MAHA BARATHI ENGINEERING COLLEGE

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DEPARTMENT OF CIVIL ENGINEERING

Academic year 2024-2025(ODD SEM)

CE3411 – HYDRAULIC ENGINEERING LABORATORY

(REGULATION 2021)

NAME	:
DEPARTMENT	:
SUBJECT CODE/NAME	:
YEAR	:
BATCH	:

Prepared by	**Approved by**
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ASST.PROFESSOR / CIVIL	**HOD / CIVIL**

ANNA UNIVERSITY, CHENNAI

SYLLABUS (R 2021)

CE3411 HYDRAULIC ENGINEERING LABORATORY L T P C

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OBJECTIVES:

- To provide hands on experience in calibration of flow meters, performance characteristics ofpumps and turbines.

LIST OF EXPERIMENTS (Any 10 of the following)

A. FLOW MEASUREMENT

1. Calibration of Rotameter
2. Flow through Orifice meter/mouthpiece, Venturimeter and Notches
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 Reciprocating pump

D. TURBINES

10. Characteristics of Pelton wheel turbine
11. Characteristics of Francis turbine

E. DETERMINATION OF METACENTRIC HEIGHT

12. Determination of metacentric height of floating bodies.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student is expected to

CO1 Apply Bernoulli equation for calibration of flow measuring devices.
CO2 Measure friction factor in pipes and compare with Moody diagram
CO3 Determine the performance characteristics of rotodynamic pumps.
CO4 Determine the performance characteristics of positive displacement pumps. CO5 Determine the performance characteristics of turbines.

REFERENCES:

1. Hydraulic Laboratory Manual, Centre for Water Resources, Anna University, 2015.
2. Modi P.N. and Seth S.M., Hydraulics and Fluid Mechanics. Standard Book House. New Delhi,2017.
3. Subramanya K, Fluid Mechanics and Hydraulic Machines, Tata McGraw Hill Edu. Pvt. Ltd.2011

2.

CO – PO Mapping – HYDRAULIC ENGINEERING LABORATORY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PROGRAM OUTCOMES(PO)							
PO1	Knowledge of Engineering Sciences	2	3	3	3	3	3
PO2	Problem Analysis	2	2	3	3	3	3
PO3	Design / development of solutions	1	1	2	2	2	2
PO4	Investigation	3	3	3	3	3	3
PO5	Modern Tool Usage	1	1	1	1	1	1
PO6	Engineer and Society	2	2	2	2	2	2
PO7	Environment and Sustainability	2	2	2	2	2	2
PO8	Ethics	1	1	1	1	1	1
PO9	Individual and Team work	2	2	3	3	3	2
PO10	Communication	1	1	1	1	1	1
PO11	Project Management and Finance	1	1	1	1	1	1
PO12	Life Long Learning	2	2	2	2	2	2
PROGRAM SPECIFIC OUTCOMES(PSO)							
PSO1	Knowledge of Civil Engineering discipline	2	3	3	3	3	3
PSO2	Critical analysis of Civil Engineering problems and innovation	1	1	2	2	2	2
PSO3	Conceptualization and evaluation of engineering solutions to Civil Engineering Issues	1	1	1	1	1	1

TIPS FOR A BETTER LAB SESSION

Some of the Best Practices to help the Lab run smoothly while maximizing Student Learning.

1. Students should be thoroughly familiar with the Lab exercises before coming to Lab.
2. Students should treat the Laboratory Exercises as original Research.
3. Students should make sure not to miss even a single Lab Class.
4. Students must apply the concepts learned in the class to New Situations.
5. Each student must try to do their Lab Exercises Individually.
6. The instructor will hold a pre-laboratory discussion on the lab exercises.
7. Each student should write each formula clearly with the expressions of each term and units used. This will help them to understand the calculation more clearly at every stage of calculation.
8. Each student should draw the sketch showing the experimental set up of each exercise and sequence of procedure of experiment in flowchart for exercise questions given in the manual before every Lab Session.
9. The students should come prepared for Viva based on the review questions given in the lab manual.
10. If the students come unprepared, he/she will not be allowed to do the Lab exercise and will be marked absent.
11. The progress of every student will be monitored on a regular basis. Based on the progress report Extra Credit Marks will be awarded for the students in their Internals.
12. Every student must be able to explain the program concepts clearly at the end of each Lab Session.
13. Labs are for you (students) and so consider it as your duty to use it perfectly. It‟s your responsibility to take care of the computer systems and the other equipment.

"ENJOY THE JOY OF DOING EXPERIMENTS"

GENERAL INSTRUCTIONS

1. All the students are instructed to wear protective uniform and shoes before entering into the laboratory.
2. Before starting the exercise, students should have a clear idea about the principles of that exercise.
3. All the students are advised to come with completed record and corrected observation of previous experiments, defaulters will not be allowed to do their experiment.
4. Don‟t operate any instrument without getting concerned staff member‟s prior Permission.
5. All the instruments are costly. Hence handle them carefully, to avoid fine for any breakage.
6. Utmost care must be taken to avert any possible injury while on laboratory work. In case, anything occur immediately report to the staff members.

TABLE OF CONTENTS

S.No	Date	Name of the Experiment	Page No	Marks Awarded	Signature

S.No	Date	Name of the Experiment	Page No	Marks Awarded	Signature

EXPERIMENTS

DETERMINATION OF CO-EFFICIENT OF DISCHARGE FOR ORIFICE

(CONSTANT HEAD METHOD)

Exp No: 1

Date:

Aim:

To conduct an experiment on orifice and also to determine the co-efficient of discharge of the orifice by constant head method.

Apparatus required:

1. Supply tank fitted with orifice
2. Piezometer
3. Collecting tank
4. Vernier caliper
5. Stop watch
6. Scale or Steel rule

Description:

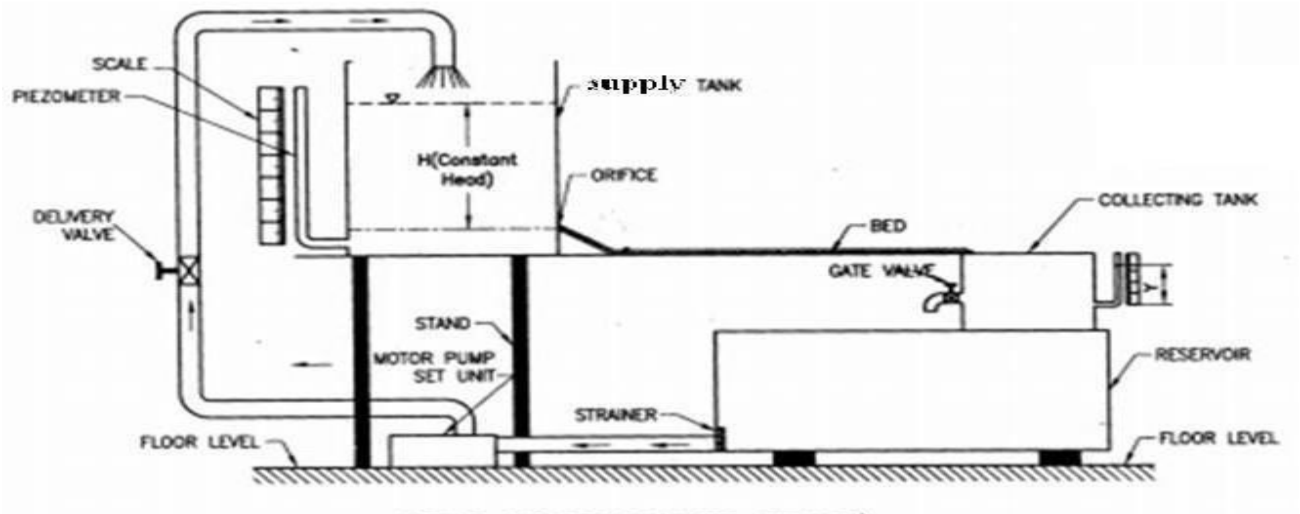
An orifice is a circular hole provided in the side of supply tank. Piezometer with scale is fitted to supply tank. A pump with pipe fittings is used to lift the water from reservoir to supply tank. It is driven by an electric motor. A collecting tank is used to collect the water falling from orifice. It is fitted with a gate valve which returns water to reservoir.

Practical Application:

Orifice is a small aperture through which the fluid passes. The thickness of an orifice in the direction of flow is very small in comparison to its other dimensions. If a tank containing a liquid has a hole made on the side or base through which liquid flows, then such a hole may be termed as an orifice. The rate of flow of the liquid through such an orifice at a given time will depend partly on the shape, size and form of the orifice.

Experimental Procedure:

1. The diameter of the orifice is recorded and the internal dimensions of the collecting tank are measured.
2. The delivery valve to the supply tank is regulated and water flow controlled so that water level becomes constant at a head, “h” m.
3. The gate valve of the collecting tank is closed tightly and the time ‟t‟ required for 10 cm rise of water in the collecting tank is observed using a stop watch.
4. The above procedure is repeated for different constant heads.
5. The observations are tabulated and the coefficient of the orifice is calculated.



ORIFICE (CONSTANT HEAD METHOD)

Observations:

1. Length of collecting tank (L) = 0.3 m
2. Breadth of collecting tank (B) = 0.3 m
3. Rise of water level in the collecting tank (h) = 0.1 m
4. Diameter of Orifice (d) = 0.010 (or) 0.012 m

Tabulation:

S.No.	**Water Head**	**Time taken for 10 cm rise**	**Actual Discharge**	**Theoretical discharge**	**Co-efficient of discharge**
	H	**t**	Q_{act}	Q_{th}	C_d
Unit	**m of water**	**sec**	m^3/sec	m^3/sec	**--**

Formula Used:

1. Actual Discharge of Orifice (Q_{act}) = $\frac{Volume}{Time}$ .... m^3/s

$Q_{act} = \frac{AR}{t} = \frac{V}{t}$ .... m^3/s

Where

V – Volume of water collected in m^3

R - Rise of water level in the collecting tank in meter

t – Time for 10 cm rise of water in the collecting tank in seconds

A – Cross sectional area of the collecting tank in m^2

2. Cross sectional area of the collecting tank (A) = L x B .... m^2

Where

L – Length of the collecting tank in meter

B – Breadth of the collecting tank in meter

3. Theoretical discharge of Orifice (Q_{th}) = $a(\sqrt{2gH})$ ....m^3/s

Where

a - Cross sectional area of Orifice in m^2

g – Acceleration due to gravity

H – Constant head in meter of water

4. Cross sectional area of Orifice (a) = $\frac{\pi}{4}$ x d^2 ....m^2

Where

d – Diameter of orifice in meter

5. Co-efficient of discharge of Orifice (C_d) = $\frac{Qact}{Qth}$

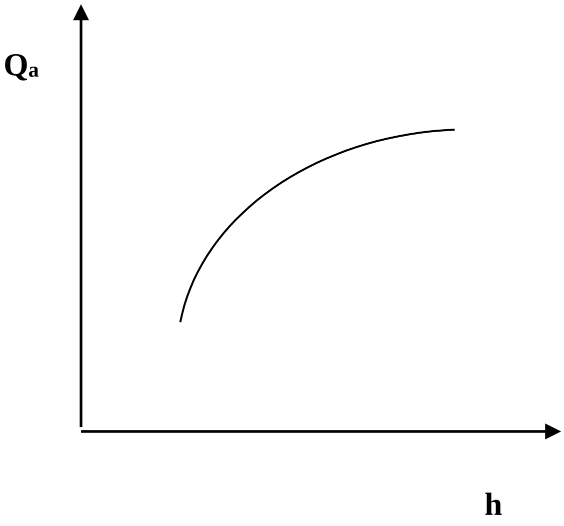
Where

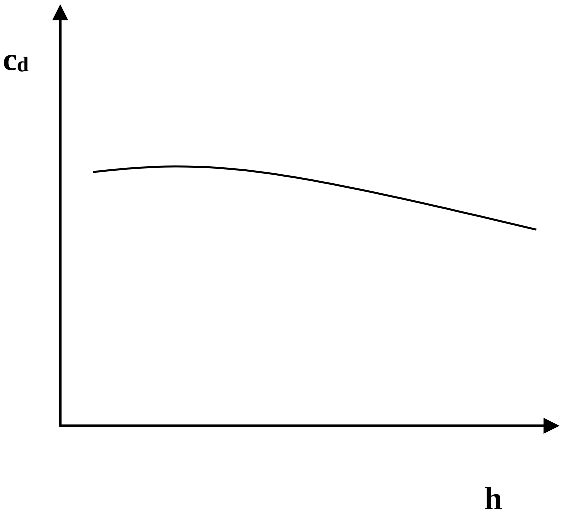
Q_{act}- Actual Discharge in m^3/s

Q_{th}- Theoretical Discharge in m^3/s

Graph:

1. Head (h) V_s Actual Discharge (Q_a)
2. Head (h) V_sCoefficient of Discharge (C_d)





Result:

Thus the co-efficient of discharge of orifice is calculated.

Average co-efficient of discharge (C_d) = ________________

DETERMINATION OF CO-EFFICIENT OF DISCHARGE FOR ORIFICE

(TIME FALL METHOD)

Exp No: 2

Date:

Aim:

To conduct an experiment on orifice and also determine the co-efficient of discharge of the orifice by time fall (variable head) method.

Apparatus required:

1. Supply tank fitted with orifice
2. Piezometer
3. Collecting tank
4. Stop watch
5. Scale or Steel rule

Description:

An orifice is a circular hole provided in the side of balancing tank. Piezometer with scale is fitted to balancing tank. A pump with pipe fittings is used to lift the water from reservoir to balancing tank. It is driven by an electric motor. A collecting tank is used to collect the water falling from orifice. It is fitted with a gate valve which returns water to reservoir.

Practical Application:

The rate of flow of the liquid through such an orifice at a given time will depend partly on the shape, size and form of the orifice. An orifice usually has a sharp edge so that there is minimum contact with the fluid and consequently minimum frictional resistance at the sides of the orifice. If a sharp edge is not provided, the flow depends on the thickness of the orifice and the roughness of its boundary surface too.

Experimental Procedure:

1. The diameter of the orifice is recorded and the internal dimensions of the collecting tank are measured.
2. The delivery valve to the supply tank is regulated and allows water flow into supply tank
3. Close the delivery valve when supply tank is filled completely with water.
4. Then switch off the pump.
5. Then the time‟t‟ required for fall of head from H_1 to H_2 in the collecting tank is observed using a stop watch.
6. The above procedure is repeated for different values of H_1 and H_2
7. The observations are tabulated and the coefficient of discharge of the orifice is computed.

Observation:

1. Length of collecting tank (L) = 0.3 m
2. Breadth of collecting tank (B) = 0.3 m
3. Rise of water level in the collecting tank (h) = 0.1 m
4. Diameter of Orifice (d) = 0.010 (or) 0.012 m

Tabulation:

S.No.	Water Head	Water Head	Time for varying in level from H_1 to H_2	Co-efficient of discharge
	H_1	H_2	t	C_d
Unit	m of water	m of water	Sec	

Formula Used:

1. Co-efficient of discharge of Orifice (C_d) = $\dfrac{2A(\sqrt{H_1} - \sqrt{H_2})}{t \cdot a\sqrt{2g}}$

Cross sectional area of the supply tank = L x B.......................m^2

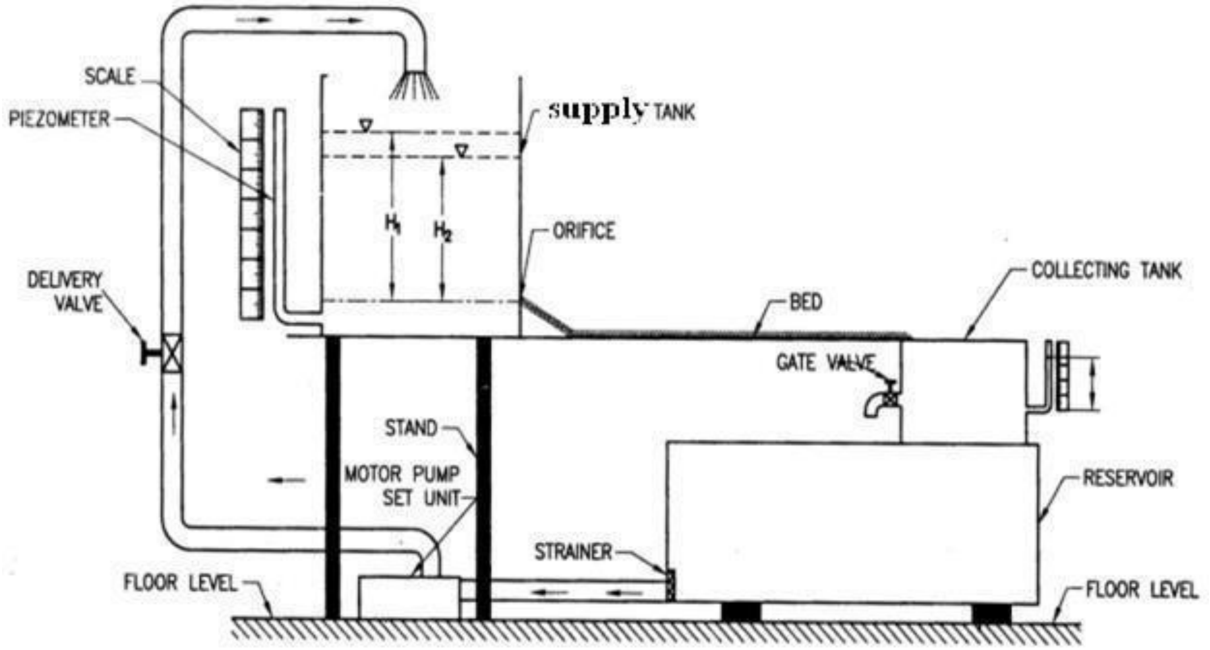
H_1 – Initial position of water in supply tank

H_2 – Final position of water in supply tank

t – Time taken in sec

a - Cross sectional area of orifice = $\frac{\Pi}{4} d^2$ .... m^2

d – Diameter of orifice in meter



ORIFICE (TIME FALL METHOD)

Result:

Thus the co-efficient of discharge of orifice is calculated.

