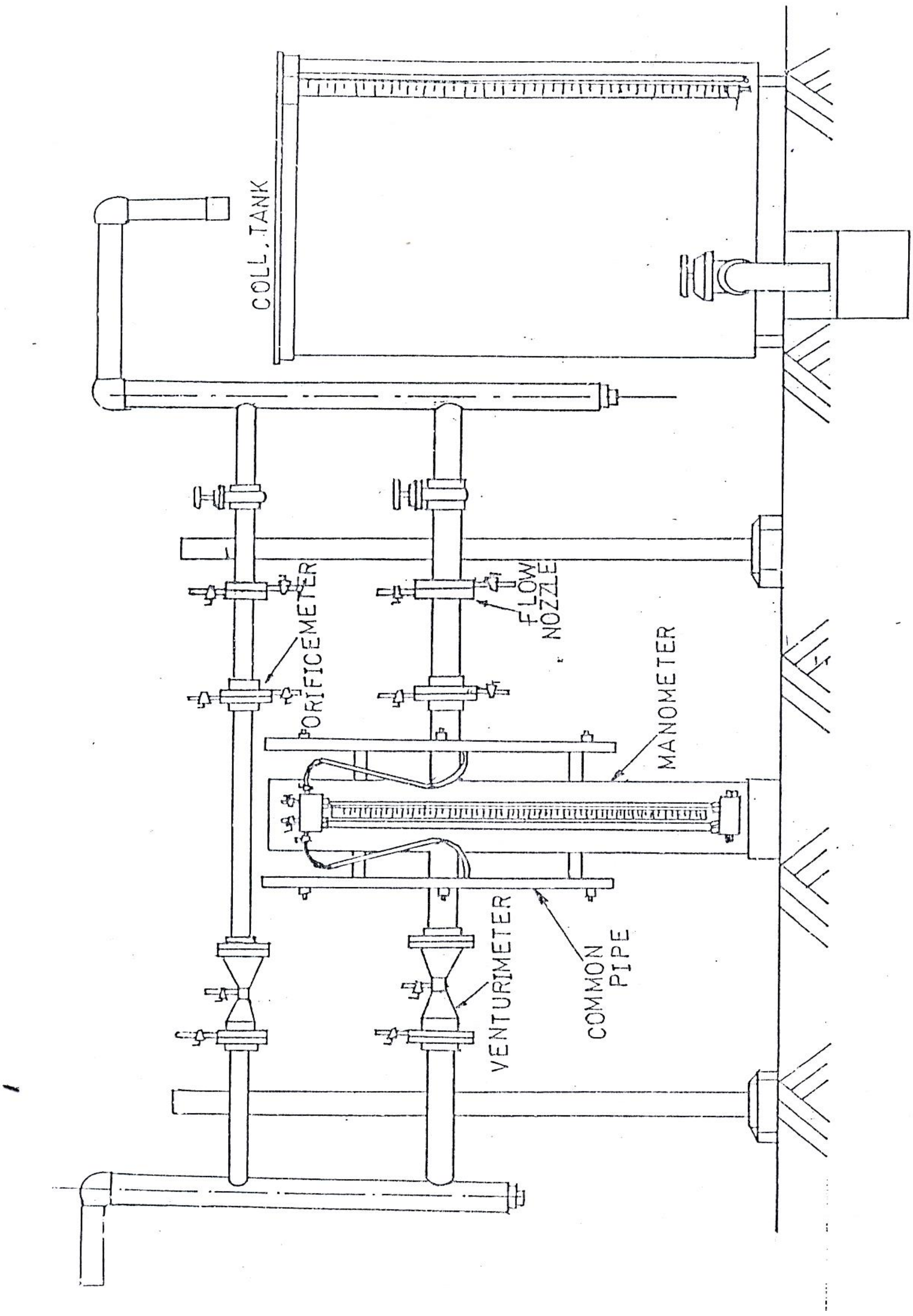
8. **Define Turbulent flow**

**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?

$C_d$= 0.9-0.95



COLL. TANK
ORIFICEMETER
FLOW NOZZLE
MANOMETER
VENTURIMETER
COMMON PIPE

**Ex. no: 3** **Date:**

# DETERMINATION OF CO-EFFICIENT OF DISHCARGE FOR THE ORIFICEMETER

## 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.

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

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

## 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 | | | | | | | | |

$h_2$= 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.

## 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 =

**Tabulation:**

| S.No | C/S area m2 | Time for 10 cm raise (sec) | Discharge (Q) $cm^3$/sec | Velocity (V) m/s | Velocity head $V^2/2g$ (m) | Pressure head $P/\rho g$(m) | Datum head (m) | Total head (m) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

## VIVA VOCE QUESTIONS
## ORIFICE METER

1. Manometer

A Manometer is a device to measure pressures. A common simple manometer consists of a U shaped tube of glass filled with some liquid.

2. Simple U-tube manometer is used to measure?

Negative Gauge Pressures.

3. For a stationary fluid, the local pressure of the fluid vary With ?

depth only

4. What is the device used for the measurement of discharge in pipe?

Orifice meter

5. What do you mean by large orifice?

If the head of liquid is less than 5 times the depth of orifice is called 'large orifice'

6.What is the coefficient of discharge for an orifice meter ?

0.58 and 0.65

7. Piezometer is used to measure?

very low pressures

8. What are the instruments used to measure flow on the application of Bernoulli's theorem?

Venturimeter, Orifice plate, nozzle and pitot tube

9. what is cheapest device for the measurement of flow ?

ORIFICEMETER

10.The Ratio of inertia force to surface tension is known as <u>Weber's number</u>

**Ex.no-4** **Date:**

## BERNOULLI'S APPARATUS

**AIM:**

To verify Bernoulli's theorem using Bernoulli's apparatus.

**APPARATUS REQUIRED:**

1. Bernoulli's apparatus
2. A stop-watch.

**FORMULA REQUIRED:**

$$\frac{P}{\rho g} + \frac{V^2}{2g} + z = H_{total}$$

Where,

$H_{total}$ – Total head

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

$\frac{P}{\rho g}$ - Pressure head , Z – Datum head

**PROCEDURE:**

1. The electric motor is started and water is allowed to flow in the given apparatus.
2. The outlet valve of the apparatus is adjusted and maintains a constant head.
3. There should not be any air bubble in the piezometric tubes and the apparatus.
4. Thus pressure head and the various section of conduit are maintained.
5. Note down the manometric readings.
6. Measure the time taken for 10cm raise in collecting tank.
7. Using Bernoulli's equations calculate the total head.

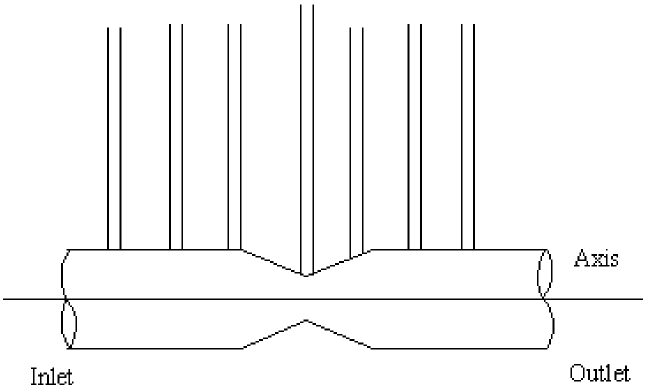



**Fig. Bernoulli's apparatus**

**GRAPH :**

Plot the graph taking,

(i) C/s area Vs Pressure head

(ii) C/s area Vs Velocity head

(iii) C/s areaVs Total head

**OBSERVATION:**

Length of the collecting tank, L = ……….. cm

Breadth of the collecting tank, B = ……….. cm

Diameter of the orifice, d = ……….. cm

| S.no | Head, 'H' (cm) | Time for 10 cm rise, 't' sec. | Actual discharge, $Q_a$ ($cm^3/s$) | Theoretical discharge, $Q_t$ ($cm^3/s$) | Co-efficient of discharge $C_d = Q_a / Q_t$ |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |



