MALLA REDDY ENGINEERING COLLEGE

Approved by AICTE, New Delhi
and
Affiliated by JNTUH, Hyderabad

MECHANICAL ENGINEERING DEPARTMENT

Accredited by NBA

LAB MANUAL

FLUID MECHANICS & HYDRAULIC MACHINERY LAB

Prepared by
Lab Incharge of Mechanical Engineering Department
(2015 – 16)

MALLA REDDY ENGINEERING COLLEGE
Post Via Hakeempet, Maisammaguda (Hamlet), Gundlapochampally Village, Medchal (Mandal), RangaReddy (Dist), Andhra Pradesh Pin: **500014**
www.chmrec.com

FOREWORD WITH SPECIAL EMPHASIS ON

IMPORTANCE OF THE LABORATORIES

The dawn of the new millennium, symbolizes globalization and liberalization policy in our country. In one stroke, this phenomenon has resulted in the challenging task of imparting world class technical education. It is a fact that technology drives the modern society. Keeping the challenges in mind, the successful delivery of the education philosophy is divided into two inter-related components, namely, theory and practical. The practical have to support in assimilation and thorough understanding of the theoretical content in a subject.

All the laboratory procedures are designed and developed to meet the fast growing challenges in the area of the specialization and as per the curriculum of Mechanical Engineering branch. The manual is prepared to meet the academic, industrial and personality building challenges.

The layout of each lab, list of experiments, description, possible calculations, expected graphs and related questions in each lab are provided with possible quiz questions. This whole exercise helps in thorough understanding of each experiment, the total experiments in a lab and all the laboratories in the department. This approach, for sure, will help the students in understanding and usage of latest technologies.

(Head, Department of Mechanical Engineering)

CONTENTS

GENERAL CONTENT IN EACH EXPERIMENT:

S.No.	Description
1	**WHAT TO DO**
2	**DESCRIPTION OF APPARATUS**
3	**THEORY BEHIND**
4	**PANEL DETAILS**
5	**PREPARATION OF EQUIPMENT**
6	**LIMITATIONS**
7	**PROCEDURE**
8	**AFTERMATH (OBSERVATIONS & CALCULATIONS)**
9	**TABULATIONS & GRAPHS**
10	**DISCUSSION ON RESULTS**
11	**CONCLUSIONS OF THE RESULT**
12	**DISCUSSION ON APPLICATIONS**

Exp No: Date:

IMPACT OF JET ON VANES

Aim: Determine the Coefficient of impact by comparing the momentum in a fluid jet with the force generated when it strikes a fixed surface and Comparative analysis of different jets and vanes.

Apparatus:

Jet vane apparatus, Weights, Stopwatch. Pump set, jet chamber, Rotameter for flow measurement and direct analog force indicator.

SPECIFICATION:

Different diameters of jets namely

1. 4 mm
2. 6 mm
3. 8 mm

Are provided for the comparative studies with different types of vanes namely

1. Flat
2. Inclined
3. Curved

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Fix the required vane and jet of study to the Acrylic chamber.
3. Keep the delivery valve and Bypass valve in **OPEN** condition.
4. Connect the power cable to 1Ph, 230V, 10 Amps with proper earth connection.
5. Press the green button on the Starter to check the flow and
6. Press the Red button to stop the operation

LIMITATIONS

- Check and note the Maximum and minimum FLOW RATE for the particular jet.
- Operate within this range.
- Start the operation from 10LPM for all the jets except 4mm which can be started from 8LPM.
- Operate within the range only.

PROCEDURE FOR MANUAL OPERATION:

1. Press the green button switch on the starter.
2. Now slowly operate the bypass valve to vary the discharge (delivery valve) and note down the following:
   a. Water Flow Rate in LPM
   b. Load on the Vane, Kg.
3. Change the discharge using the bypass valve and repeat the above step.
4. Once the experiment is done, open the bypass valve completely and Press the Red button on the starter to stop the operation.

AFTERMATH
OBSERVATIONS:

Sl. No.	Dia of Jet	Type of vane	Flow indicator Reading 'Q'		Force Indicator 'F_a' Kgf
			lpm	m^3/sec	
1					
2					
3					
4					

PROCEDURE FOR COMPUTERIZED

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the "COMPORT" , "TYPE OF VANE" and "DIAMETER OF THE JET" under test, once selected the connectivity is created.
5. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump by pressing the green button and slowly operate the bypass valve to set the FLOWRATE.
7. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.
8. Repeat the Step 6 to 7 for different flow rates.
9. Once experiment is completed, press "STOP" button on the screen to stop the experiment.
10. Open the Bypass valve completely and press the red button on the starter to stop the operation of the pump.
11. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS:

1. AREA OF THE JET, H

$$A = \frac{\pi\, x\, (D^2)}{4} \qquad m^2$$

Where,

D = Diameter of the jet

2. DISCHARGE, Q

$$Q_A = \frac{LPM}{60000}\, m^3/s$$

Where,

LPM = Flowrate in digital indication, lpm

3. VELOCITY, V

$$V = \frac{Q_A}{A} \qquad m/s$$

4. THEORETICAL FORCE, Fth

$$F_{th} = \frac{\rho\, A\, V^2}{g} \; kg \qquad \text{FLAT}$$

$$F_{th} = \frac{2\rho\, A\, V^2}{g} \; kg \qquad \text{HEMI - SPHERE}$$

$$F_{th} = \frac{2\rho\, A\, V^2\, Sin\theta}{g} \; kg \qquad \text{INCLINED}$$

Where,

ρ	=	Density of Water, kg/m^3
Q	=	Discharge, m^3/sec
2θ	=	Angle of inclination = 60°
V	=	Velocity, m/s