Average co-efficient of discharge (C_d) = ------------------

DETERMINATION OF CO-EFFICIENT OF DISCHARGE FOR VENTURIMETER

Exp. No. : 3

Date:

Aim:

To conduct an experiment on venturimeter, determine the co-efficient of discharge and plot the characteristic curves.

Apparatus Required:

1. Scale or Steel rule
2. Stop watch
3. Measuring tank or collecting tank
4. Venturimeter
5. Differential U tube mercury monometer.

Description:

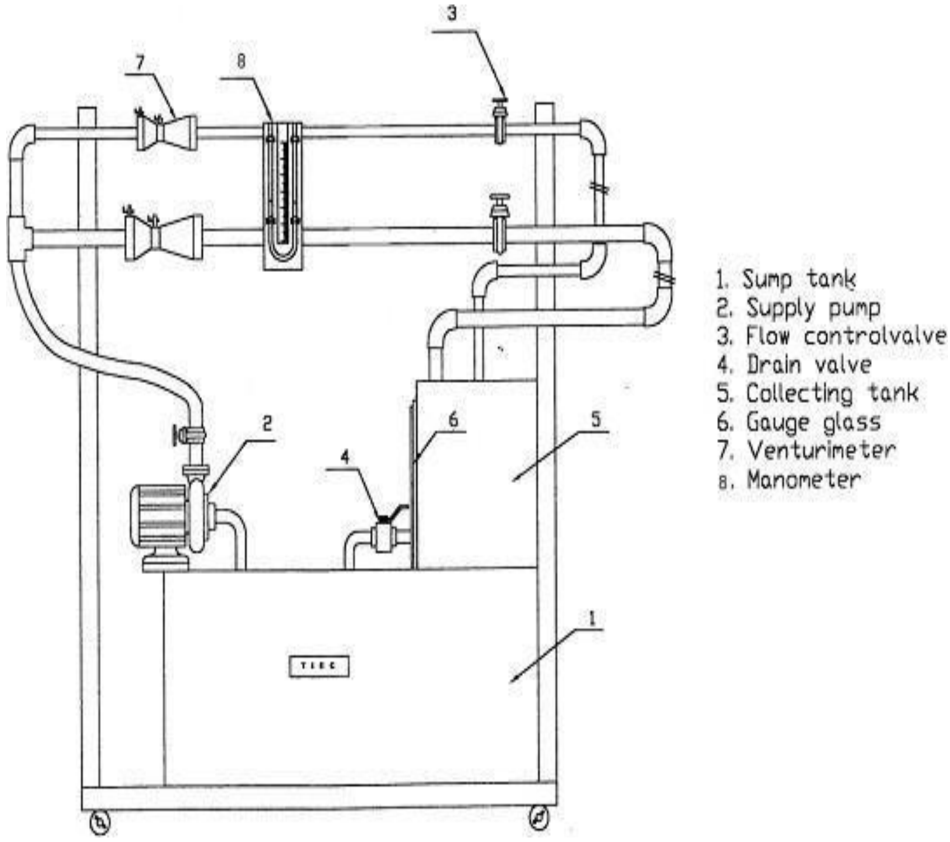
A venturimeter is used to measure the flow rate of a fluid in a pipe. A venturimeter consists of a short length of pipe narrowing to a throat in the middle and then diverging gradually to the original diameter of the pipe. The water flows through the meter, velocity is increased due to the reduced area and hence there is a pressure drop. By measuring the pressure drop in the venturimeter with a manometer, the flow rate is calculated from Bernoulli's equation. The pressure tapping are connected to a common middle chamber, which in turn is connected to a mercury manometer. The pipe line is provided with a flow control valve.

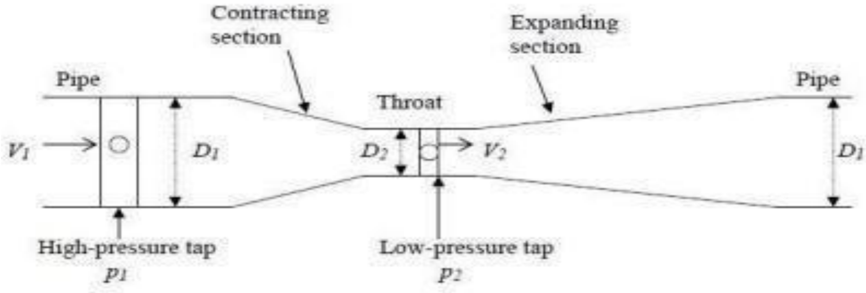
Practical Application:

A venturi meter is also called a venturi flowmeter. It is used to calculate the velocity of fluids running through a pipeline. The fluid may be a liquid or a gas. The meter consists of a pipe with a narrowing throat that expands back to its original diameter on the other side of the choke point. The venturi meter calculates velocity by measuring the pressure head at both points before and after the narrowed throat.

Tabulation:

S.No	Manometer Reading		Pressure Drop	Time for 10 cm rise of water in the collecting tank	Actual Flow Rate	Theoretical Discharge	Coefficient of Discharge
	h_1	h_2	H	t	Q_{the}	Qt_{he}	C_d
	cm of water	Cm of water	m of water	sec	m^3/sec	m^3/sec	





Observations:

1. Length of collecting tank (L) = 0.4 m
2. Breadth of collecting tank (B) = 0.4 m
3. Rise of water level in the collecting tank (h) = 0.1 m
4. Diameter of venturi meter inlet (d_1) = 0.025 m
5. Ratio of inlet and throat diameter = 0.6

Experimental Procedure:

1. Select the required flow meter (venturimeter)
2. Open its cocks and close the other cocks so that only pressure for the meter in use is communicated to the manometer.
3. Open the flow control valve and allow a certain flow rate.
4. The diameter of inlet and throat are recorded and the internal dimensions of the collecting tank are measured.
5. The outlet valve is opened slightly and the manometric heads in both the limbs (h_1 & h_2) are noted.
6. Collect the water in the collecting tank.
7. Close the drain valve and find the time taken for 'h' cm rise in the tank.
8. The above procedure is repeated gradually increasing the flow and observing the required readings.
9. The observations are tabulated and the co-efficient of discharge of Venturimeter is computed.

Formula Used:

1. Actual Discharge (Q_{act}) = $\frac{Volume}{Time}$....................................m^3/s

$$Q_{act} = \frac{Ah}{t} \quad = \frac{V}{t} \text{........................ m}^3\text{/s}$$

Where,

V – Volume of water collected in collecting tank in m^3

h - Rise of water level in the collecting tank in meter

t – Time for 10 cm rise of water in the collecting tank in seconds

A – Cross sectional area of the collecting tank in m^2

2. Cross sectional area of the collecting tank (A) = L x B........................m^2

Where,

L – Length of the collecting tank in meter

B – Breadth of the collecting tank in meter

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

Where,

a_1 - Cross sectional area of Venturimeter inlet in m^2

a_2 - Cross sectional area of Venturimeter throat in m^2

H – Equivalent pressure drop in meter of water

4. Cross sectional area of venturimeter inlet $a_1 = \frac{\Pi}{4} d_1{}^2$ .... m^2

Where

d_1 – Diameter of venturimeter inlet in meter

5. Cross sectional area of throat (a_1) $= \frac{\Pi}{4} d_2{}^2$ .... m^2

Where

d_2 – Diameter of venturimeter throat in meter

6. Co-efficient of discharge (C_d) $= \frac{Qact}{Qth}$

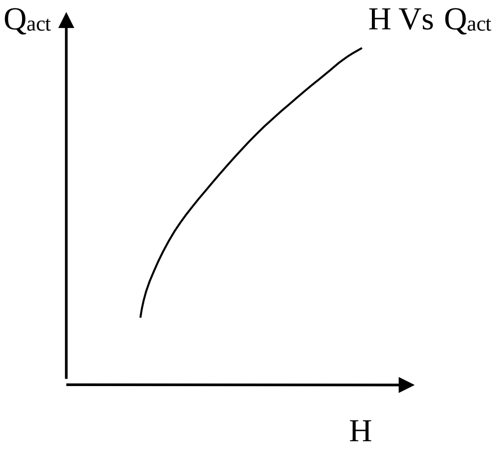
Where,

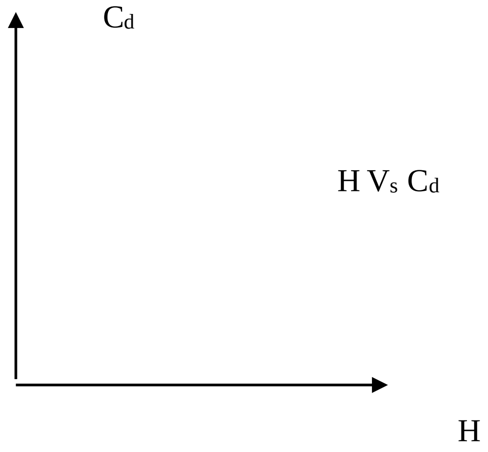
Q_{act} - Actual Discharge in m^3/s

Q_{th} - Theoretical Discharge in m^3/s

Graph:

1. Head (H) V_s Actual Discharge (Q_{act})
2. Head (H) V_s Co-efficient of Discharge (C_d)





Result:

Thus the co-efficient of discharge of venturimeter is calculated.

Co-efficient of discharge (C_d) = ________________

DETERMINATION OF CO-EFFICIENT OF DISCHARGE FOR ORIFICE METER

Exp No: 4

Date:

Aim:

To conduct an experiment on orifice meter, determine the co-efficient of discharge and plot the characteristic curves.

Apparatus required:

1. Orifice meter
2. Differential „U‟ tube mercury manometer
3. Collecting tank
4. Stop watch
5. Scale or Steel rule

Description:

Orifice meter is a device, used to measure the discharge of any liquid flowing through a pipe line. The difference in pressure between the inlet and the diaphragm of the orifice meter is recorded by using a mercury differential manometer. The actual discharge is calculated based on the particular time for a volume of water rise in the collecting tank.

Practical Application:

The most common device used in gas flow measurement is the orifice flow meter. It is capable of very accurate measurement provided it is properly applied, designed, installed, maintained and interpreted. It is the intention of this article to cover these aspects of the orifice meter so that the use of the device can be evaluated and a proper decision made on application.

Experimental Procedure:

1. The diameter of the inlet and orifice are recorded and the internal dimensions of the collecting tank are measured.
2. Keeping the outlet valve of the orifice meter is fully closed. The inlet valve of the orifice meter is opened fully.

Tabulation:

S.No	Manometer Reading		Pressure Drop	Time for 10 cm rise in coll. Tank	Actual Flow Rate	Theoretical flow rate	Coefficient of Discharge
	h_1	h_2	H	t	$Q_a x10^{-3}$	$Q_t x10^{-3}$	C_d
Unit	Cm of water	Cm of water	m of Water	sec	m^3/sec	m^3/sec	--

3. The outlet valve is opened slightly and the manometer heads in both the limbs (h_1 and h_2) are noted.
4. The outlet of the collecting tank is closed and the time"t" required for 10 cm of water rise inthe collecting tank is observed using a stop watch.
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 the orifice meter is calculated

Formula Used:

1. Actual Discharge $(Q_{act}) = \frac{Volume}{Time}$ .... m^3/s

$Q_{act} = \frac{Ah}{t} = \frac{V}{t}$ .... m^3/s

Where,

V – Volume of water collected in m^3

h - Rise of water level in the collecting tank in meters

t – Time for 10 cm rise of water in the collecting tank in seconds

A – Cross sectional area of the collecting tank in m^2

2. Cross sectional area of the collecting tank (A) = L x B...................... m^2

Where,

L – Length of the collecting tank in meters

B – Breadth of the collecting tank in meters

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

Where,

a_1 - Cross sectional area of orifice meter inlet in m^2

a_2 - Cross sectional area of orifice meter in m^2

H – Equivalent pressure drop in meters of water

4. Cross sectional area of orifice meter inlet $a_1 = \frac{\Pi}{4} d_1^2$.......................................m^2

Where, d_1 – Diameter of orifice meter inlet in meter

5. Cross sectional area of Orifice $a_2 = \frac{\Pi}{4} d_2^2$.....................................m^2

Where,

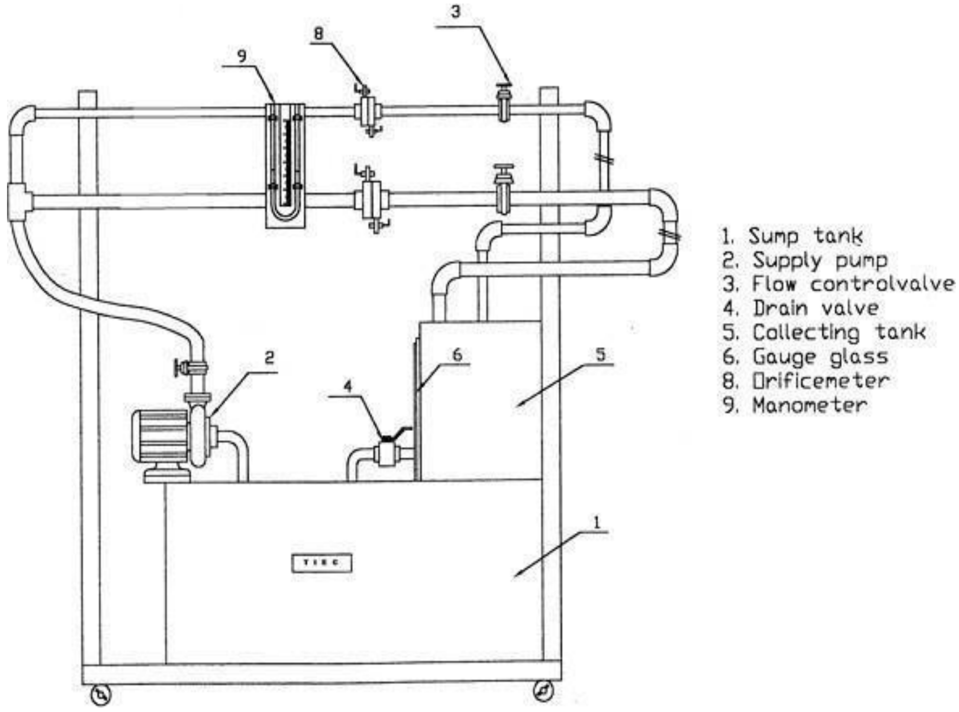
d_2 – Diameter of orifice in meter

6. Co-efficient of discharge of orifice meter(C_d) = $\frac{Q_{act}}{Q_{th}}$

Where

Q_{act} - Actual Discharge in m^3/s

Q_{th} - Theoretical Discharge in m^3/s

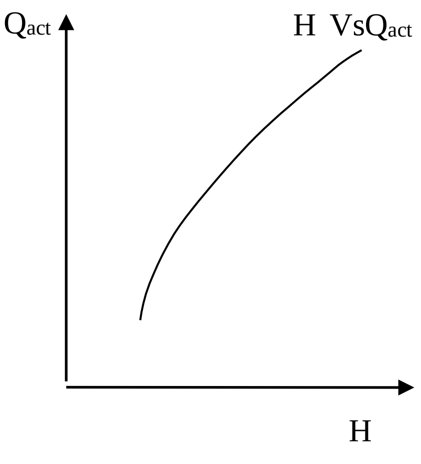


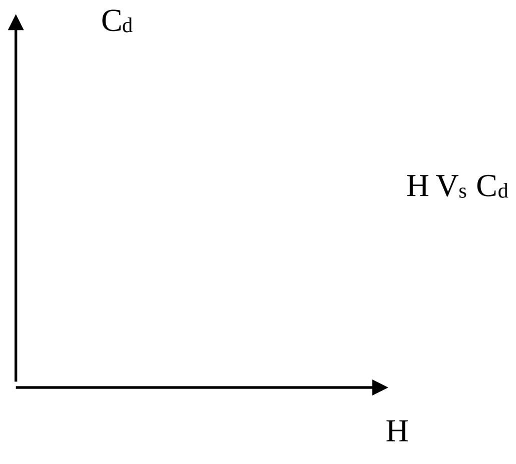
Observations:

1. Length of collecting tank (L) = 0.4 m
2. Breadth of collecting tank (B) = 0.4 m
3. Rise of water level in the collecting tank (h) = 0.1 m
4. Diameter of Orifice meter inlet (d_1) = 0.025m
5. Diameter of Orifice (d_2) = 0.015 m
6. Specific gravity of fluid flowing through the pipe (Water) (S_w) = 1

Graph:

1. Head (H) Vs Actual Discharge (Q_{act})
2. Head (H) Vs Co-efficient of Discharge (C_d)





Result:

Thus the co-efficient of discharge of Orifice meter is calculated.

Co-efficient of discharge (C_d) = _______________

CALCULATION OF THE RATE OF FLOW USING ROTOMETER

Exp No: 5

Date:

Aim: To determine the percentage error in Rotometer with the actual flow rate.

Apparatus required:

1. Rotometer setup
2. Measuring scale
3. Stopwatch.

Formulae:

1. **Actual discharge:**

$Q_{act} = A \times h / t$ (m^3/s)

Where:

A = Area of the collecting tank (m^2)

h= 10 cm rise of water level in the collecting tank $(10^{-2}$ m).

t = Time taken for 10 cm rise of water level in collecting tank.