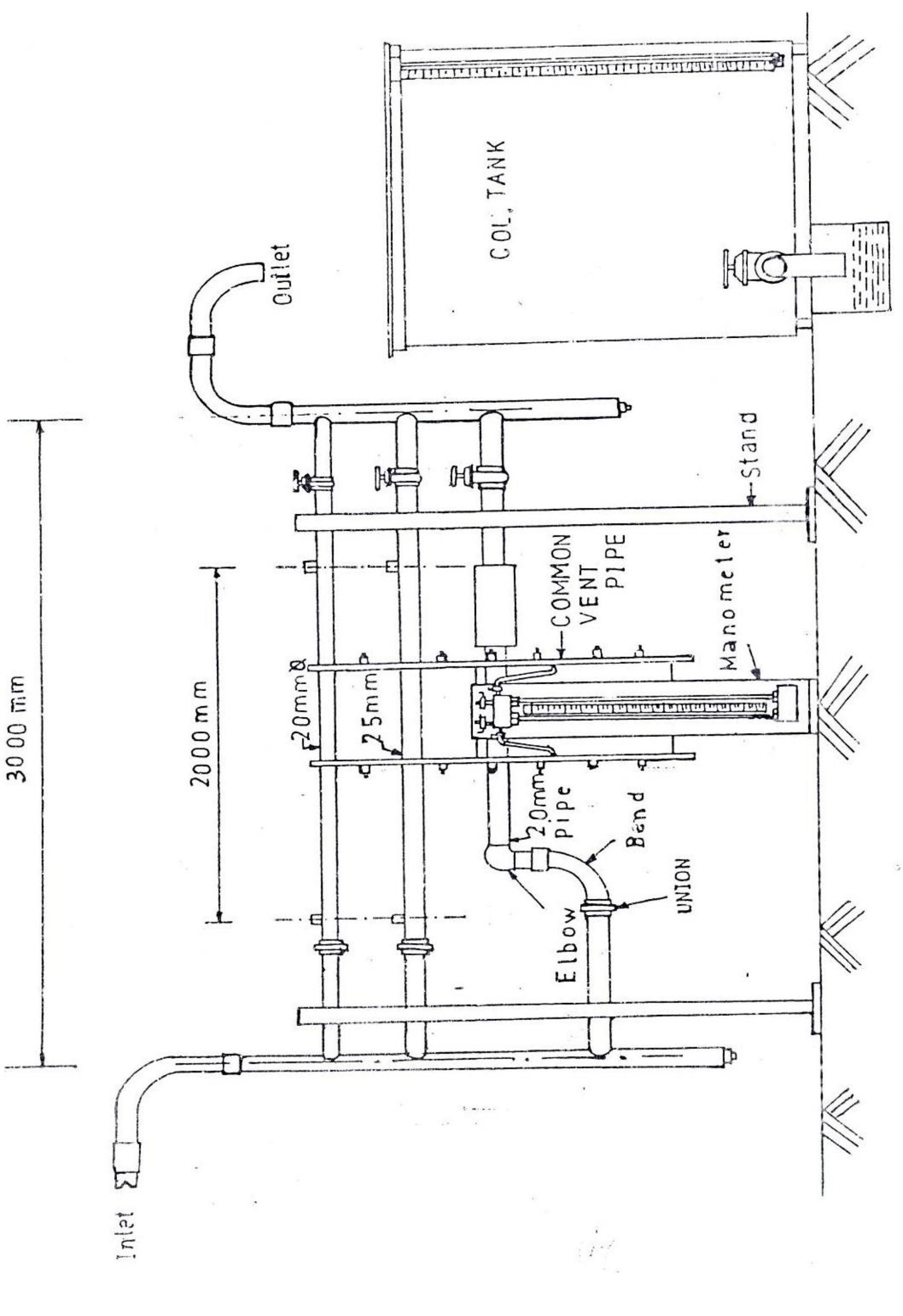
**Result:**

Thus the Bernoulli's equation is verified by using Bernoulli's apparatus and it is also verified by graphically. The total head is ________

## VIVA VOCE QUESTIONS

## BERNOLLI'S APPARATUS

1. Why is a bernoulli's experiment carried out?
   To demonstrate the variation of pressure along the converging-diverging pipe section.
2. What does a bernoulli's theorem represent?
   It is an approximate relation between pressure, velocity and elevation.
3. In which kind of region is Bernoulli's theorem valid.
   It is valid in regions of steady, incompressible flow where the net frictional forces are negligible.
4. How is a bernoulli's equation obtained?
   It is obtained when the Euler's equation is integrated along the streamline for a constant density fluid.
5. State bernoulli's equation.
   It states that the " sum of kinetic energy, pressure energy, potential energy per unit weight of fluid at any point remains constant".
6. How can a bernoulli's theorem be written.
   Velocity head+ static head+ potential head = a constant.
7. The pressure head is given by?
   P/w
8. How is the velocity head represented?
   V/2g
9. What symbol represents the pressure head.
   Z
10. Tell one assumption made in the derivation of bernoulli's equation.
    The assumption made is that the flow is irrotational.




LOSSES IN PIPE LINES(MINOR & MAJOR)

**Ex. no: 5** **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

**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 =

| | | |
|---|---|
| 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.

**MODEL CALCULATION:**

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

= mm²

2. Internal plan area of collecting tank

= L x B

= mm²

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 =

**OBSERVATIONS:**

Length of collection tank, L = m, Breadth of collection tank, B = m

Dia of inlet pipe , $d_1$ = m, Dia of outlet pipe , $d_2$ = m

Area of inlet pipe , $a_1$ = $m^2$, Area of outlet pipe , $a_2$ = $m^2$

*CALCULATION – COEFFICIENT OF EXPANSION*

| *Sl. No.* | *Difference in mercury level* $X = h_1 \sim h_2$ *(cm)* | $h_f = X \times 12.6$ *(cm)* | *Time for 10 cm rise 't' sec.* | $Q = Ay/t$ $cm^3/s$ | $V_1 = Q/a_1$ $cm/s$ | $V_2 = Q/a_2$ $cm/s$ | $h_e = (V_1 - V_2)^2 / 2g$ |
|---|---|---|---|---|---|---|---|
| 1. | | | | | | | |
| 2. | | | | | | | |
| 3. | | | | | | | |
| 4. | | | | | | | |
| 5. | | | | | | | |
| 6. | | | | | | | |
| 7. | | | | | | | |

## 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 to 2.0.
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: 6** **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 pipe $C_b$ =

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

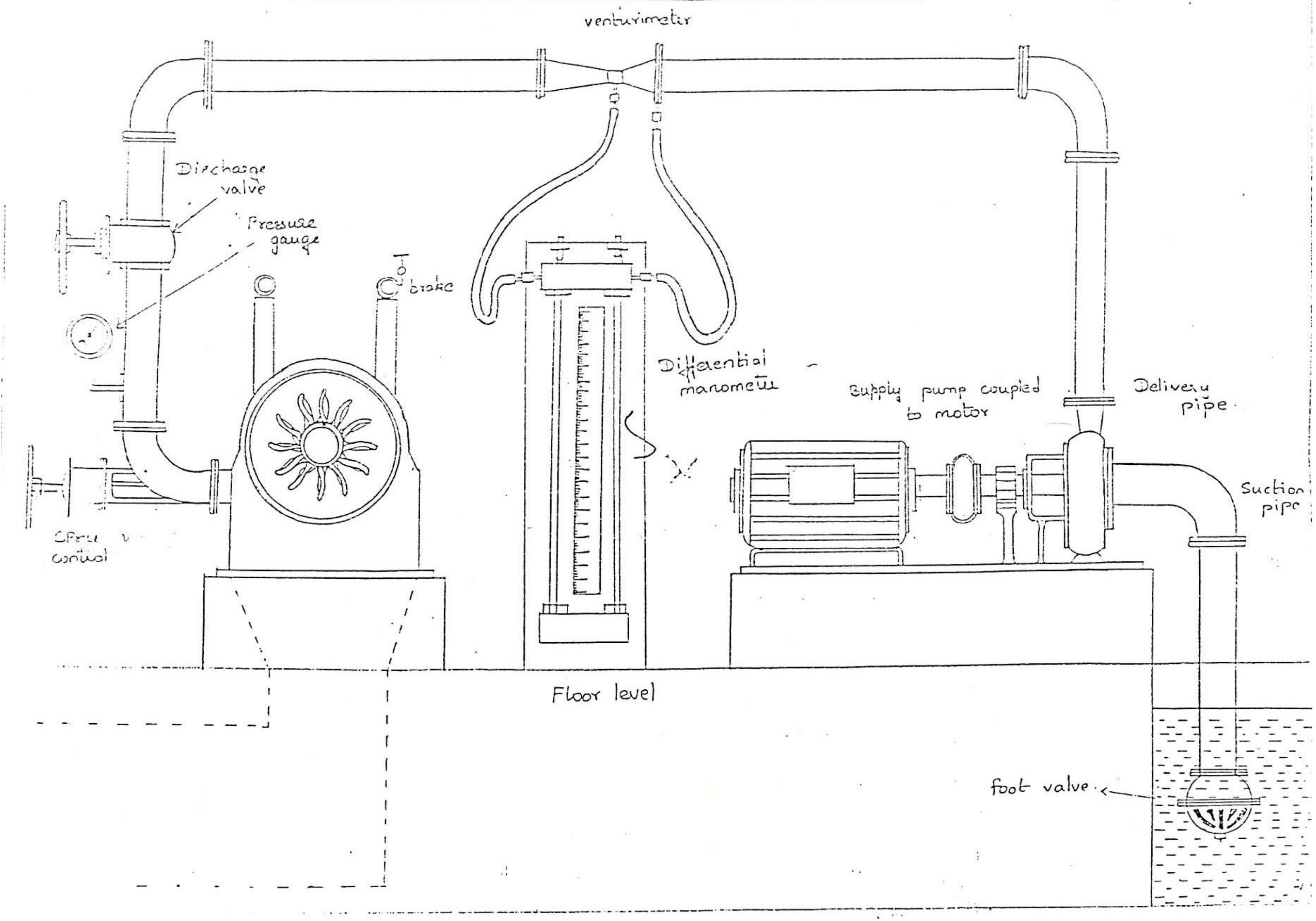
9. What is the formula to calculate minor losses