5. Co – Efficient of Impact, Ci

$$C_i = \frac{F_a}{F_{th}}$$

TABULATIONS :

Jet Dia in mm	Type of vane	Qlpm	Actual Force F_a in Kgf	Theoretical Force F_{th} in Kgf	Coefficient of impact $C_i = F_a / F_{th}$

DISCUSSIONS ON THE RESULTS :

General Possibilities of Errors if occurred.
Outcome of Results - applications

CONCLUSIONS OF THE RESULTS TABULATED:

Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

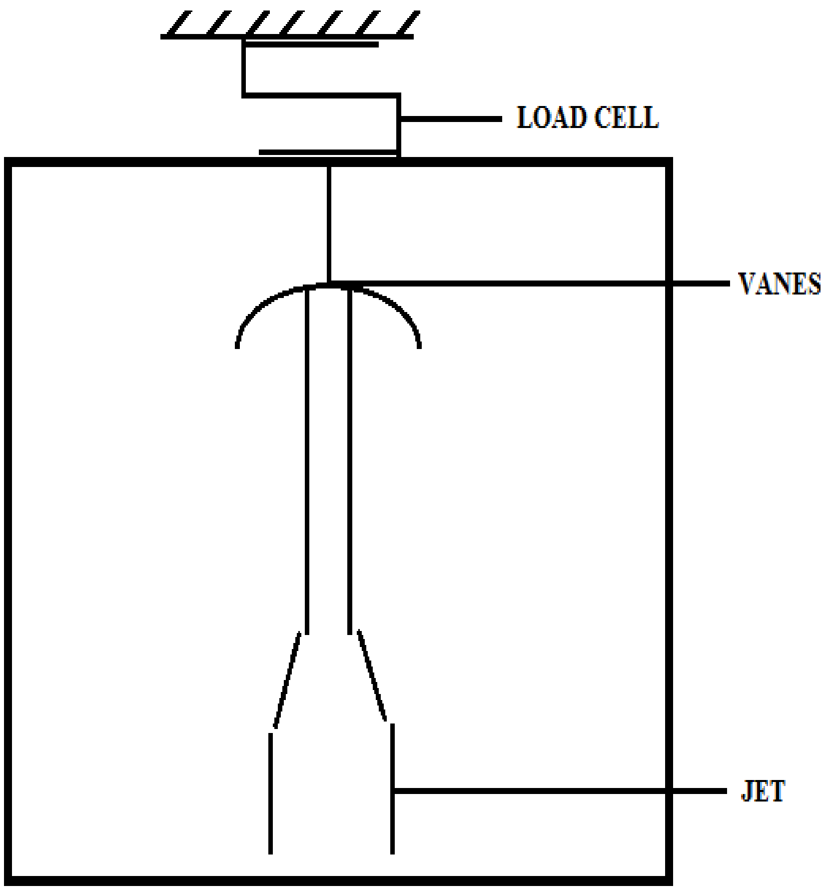
PRECAUTIONS

1) Do not run the pump dry.
2) Clean the tanks regularly, say for every 15 days.
3) Do not run the equipment if the voltage is below 180V.
4) Check all the electrical connections before running.
5) Before starting and after finishing the experiment the main control valve should be in close position.
6) Do not attempt to alter the equipment as this may cause damage to the whole system

Viva Questions:

1. What is the Impact of jet
2. What is the jet of propulsion?
3. Write expression for force exerted by a jet of water on a stationary plate in the direction of jet.
4. Write expression for force exerted by a jet of water on a moving plate in the direction of jet.
5. Write expression for force exerted by a jet of water on a stationary inclined plate in the direction of jet.
6. Write expression for force exerted by a jet of water on a moving inclined plate in the direction of jet.
7. Write expression for force exerted by a jet of water on a stationary curved plate in the direction of jet.
8. Write expression for force exerted by a jet of water on a moving curved plate in the direction of jet.
9. When a jet of water strikes a hinged plate, what is the angle of swing about the hing?
10. What is the efficiency of a series of vanes?
11. Define nozzle and jet.
12. What is the range of co-efficient of velocity and co-efficient of impact?
13. What is the practical significance of impact of jet?
14. How will you measure the pressure of jet?
15. What is the energy available at the end of a nozzle?

IMPACT OF JET ON VANES



TYPES OF VANES :
1. Flat
2. Unclined
3.Circular

TYPES OF JET :
1. 4mm
2. 6mm
3. 8mm

Exp No: Date:

PELTON WHEEL TURBINE

AIM:

a. Study the Performance Characteristics of the turbine under Constant Head and Constant Speed.
b. Draw Characteristics curves of turbine at different head.
c. Comparative analysis of the curves.

APPARATUS:

1. Centrifugal Pump of Kirloskar Make.
2. Turbine Unit
3. Sphere Rod Assembly
4. Sump Tank
5. Orifice meter with pressure tapping's.

OPERATION:

1. Connect the supply water pump – water unit to 3ph, 440 V, 30A electrical supply, with neutral and earth connections and ensure the correct direction of the pump motor unit.
2. Keep the Butterfly valve at closed Position.
3. Keep the loading at minimum.
4. Press the green button of the supply pump starter. Now the pump picks up the full speed and becomes operational.