Conversion:

Actual flow rate (lit / min), $Q_{act} = Q_{act} \times 1000 \times 60$ lit /min

$$\text{Percentage error of Rotometer} = \frac{\text{Rotometer reading} \sim \text{Actual} \times 100\ \%}{\text{Rotometer reading}}$$

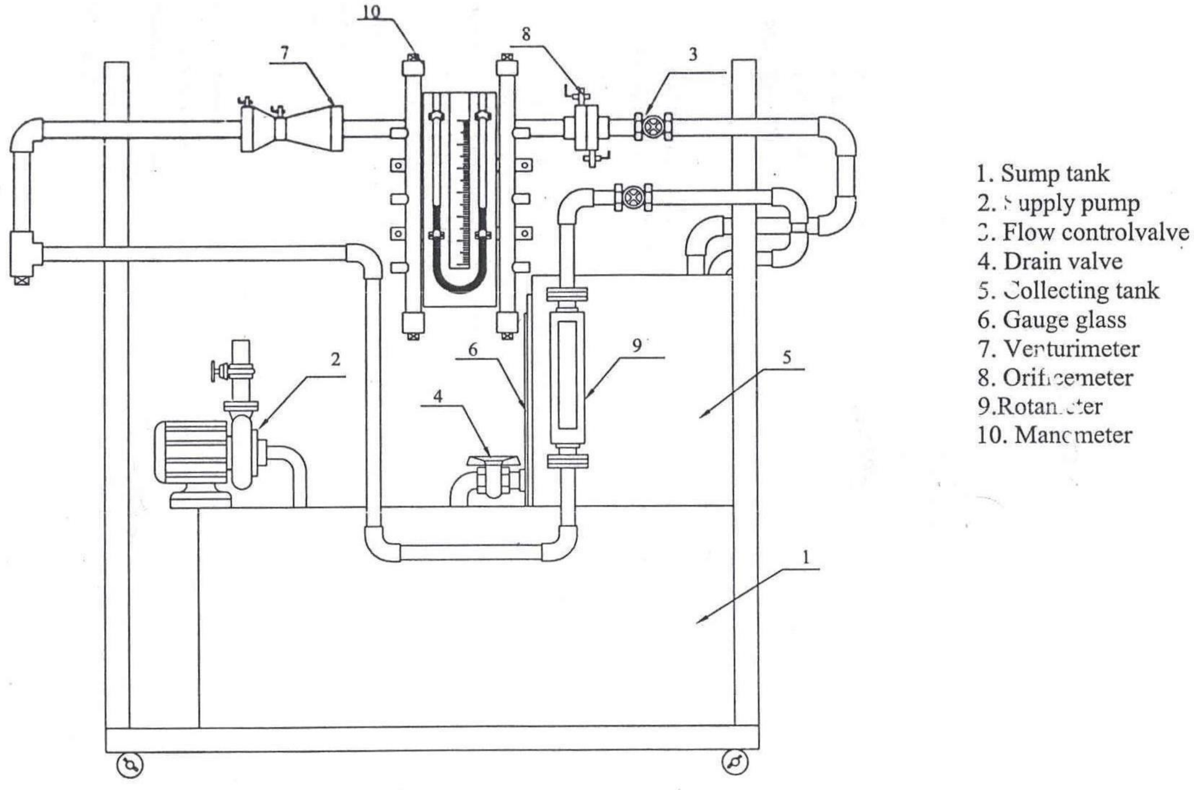
$$= R \sim Q_{act} / R \times 100\ \%$$

Procedure:

1. Switch on the motor and the delivery valve is opened
2. Adjust the delivery valve to control the rate in the pipe
3. Set the flow rate in the Rotometer, for example say 50 liters per minute
4. Note down the time taken for 10 cm rise in collecting tank
5. Repeat the experiment for different set of Rotometer readings
6. Tabular column is drawn and readings are noted
7. Graph is drawn by plotting Rotometer reading Vs percentage error of the Rotometer

Tabulation:

.No	Rotometer Reading (lpm)	Actual Discharge Q_{act} (m^3/sec)	Time taken for 10cm rise of water In tank (t sec)	Actual discharge Q (lpm)	Percentage Error of Rotometer (%)



ROTO METER TEST RIG

RESULT:

The percentage error of the Rotometer was found to be ....%

DETERMINATION OF FRICTION LOSSES IN PIPES

MAJOR LOSSES IN PIPE FLOW

Exp. No. : 6
Date:

Aim:

To study about flow through pipes and determine the friction factor using Darcy-Weisbach formula and Chezy's constant for the given pipe.

Apparatus Required:

1. Stop watch
2. Scale
3. Collecting (measuring) tank
4. Manometer

Description:

When water flows through a pipe a certain amount of energy (or pressure energy) has to be spent to overcome the friction due to the roughness of the pipe surface. This roughness effect or friction effect depends upon the material of pipe and scale formation if any when the surface is smooth the friction effect is less. For an old pipe due to scale formation or chemical deposits, it increases the roughness of inner surface of pipes and hence the friction effect is higher.

Practical Application:

Friction loss is the measure of the reduction in the total head of the liquid as it moves through a system. The total head is the sum of the elevation head, velocity head and pressure head. Head loss is unavoidable and is present because of the friction between the fluid and the walls of the pipe and is also present between adjacent fluid particles as they flow along the pipe. Head loss is a measure of the reduction in the total head (sum of elevation head, velocity head and pressure head) of the fluid as it moves through a fluid system. This is unavoidable in real fluids.

Experimental Procedure:

1. The internal dimensions of the collecting tank and the length of the pipeline between two pressure tapping cocks are measured.
2. Keeping the outlet valve of the pipe fully closed, the inlet valve of the pipe is opened fully.
3. The outlet valve is slightly opened and the manometric heads in both limbs (h_1 and h_2) are noted.
4. The outlet valve of the collecting tank is tightly closed and the time"t" required for 10 cm rise of water in the collecting tank is observed by using a stop watch.
5. The above procedure is repeated by increasing the flow and observing the corresponding readings.

Tabulation:

S .No	Manometer Reading		Loss of Head	Time for „h‟ m rise in collecting tank	Actual Discharge	Flow velocity	Darcy friction Factor	Loss of Head per unit length of pipe	Chezy ‟s constant
	Left limb reading	Right limb reading							
	h_1	h_2	H	t	Q_{act}	V	f	i	C
Unit	cm of water	cm of water	m of water	Sec	m^3/sec	m/s	--	--	--

Formula Used:

1. Cross sectional area of the collecting tank (A) = L x B .... m^2

   Where

   L – Length of the collecting tank in meter

   B – Breadth of the collecting tank in meter

2. Actual Discharge (Q_{act}) = $\frac{Volume}{Time}$ .... m^3/s

   $Q_{act} = \frac{Ah}{t}$ =...$\frac{V}{t}$........................ m^3/s

   Where

   V – Volume of water collected in collecting tank in m^3

   h - Rise of water level in the collecting tank in meter

   t – Time for 'h' cm rise of water in the collecting tank in seconds

   A – Cross sectional area of the collecting tank in m^2.

3. Cross sectional area of pipe (a) = $\frac{\pi}{4}$ x d^2.................... m^2

   Where

   d – Diameter of pipe in meter

4. Flow velocity or velocity of flowing fluid (V) = $\frac{Qact}{a}$..................... m/s

   Where

   Q_{act}- Actual Discharge in m^3/s

   a– Cross sectional area of pipe in m^2.

5. Darcy-Weisbach‟s friction factor (f) = $\frac{2gdH}{4LV^2}$

   Where,

   d – Diameter of pipe in meter

   H –loss of Head in meter of water

   L – Length of pipe in meter

   V – Flow velocity or velocity of flowing fluid in m/s

6. Hydraulic mean radius (m) = $\frac{a}{p}$ .... m

   Where,

   a - Cross sectional area of pipe in m^2

   p- Perimeter of pipe in meter

   (OR)

Hydraulic mean radius (m) = $\frac{d}{4}$ (for circular pipes)..................... m

7. Loss of head per unit length (i) = $\frac{H}{L}$

Where,

H – loss of Head in meter of water

L – Length of pipe in meter

8. Chezy's Constant (C) = $\frac{V}{\sqrt{mi}}$

Where,

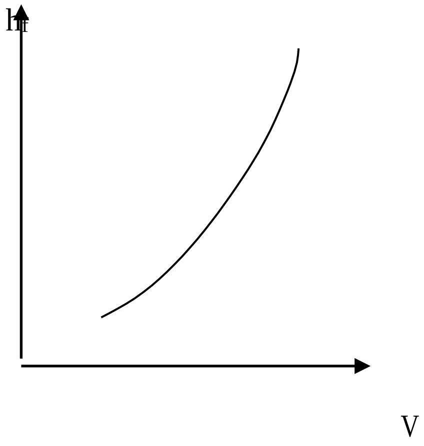
V – Flow velocity or velocity of flowing fluid in m/s

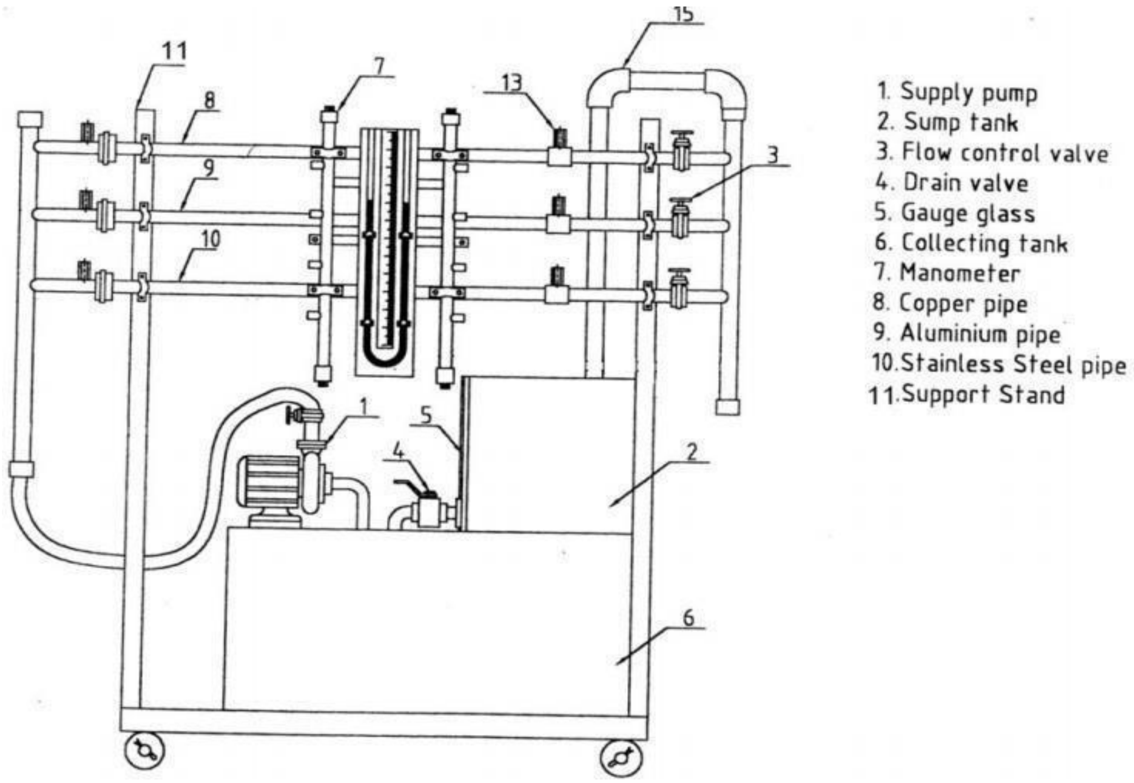
m – Hydraulic mean radius in meter

i – Loss of head per unit length.

Graph:

1. Flow Velocity (V) V_s Head Loss (h_f)





Observations:

1. Diameter of Pipe (d) = 0.0125 m
2. Length of the pipe (L) = 1.25 m
3. Rise of water level in the collecting tank (h) = 0.1 m
4. Length of the collecting tank (L) = 0.4 m
5. Breadth of the collecting tank (B) = 0.4 m

Result:

Thus the friction factor for pipe is calculated.

1. Friction factor for Darcy-Weisbachformula (f) = ____________
2. Chezy‟s constant (C) = ____________

STUDY OF MINOR LOSSES IN PIPES

(LOSS DUE TO PIPE FITTINGS)

Exp. No. : 7

Date:

Aim:

To study flow in pipes and determine the loss co-efficient of the given pipe at the following sections

1. Sudden Enlargement
2. Sudden Contraction,
3. Bend
4. Elbow

Apparatus Required:

1. Stop watch
2. Steel rule
3. Collecting tank

Description:

In general pipelines system includes several auxiliary components in addition to pipes. These components include the following.

1. Transitions of sudden expansion and contraction for changing pipe size.
2. Elbows and bends for changing the flow direction.

These components introduce disturbances in the flow that cause turbulence and hence mechanical energy loss in addition to that which occurs in the basic pipe flow due to friction. The energy loss although while occurs over a finite distance, when viewed from the perspective of an entire pipe system are localized near the component. Hence these losses are referred to as local losses or minor losses. It should be remembered that sometimes these losses are dominant losses in a piping system.

Practical Application:

For any pipe system, in addition to the friction loss computed for the length of pipe. Most pipe systems consist of considerably more than straight pipes. These additional components add to the overall head loss of the system. Such losses are generally termed minor losses, with the apparent implication being that the majority of the system loss is associated with the friction loss.

Tabulation:

Experiment	S.No	Manometer Reading		Head Loss	Time for 10 cm rise in collecting tank	Actual Discharge	Flow velocity	Loss Co-efficient
		Left limb reading	Right limb reading					
--		H_1	H_2	H	T	Q	V	K
--	Unit	cm of water	cm of water	m of water	Seconds	m^3/sec	m/s	--
Sudden Enlargement	1.							
	2.							
	3.							
Sudden Contraction	1.							
	2.							
	3.							
Bend	1.							
	2.							
	3.							
Elbow	1.							
	2.							
	3.							

Experimental Procedure:

1. Select the required pipe line
2. The outlet valve is slightly opened and the manometric heads in both limbs (h_1 and h_2) are noted.
3. The outlet valve of the collecting tank is tightly closed and the time "t" required for 10 cm rise of water in the collecting tank is observed by using a stop watch.
4. The above procedure is repeated by increasing the flow and observing the corresponding readings.

Formula Used:

Sudden Enlargement

1. Loss co- efficient for sudden enlargement (K_e) $= \frac{HL}{v2/2g}$

Where

H_L- Head loss in m of water.

ν – Flow velocity or Velocity of flowing fluid in m/s.

2. Head loss $H_L = H + V^2/2g\ [1 - (\frac{a1}{a2})^2]$.................... m of water

Where

H_L - Loss of head in m of water

a_1 - Cross sectional area of pipe before enlargement in m^2

a_2 = Cross sectional area of pipe after enlargement in m^2.

ν– Flow velocity or Velocity of flowing fluid in m/s

3. Flow Velocity or Velocity of flowing fluid (V) = $\frac{Qact}{a}$ .... m/s

Where

Q_{act}– Actual Discharge in m^3/s

a – Cross sectional area of pipe in m^2.

4. Actual Discharge (Q_{act}) $= \frac{Volume}{Time}$...................... m^3/s

$Q_{act} = \frac{Ah}{t} = \frac{V}{t}$ .... m^3/s

Where

V – Volume of water collected in m^3

h - Rise of water level in the collecting tank in meter

t – Time for 10 cm rise of water in the collecting tank in seconds

A – Cross sectional area of the collecting tank in m^2.

5. Cross sectional area of pipe (a) $= \frac{\pi}{4}\ d^2$.................... m^2Where

d – Diameter of pipe in meter

6. Cross sectional area of pipe before enlargement (a_1) = $\frac{\pi}{4}$ d_1^2 m^2

Where

d_1 – Diameter of pipe before enlargement in meter

7. Cross sectional area of pipe after enlargement (a_2) = $\frac{\pi}{4}$ d_2^2……………………………m^2

Where

d_2 – Diameter of pipe after enlargement in meter

8. Cross sectional area of the collecting tank (A) = L x B.........................m^2

Where

L – Length of the collecting tank in meter

B – Breadth of the collecting tank in meters

Sudden contraction

1. Loss co- efficient for sudden contraction (K_c) = $\frac{HL}{v2/2g}$

Where

H_L - Loss in m of water.

ν – Flow velocity or Velocity of flowing fluid in m/s.

2. Loss H_L= H + $\frac{v2}{2g}$ [1 - ($\frac{a1}{a2}$) $^{2.}$] .... m of water

Where

H_L - Loss of head in m of water

V– Flow velocity or Velocity of flowing fluid in m/s

a_3 - Cross sectional area of pipe before contraction in m^2.

a_4 - Cross sectional area of pipe after contraction in m^2.

3. Cross sectional area of pipe before contraction (a_3) = $\frac{\pi}{4}$ d_3^2 m^2

Where

d_3 – Diameter of pipe before contraction in meter

4. Cross sectional area of pipe after contraction(a_4) = $\frac{\pi}{4}$ d_4^2……………………………m^2

Where

d_4 – Diameter of pipe after contraction in meter

Bend

1. Loss co- efficient for bend (K_b) = $\frac{HL}{v2/2g}$

Where

H_L - Loss in m of water.

V– Flow velocity or Velocity of flowing fluid in m/s.

2. Loss H_L = H ....m of water

Where

H - Loss of head in m of water

Elbow

1. Loss co efficient for elbow (K_L) = $\frac{HL}{v2/2g}$

Where

H_L - Loss in m of water.

V – Flow velocity or Velocity of flowing fluid in m/s.