$h_f = ( k*V^{2/} 2g)$

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

70

EXPERIMENTAL SETUP OF PELTON WHEEL TURBINE



**Ex. no: 7** **Date:**

## PERFORMANCE CHARACTERISTICS OF PELTON WHEEL

### AIM:

To conduct the load test on the given pelton wheel turbine by keeping constant gate opening, constant pressure &varying speed and draw the characteristic curves.

### APPARATUS REQUIRED:

1. Pelton wheel turbine unit
2. Supply pump set
3. Tachometer

### DESCRIPTION:

The pelton wheel turbine has been classified as an impulse turbine, where the available head is wholly converted into velocity energy with approximate axial flow it is used for very high heads. It is a most efficient type of impulse turbine. The jet of water impinges on the wheel from one or more nozzles and strikes on the buckets. The buckets are of double hemispherical cup shape. The flow of water is regulated by the needle nozzle. The buckets are so shaped that the jet is discharged backwards.

The supply to the turbine is affected by means of a centrifugal pump. The discharge is measured by an orifice meter. The difference in pressure is measured by a differential manometer. The pressure gauge at the inlet of the turbine measures the net head supplied by the pump to the turbine.

OBSERVATION:

Diameter of the brake drum, D= 0.3 m

Diameter of the rope, d= 0.016 m

Specific weight of water $W = 9810\ N/m^3$

TABULATION:

| Sl. No. | Gate opening | Pressure gauge reading, G | Pressure head, Total head = Gx10 | Manometer reading h1 | Manometer reading h2 | $h=(h1-h2) \times 13.6$ | Actual discharge $Qa = 0.0055 \sqrt{h}$ | Dead weight of hanger, $w_D$ | Weight on the hanger, $w_H$ | Total weight $W_b = w_D + w_H$ | Spring load, $w_s$ | Net weight on drum $W = (w_b - w_s) \times 9.81$ | Torque, $T = (D+d/2) \times W$ | Input power $P_i = 9.81 \times Q \times h$ | Speed (N) | Output power $P_0=(2\pi NT) / 60000$ | Efficiency, $\eta$=(output power/ input power) x 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | kg/ $cm^2$ | m of water | m of Hg | | m of water | $m^3$/ sec | kg | kg | kg | kg | N | N_m | kW | rpm | kW | % |
| 1. | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | |

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 on the rope brake dynamometer s and the computed from the output and the input.

For any settings of the spear first the turbine is run for sometimes at a light load. In the variable speed test the brake load is increased gradually by adding dead weights on the load hangers. Until the turbine is finally ceases to revolve. The net supply head on the turbine can be varied by regulating the discharge gate valve of the pump.

| | | |
|---|---|---|
| Actual discharge | $Qa=0.0055 \sqrt{h}$ | cumec |
| Total brake load | $Wb=Wh+Wd$ | kg |
| Net weight on the drum | $W= (Wb-Ws) \times 9.81$ | N |
| Torque | $T = \{(D+d)/2\} \times W$ | Nm |
| Input power | $Pi= 9.81 \times Q \times H$ | kW |
| Output power | $Po=2 \pi NT / 60{,}000$ | kW |
| Efficiency | $\eta = Po/Pi \times 100$ | % |
| specific speed | $Ns= N\sqrt{Po} / (H^{5/4})$ | |

Where

| | |
|---|---|
| h= manometer head | in m |
| Wh= weight on hanger | in Kg |
| Wd=dead of the weight of hanger | in kg |
| Ws= spring load | in Kg |
| D= diameter of brake drum | in m |

| | |
|---|---|
| d= diameter of rope | in m |
| H = pressure head | in m of water |
| N= Speed of the shaft | in RPM |

PROCEDURE:

1. The supply pump is first started with the discharge valve completely closed.
2. The Gate opening is done to the required %
3. The gate valve is opened to the required head of water by regulating the discharge valve.
4. The pressure gauge readings are measured.
5. The Manometer readings (h1 & h2) are measured.
6. Making the spring load (Ws) as 0.5 kg the load on the hanger is varied form 0 to 10kg. Again by making the spring load (Ws) as 1 kg the load on the hanger is varied from 12 to 20kg.
7. The speed of the shaft is measured by tachometer at every set of loadings (0, 2, 4…20 kg).
8. After that, Discharge valve is fully closed and the motor is switched off.

MODEL CALCULATION:

(Formulae to be used)

Total head $= G \times 10$

U-tube differential manometric head $h = (h1 - h2) \times 13.6$

Actual discharge $Qa = 0.0055 \sqrt{h}$

Net weight of the drum $W = (W_B - W_S) \times 9.81$

Input power $P_i = 9.81 \times Q \times h$

Output power $P_0 = (2\pi NT) / 60000$

Efficiency $\eta = (Po/P_i) \times 100$

**GRAPHS:**

The following graphs are drawn taking speed on x- axis.

1. Speed vs Efficiency
2. Speed vs. Output power

At the point of the maximum efficiency of the graph the corresponding values of speed & output power are arrived from the graph.

**RESULT:**

The characteristic curves are drawn from the point of maximum efficiency. The best driving conditions are found out.

The best driving conditions of the turbine are obtained when,

| | | |
|---|---|---|
| 1. Maximum efficiency | $\eta_{max}$ | = |
| 2. Speed | N | = |
| 3. Output power | Po | = |
| 4. Specific speed | $N_s$ | = |

## VIVA VOCE QUESTIONS

## PELTON WHEEL TURBINE

**1. In a turbine what will be considered to identify the Fluid Input Power?**

Fluid Input Power = Mechanical Loss + Hydraulic Losses + Useful shaft power output.

**2. How will you find the Hydraulic Losses?**

Hydraulic Losses = Impeller Loss + Casing Loss + Leakage Loss

**3. On what does the efficiency of a Pelton wheel turbine depends on.**

The optimum value of the overall efficiency of a Pelton turbine depends both on the values of the specific speed and the speed ratio.

**4. What are the efficiencies of a turbine?**

Hydraulic efficiency

Mechanical efficiency

Volumetric efficiency

Overall efficiency

**5. Define Gross Head of a turbine.**

The difference between head race level and tail race level is known as Gross Head

**6. Define Net head of a turbine.**

It is also called effective head and is defined as the head available at the inlet of the turbine.
H = Hg – hf

**6.What are called turbines?**

Hydraulic turbines are the machines which use the energy of water and convert itinto mechanical energy. The mechanical energy developed by a turbine is used in running the electrical generator which is directly coupled to the shaft.

**7.Define volumetric efficiency.**

The ratio of the volume of the water actually striking the runner to the volume of water supplied to the turbine is defined as volumetric efficiency.

**8. Define Jet Ratio.**

It is defined as the ratio of the pitch diameter (D) of the Pelton wheel to the diameter of the jet (d). It is denoted by „m‟ and is given as m = D/d

**9.Uses of draft tube:**

Discharges water to tail race safely Converts a large proportion of rejected kinetic energy into useful pressure energy Net head of the turbine is increased.

**10. What is roto dynamic pump?**

When the increase in pressure is developed by rotating impeller or by action of centrifugal force then the pump is called as roto dynamic pump.

**Ex. no: 8** **Date:**

## PERFORMANCE CHARACTERISTICS OF FRANCIS TURBINE

**AIM:**

To conduct the load test on the given Pelton wheel turbine by keeping constant gate opening, constant pressure & varying speed and draw the characteristics curves.