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Set the operation to be studied by operating the valves in the equipment.
3. Keep the Discharge Valve in Close condition.
4. Slightly Open the Spear Valve for very next to minimum position.
5. Open the Inlet Valve of Turbine under study.
6. Connect the power cable to 3Ph, 440V, 20 Amps with proper earth connection.
7. Press the green button on the Starter and check the direction of the motor and Press the Red button to stop the operation

LIMITATIONS

- Maximum Head of operation 4kg/cm^2.
- Maximum RPM of turbine – 1500rpm.

PROCEDURE FOR MANUAL OPERATION:

A. *TO OBTAIN CONSTANT HEAD CHARACTERISTICS.*

1. Set the Vane position.
2. Keep the Delivery valve open at Maximum.
3. Set the head at required value.
4. Now apply the load.
5. Operating the Spear Valve, maintain the head to the Set value.
6. Repeat the steps 4 and 5 till the maximum load the turbine can take.
7. In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loadings.

B. TO OBTAIN CONSTANT SPEED CHARACTERISTICS.

1. Set the Vane position.
2. Keep the Delivery valve open at Maximum.
3. Set the speed to the required value using the same delivery Valve.
4. Now apply the load.
5. Operating the Spear Valve, maintain the speed to the Set value.
6. Repeat the steps 4 and 5 till the maximum load the turbine can take.
7. In the meantime, Note down the turbine speed, delivery head, vacuum head and Venturimeter readings for each loadings.

OBSERVATIONS:

Constant Head/Speed – Manual and computerized

Sl. No	Turbine speed'N' rpm	Delivery Pressure`P'		Venturimeter Head'p'		Load,kg		
		bar	x10m	bar	x10m	F1	F2	F=F1~F2

<u>PROCEDURE FOR COMPUTERIZED</u>

A. *TO OBTAIN CONSTANT HEAD CHARACTERISTICS.*

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the "COMPORT" and "TYPE OF TURBINE" under test, once selected the connectivity is created.
5. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump by pressing the green button and slowly operate the delivery valve to set the pressure.
7. Set the head at required value.
8. Now apply the load.
9. Operating the delivery valve, maintain the head to the set value.
10. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.
11. Repeat the Step 8 to 9 for different Loads.
12. Once experiment is completed, press "STOP" button on the screen to stop the experiment.
13. Close the delivery valve completely and press the red button on the starter to stop the operation of the pump.
14. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS

1. **<u>TOTAL HEAD, H</u>**

$$H = \left(P + \frac{P_v}{760}\right) * 10\ m\ of\ Water \quad \textbf{MANUAL}$$

$$H = (P + P_v) * 10\ m\ of\ Water \quad \textbf{DIGITAL}$$

Where,

P = Delivery Pressure, kg/cm²
Pv = Vacuum Pressure, kg/cm²

2. **<u>DIFFERENTIAL , Pdiff</u>**

$$P_{diff} = (P_1 \sim P_2)\ x\ 10 \quad m\ of\ WC \quad \textbf{MANUAL}$$

$$P_{diff} = \Delta P\ x\ 10 \quad m\ of\ WC \quad \textbf{DIGITAL}$$

3. **<u>DISCHARGE, Q</u>**

$$Q = \frac{C_c A_1 A_2 \sqrt{(2\ x\ g\ x\ P_{diff})}}{\sqrt{(A_1^2 - A_2^2)}} \quad m^3/sec$$

Where,

A1	=	cross sectional area of pipe, m^2
A2	=	cross sectional area of throat/orifice, m^2
g	=	Acceleration due to gravity = 9.81 m/s^2
Pdiff	=	Total head(Digital Reading)
d1	=	diameter at the inlet pipe
	=	0.050 for Venturimeter & Orifice meter
d2	=	throat/orifice
	=	0.025 for Venturimeter & Orificemeter

Cross sectional Area is calculated based on the following formula

$$A_{suffix} = \frac{\pi\ x\ (d_{suffix}{}^2)}{4} \qquad m^2$$

4. **INPUT POWER, IP (Electrical)**

$$IP = \frac{W\ Q\ H}{1000}\ kW$$

Where,
Q = Discharge
W = Density of Water = 9810 N/m^3
H = Head on the Turbine

5. **TORQUE ON THE TURBINE, T**

$$T = (F_1 \sim F_2) * r * 9.81\ Nm$$

Where,
F1 & F2 = Load on the Turbine, kg
r = Radius of Brake Drum, = 0.125m

6. **OUTPUT POWER, OP (Hydraulic)**

$$OP = \frac{2\,\pi\,N\,T}{60000} \quad kW$$

Where,

N	=	Turbine Speed
T	=	Torque on the Turbine

7. <u>Efficiency of the pump, η%</u>

$$\eta\% = \frac{OP\ x\ 100}{IP}$$

8. <u>Unit Quantities – Under Unit Head,</u>

a) <u>Unit Speed,</u>

$$N_u = \frac{N}{\sqrt{H}}$$

b) <u>Unit Power,</u>

$$P_u = \frac{P}{H^{3/2}}$$

c) **Unit Discharge,**

d) **Specific Speed,**

$$Q_u = \frac{Q}{\sqrt{H}}$$

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

TABULATIONS :

Sl. No	Total Head H, m	Discharge Q, m^3/sec	IP, KW	OP, KW	Turbine efficiency %η

Sl. No	Unit Power	Unit Head	Unit Discharge	Specific Speed

GRAPHS:

- Discharge Vs Head
- OP Vs Head
- Efficiency Vs Head

RESULT:

1) Graphs plotted show the constant head/speed characteristics of the turbine.
2) An attempt has been made to provide the facility to understand the various components of the turbine & present the characteristic curves.