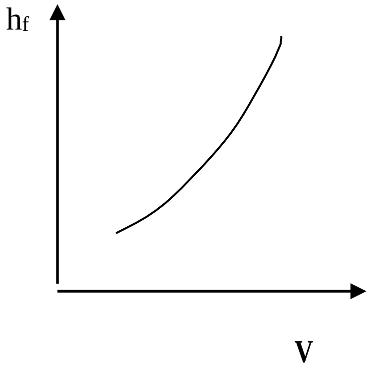
2. Loss H_L = H.....................m of water

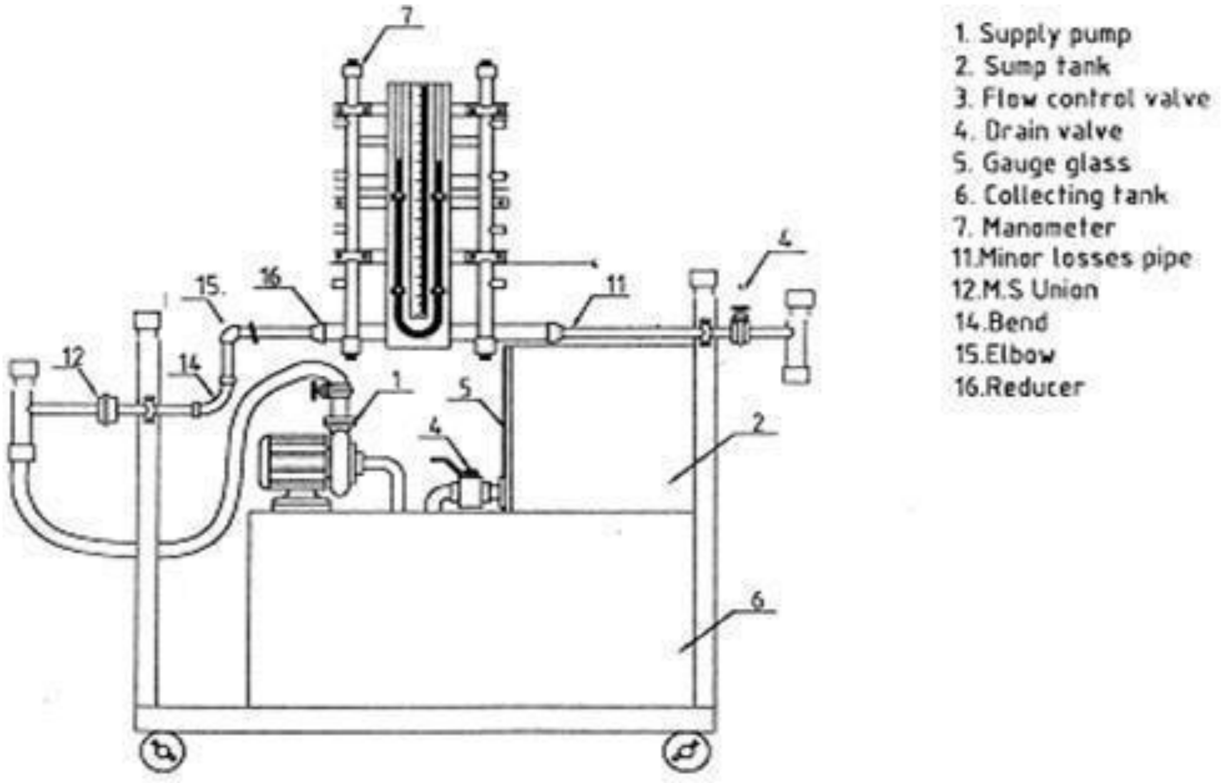
Where

H - Loss of head in m of water

Graph:

The Flow velocity (V) V_sHead (h_f) graphs are drawn for Loss of head due to various pipe fittings





Observations:

1. Rise of water level in the collecting tank (h) = 0.1 m.
2. Length of the collecting tank (L) = 0.4 m.
3. Breadth of the collecting tank (B) = 0.4m.
4. Sudden Enlargement
   a. Diameter of pipe before enlargement (d_1) =0.016 m
   b. Diameter of pipe after enlargement (d_2) =0.026 m
5. Sudden Contraction
   a. Diameter of pipe before contraction (d_3) =0.026 m
   b. Diameter of pipe after contraction (d_4) =0.016 m
6. Diameter of pipe (d) =0.0125 m

Result:

Loss Co-efficient for the following auxiliary components are

1. Loss Co-efficient for Sudden expansion (K_e) = ____________
2. Loss Co-efficient for Sudden contraction (K_c) = ____________
3. Loss Co-efficient for Bend (K_b) = ____________
4. Loss Co-efficient for Elbow (K_L) = ____________

STUDY ON PERFORMANCE CHARACTERISTICS OF PELTON TURBINE.

Exp. No.: 8

Date:

Aim:

To conduct an experiment on Pelton wheel turbine and also determine the performance and plot the characteristic curves.

Apparatus Required:

1. Tachometer
2. Pelton Wheel
3. Steel rule
4. Dead Weights

Description:

Pelton turbine is an impulse turbine used to utilize high head of water for generation of electricity. All the available pressure head is converted to kinetic energy by means of a spear wheel and a nozzle arrangement. The water leaves the nozzle in a jet formation. Then the jet of water strikes the buckets of the Pelton wheel runner. The jet deflects through more than to 170 degree. While passing along the buckets water is deflected causing a change in momentum of the water jet hence the impulse force is supplied to the cups. The specific speed of the Pelton wheel varies from 10 to 100. The Pelton wheel is supplied with water under high pressure by a centrifugal pump. The water flow through a venturimeter to the Pelton wheel. A gate valve is used to control the flow rate to the turbine. The nozzle opening is controlled by spear wheel at the entrance of the turbine. The turbine is located by applying dead weight. On the brake drum placing the weight and the weight hanger does this the inlet head is read. From the pressure gauge, the speed of the turbine is measured with the tachometer.

Practical Application:

The Pelton Wheel is the only form of impulse turbine in common industrial use. It is a robust and simple machine which is ideal for the production of power from low volume water flows at a high head with reasonable efficiency

Tabulation:

S.No	Press Gauge	Total Head	Venturimeter reading		Pressure Head	Actual Discharge	Speed of Turbine	Weight on Hanger	Weight on Spring	Net Weight	Turbine Input Power	Turbine output Power	Efficiency
			Inlet Pre.	Throat Pres.									
	P	H	P_1	P_2	dH	Q_{act}	N	w_1	W_2	w	IP	OP	η
unit	Kg/cm^2	m of water	Kg/cm^2	Kg/cm^2	m of Water	m^3/sec	rpm	N	N	N	Kw	Kw	%

Experimental Procedure:

1. Close the delivery gate valve completely and start the pump.
2. Openthe gate valve 8/15th position and note the pressure gauge reading at the inlet of the turbine.
3. Note the venturimeter pressure gauge readings, P_1 and P_2.
4. Measure the turbine speed with tachometer (for no load condition).
5. Note the weight on hanger and spring
6. Open the cooling water valve for cooling the brake drum.
7. Then add additional weights and repeat the above procedure forvarying loads.

Formula Used:

1. Efficiency of pelton turbine (η) = $\frac{OP}{IP}$ x 100

Where

OP - Output power of the peltonturbine in kW

IP - Input power of the peltonturbine in kW

2. Input power peltonturbine (IP) = ν x Q_{act} x H.........................kW

Where,

ν – Specific weight of water in kN/m^3

Q_{act}– Actual discharge in m^3/s

H – Total head in m of water.

3. Output power pelton Turbine (OP) = $\frac{2\pi NT}{60}$ x 1000...................... kW

Where,

N – Speed of peltonturbine in rpm

T – Torque in N-m

4. Torque (T) = w x g x r. .... N-m

Where,

w- Net weight in N

r - Equivalent drum radius in meter.

5. Total head (H) = 10P...................... m of water

Where,

P – Pressure gauge readings in Kg/cm^2.

6. Pressure head (dH) = 10 (P_1 - P_2)....................... m of water

Where,

P_1 - Venturimeter inlet pressure in Kg/cm_2

P_2 - Venturimeter throat pressure in Kg/cm_2

7. Net weight (w) = $w_1 - w_2 + w_0$ ....N

Where,

w_1 – Weight of hanger in N

w_2 - Dynamometer reading in N

w_0 – weight of empty hanger in N

8. Actual discharge (Q_{act}) = $\dfrac{C_d a_1 a_2 \sqrt{2g.dH}}{\sqrt{a_1^2 - a_2^2}}$ X 0.1 .... m^3/sec

Where,

a_1 – area of cross section of venturimeter inlet in m^2

a_2 – area of cross section of venturimeter throat in m^2

C_d – Co- efficient of discharge of venturimeter

dH –Pressure Head in m of water 0.1m–

Correction Head

9. Equivalent drum radius r = $\frac{D+d}{2}$ …................. m

Where,

D – Brake drum diameter in m

d – Rope diameter in m

10. Pressure head (dH) =10 x ($P_1 - P_2$)...................... m of water

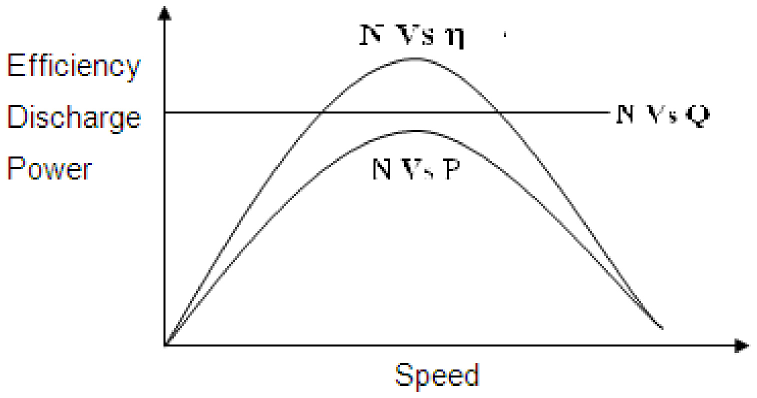
Where

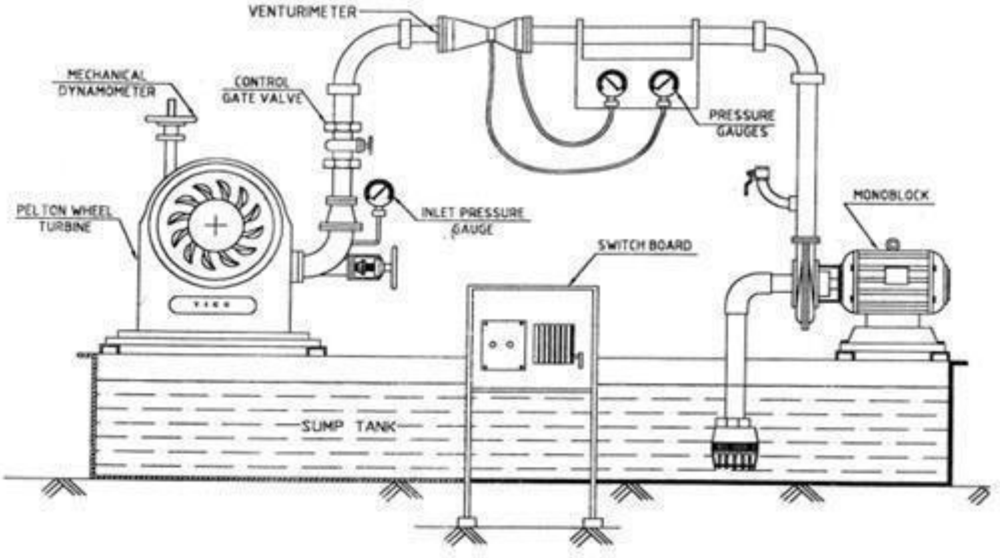
P_1 - Venturimeter inlet pressure in Kg/cm^2

P_2 - Venturimeter throat pressure in Kg/cm^2

Graph:

1. Speed (N) Vs Power (P)
2. Speed (N)Vs Efficiency (η)
3. Speed (N)Vs Discharge (Q)





Observations:

1. Weight of empty hanger (W_o) = 10 N
2. Inlet diameter of Venturimeter (d_1) = 0.05 m
3. Throat and inlet Diameter ratio of venturimeter = 0.6 m
4. Co efficient of discharge of Venturimeter (C_d) = 0.96
5. Brake drum diameter (D) = 0.2 m
6. Specific weight of water (ν) = 1000kN/m^3
7. Rope diameter (d) = 0.015m

Result:

Thus the performance of pelton wheel turbine is calculated and the characteristic curves were plotted. From the graph the following results are obtained.

1. Maximum efficiency of pelton wheel (η) =________________%
2. Input power of pelton wheel (IP) =_________________kW
3. Output power of pelton wheel (OP) =_________________kW

STUDY ON PERFORMANCE CHARACTERISTICS OF FRANCIS TURBINE

Exp. No.:9

Date:

Aim:

To conduct an experiment on a Francis Turbine and also determine the performance and plot the characteristic curves.

Apparatus Required:

1. Tachometer
2. Francis Turbine
3. Dead Weights

Description:

Francis Turbine is a reaction type hydraulic turbine used in dams and reservoirs of medium height to convert hydraulic energy into mechanical and electrical energy. Francis Turbine is a radial energy flow reaction Turbine under pressure of water. The water enters to wheel at the outer periphery and flow inwards towards the centre of the wheel. The flow through the pipelines into the Turbine is measured with the Venturimeter is provided with a pressure gauges. The net pressure difference across the turbine inlet and outlet are measured with a set of pressure gauge and Vacuum gauge. The Turbine output torque is determined with a rope brake drum dynamometer. A tachometer is used to measure the speed.

Practical Application:

Francis turbines generally are the most efficient solution for heads ranging from 40 to 600 meters. The runner design can be adapted to get the highest level of efficiency in its whole range of application. Francis turbines are very robust and able to sustain the high mechanical stress resulting from high heads.

Experimental Procedure:

1. Close the delivery gate valve completely and start the pump.
2. Add minimum load to the weight hanger of the brake drum - say 1 kg.
3. Open the gate valve while monitoring the inlet pressure to the turbine.
4. Open the cooling water valve for cooling the brake drum.
5. Measure the turbine speed with tachometer.
6. Note the pressure gauge reading at the turbine inlet.
7. Note the venturimeter pressure gauge readings, P_1 and P_2.
8. Add additional weights and repeat the experiment for other loads.

Tabulation:

S.No	Pre. Gauge	Total Head	Venturimeter reading		Pressure Head	Actual Discharge	Speed of Turbine	Weight on Hanger	Weight on Spring	Net Weight	Turbine Input Power	Turbine output Power	Efficiency
			Inlet Pre.	Throat Pres.									
	P	H	P_1	P_2	dH	Q_{act}	N	w_1	W_2	w	IP	OP	H
unit	Kg/cm^2	m of water	Kg/cm$_2$	Kg/cm$_2$	m of Water	m^3/sec	rpm	N	N	N	Kw	Kw	%

Formula Used:

1. Efficiency of Francis turbine (η) = $\frac{OP}{IP}$ x 100

   Where

   OP - Output Power of the Francis Turbine in KW

   IP - Input Power of the Francis Turbine in KW

2. Input power Francis Turbine (IP) = ν $Q_{act}H$ ....kW

   Where,

   ν – Specific weight of water in KN/m^3

   Q_{act}- Actual Discharge in m^3/s

   H - Total head in m of water.

3. Output power Francis Turbine (OP) = $\frac{2\pi NT}{60}$ x 1000....................... kW

   Where,

   N – Speed of Francis Turbine in rpm

   T – Torque in Nm

4. Torque (T) = w x g x r. .... N-m

   Where,

   w- Net weight in N

   r - Equivalent drum radius in m

5. Net weight (w) = $(w_1 – w_2 + w_0)$ .... N

   Where,

   w_1 – Weight of hanger in N

   w_2 – Dynamometer reading in N

   w_0 – Weight of empty hanger in N

6. Total head (H) = Delivery head + Suction head + Datum head .... m of water

   $H = 10 \left(P + \frac{V}{760}\right) + z$........................ m of water.

   Where,

   P – Pressure gauge readings in Kg/cm^2.