**APPARATUS REQUIRED:**

1. Francis Turbine
2. Tachometer
3. Supply pump set

**FORMULA:**

1. Actual Discharge $Q_a = 0.011\sqrt{h}$ cumec
2. Total Brake load $W_b = W_{h+}W_d$ Kg
3. Net weight on the drum $W = (W_b - W_s) \times 9.81$ N
4. Torque , $T = ((D+d)/2) \times W$ Nm
5. Input Power $P_i = 9.81 \times Q_a \times H$ kw
6. Output Power $P_o = 2\pi NT / 60,000$ kw
7. Efficiency , $\eta = P_{o/}P_i \times 100$ %
8. Specific Speed, $N_s = N\sqrt{P_o}/ H^{5/4}$ rpm

Where,

H – Manometer Head in m

$W_h$ – Weight on hanger in Kg

$W_d$ – Dead Weight of the hanger in Kg

$W_s$ – spring load in Kg

D – Diameter of brake drum in m

D – Diameter of rope

**OBSERVATIONS:**

Dia of the brake drum, D = mm, Discharge Q = K√p (h in m of water) (k = $1.0512 \times 10^{-2}$)

Diameter of the rope, t = mm, Orificemeter Head P in m of water = $(P_1-P_2)$x10

Weight of rope & Hanger = 1 kg, Effective Radius of = (D/2+t) =

Brake drum net load W = ($W_1$ + weight of rope & hanger) – $W_2$ kg.

| S.No. | Pressure Gauge Kg/cm$^2$ | Orificemeter Head Pressure Gauge reading (kg/cm$^2$) | | | Orifice meter Head, h (m) | Discharge , Q (m$^3$/s) | Weight on hanger, $W_1$ (kg) | Spring balance reading $W_2$ (kg) | Net load W, Kg | Shaft speed rpm | Output, kW | Input, kW | Efficiency, η (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $P_1$ | $P_2$ | P | | | | | | | | | |
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | |

H – Total Head in m of water

N – Speed of the Shaft in rpm.

**PROCEDURE :**

1. The supply pump is first started with the discharge value completely closed.
2. Do the gate opening to the required %.
3. The gate valve is opened to the required head of water by regulating the discharge valve.
4. Measure the pressure gauge readings.
5. Measure the manometer readings ($h_1$ & $h_2$)
6. Marking the spring load $W_S$ as 0.5 kg vary the load on the hanger 0 to 10 kg and again making the spring load $W_S$ as 1 kg vary the head on the hanger 12 to 20 kg.
7. Measure the speed of the shaft by Tachometer and set the readings (0,2,4,…. 20 kg)
8. After that discharge valve is fully closed and note the vaccum gauge readings.

**GRAPH:**

The following graphs are drawn by taking speed on X – axis.

1. Speed Vs efficiency
2. Speed Vs output power

At the point of maximum efficiency of the graph corresponding value of speed and output power are carried from the graph.



**RESULT:**

The characteristic curves are drawn from the point of maximum efficiency. The best driving condition are formed out, and the best conditions of the turbine are obtained.

When,

1. The maximum efficiency $\eta_{max}$ =
2. Speed N =
3. Specific speed $N_s$ =

## VIVA VOCE QUESTIONS

## FRANCIS TURBINE

1.**What are fluid machines or Hydraulic machines?**

The machines which use the liquid or gas for the transfer of energy from fluid torotor or from rotor to fluid are known as fluid machines.

**2. How are fluid machines classified?**

Fluid machines are classified into two categories depending upon transfer ofenergy:

1. Turbines – hydraulic energy is converted to mechanical energy and thenelectrical energy.
2. Pumps – electrical energy is converted to mechanical energyand then hydraulic energy.

**3. What are called turbines?**

Hydraulic turbines are the machines which use the energy of water and convert itinto mechanical energy. The mechanical energy developed by a turbine is used in running the electrical generator which is directly coupled to the shaft.

**4. What is known as Euler's equation for turbo-machines?**

The general expression for the work done per second on impeller is

$\rho Q[V_{w1}u_1 + V_{w2}u_2]$

**5. Define Gross Head of a turbine**.

The difference between head race level and tail race level is known as Gross Head

**6. Define Net head of a turbine.**

It is also called effective head and is defined as the head available at the inlet of the turbine.
$H = H_g – h_f$

**7. What are the efficiencies of a turbine?**

Hydraulic efficiency

Mechanical efficiency

Volumetric efficiency

Overall efficiency

**8. Define Hydraulic efficiency.**

It is defined as the ratio of the power given by water to the runner of a turbine to

the power supplied by the water at the inlet of the turbine.

Power delivered to runner (runner power)

$\varepsilon h$ = ----------------------------------------------------------

Power supplied at inlet (water power)

Water power = $\gamma QH = (1/2)\, m\, v^2$

**9. Define Mechanical efficiency.**

The ratio of the power available at the shaft of the turbine to the power delivered

to the runner is defined as mechanical efficiency.

Power available at the shaft (shaft power)

$\varepsilon m$ = ----------------------------------------------------------

Power delivered to runner (runner power)

**10. Define volumetric efficiency.**

The ratio of the volume of the water actually striking the runner to the volume of water supplied to the turbine is defined as volumetric efficiency.

**Ex. no: 9** **Date:**

## PERFORMANCE CHARACTERISTICS OF KAPLAN TURBINE

**AIM:**

To study the performance of the Kaplan turbine and to draw the characteristic curves of the Kaplan turbine

**APPARATUS REQUIRED:**

1. Kaplan turbine
2. Pressure gauge
3. Scale
4. Tachometer

**DESCRIPTION:**

Kaplan turbine consists of series of disc of buckets fixed around the periphery of circular disc or circular where called runner. The runner mounted on shaft water is supplied by a pump through pipe. The other end of pipe in fitted with nozzle. The amount of water flowing out of nozzle is controlled by a spear. The difference in pressure is measured by differential manometer. The rate of flow through the pipe is measured by a Venturimeter. The water is discharged through a draft tube in total race.

**FORMULA:**

1. **Input power (I/P):**

I/P = W x Q x H kW

Where,

W – Specific weight of water (9810 $N/m^3$)

Q – Discharge ($m^3/s$)

H – Head of water at inlet of turbine (m)

**2. Brakepower :**

BP = {2πNT x 9.81}/60000 Kw

Where,

N – Speed of turbine (rpm)

D – Brake down diameter (m)

**OBSERVATIONS:**

Dia of the brake drum, D =  mm, Discharge Q = K√p (h in m of water) (k = $2.3652 \times 10^{-2}$)

Diameter of the rope, t =  mm,  Orificemeter Head P in m of water = $P_1 - P_{2\ x}\ 10$

Weight of rope & Hanger = 1 kg,  Effective Radius of = (D/2+t) =

Brake drum net load W = ($W_{1\ +}$ weight of rope & hanger) – $W_2$ kg.

| S.No. | Pressure Gauge Kg/cm² | Orificemeter Head Pressure Gauge reading (kg/cm²) | | | Discharge , Q (m³/s) | Weight on hanger, $W_1$ (kg) | Spring balance reading $W_2$ (kg) | Net Weight W, Kg | Shaft speed rpm | Output, kW | Input, kW | Efficiency, ɳ (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $P_1$ | $P_2$ | P | | | | | | | | |
| 1. | | | | | | | | | | | | |
| | | | | | | | | | | | | |
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**GRAPH**

1. Speed in rpm vs. Efficiency in %
2. Speed in rpm vs. output power

T – Turbine speed in RPM

T = Torque in kgm, (effective radius of the brakedrum in meters (R) x The net brakeload in kg. (w)

$R_e$= 0.165 m

**4. Efficiency of turbine (n):**

N = (OP / IP) x 100 %

**5. Specific speed (Ns):**

$Nu = N\sqrt{P} \ / \ (H)^{5/4}$ rpm

Where,

N – Speed or maximum efficiency (rpm)

P – Output power corresponding to maximum efficiency (kw)

H – Head and inlet of turbine (m)

**PROCEDURE:**

1. Keep the runner vane at require opening.Keep the guide vanes at require opening.
2. Prime the pump if necessary. Close the main sluice valve and then start the pump.
3. Open the sluice valve for the required discharge when the pump motor switches from start to delta mode.
4. Load the turbine by adding weights hanger. Open the brake drum cooling water gate valve for cooling the brake drum.
5. Measure the turbine rpm with tachometer. Note the pressure gauge and vacuum gauge readings
6. Note the orifice meter pressure readings. Repeat the procedure for other loads.