3) The unit head and other quantities are calculated from the knowledge of constant head characteristics.
4) The numerical values in graphs and design calculations should be looked upon as **qualitative figures** rather than quantitative ones as some of the components available in the market for constructing the turbine are limited.

CONCLUSIONS OF THE RESULTS TABULATED:

Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

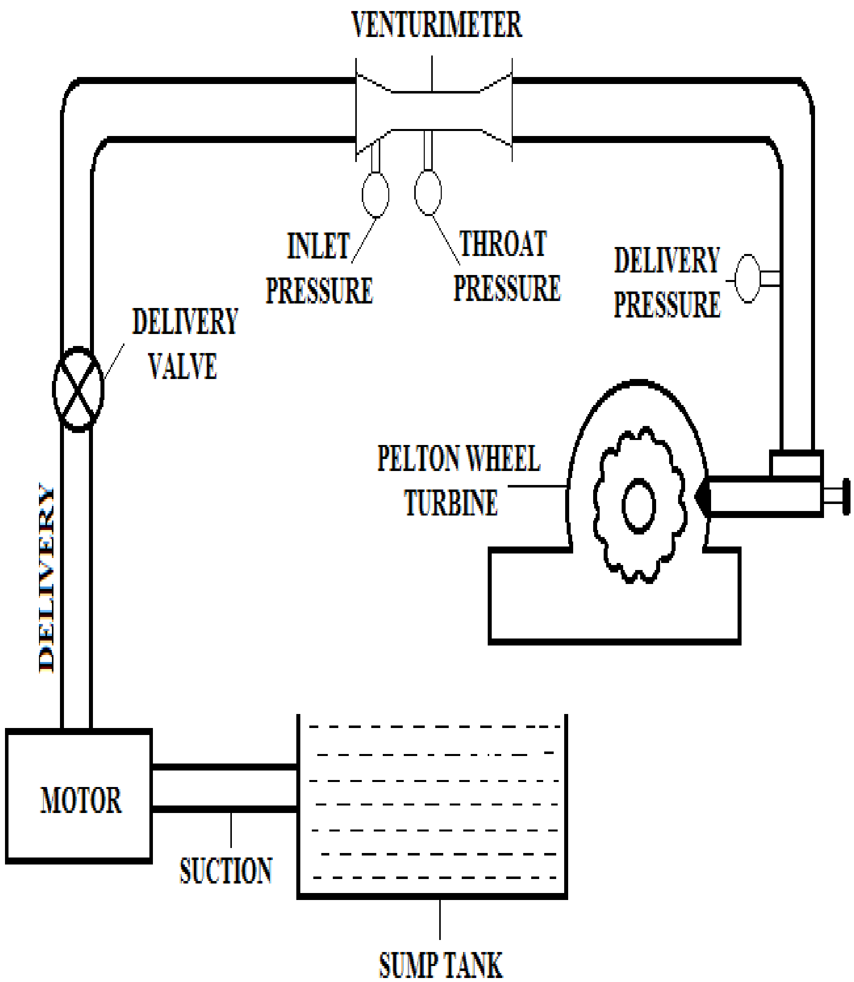
Precautions:

1. Do not start the pump if there is no water in the sump tank.
2. Check the direction of rotation of pump.
3. Supply sufficient cooling water to the rope brake down when the turbine is in running condition.
4. Make sure that there is no load on the turbine while starting and stopping the pump.

Viva Questions:

1. What is Turbine ?
2. How do you classify turbines ?
3. Differentiate between Impulse turbine and Radial flow turbine.
4. Pelton wheel turbine is which type of turbine ?
5. On what basis the dimensions of bucket are designed ?
6. What are the energies available at inlet of the Pelton wheel turbine ?
7. What is the jet ratio ?.
8. What is the condition for maximum efficiency of Pelton wheel ?
9. Why the Draft tube is not provided in the Pelton wheel turbine ?
10. What are the functions of casing of the Pelton wheel turbine?
11. What is the braking jet ?
12. What are the main components of pelton wheel ?

PELTON WHEEL TURBINE



Exp No: Date:

FRANCIS TURBINE SETUP

AIM:

a) Study the Performance Characteristics of the turbine under Constant Head and Constant Speed.

b) Draw Characteristics curves of turbine at different head.

c) Comparative analysis of the curves.

APPARATUS:

1. Monobloc Centifugal Pump of Kirloskar Make.
2. Turbine Unit
3. Sump Tank
4. Venturimeter with pressure tappings

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Set the operation to be studied by operating the valves in the equipment.
3. Keep the Discharge Valve in Close condition.
4. Open the Inlet Valve of Turbine under study and close the other.
5. Connect the power cable to 3Ph, 440V, 20 Amps with proper earth connection.
6. Press the green button on the Starter and check the direction of the motor and Press the Red button to stop the operation

LIMITATIONS

- Maximum Head of operation 2kg/cm^2.
- Maximum RPM of turbine – 2800rpm.

PROCEDURE FOR MANUAL OPERATION:

B. TO OBTAIN CONSTANT HEAD CHARACTERISTICS.

1. Set the Vane position.
2. Keep the Delivery valve open at Maximum.
3. Set the head at required value.
4. Now apply the load.
5. Operating the delivery valve, maintain the head to the Set value.

6. Repeat the steps 4 and 5 till the maximum load the turbine can take.
7. In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loadings.