7. Actual discharge (Q_{act}) = $\frac{C_d\, a_1\, a_2 \sqrt{2g.dH}}{\sqrt{a_1^2 - a_2^2}}$ X 0.127.................m^3/sec

   Where,

   a_1 – area of cross section of venturimeter inlet in meter

   a_2– area of cross section of venturimeter throat in meter

   C_d – Co efficient of discharge of venturimeter

   dH – Pressure Head in m of water

   0.127m – Correction Head

8. Equivalent drum radius r = $\frac{D+d}{2}$ …................. m

Where,

D – Brake drum diameter in m

d – Rope diameter in m

9. Pressure head (dH) = 10 (P_1 - P_2)....................... m of water

Where,

P_1 - Venturimeter inlet pressure in Kg/cm_2

P_2 - Venturimeter throat pressure in Kg/cm_2

10. Net weight (w) = $w_1 - w_2 + w_0$..................................... N

Where,

w_1 – Weight of hanger in N

w_2 - dynamometer reading in N

w_0 – weight of empty hanger in N

11. Pressure head (dH) =10 x ($P_1 - P_2$)...................... m of water

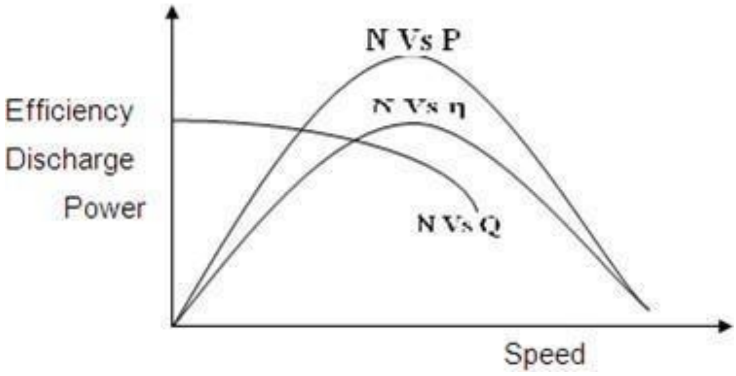
Where,

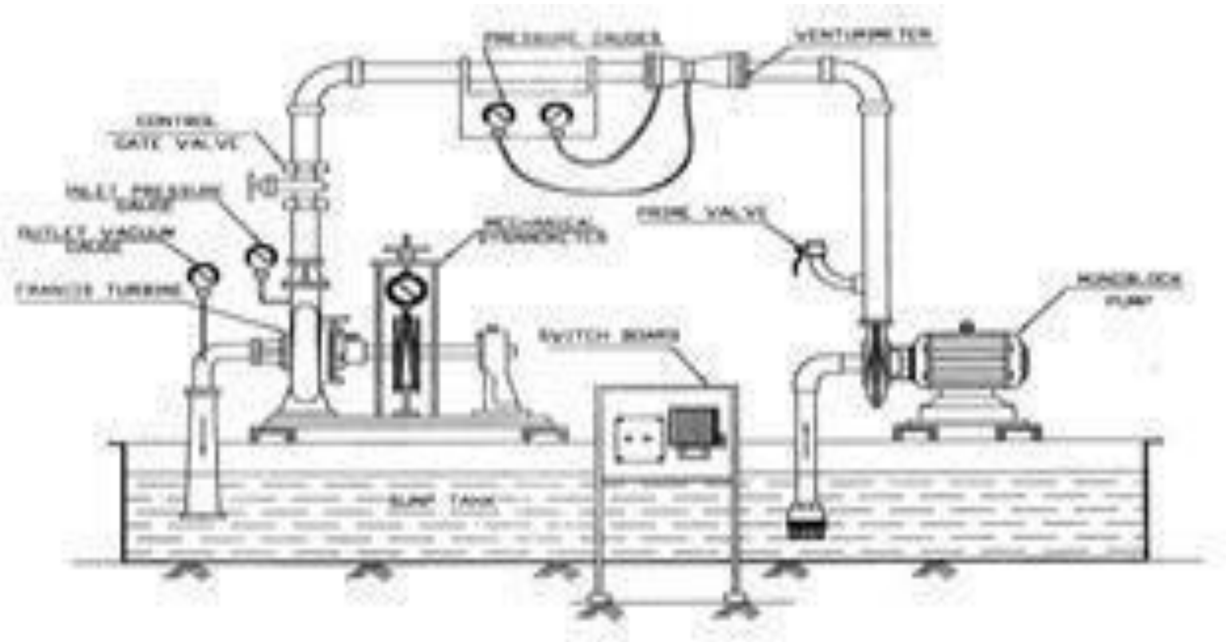
P_1 - Venturimeter inlet pressure in Kg/cm^2

P_2 - Venturimeter throat pressure in Kg/cm^2

Graph:

1. Speed(N) Vs Power (P)
2. Speed(N) Vs Efficiency (η)
3. Speed(N) Vs Discharge(Q)





Observations:

1. Weight of empty hanger (W_o) = 10 N
2. Ratio between inlet and throat diameter (d/d_0) = 0.6
3. Inlet diameter of Venturimeter (d_1) = 0.065 m.
4. Co efficient of discharge of Venturimeter (C_d) = 0.96
5. Brake drum diameter (D) = 0.2 m
6. Specific weight of water (s) = 1000 KN/m^3
7. Rope diameter (d) = 0.015 m

Result:

Thus the performance of a Francis turbine is measured and the characteristic curves were plotted.

1. Maximum Efficiency of Francis turbine (η_{max}) =______________%
2. Input power of Francis turbine (IP) =_____________kW
3. Output power of Francis turbine (OP) =_____________kW

STUDY ON PERFORMANCE CHARACTERISTICS OF KAPLAN TURBINE

Exp. No.: 10

Date:

Aim:

To conduct an experiment on a Kaplan Turbine, measure the performance and plot the characteristics curves.

Apparatus Required:

1. Tachometer
2. Dead Weight

Description:

Kaplan turbine is an axial flow reaction turbine used in dams and reservoirs of low height to convert hydraulic energy into mechanical and electrical energy. They are best suited for low heads say from 10m to 50m. The specific speed ranges from 200 to 1000. Water under pressure from pump enters through the volute casing and the guide vanes into the runner. While passing through the spiral casing and guide vanes, a portion of the pressure energy is converted into kinetic energy. Water thus enters the runner at a high velocity and as it passes through the runner vanes, the remaining potential energy is converted into kinetic energy. Due to the curvature of the vanes, the kinetic energy is transformed into the mechanical energy. The water from the runner is then discharged into the draft tube.

Practical Application:

Kaplan turbines are primarily used in the low head range with large volumes of water. The adjustability of the guide vanes and runner blades allows optimal use of varying water flow. 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. Inexpensive micro turbines are manufactured for individual power production with as little as two feet of head. Kaplan turbine is low head turbine

Experimental Procedure:

1. Close the delivery gate valve completely and start the pump.
2. Add minimum load to the weight hanger of the brake drum
3. Open the gate valve while monitoring the inlet pressure to the turbine.
4. Open the cooling water valve for cooling the brake drum.
5. Measure the turbine speed with tachometer.
6. Note the pressure gauge reading at the turbine inlet.
7. Note the venturimeter pressure gauge readings, P_1 and P_2.
8. Add additional weights and repeat the experiments for other loads.

Tabulation:

S.No	Pre. Gauge	Total Head	Venturimeter reading		Pressure Head	Actual Discharge	Speed of Turbine	Weight on Hanger	Weight on Spring	Net Weight	Turbine Input Power	Turbine output Power	Efficiency
			Inlet Pre.	Throat Pres.									
	P	H	P_1	P_2	dH	Q_{act}	N	w_1	W_2	w	IP	OP	η
unit	Kg/cm^2	m of water	Kg/cm^2	Kg/cm^2	m of Water	m^3/sec	rpm	N	N	N	kW	kW	%

Formula Used:

1. Efficiency of Kaplan turbine $(\eta) = \frac{OP}{IP} \text{ x } 100$

   Where,

   OP - Output Power of the Kaplan Turbine in kW

   IP - Input Power of the Kaplan Turbine in kW

2. Input power Kaplan Turbine (IP) = $\nu\, Q_{act} H$.................... kW

   Where,

   ν – Specific weight of water in kN/m^3

   Q_{act}- Actual Discharge in m^3/s

   H - Total head in m of water.

3. Output power kaplanturbine (OP) = $\frac{2\pi NT}{60} \text{ x } 1000$....................... kW

   Where,

   N – Speed of Kaplanturbine in rpm

   T – Torque in N.m

4. Torque (T) = w.g.r ....N.m

   Where,

   w- Net weight in N

   r - Equivalent drum radius in m

5. Net weight (w) = $(w_1 - w_2 + w_0)$. .... N

   Where,

   w_1 – Weight of hanger in N

   w_2 – dynamometer reading in N

   w_0 – weight of empty hanger in N

6. Total head (H) = Delivery head + Suction head + Datum head .... m of water

   $$(H) = 10\left(P + \frac{V}{760}\right) + z \text{........................ m of water.}$$

   Where,

   P – Pressure gauge reading in Kg/cm^2.

   V – Vaccum gauge reading in kg/cm^2

7. Actual discharge (Q_{act}) = $\frac{C_d\, a_1\, a_2 \sqrt{2g.\,dH}}{\sqrt{a_1^2 - a_2^2}}$ X 0.199................m^3/sec

   Where,

   a_1 – area of cross section of venturimeter inlet in m

   a_2– area of cross section of venturimeter throat in m

   C_d – Co efficient of discharge of venturimeter

   dH –Pressure Head in m of water

   0.199m – Correction Head

8. Equivalent drum radius r = $\frac{D+d}{2}$ …................. m

Where,

D – Brake drum diameter in meter

d – Rope diameter in meter

9. Pressure head (dH) = 10 (P_1 - P_2)....................... m of water

Where,

P_1 - Venturimeter inlet pressure in Kg/cm_2

P_2 - Venturimeter throat pressure in Kg/cm_2

10. Net weight (w) = $w_1 - w_2 + w_0$......................................N

Where,

w_1 – Weight of hanger in N

w_2 – Dynamometer reading in N

w_0 – Weight of empty hanger in N

11. Pressure head (dH) =10 x ($P_1 - P_2$)...................... m of water

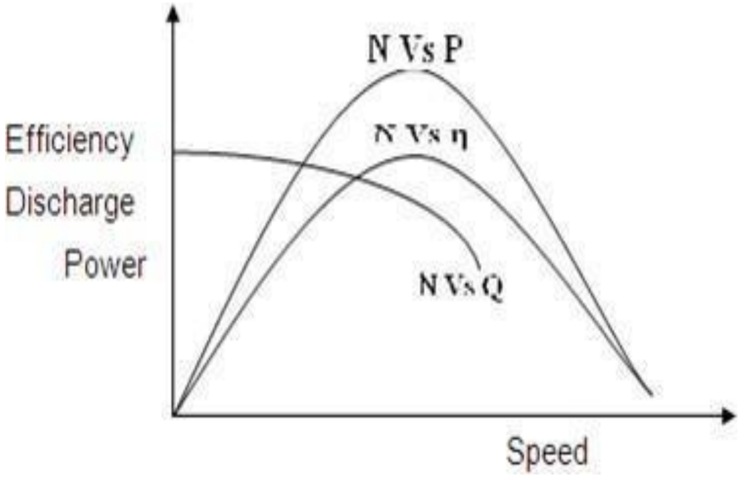
Where

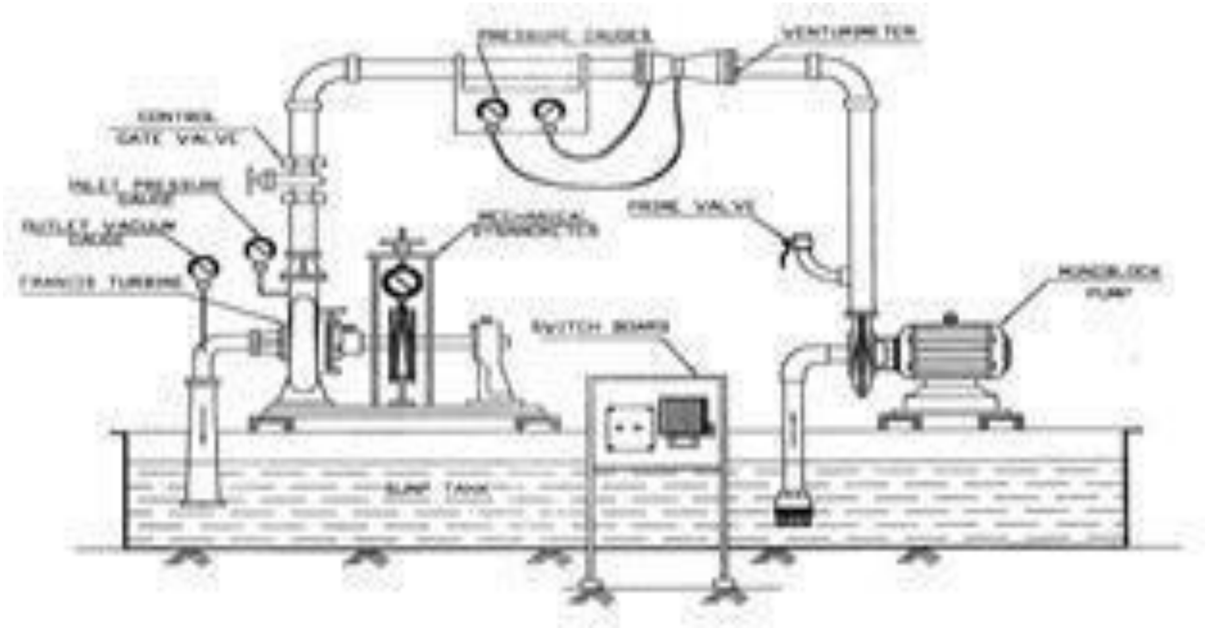
P_1 - Venturimeter inlet pressure in Kg/cm^2

P_2 - Venturimeter throat pressure in Kg/cm^2

Graph:

1. Speed (N) V_sPower (P)
2. Speed (N) V_s Efficiency (η)
3. Speed (N) V_s discharge (Q)





Observations:

1. Rope diameter (d) = 0.015m
2. Weight of empty hanger (W_o) = 1 Kg
3. Inlet diameter of Venturimeter (d_1) = 0.1 m
4. Ratio of inlet and throat diameter (d_2) = 0.6
5. Co efficient of discharge of Venturimeter (C_d) = 0.98
6. Brake drum diameter (D) = 0.2 m
7. Specific weight of water (v) = 9.81 KN/m^3

Result:

Thus the performance of a Kaplan turbine is calculated and the characteristic curves were plotted.

1. Maximum Efficiency of Kaplan turbine (η_{max}) =_____________%
2. Input power of Kaplan turbine (IP) =_____________kW
3. Output power of Kaplan turbine (OP) =_____________kW

STUDY ON PERFORMANCE CHARACTERISTICS OF SUBMERSIBLE PUMP

Exp. No. : 11

Date:

Aim :

To conduct an experiment on a Submersible pump at various head and discharge to obtain the pump characteristics.

Apparatus Required:

1. Stop watch
2. Tachometer
3. Scale (steel rule)

Description:

The vertical submersible pump is a multistage pump set with each set made of a mixed flow impeller with axial diffuser assembly. The shaft of pump is connected to a motor which is housed on the bottom of the set. The pump and motor assembly is fully submerged in water. An integral foot valve is at the bottom set of the pump assembly. The submersible pump is used to lift water from borewells.

The test rig consists of a 3 – stage submersible pump driven by a 2 HP motor (220 Volts, 3 – phase) and suitable 25mm (1”) pipelines. A pressure gauge is fitted in the delivery pipe line to measure the delivery head. An energy meter and stopwatch are provided to measure the input to the motor and a collecting tank to measure the actual discharge.

Note: As the motor driving the submersible pump is also submerged, it is cooled by water unlike other motor pump sets which are air cooled. Hence, prior to operating the pump set the motor should be filled with water as instructed in the pump user manual. The operator is also expected to be read the user manual and be completely thorough with the operation of the submersible pump.

Practical Application:

(1) extremely deep wells which may present problems with shafting, especially if the well is crooked, (2) installation subjected to surface flooding which may be damaging to electric motors, (3) applications such as booster pumps that are in locations that require quiet operation, (4) installations where there is little or no floor space to install the unit, such as under a street or sidewalk, (5) horizontal pipe line booster pumps placed directly in the pipe line, and (6) agriculture installations where time consuming maintenance operations offers a great savings and security from ever rising vandalism of irrigation pumping units.

Tabulation:

S.NO	Pressure Gauge Reading	Total Head	Time for 10 cm rise in coll. tank	Actual Dischare x 10^{-3}	Time for 10 revol. of energy meter disc	Input Power	Output Power	Efficiency
	P	H	t	Q_{act}	T	IP	OP	η
Unit	Kg/cm^2	m of water	Sec	m^3/s	ses	Kw	Kw	%

Experimental Procedure:

1. Check whether the pump is fully submerged in water.
2. Start the pump. Note the following,
    - (i) The pressure gauge reading P in kg/mm²
    - (ii) The distance between the water level and pressure gauge – Hs m.
    - (iii) Time taken for 10 revolutions energy meter disc – T sec.
    - (iv) Time taken for 10cm rise in collecting tank „t‟ sec.
3. Take 5-6 readings by varying the head from maximum at shutoff to minimum where gate valve is fully open. This is done by throttling the delivery valve.

Formula Used:

1. Efficiency of Submersible pump (η) = $\frac{OP}{IP}$ x 100 %

    Where,

    OP - Output power of the Submersible pump in kW.

    IP - Input Power of the Submersible pump in kW.

2. Output Power of the Submersible pump (OP) = $\nu Q_{act} H$. ....kW

    Where,

    ν - Specific weight of water in kN/m^3

    Q_{act}- Actual Discharge in m^3/s

    H - Total head in m of water.

3. Actual Discharge (Q_{act}) = $\frac{Volume}{Time}$ .... m^3/s

    $$Q_{act} = \frac{Ah}{t} = \frac{V}{t} .... m^3/s$$

    Where,

    V – Volume of water collected in m^3

    h - Rise of water level in the collecting tank in m

    t - Time for 10 cm rise of water in the collecting tank in sec

    A – Cross sectional area of the collecting tank in m^2.

4. Cross sectional area of the collecting tank (A) = L x B .... m^2

    Where,

    L – Length of the collecting tank in m

    B – Breadth of the collecting tank in m

5. Total head (H) = [10p+Hs] m of Water.

   H = 10 (P)...................... m of water.

   Where,

   P – Pressure gauge readings in Kg/cm^2.

6. Input Power of the Reciprocating pump (IP) = IP $_{motor}$ η_{mot}.................................. kW

   Where ,

   IP$_{motor}$– Input Power of Motor in kW

   η_{mot}– Efficiency of motor

7. Input Power of Motor (IP$_{motor}$) = $\frac{R}{NT}$ x 3600 .... kW

   Where,

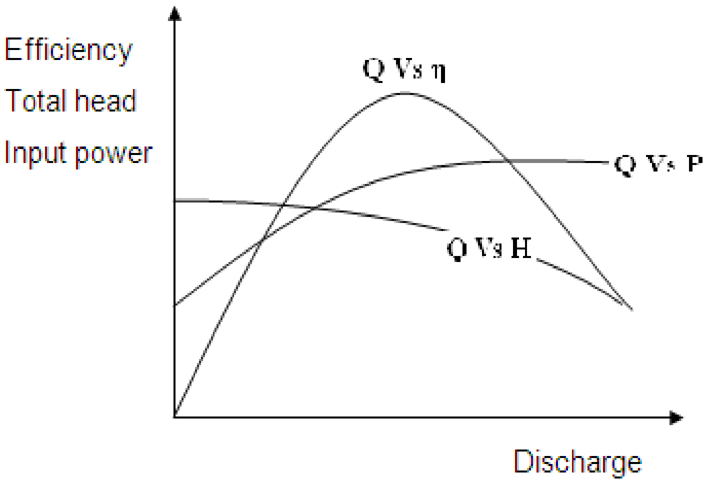
   R – Number of revolutions in the energy meter disc.