**RESULT:**

| | | |
|---|---|---|
| (i) | Maximum efficiency | = |
| (ii) | Corresponding output power | = |
| (iii) | Corresponding input power | = |
| (iv) | Specific speed | = |

# VIVA VOCE QUESTIONS

## KAPLAN TURBINE

**1. Define Overall efficiency**.

It is defined as the ratio of the power available at the shaft of the turbine to the power supplied by the water at the inlet of the turbine.

$$\eta_o = \frac{\text{Power available at the shaft (shaft power)}}{\text{Power supplied at inlet (water power)}}$$

$$\eta_o = \eta_h \, \eta_m \, \eta_v \quad \text{(or)} \quad \eta_o = \eta_h \, \eta_m$$

**2. Define Jet Ratio.**

It is defined as the ratio of the pitch diameter (D) of the Pelton wheel to the diameter of the jet (d). It is denoted by „m" and is given as m = D/d

**3 .Uses of draft tube:**

Discharges water to tail race safely Converts a large proportion of rejected kinetic energy into useful pressure energy Net head of the turbine is increased.

**4.. Types of draft tube:**

Conical draft tube, Simple elbow tube

**5. Define Runaway speed of Turbine.**

The max speed reached by the turbine after the removal of the external load is called runaway speed of turbine. The various rotating components of the turbine should be designed to remain safe at the runaway speed.

**6. What is roto dynamic pump?**

When the increase in pressure is developed by rotating impeller or by action of centrifugal force then the pump is called as roto dynamic pump.

**7. Define Centrifugal pump.**

Hydraulic pump means it converts mechanical energy into hydraulic energy. If the mechanical energy is converted into pressure energy means of centrifugal force acting on the fluid, the hydraulic machine is called Centrifugal Pump.

**8. What are an impulse turbine and a reaction turbine?**

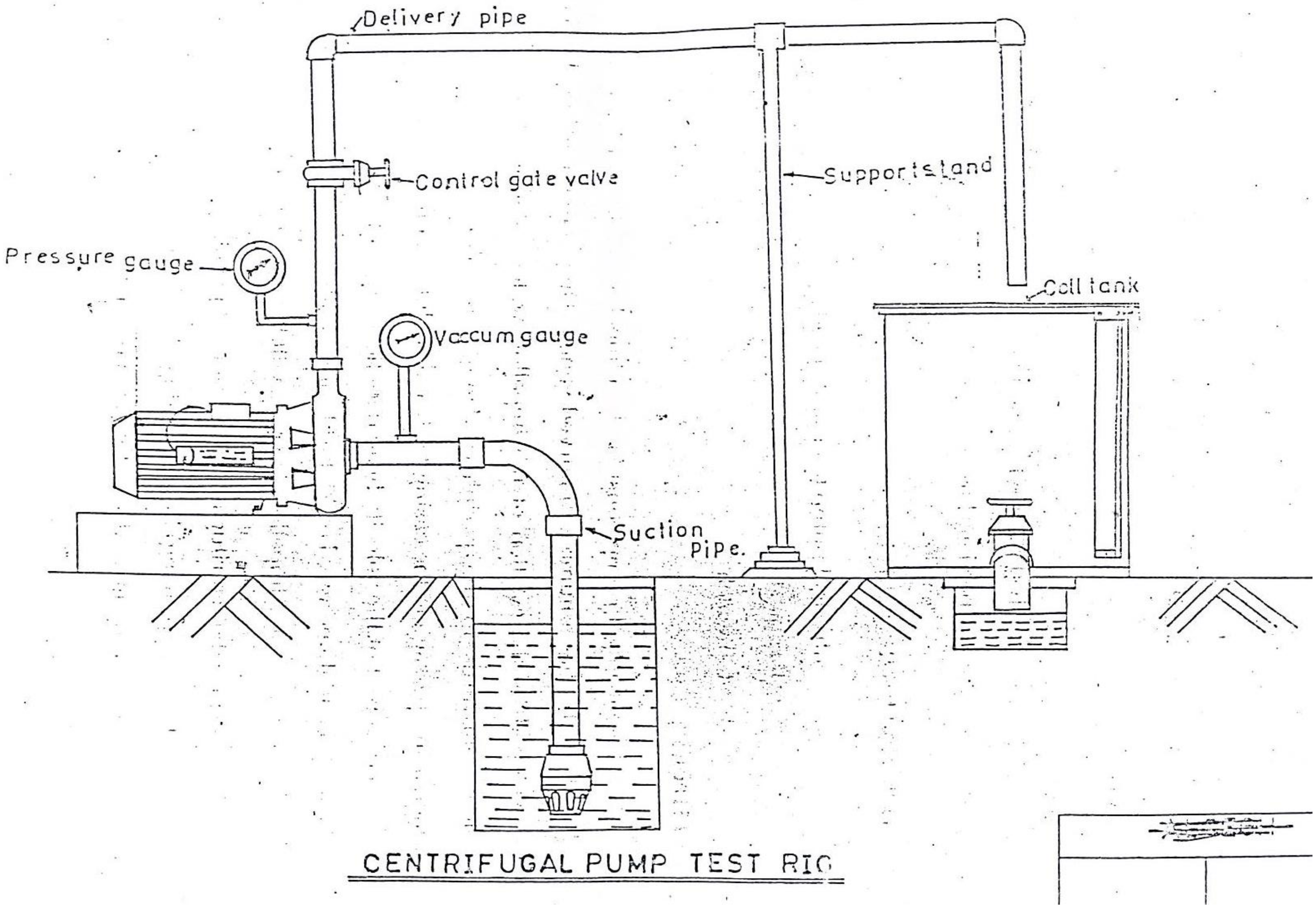
Impulse Turbine: If at the inlet of the turbine, the energy available is only kinetic energy, the turbine is known as impulse turbine. The pressure at the inlet of the turbine is atmosphere. This turbine is used for high heads. The water strikes the bucket along the tangent of the runner. Ex: Pelton Wheel Turbine. Reaction Turbine: If at the inlet of the turbine, the water possesses kinetic energy as well as pressure energy, the turbine is known as reaction turbine. As the water flows through the runner, the water is under pressure and the pressure energy goes on changing into kinetic energy. The runner is completely enclosed in an air-tight casing and the runner and casing is completely full of water. This turbine is used for medium heads. Ex: Francis Turbine

**9. What is mean by multi stage pump?**

If more than one impeller is used in pump then such type is known as multistage pump.

**10. Define Radial flow reaction turbine and their types.**

If water flows in the radial direction in the turbine then it is referred as radial flow turbine. Types: Inward radial flow reaction turbine: If the water flows from outwards to inwards through the runner, the turbine is known as inward radial flow reaction turbine. Here the outer diameter of the runner is inlet diameter whereas the inner diameter of the runner is outlet diameter. Outward radial flow reaction turbine: If the water flows from inwards to outwards through the runner, the turbine is called as outward radial flow reaction turbine. Here the outer diameter of the runner is outlet diameter whereas the inner diameter of the runner is inlet diameter.




CENTRIFUGAL PUMP TEST RIG

**Ex. no: 10** **Date:**

# PERFORMANCE CHARACTERISTICS OF A CENTRIFUGAL PUMP

## AIM:

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

## APPARATUS REQUIRED:

1. Centrifugal pump (constant speed)
2. Metre scale
3. Stop watch

## THEORY:

A centrifugal pump consists of an impellor rotating inside a casing. The impellor has a number of curved vanes. Due to the centrifugal force developed by the rotation of the impellor, water entering at the center flows outwards to the periphery. Here it is collected in a gradually increasing passage in the casing known as volute chamber. This chamber converts a part of the velocity head (kinetic energy) of water into pressure head (potential energy).for higher heads, multi stage centrifugal pumps having two or more impellors in series will have to be used.

Note: since the centrifugal pump is not self priming, the pump must be filled with water (priming) before starting. For this reason water should not be 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 | Ne= | rev/kwh |
| Specific weight of water | w= | 9810 $N/m^3$ |

**TABULATION:**

| Sl.No | Pressure gauge reading G | Pressure head Gx10 | Vacuum gauge reading "V" | Vacuum head Vx0.0136 | Total Head H = (Gx10)+ (Vx0.0136)+X | Time for h=0.1m 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 = 3600xNr/NexT | Output power Po= wQH | Efficiency = Output power/input powerx100 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit | $kg/cm^2$ | 'm' of water | 'mm' of Hg | 'm' of water | 'm' of water | seconds | $m^3/sec$ | seconds | kW. | kW | % |
| 1. | | | | | | | | | | | |
| 2. | | | | | | | | | | | |
| 3. | | | | | | | | | | | |
| 4. | | | | | | | | | | | |
| 5. | | | | | | | | | | | |
| 6. | | | | | | | | | | | |

1. Actual discharge $Q_a = AH/t_1$ cumec

Where:

A=area of the collecting tank $m^2$

H=rise of water in the collecting tank m

$t_1$=time taken for" h" m rise of water in the collecting tank

2. Total head h=Gx10+vx0.0136+ X m of water

Where:

G=pressure gauge reading
v=vacuum gauge reading
X=correction head = the difference in level between the centers of pressure gauge and vacuum gauge.