B. TO OBTAIN CONSTANT SPEED CHARACTERISTICS.

1. Set the Vane position.
2. Keep the Delivery valve open at Maximum.
3. Set the speed to the required value using the same delivery Valve.
4. Now apply the load.
5. Operating the delivery valve, maintain the speed to the
   Set value.
6. Repeat the steps 4 and 5 till the maximum load the turbine can take.
7. In the meantime, Note down the turbine speed, delivery head, vacuum head and Venturimeter readings for each loadings.

OBSERVATIONS:

Constant Head/Speed - Computerized

Sl. No	Turbine speed N rpm	Delivery Pressure`P'		Vacuum pressure 'Pv'		Venturimeter Head P		Load,	
		bar	x10m	bar	x10 m	bar	x10m	Voltage V volts	Current (I)amps

Constant Head/Speed – Manual

Sl. No	Turbine speed N rpm	Delivery Pressure`P'		Vacuum pressure 'Pv'		Venturimeter Head		Load, Kg		
						P1 ~P2				
		bar	x10m	bar	x10m	bar	x10m	F1	F2	F=F1~F2

PROCEDURE FOR COMPUTERIZED

B. TO OBTAIN CONSTANT HEAD CHARACTERISTICS.

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the "COMPORT" and "TYPE OF TURBINE" under test, once selected the connectivity is created.
5. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump by pressing the green button and slowly operate the delivery valve to set the pressure.
7. Set the head at required value.
8. Now apply the load.
9. Operating the delivery valve, maintain the head to the set value.
10. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.
11. Repeat the Step 8 to 9 for different Loads.
12. Once experiment is completed, press "STOP" button on the screen to stop the experiment.
13. Close the delivery valve completely and press the red button on the starter to stop the operation of the pump.
14. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS

1. TOTAL HEAD, H

$$H = \left(P + \frac{P_v}{760}\right) * 10 \; m \, of \, Water \quad \textbf{MANUAL}$$

$$H = (P + P_v) * 10 \; m \, of \, Water \quad \textbf{DIGITAL}$$

Where,

P = Delivery Pressure, kg/cm²
Pv = Vacuum Pressure, kg/cm²

2. DIFFERENTIAL , Pdiff

$$P_{diff} = (P_1 \sim P_2) \, x \, 10 \quad m \, of \, WC \quad \textbf{DIGITAL / MANUAL}$$

$$P_{diff} = \Delta P \, x \, 10 \quad m \, of \, WC$$

3. DISCHARGE, Q

$$Q = \frac{C_c A_1 A_2 \sqrt{(2 \, x \, g \, x \, P_{diff})}}{\sqrt{(A_1^2 - A_2^2)}} \quad m^3/sec$$

Where,

A1	=	cross sectional area of pipe, m^2
A2	=	cross sectional area of throat/orifice, m^2
g	=	Acceleration due to gravity = 9.81 m/s^2
Pdiff	=	Total head (Digital Reading)
d1	=	diameter at the inlet pipe
	=	0.100 for Venturimeter & Orifice meter
d2	=	throat/orifice
	=	0.05 for Venturimeter & Orifice meter

Cross sectional Area is calculated based on the following formula

$$A_{suffix} = \frac{\pi\, x\, (d_{suffix}{}^2)}{4} \qquad m^2$$

4. INPUT POWER, IP (Electrical)

$$IP = \frac{W\ Q\ H}{1000}\ \ kW$$

Where,

Q	=	Discharge
W	=	Density of Water = 9810 N/m^3
H	=	Head on the Turbine

5. **OUTPUT POWER, OP (Hydraulic)**

$$OP = \frac{V * I}{1000\ * \eta_T * \eta_m} \qquad kW$$

Where,

V	=	Generator Voltage
I	=	Generator Current
ηT	=	Transmission Efficiency = 0.08
ηM	=	Generator Efficiency = 0.075

6. Efficiency of the pump, η%

$$\eta\% = \frac{OP\ x\ 100}{IP}$$

7. Unit Quantities – Under Unit Head,

a) Unit Speed,

$$N_u = \frac{N}{\sqrt{H}}$$

b) <u>Unit Power,</u>

$$P_u = \frac{P}{H^{3/2}}$$

c) **Unit Discharge,**

d) **Specific Speed,**

$$Q_u = \frac{Q}{\sqrt{H}}$$

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

TABULATIONS :

Sl. No	Total Head H, m	Discharge Q, m³/sec	IP, KW	OP, KW	Turbine efficiency %η

Sl. No	Unit Power	Unit Head	Unit Discharge	Specific Speed

GRAPHS:

- Discharge Vs Head
- OP Vs Head
- Efficiency Vs Head

RESULT:

5) Graphs plotted show the constant head/speed characteristics of the turbine.
6) An attempt has been made to provide the facility to understand the various components of the turbine & present the characteristic curves.
7) The unit head and other quantities are calculated from the knowledge of constant head characteristics.
8) The numerical values in graphs and design calculations should be looked upon as **qualitative figures** rather than quantitative ones as some of the components available in the market for constructing the turbine are limited.