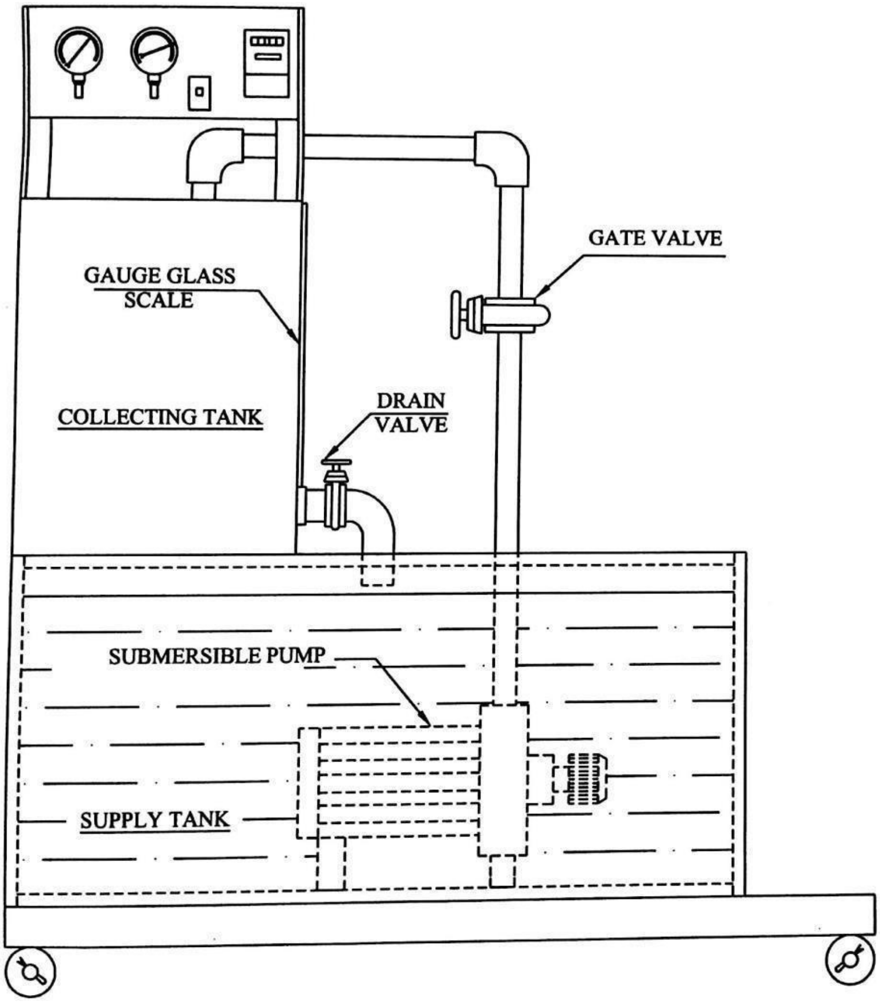
   N – Energy meter constant in rev / kW-hr

   T – Time for 10 revolution of energy meter disc in sec

Graph:

1. Discharge(Q) Vs Efficiency (η)
2. Discharge(Q) Vs Power(P)
3. Discharge (Q) Vs Total Head(H)





Observations:

1. Length of the collecting tank (L) = 0.5 m.
2. Breadth of the collecting tank (B) = 0.5 m.
3. Rise of water level in the collecting tank (h) = 0.1 m
4. Number of revolutions in the energy meter disc (R) = 10
5. Energy meter constant (N) = 3200 rev/kw.hr
6. Motor efficiency (η_{motor}) = 80 % (assumed)
7. Specific weight of water (v) = 9.81KN/m^3

Result:

Thus the performance of single stage Submersible pump is calculated and the characteristic curves are plotted.

Efficiency of Submersible pump (η_{max}) =___________%

STUDY ON PERFORMANCE CHARACTERISTICS OF RECIPROCATING PUMP

Exp. No. : 12

Date:

Aim:

To conduct an experiment on a reciprocating pump at various speeds, measure the performance and draw the characteristic curves.

Apparatus Required:

1. Collecting tank
2. Stop watch
3. Tachometer
4. Scale (steel rule)

Description:

Reciprocating pump is also known as positive displacement pump because the liquid is pushed out of the cylinder into the delivery pipe by the actual displacement of the piston or plunger. These pumps usually have one or more chambers, which are alternately filled with the liquid to be pumped and then emptied again. As such the discharge of liquid pumped by these pumps almost wholly depends on the speed of the pump.

The experimental setup consists of a reciprocating pump mounted on a supply tank. The pump is driven by an electric motor with pulley arrangement. The outlet from the pump is collected in a collecting tank. This tank is fitted with a gauge glass scale fitting and a drain valve. Suitable pressure and vacuum gauges and a pressure relief valve are fitted in the pump pipelines. An energy meter is provided to determine input power to the motor.

Practical Application:

A **reciprocating pump** is a positive plunger pump. It is often used where relatively small quantity of liquid is to be handled and where delivery pressure is quite large

Tabulation:

S.No	Pressure Gauge Reading	Vaccum Gauge Reading	Total Head	Time for 10 cm rise in coll. Tank	Actual Discharge x 10^{-3}	Time for 10 revol. of energy meter disc	Input Power	Output Power	Efficiency
	P	V	H	t	Q_{act}	T	IP	OP	η
Unit	Kg/cm^2	cm of water	m of water	Sec	m^3/s	ses	Kw	Kw	%

Experimental Procedure:

1. Prime the pump with water if required.
2. Close the delivery gate valve completely.
3. Start the motor and adjust the gate valve to required pressure and delivery.
4. Note the following readings
   a) The pressure gauge reading (P) in kg/cm^2.
   b) The vacuum gauge reading (V) in mm of Hg.
   c) Time for R revolutions of Energy meter disc (T) in seconds
   d) Time for 'h' cm rise of water in the collecting tank (t) in seconds.
   e) Speed of the pump (N_1) in rpm
5. Take 4 or 5 sets of readings by varying the heads

Formula Used:

1. Efficiency of Reciprocating pump (η) = $\frac{OP}{IP}$ x 100 %

   Where

   OP - Output power of the reciprocating pump in kW

   IP - Input power of the reciprocating pump in kW

2. Output Power of the Reciprocating pump (OP) = $\nu Q_{act} H$...................... kW

   Where

   ν - Specific weight of water in kN/m^3

   Q_{act}- Actual Discharge in m^3/s

   H - Total head in m of water.

3. Actual Discharge (Q_{act}) = $\frac{Volume}{Time}$ .... m^3/s

   $Q_{act} = \frac{Ah}{t} = \frac{V}{t}$........................m^3/s

   Where

   V – Volume of water collected in m^3

   h - Rise of water level in the collecting tank in m

   t - Time for 10cm rise of water in the collecting tank in sec

   A – Cross sectional area of the collecting tank in m^2.

4. Cross sectional area of the collecting tank (A) = L x B .... m^2

   Where,

   L – Length of the collecting tank in m

   B – Breadth of the collecting tank in m

5. Total head (H) = Delivery head + Suction head + Datum head

$$(H) = 10\left(P + \frac{V}{760}\right) + z \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ m of water.}$$

Where,

P – Pressure gauge reading in Kg/cm^2.

V – Vacuum gauge reading in mm of Hg.

Z – Difference in gauge level (Datum head) in m

6. Input Power of the reciprocating pump (IP) = $IP_{motor}\,\eta_{mot}$ .... kW

Where,

IP_{motor}- Input power of motor in kW

η_{mot}– Efficiency of motor

7. Input Power of Motor (IP_{motor}) = $\frac{R}{NT}$ x 3600. ....kW

Where

R – Number of revolutions in the energy meter disc

N – Energy meter constant in rev / kW-hr

T – Time for 10 revolution of energy meter disc in sec

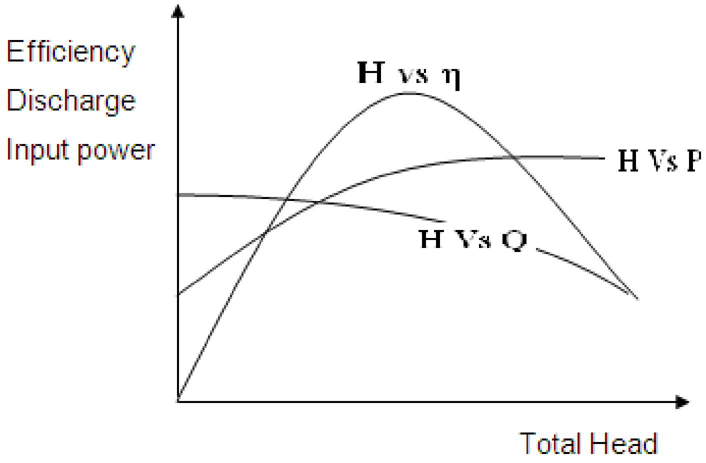
8. Area of the cylinder (A_1) = $\frac{\pi}{4}D^2$ .... m^2

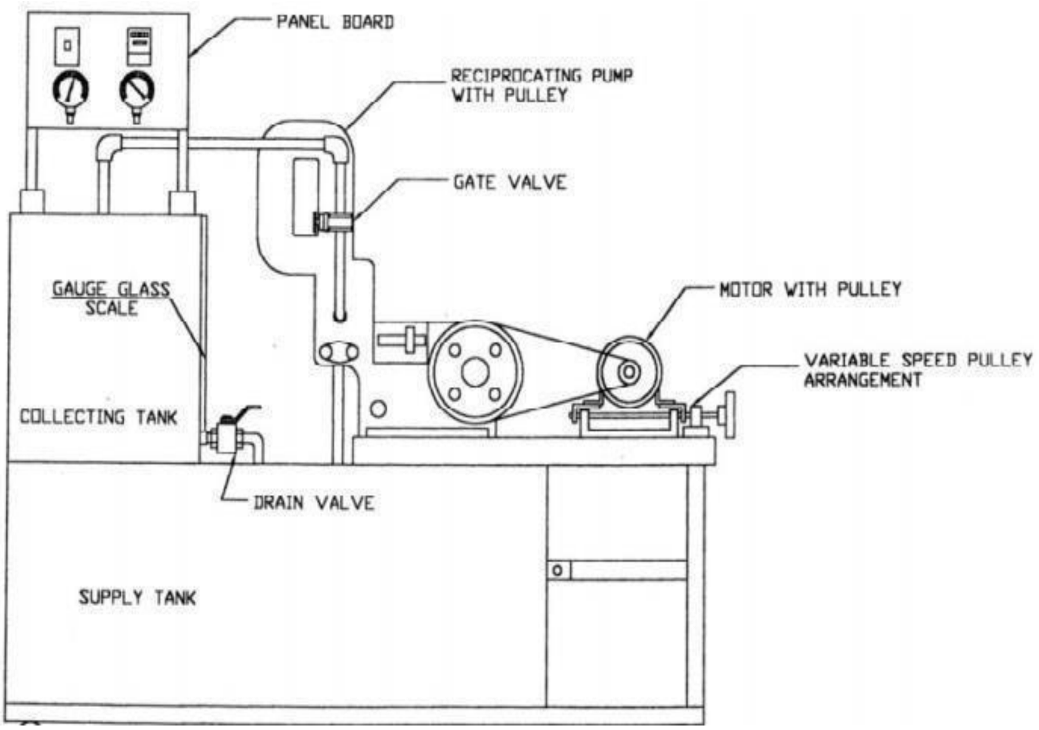
Where

D – Piston diameter in m

Graph:

1. Total Head (H)V_s Efficiency (η)
2. Total Head (H) V_sPower (P)
3. Total Head (H) V_sDischarge (Q_{act})





Observations:

1. Length of the collecting tank (L) = 0.4 m.
2. Breadth of the collecting tank (B) = 0.4 m.
3. Rise of water level in the collecting tank (h) = 0.1m
4. Number of revolutions in the energy meter disc (R) = 10
5. Energy meter constant (N) = 3200 rev/kW.hr
6. Motor efficiency (η_{motor}) = 80 % (assumed)
7. Specific weight of water (√) = 1000 KN/m^3
8. Stroke length of piston (L) = 0.0445 m
9. Diameter of piston (D) = 0.038 m

Result:

Thus the performance of reciprocating pump is determined and the characteristic curves are plotted.

Maximum efficiency of the reciprocating pump (η_{max}) =_____________%

STUDY ON PERFORMANCE CHARACTERISTICS OF CENTRIFUGAL PUMP

Exp. No. : 13

Date:

Aim :

To conduct an experiment on a single stage centrifugal pump at various head and discharge to obtain the pump characteristics.

Apparatus Required:

4. Stop watch
5. Tachometer
6. Scale (steel rule)

Description:

Centrifugal pump is a roto-dynamic pump in which a dynamic pressure is created which enables to raise liquid from a lower level to a higher level. In these pumps, the whirling motion imparted to the liquid by the blades of the impeller causes a centrifugal force to act on the rotating liquid. Hence these pumps are called centrifugal pumps. In addition to this force, as the liquid passes through the rotating impeller there is an increase in pressure due to change in its angular momentum. Thus the high-pressure liquid rises through the delivery pipe to the required height. Because of their simplicity, low cost and ability to operate under a variety of conditions, centrifugal pumps are one of the most popular type.

A centrifugal pump consists of an impeller rotating inside a casing. The impeller has a number of curved vanes. Due to the centrifugal force developed by the rotation of the impeller water entering at the center flows outwards to the periphery. Here it is collected in a gradually increasing passage in the casing known as a volute chamber. This chamber converts a part of the velocity head (kinetic energy) of the water in to pressure head (potential energy).

Practical Application:

Centrifugal pumps are a popular choice for low viscosity (thin) liquids that need to be pumped at high flow rates. Centrifugal pumps are often used in many industrial, municipal and commercial applications and are usually quick to install and easy to repair.The centrifugal pump has many advantages which make it one of the most widely used types of pumps in the waste water industry.Some of the advantages are: construction, operation, maintenance, a wide tolerance for moving parts, self-limitation of pressure, adaptable to high speed drive systems such as electric motors, small space requirements, and rotary rather than reciprocating motion

Tabulation

S.NO	Pressure Gauge Reading	Vaccum Gauge Reading	Total Head	Time for 10 cm rise in coll. tank	Actual Dischare x 10^{-3}	Time for 10 revol. of energy meter disc	Input Power	Output Power	Efficiency
	P	V	H	t	Q_{act}	T	IP	OP	η
Unit	Kg/cm^2	cm of water	m of water	Sec	m^3/s	ses	Kw	Kw	%

Experimental Procedure:

1. Prime the pump with water if required.
2. Close the delivery gate valve completely.
3. Start the motor and adjust the gate valve to required pressure and delivery.
4. Note the following readings
   - a) The pressure gauge reading (P) in kg/cm^2.
   - b) The vacuum gauge reading (V) in mm of Hg.
   - c) Time for R revolutions of Energy meter disc (T) in seconds
   - d) Time for 'h' cm rise of water in the collecting tank (t) in seconds.
   - e) Speed of the pump (N_1) in rpm
5. Take 4 or 5 sets of readings by varying the heads

Formula Used:

8. Efficiency of Centrifugal pump (η) = $\frac{OP}{IP}$ x 100 %

Where,

OP - Output power of the centrifugal pump in kW.

IP - Input Power of the centrifugal pump in kW.

9. Output Power of the Centrifugal pump (OP) = $\nu Q_{act} H$. .... kW

Where,

ν - Specific weight of water in kN/m^3

Q_{act}- Actual Discharge in m^3/s

H - Total head in m of water.

10. Actual Discharge (Q_{act}) = $\frac{Volume}{Time}$ .... m^3/s

$$Q_{act} = \frac{Ah}{t} = \frac{V}{t} \text{.......................} \; m^3/s$$

Where,

V – Volume of water collected in m^3

h - Rise of water level in the collecting tank in m

t - Time for 10 cm rise of water in the collecting tank in sec

A – Cross sectional area of the collecting tank in m^2.

11. Cross sectional area of the collecting tank (A) = L x B .... m^2

Where,

L – Length of the collecting tank in m

B – Breadth of the collecting tank in m

12. Total head (H) = Delivery head + Suction head + Datum head

$$H = 10\left(P + \frac{V}{760}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ m of water.}$$

Where,

P – Pressure gauge readings in Kg/cm^2.

V – Vacuum gauge readings in mm of Hg.

13. Input Power of the Reciprocating pump (IP) = $IP_{motor}\ \eta_{mot} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ kW

Where ,

IP_{motor} – Input Power of Motor in kW

η_{mot} – Efficiency of motor

14. Input Power of Motor (IP_{motor}) = $\frac{R}{NT}$ x 3600 .... kW

Where,

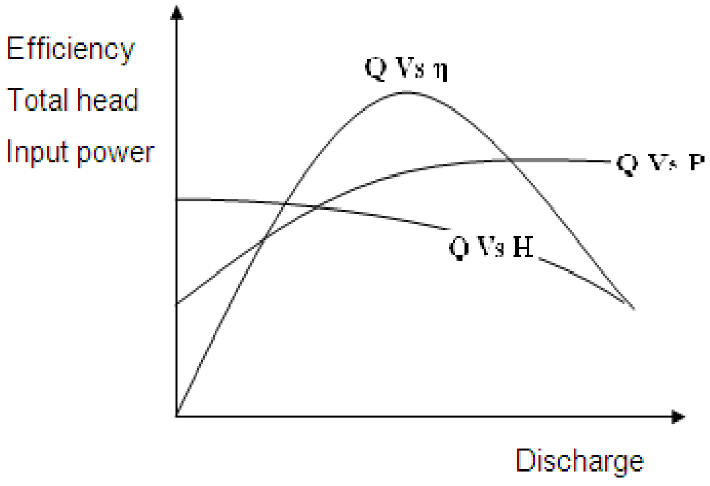
R – Number of revolutions in the energy meter disc.