3. Input power pi= 3600xnr/ (ne x $t_2$) kW

Where:

Nr=No of revolutions counted in energy meter disc.

Ne= Energy metre constant.

$t_2$= Time taken for nr revolutions in the energy meter

4. Output power po = w$Q_a$h kW

Where:

W=sp .wt of water 9.81 kN/$m^3$

5. Efficiency$\eta$ =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 centers of 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 & vacuum gauge readings.

b) Time ($t_1$) for " H" m rise of water in the collecting tank

c) Time ($t_2$) for "nr" revolutions in the energy meter disc.

5. The above procedure is repeated varying the pressure gauge reading.

MODEL CALCULATION:

1. Total head (h) = Gx10+vx0.0136+ X m of water

=

2. Actual discharge = $Q_a$ =AH/$t_1$ cumec

=

3. Input power (Pi) = 3600xnr/ (ne x $t_2$) kW

=

4. Output power (Po) = w$Q_a$h kW

=

5. Efficiency (η) = output power/input power x 100 %

=

GRAPHS:

The following graphs are drawn taking discharge "$Q_a$" on x-axis.

1. Discharge vs. Total head
2. Discharge vs. Input power
3. Discharge vs. Efficiency

At the point of the maximum efficiency of the graph the corresponding values of discharge, head & input power are arrived from the graph.

RESULT:

The characteristic curves are drawn from the point of maximum efficiency. The best driving conditions are found out and the best driving conditions of the pump 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-Velocity

R-Radius

**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.

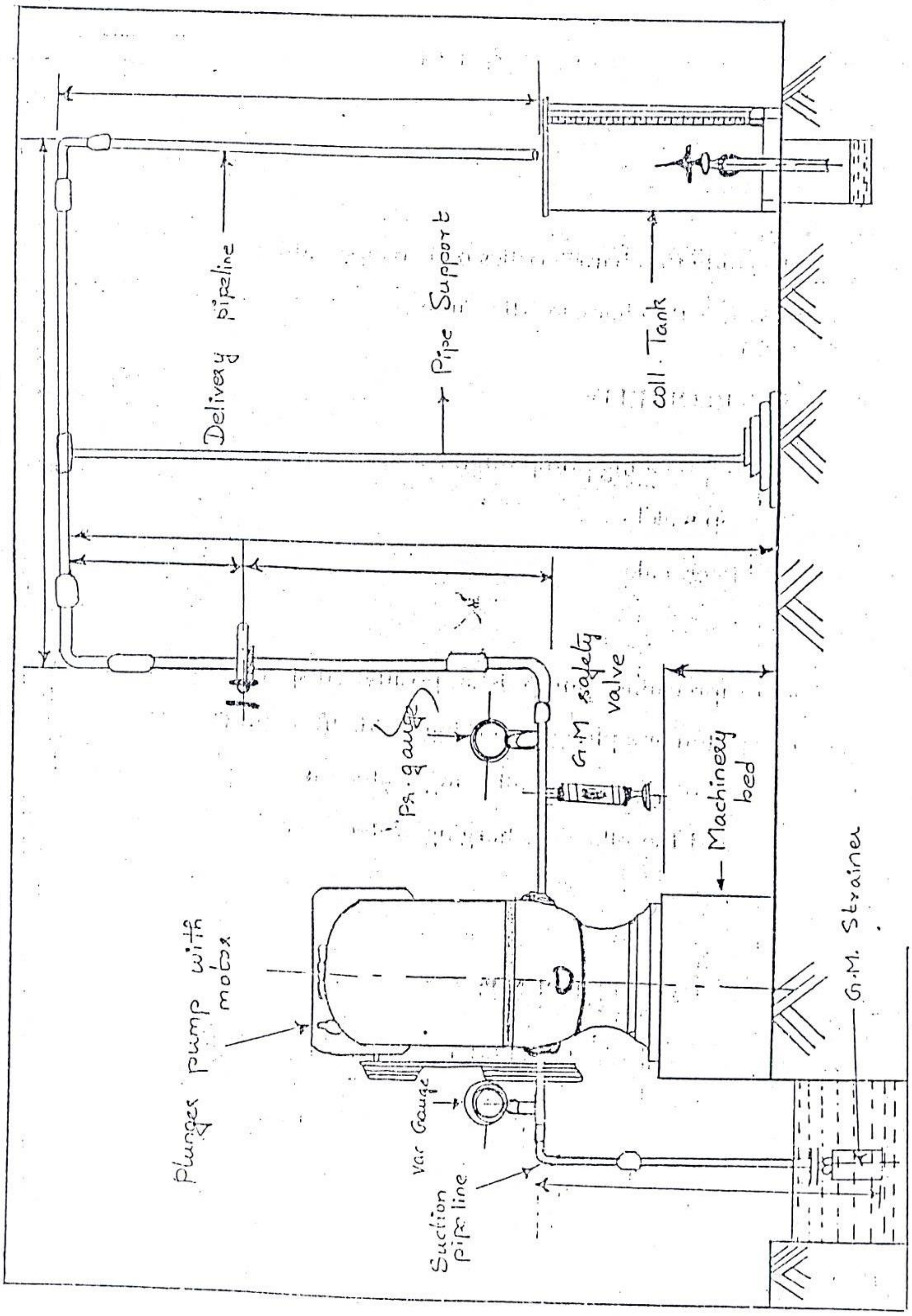
**7. Which pump is more efficient Centrifugal pump or Reciprocating pump?**
Centrifugal pump.
Because flow rate is higher compared to reciprocating pump. Flow is smooth and it requires less space to install. Lower initial cost and lower maintenance cost.

**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.



**Ex. no: 11** **Date:**

# PERFORMANCE CHARACTERISTICS OF A RECIPROCAL PUMP

## AIM:

To study the characteristics of a reciprocating pump at constant speed and to draw the characteristic curves.

## APPARATUS REQUIRED:

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

## DESCRIPTION:

The reciprocating pump is a positive displacement pump and Consists of a piston or a plunger working inside the cylinder. The Cylinder has two valves. One allowing water into the cylinder from the suction pipe and the other discharging water from the cylinder into the delivery pipe.

## SPECIFICATION OF THE PUMP:

Type - Double Acting Single Cylinder

1. Piston stroke l = 44.5mm
2. Piston diameter = 38mm
3. Suction pipe dia = 25m
4. Delivery pipe dia =18 mm

## OBSERVATION:

| | | |
|---|---|---|
| Size of the tank | L = | m |
| | B = | m |
| Area of the tank | A = | $m^2$ |
| Correction head | X = | m |
| Energy meter constant | Ne = | rev/kwh |
| Length of stroke | L = | m |
| Speed of the pump | N = | rpm |
| Diameter of the cylinder | d = | m |
| Specific weight of water | w = 9810 | $N/m^3$ |

## TABULATION:

| Sl. No. | Pressure gauge reading "G" | Pressure head = Gx10 | Vacuum gauge reading "V" | Vacuum head Vx 0.0136 | Total head H = Gx10 + Vx0.0136 + X | Time for h=0.1m rise of water in the tank '$t_1$' | Actual discharge $Q = Ah/t_1$ | Theoretical discharge $Qt = 2A_1LN/60$ | % of slip = Qt – Qa/Qtx 100 | Time for Nr=10 revolution in the energy meter '$t_2$' | Input power $Pi = 3600 \times Nr/Ne \times t_2$ | Output power Po = wQH | Efficiency = Output power / Input power X 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit | kg/$cm^2$ | 'm' of water | 'mm' of Hg | 'm' of water | 'm' of water | Sec. | $m^3/s$ | $m^3/sec$ | % | sec | kW | kW | % |
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |

1. Actual Discharge $Qa = AH/t$ cumec

Where:

A=Area of the Collecting Tank
h = rise of water in the tank
t= time taken for "h" m rise of water in the tank

2. Total Head h= GX10 +VX0.0136+X m of water

Where:

G= pressure gauge reading
V=vacuum gauge reading
X= correction head - the difference in level between The center of pressure gauge & vacuum gauge

3. Input power Pi=3600*Nr/Ne*T KW

Where:

Nr= No of revolutions counted in the energy meter disk
Ne= energy meter constant
T= time taken for Nr revolutions in the energy meter disk

4. Out power Po=W*Qa*h KW

Where:

W= sp .wt of water
Qa= Actual discharge
h= Total head

5. Theoretical discharge Qt= 2A1LN/60 cumec

Where:

A1=area of the cylinder
L= length of the stroke
N= speed of the pump

6. % of slip = (Qt-Qa)/Qt X 100

7. Efficiency $\eta$= output power/input power X100 IN%

PROCEDURE:

1 The internal plan dimensions of the collecting tank are measured.

2. Correction head. (The difference in level between the centers of 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.

d) Pressure gauge & vacuum gauge readings.

e) Time ($t_1$) for " h" m rise of water in the collecting tank

f) Time ($t_2$) for "Nr" revolutions in the energy meter disc.