CONCLUSIONS OF THE RESULTS TABULATED:

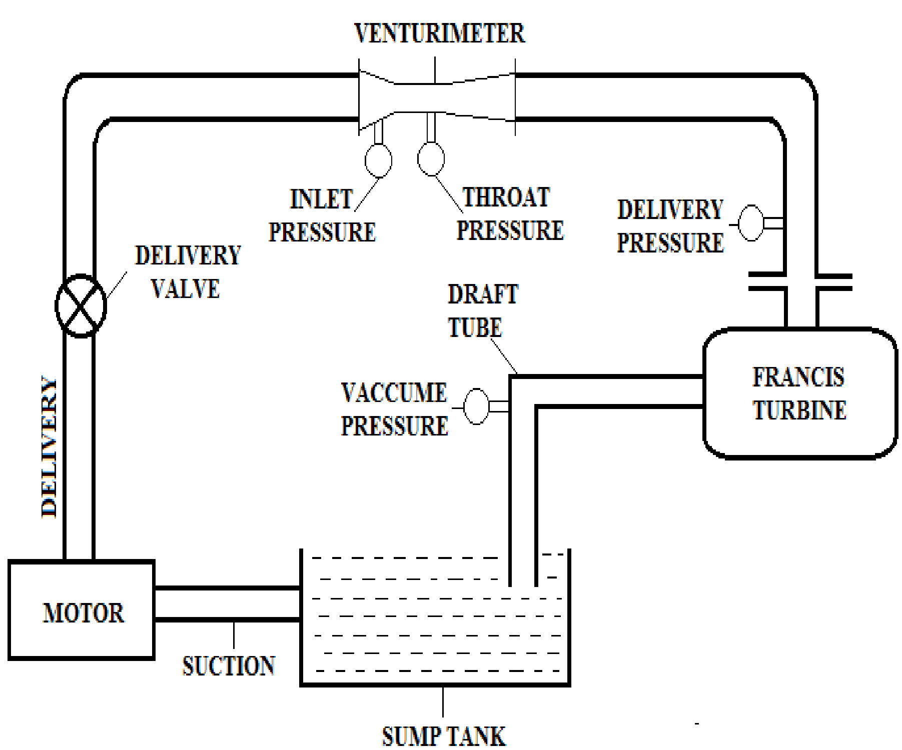
Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

Viva Questions:

1. What is Turbine ?
2. How do you classify turbines ?
3. Differentiate between Impulse turbine and Radial flow turbine.
4. Francis turbine is which type of turbine ?
5. What are the functions of Draft tube ?
6. What are the energies available at inlet of the Francis turbine ?
7. List out different types of Draft tubes.
8. Why the Draft tube is submerged in the below water level of the tail race ?
9. Why Draft tube is provided in the Francis turbine ?
10. What is the function of casing of the Francis turbine ?

FRANCIS TURBINE



Exp No: Date:

KAPLAN TURBINE SETUP

AIM:

d) Study the Performance Characteristics of the turbine under Constant Head and Constant Speed.

e) Draw Characteristics curves of turbine at different head.

f) Comparative analysis of the curves.

APPARATUS:

5. Monobloc Centifugal Pump of Kirloskar Make.
6. Turbine Unit
7. Sump Tank
8. Venturimeter with pressure tappings

PREPARATION OF EQUIPMENT:

7. Fill in the sump tank with clean water.
8. Set the operation to be studied by operating the valves in the equipment.
9. Keep the Discharge Valve in Close condition.
10. Open the Inlet Valve of Turbine under study and close the other.
11. Connect the power cable to 3Ph, 440V, 20 Amps with proper earth connection.
12. Press the green button on the Starter and check the direction of the motor and Press the Red button to stop the operation

LIMITATIONS

- Maximum Head of operation 2kg/cm^2.
- Maximum RPM of turbine – 2800rpm.

PROCEDURE FOR MANUAL OPERATION:

C. TO OBTAIN CONSTANT HEAD CHARACTERISTICS.

8. Set the Vane position.
9. Keep the Delivery valve open at Maximum.
10. Set the head at required value.
11. Now apply the load.
12. Operating the delivery valve, maintain the head to the Set value.
13. Repeat the steps 4 and 5 till the maximum load the turbine can take.

14. In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loadings.

B. TO OBTAIN CONSTANT SPEED CHARACTERISTICS.

8. Set the Vane position.
9. Keep the Delivery valve open at Maximum.
10. Set the speed to the required value using the same delivery Valve.
11. Now apply the load.
12. Operating the delivery valve, maintain the speed to the
    Set value.
13. Repeat the steps 4 and 5 till the maximum load the turbine can take.
14. In the meantime, Note down the turbine speed, delivery head, vacuum head and Venturimeter readings for each loadings.

OBSERVATIONS:

Constant Head/Speed - Computerized

Sl. No	Turbine speed N rpm	Delivery Pressure`P’		Vacuum pressure ‘Pv’		Venturimeter Head P		Load,	
		bar	x10m	bar	x10 m	bar	x10m	Voltage V volts	Current (I)amps

Constant Head/Speed – Manual

Sl. No	Turbine speed N rpm	Delivery Pressure`P’		Vacuum pressure ‘Pv’		Venturimeter Head P1 ~P2		Load, Kg		
		bar	x10m	bar	x10m	bar	x10m	F1	F2	F=F1~F2

<u>PROCEDURE FOR COMPUTERIZED</u>

C. TO OBTAIN CONSTANT HEAD CHARACTERISTICS.

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the “COMPORT” and “TYPE OF TURBINE” under test, once selected the connectivity is created.
5. Press “START” button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump by pressing the green button and slowly operate the delivery valve to set the pressure.
7. Set the head at required value.
8. Now apply the load.
9. Operating the delivery valve, maintain the head to the set value.
10. For the adjusted valve position, all the values will be displayed on the screen, now, press “STORE” button to store the required data.
11. Repeat the Step 8 to 9 for different Loads.
12. Once experiment is completed, press “STOP” button on the screen to stop the experiment.
13. Close the delivery valve completely and press the red button on the starter to stop the operation of the pump.
14. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS