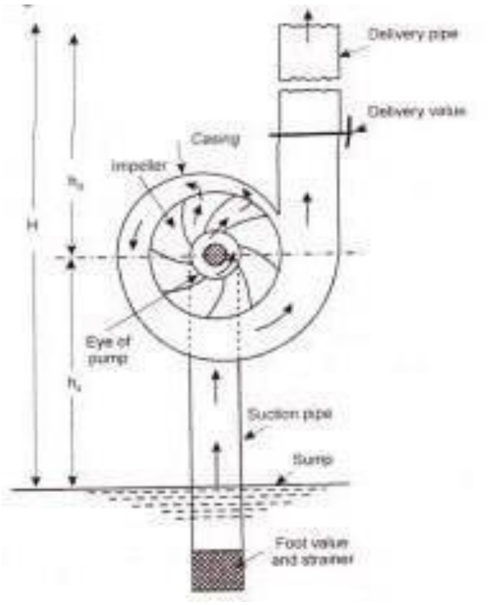
N – Energy meter constant in rev / kW-hr

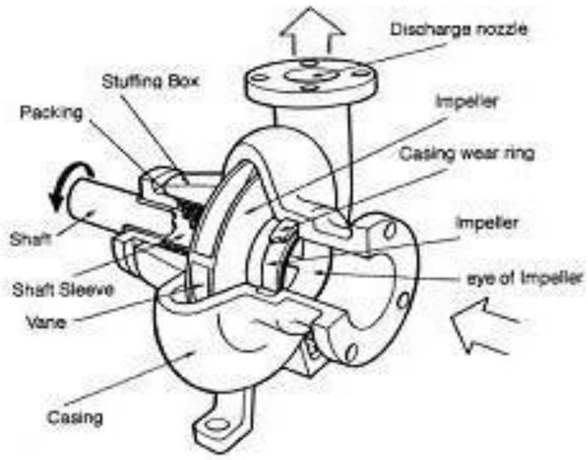
T – Time for 10 revolution of energy meter disc in sec

Graph:

4. Discharge(Q) Vs Efficiency (η)
5. Discharge(Q) Vs Power(P)
6. Discharge (Q) Vs Total Head(H)







Observations:

1. Length of the collecting tank (L) = 0.5 m.
2. Breadth of the collecting tank (B) = 0.5 m.
3. Rise of water level in the collecting tank (h) = 0.1 m
4. Number of revolutions in the energy meter disc (R) = 10
5. Energy meter constant (N) = 3200 rev/kw.hr
6. Motor efficiency (η_{motor}) = 80 % (assumed)
7. Specific weight of water (v) = 9.81KN/m^3

Result:

Thus the performance of single stage centrifugal pump is calculated and the characteristic curves are plotted.

Efficiency of centrifugal pump (η_{max}) =___________%

FLOW THROUGH VARIABLE DUCT AREA – BERNOULLI'S EXPERIMENT

Exp No: 14

Date:

Aim:

To conduct an experiment on a Bernoulli‟s theorem for variable duct areas .

Apparatus required:

7. Piezometer
8. Collecting tank
9. Stop watch
10. Scale or Steel rule

Theory:

Bernoul i‟s equation is an energy equation and in the form given below is applicable to an incompressible, steady, and inviscid flow. The equation relates the pressure energy, kinetic (velocity) energy, and the potential (elevation) energy of a particle in a liquid and states that the sum of these energies is constant along a streamline.

$P+V^2/2g+ Z = \text{Constant}.$

i. e, for two particles on a stramline,

$P_1+V_1^2/2g + Z_1 = P_2+V_2^2/2g + Z_2$

Here, P is the static pressure, is the density V is the velocity, and Z is the elevation of the fluid particle.

Experimental Procedure:

1. Switch on the supply pump and slowly open the supply gate valve and the outlet regulating gate value and adjust both valves such that for a particular head in the receiving cylinder, the inflow and the outflow are matched i.e, the head in the receiving cylinder should be maintained constant. Observe the change of levels in the glass tubes. Since the cross sectional area if path is varying, the velocity of fluid and hence the pressure head varies at each point (note: Q=a1 x v1 = a2 x V2).

2. Note the height of water above the center of the conduit in each tube. This height corresponds to static pressure head P at that point.

3. Determine the time taken for certain rise in the water level in the collecting tank and calculate the flow rate.

4. Calculate the velocity of water at points where the pressure heads are measured.

5. Calculate the sum of pressure head the velocity head at all eleven points and plot this value against the X-direction (flow direction). It will be observed that the total head decreases gradually, especially in the diverging section due to the various losses – friction, separation, etc,

Observation:

1. Length of collecting tank (L) = 0.3 m
2. Breadth of collecting tank (B) = 0.3 m
3. Rise of Level = 0.1 m
4. Time for „h‟ m rise of water in the collecting tank (t) =_________sec
5. Datum head (Z) = m
6. Acceleration due to gravity (g) =____________m/s^2

Tabulation:

Section	Cross sectional Area (a) Sq.m (10^{-3})	Peizometer reading P Cm of water	Section velocity V m/sec	Velocity Head 100 ($V^2/2g$) Cm of water	Total Head= Pressure Head +Velocity Head Cm of water
1	1.175				
2	0.975				
3	0.800				
4	0.600				
5	0.450				
6	0.312				
7	0.450				
8	0.600				
9	0.800				
10	0.975				
11	1.175				

Formula Used:

1. Actual Discharge $(Q_{act}) = \frac{Volume}{Time}$.......................................m^3/s

$$Q_{act} = \frac{Ah}{t} = \frac{V}{t}$$ .... m^3/s

Where,

V – Volume of water collected in collecting tank in m^3

h - Rise of water level in the collecting tank in meter

t – Time for 10 cm rise of water in the collecting tank in seconds

A – Cross sectional area of the collecting tank in m^2

2. Cross sectional area of the collecting tank (A) = L x B....................... m^2

Where,

L – Length of the collecting tank in meter

B – Breadth of the collecting tank in meter

3. Section Velocity $(Q_{th}) = \frac{Q}{a}$ m/ s

Where,

Q – Discharge m^3/s

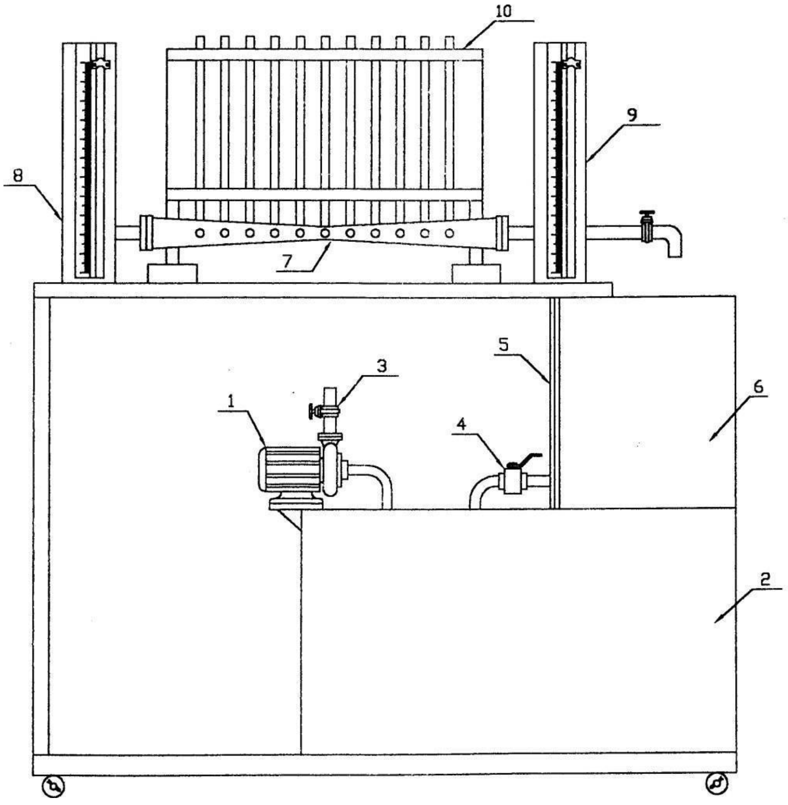
a - Cross sectional area of peizometer pressure taps in m^2

Where

4. Velocity Head = 100 $(V^2/ 2g)$ cm of water

Where

V- section velocity m/s



1. Supply pump
2. Sump tank
3. Flow control valve
4. Drain valve
5. Gauge glass
6. Collecting tank
7. Convergent-divergent tube
8. Inlet chamber
9. Outlet chamber
10. Multilimb manometer

BERNOULLI'S EXPERIMENT

Result:

Thus the Bernoulli's theorem has been verified experimentally.

CONDUCTING EXPERIMENTS AND DRAWING THE CHARACTERISTICS CURVES OF GEAR OIL PUMP

Exp No: 15

Date:

AIM:

To draw the characteristics curves of gear oil pump and also to determine efficiency of given gear oil pump.

APPARATUS REQUIRED:

1. Gear oil pump setup
2. Meter scale
3. Stop watch

DESCRIPTION:

The gear oil pump consists of two identical intermeshing spur wheels working with a fine clearance inside the casing. The wheels are so designed that they form a fluid tight joint at the point of contact. One of the wheels is keyed to driving shaft and the other revolves as the driven wheel.

The pump is first filled with the oil before it starts. As the gear rotates, the oil is trapped in between their teeth and is flown to the discharge end round the casing. The rotating gears build-up sufficient pressure to force the oil in to the delivery pipe.

PROCEDURE:

1. The gear oil pump is stated.
2. The delivery gauge reading is adjusted for the required value.
3. The corresponding suction gauge reading is noted.
4. The time taken for „N‟ revolutions in the energy meter is noted with the help of a stopwatch.
5. The time taken for „h‟ rise in oil level is also noted down after closing the gate valve.
6. With the help of the meter scale the distance between the suction and delivery gauge is noted.
7. For calculating the area of the collecting tank its dimensions are noted down.
8. The experiment is repeated for different delivery gauge readings.
9. Finally the readings are tabulated.

FORMULAE:

1. ACTUAL DISCHARGE:

$Q_{act} = A \times y / t$ (m^3 / sec)

Where,

A = Area of the collecting tank (m^2)

y = Rise of oil level in collecting tank (cm)

t = Time taken for „h‟ rise of oil in collecting tank (s)

2. TOTAL HEAD:

$H = H_d + H_s + Z$

Where,

H_d = Discharge head; $H_d = P_d \times 12.5$, m

H_s = Suction head;

$P_d = P_s \times 0.0136$,m

Z = Datum head, m

P_d = Pressure gauge reading, kg / cm^2

P_s = Suction pressure gauge reading, mm of Hg

3. INPUT POWER:

$P_i = (3600 \times N) / (E \times T)$ (kw)

Where,

N_r = Number of revolutions of energy meter disc

N_e = Energy meter constant (rev / Kw hr)

t_e = Time taken for „Nr‟ revolutions (seconds)

4. OUTPUT POWER:

$P_o = 9.81 \times W \times Q_{act} \times H$ (Kilowatts)

Where,

W = Specific weight of oil (N /m^3)

Q_{act} = Actual discharge (m^3 / s) h

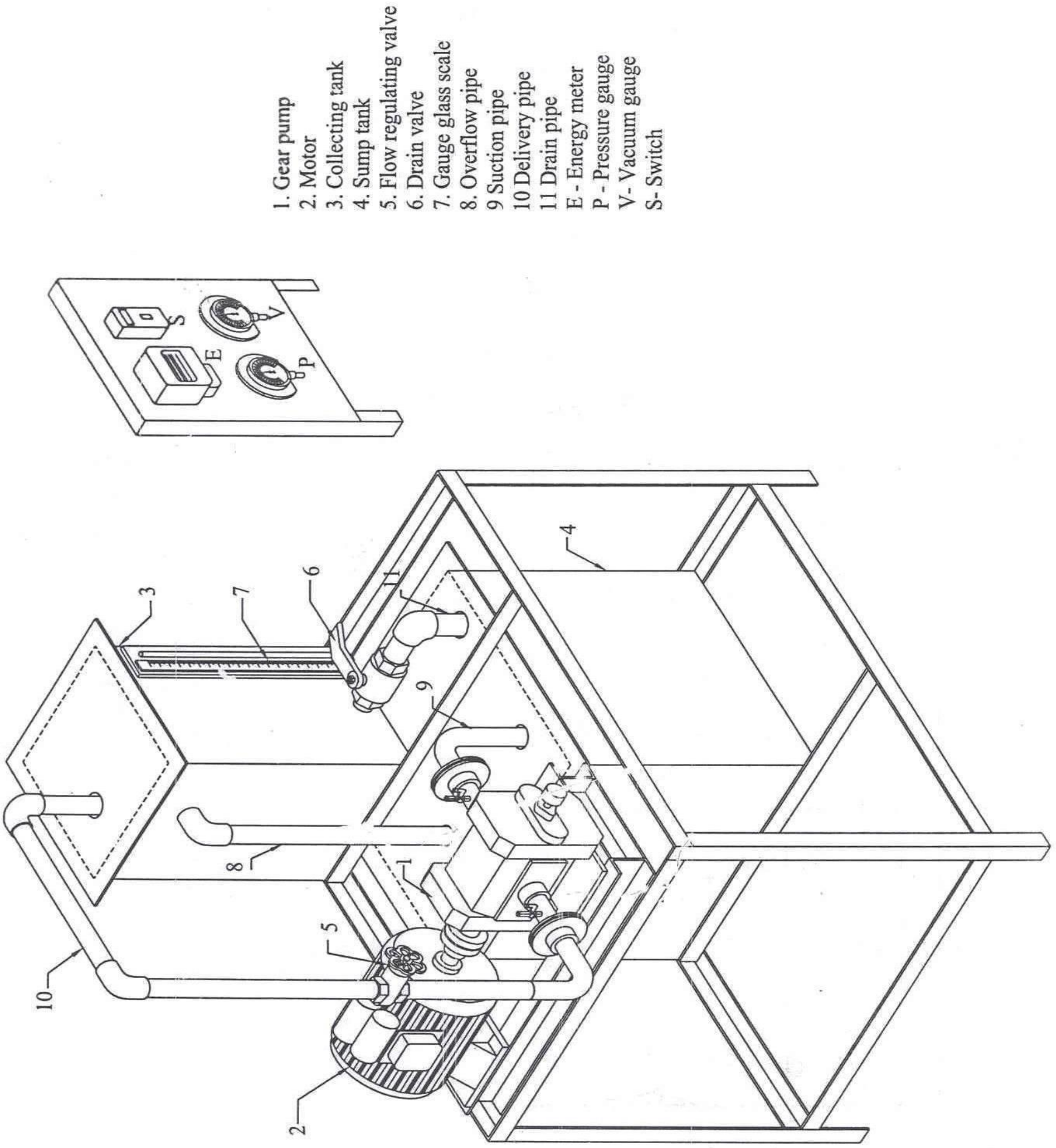
H = Total head of oil (m)

5. EFFICIENCY:

$\eta\% = (\text{Output power } P_o / \text{input power } P_i) \times 100$

GRAPH

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power



GEAR PUMP

TABULATION:

S.No	Delivery pressure reading Pd kg / cm^2	Suction pressure reading Ps mm of Hg	Delivery head Hd = Pdx12.5 m	Suction head Hs = Ps x 0.0136 m	Datum head Z m	Total head H m	Time taken for 10 cm of rise of water in tank t sec	Actual discharge Q m^3/s	Time taken for N rev of energy meter disc t sec	Input power Pi kw	Output power Po kw	η %
											Mean =	

RESULT:

Thus the performance characteristic of gear oil pump was studied and maximum efficiency was found to be............%.

DETERMINATION OF METACENTRIC HEIGHT

Exp No: 16

Date:

Aim

To determine the metacentric height of a ship model.

Description:

The equipment consists of a vessel representing a small model ship equipped with loading and measuring devices for the observation of heel of the vessel. Weights are provided for loading the keel, port, and star board sides and at known distances across the bridge bar. The bridge bar is graduated across with five grooves carrying two swinging weights mounted on knife edges. A linear scale fitted to the bridge bar is used to measure the distance of loading. A graduated scale marked in degrees over which a free swinging pointer is used to measure the angles of inclination. The ship floats in a sump tank.

Experimental procedure:

1. Find the weight of the ship –W without the load, in a balance.
2. Load the ship with circular loads at the keel as a cargo ship.
3. Keep the larger swinging weight in the notch nearest to the mast i.e. 2 cm, and the smaller in the second notch i.e. at 4 cm., from the mast on the other side. The mast should now remain vertical. If not with the help of the nuts at the side of the ship, bring it to zero now the moments acting on the ship is zero.
4. Shift one of the sliding weights (swinging weight) to the next notch.
5. Note the angle of inclination T
6. Note the distance of the weight , X_1 for bigger weight w_1 and X_2 for smaller weight w_2
7. Repeat the process for 5 different angles of inclination.
8. Keep the circular weights now on the star board for war type ship and repeat the experiments.

Calculations:

Weight of bigger weight = w_1 Kg
Weight of smaller weight = w_2 Kg
Distance for bigger weight =X_1 cm
Distance for smaller weight =X_2 cm
Moment of bigger weight = $w_1 * X_1$
Moment of smaller weight = $w_2 * X_2$
The resultant moment acting on the ship = $(w_1 * X_1)-(w_2 * X_2)$
= wX
Since the ship is in equilibrium, wX = W * GM tan T
(where T is the angle of inclination)
i. e, Metacenric height GM = (wX)/W tan T

Model ship

Sample calculation:

Weight of bigger weight W_1 = 0.5 Kg
Weight of smaller weight W_2 = 0.25 Kg
Distance for bigger weight X_1 = 7 cm
Distance for bigger weight X_2 = 6 cm
Moment of bigger weight $W_1 * X_1$ = 0.5*7
= 3.5
Moment of bigger weight $W_2 * X_2$ = 0.25*6
= 1.5
Resultant moment WX =$(W_1 *X_1)-(W_2*X_2)$

= 2

Weight of ship W = 11 Kg
Angle of inclination ɵ = 5°
Metacentric height GM = WX/W tan ɵ
=2/11 tan (5°)
= 2.078
Since the ship is in equilibrium WX = W* GM* tan ɵ
2 = 11*2.078* tan (5°)
2 = 1.999

Result:

Thus the determination of the Meta centric height of a ship model is studied.