5. The above procedure is repeated varying the pressure gauge reading.

MODEL CALCULATION:

1. Actual Discharge Qa = Ah/t cumec

=

2. Total Head H = GX10 +VX0.0136+X m of water

=

3. Input power Pi =3600*Nr/Ne*T KW

=

4. Out power Po =W*Qa*H KW

=

5. Theoretical discharge Qt= 2A1LN/60 cumec

=

6. % of slip = (Qt-Qa)/Qt X 100

=

7. Efficiency η = output power/input power X100 IN%

=

## GRAPHS:

The following graphs are drawn taking discharge "$Q_a$" on x-axis.

d) Discharge vs. Total head

e) Discharge vs. Input power

f) Discharge vs. Efficiency

At the point of the maximum efficiency of the graph the corresponding values of discharge, head & input power are arrived from the graph.

## RESULT:

The characteristic curves are drawn from the point of maximum efficiency. The best driving conditions are found out and the best driving conditions of the pump 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: 12** **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:**

5. Gear oil pump fitted with all accessories
6. Meter scale
7. 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

Where,

## OBSERVATIONS:

| | | | |
|---|---|---|---|
| Size of the tank | L= | | m |
| | B= | | m |
| Area of the tank | A = | | $m^2$ |
| Correction head | X= | | m |
| Energy meter constant | Ne= | | rev/kwh |
| Specific weight of water | w= | 9810 $N/m^3$ | |

## TABULATION:

| Sl.No | Pressure gauge reading G | Pressure head G×10 | Vacuum gauge reading "V" | Vacuum head V×0.0136 | Total Head H = (G×10)+(V×0.0136)+X | Time for h=0.1m 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×Nr/Ne×T | Output power Po= wQH | Efficiency = Output power/input power×100 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit | $kg/cm^2$ | 'm' of water | 'mm' of Hg | 'm' of water | 'm' of water | seconds | $m^3/sec$ | seconds | kW. | kW | % |
| 1. | | | | | | | | | | | |
| 2. | | | | | | | | | | | |
| 3. | | | | | | | | | | | |
| 4. | | | | | | | | | | | |
| 5. | | | | | | | | | | | |
| 6. | | | | | | | | | | | |

Q – Discharge ($m^3/s$)

$V_w$ – Specific weight of water (9810N/$m^3$)

H – Total head (m)

5. Efficiency:

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

**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 of the 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: 13** **Date:**

## DETERMINATION OF METACENTRIC HEIGHT OF FLOATING BODIES

**Apparatus:**

1. Water bulb
2. Metacentric height apparatus
3. Scale or measuring tube

**Procedure:**

1. First of all I adjust the movable weight along the vertical rod at a certain position and measured the distance of center of gravity by measuring tape.
2. Then I brought the body in the water tube and changed the horizontal moving load distance first towards right.
3. The piston tilted and suspended rod gave the angle of head, I noted the angle for respective displacements.
4. I did the same procedure for movable mass by changing its position towards left.
5. Then I took the body from water tube and find another center of gravity by changing the position of vertically moving load.
6. I again brought the body in the water tube and find the angle of head by first keeping the movable load towards right and then towards left.
7. I repeated the above procedure for another center of gravity.
8. I calculated the metacentric height by the following formula:

$$MH = w * d / W * \tan Ø$$

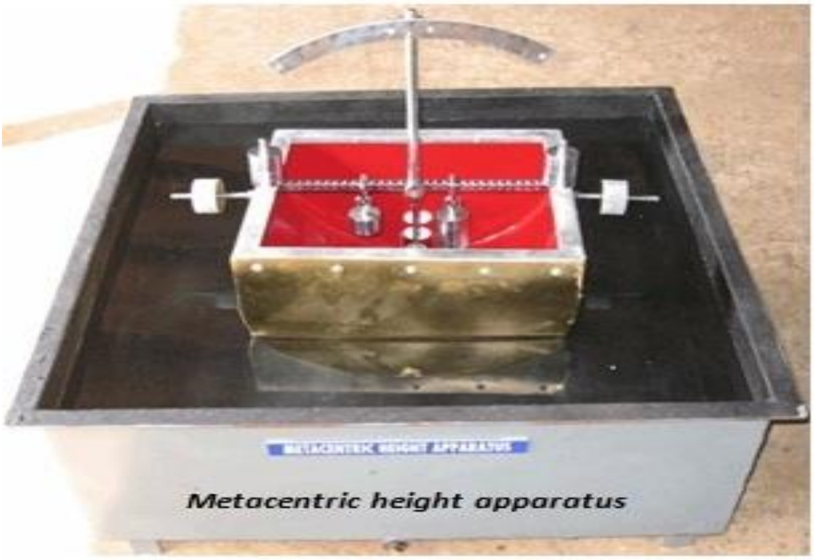
***Where***

MH = Metacentric height
w = Horizontally movable mass
d = Distance of movable mass at right or left of center
W = Mass of assemble position
Ø = Respective angle of heel

**Observationcs & Calculations:**

Horizontally movable mass = w
Mass of assemble position = W
Center of gravity = y1
Center of gravity = y2
Center of gravity = y3

**RESULT:**




Considering Right Portion

| S.No | Distance of movable mass at right of center (mm) | Y1 | Angle of head "Θ" Y2 | Y3 | Y1 | Metacentric height(MH) Y2 | Y3 |
|---|---|---|---|---|---|---|---|
| 01 | | | | | | | |
| 02 | | | | | | | |
| 03 | | | | | | | |

Considering Left Portion

| S.No | Distance of movable mass at left of center (mm) | Y1 | Angle of head"Θ" Y2 | Y3 | Y1 | Metacentric height (MH) Y2 | Y3 |
|---|---|---|---|---|---|---|---|
| 01 | | | | | | | |
| 02 | | | | | | | |
| 03 | | | | | | | |

**RESULT:**

Hence the metacentric height is identified.

## VIVA VOCE QUESTIONS

## METACENTRIC HEIGHT

1. What is a metacentric height?
   It is the measurement of initial static stability of a floating body.
2. How is the metacentric height of a ship is calculated.
   It is calculated as the distance between the centre of gravity of a ship and its metacentre.
3. What is a metacentre?
   The point at which a body floating in a liquid starts oscillating is called metacentre.
4. Define Buoyancy.
   It is the tendency of a fluid to lift a submerged body.
5. Explain about force of buoyancy.
   It is the resultant upward force or thrust exerted by a fluid on submerged body.
6. When will a body in a liquid surface be in equilibrium.
   When the gravity forces and buoyant force lie in the same vertical line the body will be in equilibrium.
7. Write the formula for calculating metacentre.
   KM = KB + BM
8. Write the formula to determine the metacentric height theoretically.
   GM = BM+ OB – OG
9. How is the metacentric height calculated practically.
   $GM = Px/(W\sin(\theta))$
10. What is KM used in the calculation of metacentre.
    KM is the distance between the keel to metacentre.

# TOPIC BEYOND SYLLABUS

## HYDRAULIC FLUME

### BROAD CRESTED WEIR

In a broad- crested weir, the crest (sill) of weir if fairly wide. The water adheres to the crest and has a surface contact while passing over it. The broad- crested weir is a critical- depth meter because under suitable conditions, the critical depth ($y_c$) occurs over the crest. The critical depth usually occurs at a distance of about 3 $y_c$ from the downstream edge from the downstream edge.
A broad- created weir is used in practice for the measurement of discharge in large open channels.

### EXPERIMENTAL SET-UP

The set-up consists of a broad- crested weir installed in an open channel or a flume. The water is supplied from a constant-head supply tank by a pipe. A gate valve is provided on the supply pipe for regulating the discharge.

A pointer-gauge is used for the measurement of water level. The pointer gauge can be fixed on a trolley. The trolley can be moved to and fro on the side walls of the flume. An venturimeter with a manometer is provided for the measurement of actual discharge with a $C_d$ value of 0.95.

### THEORY

It can be shown that for a rectangular channel the critical depth $y_c$ is equal to 2/3 E, where E is the specific energy measured above the crest. The specific energy measured above the crest. The critical velocity $v_c = \sqrt{g y_c}$ . the discharge Q is given by $Q = 1.705\ C_d\ L E^{3/2}$
If we neglect the velocity approach E=H, where H is the head over the crest. Thus $Q = 1.705\ C_d\ L E^{3/2}$
Where $C_d$ is the coefficient of discharge and L is the length of the crest. The head H is the head over the weir, measured well upstream of the sill where the water surface has no curvature.
The value of $C_d$ depends upon the length of weir the height of weir and on the roundness of corners.