1. <u>TOTAL HEAD, H</u>

$$H = \left(P + \frac{P_v}{760}\right) * 10\ m\ of\ Water$$ **MANUAL**

$$H = (P + P_v) * 10\ m\ of\ Water$$ **DIGITAL**

Where,

P = Delivery Pressure, kg/cm²

Pv = Vacuum Pressure, kg/cm²

2. <u>DIFFERENTIAL , P</u>diff

$$P_{diff} = (P_1 \sim P_2)\ x\ 10 \quad m\ of\ WC$$ **MANUAL**

$$P_{diff} = \Delta P\ x\ 10 \quad m\ of\ WC$$ **DIGITAL**

3. <u>DISCHARGE, Q</u>

$$Q = \frac{C_C A_1 A_2 \sqrt{(2\ x\ g\ x\ P_{diff})}}{\sqrt{(A_1^2 - A_2^2)}} \quad m^3/sec$$

Where,

A1	=	cross sectional area of pipe, m^2
A2	=	cross sectional area of throat/orifice, m^2
g	=	Acceleration due to gravity = 9.81 m/s^2
Pdiff	=	Total head (Digital Reading)
d1	=	diameter at the inlet pipe
	=	0.100 for Venturimeter & Orifice meter
d2	=	throat/orifice
	=	0.05 for Venturimeter & Orifice meter

Cross sectional Area is calculated based on the following formula

$$A_{suffix} = \frac{\pi\, x\, (d_{suffix}{}^2)}{4} \qquad m^2$$

4. INPUT POWER, IP (Electrical)

$$IP = \frac{W\ Q\ H}{1000}\ kW$$

Where,

Q	=	Discharge
W	=	Density of Water = 9810 N/m^3
H	=	Head on the Turbine

5. **OUTPUT POWER, OP (Hydraulic)**

$$OP = \frac{V * I}{1000\ * \eta_T * \eta_m} \quad kW$$

Where,

V	=	Generator Voltage
I	=	Generator Current
ηT	=	Transmission Efficiency = 0.08
ηM	=	Generator Efficiency = 0.075

8. Efficiency of the pump, η%

$$\eta\% = \frac{OP\ x\ 100}{IP}$$

9. Unit Quantities – Under Unit Head,

e) Unit Speed,

$$N_u = \frac{N}{\sqrt{H}}$$

f) Unit Power,

$$P_u = \frac{P}{H^{3/2}}$$

g) **Unit Discharge,**

h) **Specific Speed,**

$$Q_u = \frac{Q}{\sqrt{H}}$$

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

TABULATIONS :

Sl. No	Total Head H, m	Discharge Q, m³/sec	IP, KW	OP, KW	Turbine efficiency %η

Sl. No	Unit Power	Unit Head	Unit Discharge	Specific Speed

GRAPHS:

- Discharge Vs Head
- OP Vs Head
- Efficiency Vs Head

RESULT:

9) Graphs plotted show the constant head/speed characteristics of the turbine.
10) An attempt has been made to provide the facility to understand the various components of the turbine & present the characteristic curves.
11) The unit head and other quantities are calculated from the knowledge of constant head characteristics.
12) The numerical values in graphs and design calculations should be looked upon as **qualitative figures** rather than quantitative ones as some of the components available in the market for constructing the turbine are limited.

CONCLUSIONS OF THE RESULTS TABULATED:

Summarizing the entire operation and graphs if any

Describing the possible error factors and corrections

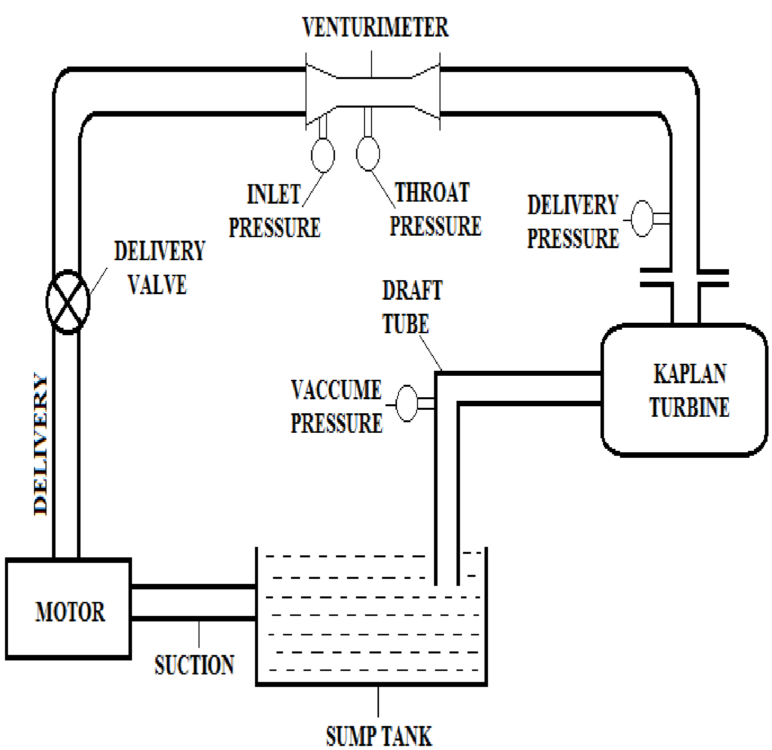
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

Viva Questions:

1. What is Turbine ?
2. How do you classify turbines ?
3. Differentiate between Impulse turbine and Radial flow turbine.
4. Francis turbine is which type of turbine ?
5. What are the functions of Draft tube ?
6. What are the energies available at inlet of the Francis turbine ?
7. List out different types of Draft tubes.
8. Why the Draft tube is submerged in the below water level of the tail race ?
9. Why Draft tube is provided in the Francis turbine ?
10. What is the function of casing of the Francis turbine ?