VIVA VOCE QUESTIONS & ANSWERS

BASIC CONCEPTS AND PROPERTIES

1. What is fluid mechanics?

Fluid mechanics is that branch of science which deals with the behavior of the fluids at rest as well as in motion.

2. Define fluid statics.

The study of fluids at rest is called fluid statics.

3. What is fluid kinematics?

The study of fluids in motion where pressure forces are not considered is called fluid kinematics.

4. What is fluid kinetics?

The study of fluids in motion where pressure forces are considered is called fluid kinetics.

5. Define density.

It is defined as the ratio of the mass of the and its volume.

Density =mass/volume. Unit=kg/m^3

6. What is specific weight?

Specific weight of a fluid is the ratio between the weight of a fluid to its volume.

Specific weight = Weight/volume.

7. Define Specific volume.

Specific volume of a fluid is defined as the volume of a fluid occupied by a unit mass or volume per unit mass of a fluid is called specific volume.

Specific volume = volume / mass.

8. Define Specific gravity.

Specific gravity is defined as the ratio of the weight density of a fluid to the weight density of a standard fluid. For liquids the standard fluid is taken water, and for gases air.

9. Define Viscosity.

Viscosity is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid. Unit = Ns/m$^{2.}$

10. Define Kinematics Viscosity.

It is defined as the ratio between the dynamic viscosity and density of fluid.

Kinematics Viscosity = viscosity/density

11. Newtons law of viscosity.

It states that the shear stress on a fluid element layer is directly proportional to the rate of shear strain.

12. What is Newtonian fluids?

Fluids which obey the newtons law of viscosity is known as Newtonian fluids.

13. What is non Newtonian fluids?

Fluids which do not obey the newtons law of viscosity is known as non Newtonian fluids.

14. What are the different types of fluids?

1) Ideal fluid.
2) Real fluid.
3) Newtonian fluids.
4) Non Newtonian fluids.
5) Ideal plastic fluid.

15. Define Surface Tension?

1) Surface tension is defined as the tensile force acting on the surface of a liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membrance under tension.

16. Define capillarity.

Capillarity is defined as the phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid.

17. Define Pascal"s law.

It states that the pressure or intensity of pressure at a point in a static fluid is equal in all directions.

18. What is absolute pressure?

It is defined as the pressure which is measured with reference to absolute vacuum pressure.

19. What is gauge pressure?

It is defined as the pressure which is measured with the help of a pressure measuring instrument, in which the atm pressure is taken as datum.

20. What is Vacuum pressure?

It is defined as the pressure below the atmospheric pressure.

21. List the pressure measuring devices?

1) Manometers.
2) Mechanical gauges.

22. Define manometers?

Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of the fluid.

23. What is mechanical gauges?

Mechanical gauges are defined as the devices used for measuring the pressure by balancing the fluid column by the spring or dead weight.

24. List the mechanical pressure gauges.

1) Diaphragm pressure gauge.
2) Bourdon tube pressure gauge.
3) Dead weight pressure gauge.
4) Bellows pressure gauge.

25. What are the different types of simple manometers?

1) Piezometer
2) U-tube manometer
3) Single column manometer.

FLIUD KINEMATICS AND FLUID DYNAMICS

1. Define the term drag.

The component of the total force in the direction of flow of fluid is known as drag.

2. Define the term lift.

The component of the total force in the direction perpendicular to the direction of flow is known as lift.

3. Mention the characteristics of laminar flow.

1) There is a shear stress between fluid layers.
2) No slip at the boundary.
3) The flow is rotational.
4) There is a continuous dissipation of energy due to viscous shear.

4. What is boundary layer?

The fluid layer in the vicinity of the solid boundary where the effects of fluid friction i.e., the variation of velocity are predominant is known as the boundary layer.

5. What is meant by laminar boundary layer?

At the initial stage i.e., near the surface of the leading edge of the plate, the thickness of boundary layer is small and the flow in the boundary layer is laminar though the main stream flow is turbulent. So the layer of the fluid is said to be laminar boundary layer.

6. Define displacement thickness.

It is defined as the distance measured perpendicular to the boundary by which the mainstream is displaced to an account of formation of boundary layer.

7. Define momentum thickness.

It is defined as the distance measured perpendicular to the boundary by which the boundary should be displaced to compensate for the reduction in momentum of flowing fluid on account of boundary layer formation.

8. Define energy thickness.

It is defined as the distance measured perpendicular to the boundary by which the boundary should be displaced to compensate for the reduction of kinetic energy of flowing fluid on account of boundary layer formation.

9. What is meant by boundary layer separation?

The boundary layer is formed on the flat plate when it is held immersed in a flowing liquid. If the immersed plate or body is curved or angular one, the boundary layer does not stick to the whole surface of the body. The boundary layer leaves the surface and gets separated from it. This phenomenon is known as boundary layer separation.

10. State the effect of boundary layer separation.

Separation of the boundary layer greatly affects the flow as a whole. In particular the formation of eddies and wake zone of disturbed flow on the downstream causes continuous loss of energy. This separation of boundary layer is undesirable, unstable and inefficient process.

11. What is meant by energy lines?

If at different sections of the pipe total energy is plotted to scale and joined by a line, the line is called energy grade line.

12. What is meant by hydraulic gradient lines?

The pressure head in a pipe decreased gradually from section of the pipe in the direction of fluid flow due to loss of energy. If pressure heads at the different sections of the pipe are joined by a straight line. This is called hydraulic grade line.

13. Define critical velocity.

The velocity at which the flow changes from the laminar to turbulent for the case of given fluid at a given temperature and given pipe is known as critical velocity.

14. What is meant by transition state?

The state at which the flow changes from laminar to turbulent is known as transition state.

15. Write down four examples of laminar flow.

1) Flow through pipes.
2) Blood flow through capillaries.
3) Laminar flow hood.
4) Laminar flow airfoil.

16. What is the physical significance of Reynold‟s number?

1) Motion of air planes.
2) Flow of incompressible fluid in closed pipes.
3) Motion of submarines, and
4) Flow around structures and other bodies immersed fully in moving fluids.

17. What is a siphon? What are its applications?

A siphon is a long bend pipe used for carrying water from a reservoir at a higher head to another reservoir at a lower head when the two reservoirs are by separated by a hill.

18. Where the Darcy weishbach & Chezy"s formulas are used?

Darcy weishbach equation is generally used for the flow through pipes.

Chezy"s formula is generally used for the flow through open channels.

19. What is pipe?

Pipe is a closed conduit, which is used for carrying fluids under pressure.

20. Classify the losses In pipes.

1. Major losses.
2. Minor losses.

21. What are pipes in series?

It is defined as the pipes of different diameters and lengths are connected with one another to form a single pipeline.

22. What is equivalent pipe?

A compound pipe consisting of several pipes of varying diameters and length may be replaced by a pipe of uniform diameter, which is known as equivalent pipe.

23. What is meant by flow through parallel pipes?

When a main pipeline divides into two or more parallel pipes, which again join together to form a single pipe and continue as a main line. These pipes are said to be pipes in parallel.

24. What are effects of cavitation in venturimeter?

Cavitation will very damage the for pipe walls and also corrodes the pipes.

25. How can pressure be measured in pitot tube?

The velocity of flow can be determined by measuring the increase in pressure energy at this point.

DIMENSIONAL ANALYSIS

1. State the fourier law of dimensional homogeneity.

The law of fourier principle of dimensional homogeneity states and equation which expresses a physical phenomenon of fluid flow should be algebraically correct and dimensionally homogeneous.

2. What is dimensionally homogeneous equation? Give example.

Dimensionally homogeneous equations means the dimensions of the terms on left hand side should be same as the dimensions of the terms on right hand side.

3. What are the uses of dimensional homogeneity?

1) To check the dimensional homogeneity of the given equation.
2) To determine the dimension of a physical variable.
3) To convert units from one system to another through dimensional homogeneity.
4) It is a step towards dimensional analysis.

4. State the methods of dimensional analysis.

1) Raleigh"s method.
2) Buckingham π theorem.

5. How are equations derived in Raleigh"s method?

The expression is determined for a variable depending upon maximum three or four variables only. If the number of independent variables more than four it is very difficult to find the expression for the dependent variable. So, a functional relationship between variables is expressed in exponential form of equations.

6. State the Buckingham π theorem.

It states that if there are „n" variables in a dimensionall y homogeneous equation and if these variables contain „m" fundamental dimensions (M,L,T) then they are grouped into (n-m) dimensionless independent π terms.

7. Define Reynold"s Number.

It is defined as the ratio of the inertia force to the viscous force of a flowing fluid denoted by Re.

Re = Inertia force/viscous force

8. Define Mach number. (μ)

It is defined as the square root of the inertia force of a flowing fluid to the elastic force.

μ = (Inertia force/Elastic force)$^{1/2}$

9. State the limitations of dimensional analysis.

1) Dimensional analysis does not give any clue regarding the selection of variables.
2) The complete information is not provided by dimensional analysis. It only indicates that there is some relationship between parameters.
3) The values of co-efficient and the nature of function can be obtained only by experiments or from mathematical analysis.

10. What are advantages of model testing?

1) The model tests are quite economical and convenient and operation of a model may be changed several times if necessary, without of increasing much expenditure.
2) With the use of models the performance of hydraulic structure/hydraulic machines can be predicated in advance.
3) Model testing can be used to detect and rectify the defects of an existing structure, which is not functioning propery.

11. Mention the applications of model testing.

1) Civil engineering structures such as dams, weirs, canals etc.

12. Define similitude.

Similitude is defined as the complete similarity between the model and the prototype.

13. What are the similarities between model and prototype?

1) Geometric similarity.
2) Kinematic similarity.
3) Dynamic similarity.

14.What is meant by Kinematic similarity?

Kinematic similarity is the similarity of motion. It corresponds to the points in the model and in the prototype.

15) Mention the types of models.

1) Undistorted models.
2) Distorted models.

16) Submarine is tested in the air tunnel. Identify the model law applicable.

Reynold‟s model law is applicable.

17) State Froude‟s model law.

Only gravitational force is more predetermining force. The law states, the Froude number is same for both model and prototype. It is known as Froude model law.

18)Mention the significance of Reynold‟s model law.

1) Motion of air planes.
2) Flow of incompressible fluid in closed pipes.
3) Motion of submarines and
4) Flow around structures and other bodies immersed fully in moving fluids.

19) In fluid flow, what does dynamic similarity mean? What are the non-dimensional numbers associated with dynamic similarity?

1) It is the similarity of forces. The flows in the model and prototype are of dynamic similar.
2) Dimensional numbers are weight, force, dynamic viscosity, surface tension and capillarity.

20) What is meant by undistorted models?

The model which is geometrically similar to its prototype is known as undistorted models. In such models, the conditions of similitude are fully satisfied.

21) Define the term scale effect.

It is impossible to product the exact behaviour of the prototype by model testing alone. The two models of same prototype behaviour will be same. So discrepancy between models and prototype will always occur. It is known as scale effect.

22) State three demerits of a distorted model.

1) Exit pressure and velocity distributions are not true.
2) A model wave may differ from that of prototype.
3) Both extrapolation and interpolation of results are difficult.

23) Define Weber Number.

It is the ratio of the square root of the inertia force to the surface tension force.

We = (Inertia force/Surface tension force)$^{1/2}$

24) What is Geometric similarity?

A model and its prototype are geometrically similar, if the ratios of the corresponding length dimensions are equal.

25) What is dynamic similarity?

It is the similarity of forces. The flows in the model and prototype are of dynamic similar.

PUMPS

1. What is rotary pumps?

If the fluid is displaced by gear system it is known as rotary pumps.

2. What is reciprocating pumps?

If the fluid is displaced by reciprocating action of piston, it is known as reciprocating pumps.

3. What is meant by fluid machines?

The device in which the fluid is in continuous motion and imparts energy conversion is known as fluid machines.

4. Write the classifications of fluid machines.

1) Hydraulic turbines
2) Compressors.

5. What is meant by hydraulic turbines?

Hydraulic turbines are the machines which convert the energy of flowing water into mechanical energy.

6. What is hydroelectric power?

The mechanical energy developed by a turbine is used to run an electric generator which is directly coupled to the shaft of the turbine. Thus, the mechanical energy is converted into electrical energy. This electrical power is known as hydroelectric power.

7. Define degree of reaction.

It is defined as the ratio between the kinetic energy change in moving blade to the kinetic energy change in the stage.

8. Write the classifications of hydraulic turbines.

1) Impulse turbine
   e.g. Pelton turbine.
2) Reaction turbine.
   e.g. Francis turbine, Kaplan turbine.

9. What is impulse turbine?

In an impulse turbine all the energy available by water is converted into kinetic energy by passing through a nozzle. The high velocity jet coming out of the nozzle then impinges on a series of buckets fixed around the rim of a wheel.

10. What is reaction turbine?

In a reaction turbine the runner utilizes both potential and kinetic energies. Here only a portion of potential energy is transformed into kinetic energy before the fluid enters the turbine runner.

11. Write the classifications of turbine according to the specific speed.

1) Low specific speed.
2) Medium specific speed.
3) High specific speed.

12. Write the classifications of turbine according to the quantity of water required.

1) High head turbine.
2) Medium head turbine.
3) High head turbine.

13. Write the classifications of turbine according to the direction of flow of water.

1) Tangential flow turbine.
2) Radial flow turbine.
3) Axial flow turbine.
4) Mixed flow turbine.

14. What is Tangential flow turbine?

In a Tangential flow turbine water flows along the tangent to the path of the runner.

15. What is Radial flow turbine?

In a Radial flow turbine water flows along the radial direction and mainly in the plane normal to the axis of rotation, as it passes through the runner.

16. Write the types of Radial flow turbine.

1) Inward Radial flow turbine.
2) Outward Radial flow turbine.

17. What is Axial flow turbine?

In an Axial flow turbine water flows parallel to the axis of the turbine shaft.

18. What is Mixed flow turbine?

In a Mixed flow turbine the water enters the blades radially and comes out axially and parallel to the turbine shaft.

19. What is gross head?

The gross head is the difference between the water level at the reservoir and the level at the tailrace.

20. What is net head?

The head available at the inlet of the turbine is known as effective or net head.

21. What is Bucket power?

The power supplied by the water jet is known as water power.

22. What is Hydraulic efficiency?

It is defined as the ratio of power developed by the runner to the power supplied by the water jet.

23. What is Mechanical efficiency?

It is the ratio of power available at the turbine shaft to the power developed by the turbine runner.

24. What is volumetric efficiency?

It is defined as the volume of water actually striking the buckets to the total water supplied by the jet.

25. What is break nozzle and mention it function?

If the spear nozzle set is closed, the runner will revolve long time due to inertia. To stop the runner in a short time, a small nozzle is provided which directs a jet of water on the backside of the buckets.

1. What is the principle of reciprocating pumps? And state its displacement type.

It operates on a principle of actual displacement of liquid by a piston or plunger, which reciprocates in a closely fitting cylinder.

2. State the main classification of reciprocating pumps.

1) According to the liquid being in contact with piston or plunger.
2) According to the number of cylinders provided.

3. Mention the main components of reciprocating pump.

1) Piston or plunger.
2) Suction and delivery pipes.
3) Crank and connecting rod.

4. What is the main difference between single acting and double acting reciprocating pump?

In a single acting reciprocating pump, the liquids acts on one side of the piston only whereas in double acting reciprocating pump, the liquid acts on both sides of the piston.

5. What is indicator diagram?

Indicator diagram is a graph plotted between the pressure head in the cylinder and the distance travelled by piston from inner dead centre for one complete revolution of the crank.

6. Define suction head.

It is the vertical height of the centre line of the pump shaft above the liquid surface in the sump from which the liquid is being raised.

7. The work saved against friction in the delivery pipe of a single acting reciprocating pump by fitting air vessel is_________.

84.8%

8. When will you select a reciprocating pump?

For obtaining high pressure or head and low discharge, a reciprocating pump is selected.

9. What are rotary pumps?

Rotary pumps resemble like a centrifugal pumps in appearance. But the working methods differs.

10. List the types of rotary pumps.

1) External pumps.
2) Internal gear pumps.
3) Lobe pumps.
4) Vane pumps.

11. Write the classifications of reciprocating pump according to the fluid being in contact with piston.

1) Single acting pump.
2) Double acting pump.

12. Write the classifications of according to the number of cylinders provided.

1) Single cylinder pump.
2) Double cylinder pump.
3) Triple cylinder pump.
4) Duplex double acting pump.
5) Quantiplex pump.

13. What is slip in reciprocating pump?

The difference between the theoretical discharge and actual discharge is called slip.

14. What is meant by cavitations?

It is defined as the phenomenon of formation of vapour bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapour pressure and the sudden collapsing of these vapour bubbles in a region of higher pressure.

15. What is the effect of cavitations in pumps?

The major effects are break down of the machine itself due to severe pitting and erosion of blade surface.

16. How can we identify the cavitation in pumps?

1) Sudden drop in efficiency.
2) Head falls suddenly.
3) More power requirement.
4) Noise and vibrations.

17. State any two precautions against cavitations.

1) The pressure should not be allowed to fall below its vapour pressure.
2) Special material coatings can be given to the surface where the cavitation occurs.

18. Define radial vane.

The liquid leaves the vane with relative velocity in a radial direction.

19. What is forward curved vane?

When the outlet tip of blade bends in the direction of motion,then it is called as forward curved vanes.

20. What is backward curved vanes?

When the outlet tip of blade bends in a direction opposite to that of motion, then it is called backward curved vane.

21. Define manometric head.

It is the head against which a centrifugal pump has to work.

22. What are the various types of casing?

1) Volute casing.
2) Vortex casing.
3) Volute casing with guide blades.

23. Where the suction pipe is placed? For what?

It is provided with a strainer at its lower end so as to prevent the entry of solid particles, debris etc into the pump.

24. What is the role of a volute chamber of a centrifugal pump?

1) To guide water to and from the impeller and
2) To partially convert the kinetic energy into pressure energy.

25. What is the maximum theoretical suction head possible for a centrifugal pump?

10.33 m.