### PROCEDURE

1. Measure the length L of the broad- created weir. This usually equal to the width of the flume. Also measure the width B of the weir.
2. Take the pointer gauge reading when the point just touches the crest $H_0$.
3. Open the supply valve and let water flow over the crest.
4. Adjust the position of the sluice gate so that flow becomes steady and the head over crest becomes constant.
5. Take the pointer gauge reading at a section well upstream of the crest ehere the water surface is horizontal H.
6. Take the manometar reading of the venturimerter and calculate the actual discharge $Q_a$.
7. Increase the discharge and repeat steps 4 to 6.

### OBSERVATION AND CALCULATIONS

**Length of the** broad- created weir, L = 250 mm
**Pointer gauge reading at the crest, H0 =**
**Pointer gauge reading at the level of water H' =**

| **S.NO** | **VENTURIMETER H1** | **VENTURIMETER H2** | **Pointer gauge H** | **Pointer gauge $H_0$** |
|---|---|---|---|---|
| | | | | |

Calculate the actual discharge using the venturimeter $Q= C_d a_1 a_2 \sqrt{2gh} / \sqrt{(a1^2-a2^2)}$

Where $a_1$ and $a_2$ are area of inlet and throat of the venturimeter. Cd= 0.95
Venturimeter pipe dia = 40mm
Throat dia = 24mm

$H= H' - H_0$

The theoretical discharge Q is given by $Q= 1.705\ C_d\ LH^{3/2}$

## RESULT

**THE COEFFICIENT OF DISCHARGE OF WEIR =**

# 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.

Take the pointer gauge reading of the water surface to measure the depths $y_1$ and $y_2$

Repeat steps 3 to 5 for different 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 | | | Y1= H1'-H0' | Y2= H2'-H0' |
|---|---|---|---|---|---|---|---|
| | h1 | h2 | H1' | H2' | H0' | | |
| | | | | | | | |



**RESULTS**

The loss energy in the hydraulic jump=

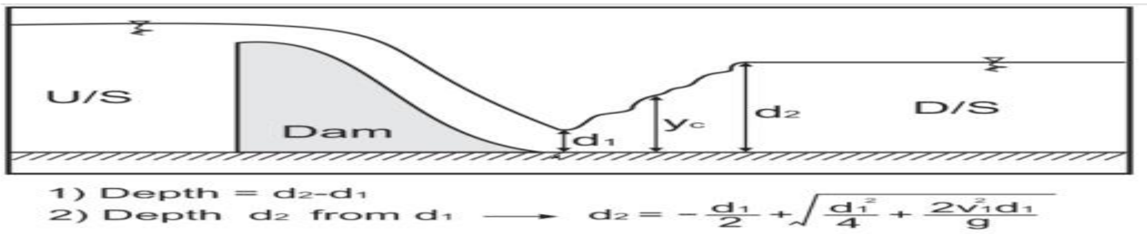
## VIVA QUESTION

## HYDRAULIC JUMP

**1. Hydraulic Jump**

The rise of water level which takes place due to transformation of super critical flow to sub critical flow is termed as hydraulic jump.

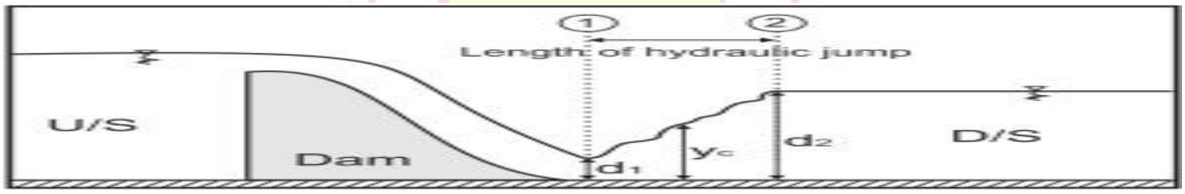
**2. Expressions for Depth of Hydraulic Depth**




**3. Expressions for Loss of Energy due to Hydraulic Jump**

The length between two sections where one section is taken just before the hydraulic jump and the other section is taken just after the hydraulic jump is termed as length of hydraulic jump.

For rectangular channels Length of hydraulic jump = 5 to 7 times the depth of hydraulic jump.




**4. Location of Hydraulic Jump**

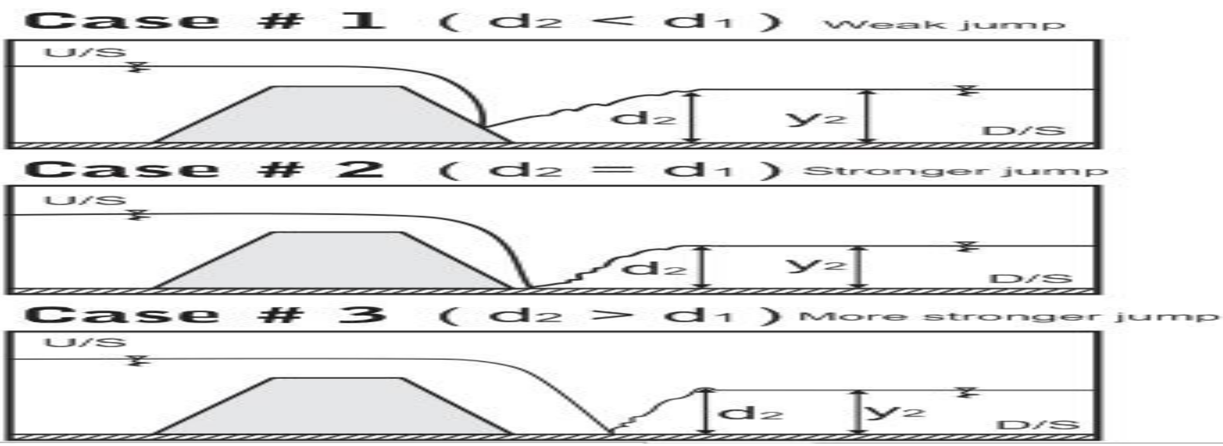
Depends on two things.

1) d2 = Depth of flow just after the hydraulic jump.

2) yc = Normal depth of flow at downstream.

**5. Types of Hydraulic Jump**

| | |
|---|---|
| 1) FN1 = 1.0 (Critical) | No jump |
| 2) FN1 = 1 to 1.7 | Undular jump |
| 3) FN1 = 1.7 to 2.5 | Weak jump |
| 4) FN1 = 2.5 to 4.5 | Oscillating jump |
| 5) FN1 = 4.5 to 9 | Steady jump |
| 6) FN1 = > 9 | Strong jump |



**6. Practical Applications of Hydraulic Jump**

1. To dissipate the energy of water flowing over the hydraulic structures and thus prevent the scouring of downstream structure.
2. To recover the head or raise the water level on the downstream side of the hydraulic structure & thus to maintain high water level in the channel for irrigation or other water distribution purposes.
3. To increase the weight on apron & thus reduce the uplift pressure under the structure by raising the water depth on apron.
4. To mix the chemicals for water purification.

**7. Flume Advantages**

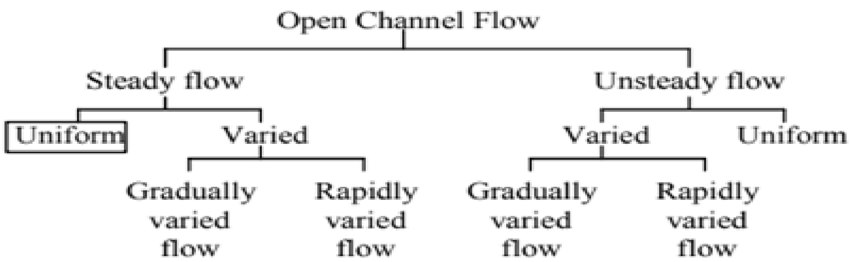
- The ability to measure higher flow rates than a comparably sized weir
- Less head loss (generally 1/4th that of a weir)
- The ability to pass debris more readily
- Wide range of styles and sizes
- Off-the-shelf availability
- Smaller installation footprint
- Less rigorous maintenance requirements

Also, most styles of flumes are resistant to changes or restrictions in the downstream hydraulics (submergence) - something not found with weirs.

# 8 OPEN CHANNEL FLOW

## 8.1 Classification & Definition

- Open channel flows are flows in rivers, streams, artificial channels, irrigation ditches, partially filled pipe etc.
- Basically, it is a flow with **free surface**.
  (Free surface is a surface with atmospheric pressure)




Classifications of Open Channel Flow