KAPLAN TURBINE



Exp No: Date:

SINGLE– STAGE CENTRIFUGAL PUMP TEST RIG

AIM:

a) Study the Performance Characteristics of the pump.

b) Draw Characteristics curves of the pump at different head.

c) Comparative analysis of the curves.

d) To Study the Stage wise built in pressure of the pump.

DESCRIPTION OF APPARATUS;

The Centrifugal Pump Test Rig comes with the following two versions along with the standard specifications:

a. DC Version.

This version has a Centrifugal pump coupled to a DC Motor with Thyrister control drive for desirable speed setting.

b. AC Version- YOUR EQUIPMENT.

This version has a Centrifugal pump coupled to an AC Motor with Stepped Cone Pulley arrangement for operating the pump at Three different speeds.

Standard Specifications:

1. The pump is of **KIRLOSKAR** make of 1hp capacity with the head of 11m head.
2. The Motor coupled is of **MEGHA ELECTRICALS** make of 2hp capacity with Thyristor control drive.
3. The above two are fitted on the Base frame.
4. Water from the sump tank is sucked by the pump and is delivered through the delivery pipe to the collecting tank.
5. **Overflow** arrangement is provided to the collecting tank.
6. **Butterfly valve** is provided in the measuring tank for instant close and release.
7. The suction and delivery can be controlled by means of **control valves**.
8. **Piezometer** with Vinyl sticker scale (For better readability) is provided to measure the height of the water collected in the measuring tank.

9. The apparatus comes with a separate **NOVAPAN** board control panel with standard accessories such as **Digital RPM Indicator**, Energy meter, Delivery and Vacuum gauges.
10. The equipment has been designed for closed circuit operation.
11. The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS angle with all the provisions for holding the tanks and accessories.

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Set the operation to be studied by operating the valves in the equipment.
3. Prime the pump. (in case of multi stage)
4. Keep the delivery valve in closed condition and suction valve in open condition of the pump in study.
5. Connect the power cable to 1Ph, 230V, 10 Amps with proper earth connection.
6. Press the green button on the Starter and set the Vacuum gauge reading to 100mm of Hg if needed.
7. Press the Red button to stop the operation

LIMITATIONS

- Check and note the Maximum and minimum Delivery head by fully opening and closing the Delivery Valve.
- Operate within the range of this head only.

PROCEDURE FOR MANUAL OPERATION:

1. Press the green button switch on the starter.
2. Now slowly open to vary the discharge (delivery valve) and note down the following:
   a. Vacuum gauge reading
   b. Delivery Pressure gauge reading.
   c. Voltmeter & Ammeter Reading.
   d. Time taken for 10 cm rise in measuring tank
   e. Speed of the pump
3. Change the discharge using the discharge valve and repeat the above step.
4. Once the experiment is done, Close the delivery valve completely and Press the Red button on the starter to stop the operation.

OBSERVATIONS:

SL. No	Delivery Pressure 'P'		Vacuum 'Pv' mm of Hg		Water flow rate(or) Discharge 'Q'		Power input		Speed of the pump, N, rpm
	bar	x10m	bar	x10m	lpm	m^3/sec	Voltage 'Volts'	Current 'Amps'	

PROCEDURE FOR COMPUTERIZED

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the "COMPORT" and "TYPE OF METER" under test, once selected the connectivity is created.
5. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump by pressing the green button and slowly operate the delivery valve to set the pressure.
7. Adjust the flow through the control valve of the pump.
8. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.
9. Repeat the Step 7 to 8 for different flow rates.
10. Once experiment is completed, press "STOP" button on the screen to stop the experiment.
11. Close the delivery valve completely and press the red button on the starter to stop the operation of the pump.
12. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS

1. **TOTAL HEAD, H**

$$H = \left(P + \frac{P_v}{760}\right) * 10\ m\ of\ Water$$ **MANUAL**

$$H = (P + P_v) * 10\ m\ of\ Water$$ **DIGITAL**

Where,

P = Delivery Pressure, kg/cm²

Pv = Vacuum Pressure, kg/cm²

2. **DISCHARGE, Q**

$$Q = \frac{A\ x\ R}{t\ x\ 100}\ m^3/s$$ **MANUAL**

OR

$$Q_A = \frac{LPM}{60000}\ m^3/s$$ } **DIGITAL**

Where,

A = Area of collecting tank = 0.16 m².

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

LPM = Flowrate in digital indication, lpm

3. INPUT POWER, IP (Electrical)

$$IP = \frac{V\ x\ I}{1000}\ kW$$ } **Single Stage**

$$IP = \frac{V * I * Pf}{1000}\ kW$$ } **Multi Stage**

Where,

V = Voltage in Volts

I = Current in Amps

Pf = Power Factor of the motor= 0.8

4. <u>OUTPUT POWER, OP (Hydraulic)</u>

$$OP = \frac{WQH}{1000}\ kW$$

Where,

W = 9810 N/m^3

Q = Discharge, m^3/sec

H = Total Head.

5. <u>Efficiency of the pump, η%</u>

$$\eta\% = \frac{OP\ x\ 100}{IP}$$

TABULATIONS :

SL. No	Total Head 'H' m of water	Discharge. Q, m^3/sec	Input power, IP, hp	Output Power, OP, hp	Efficiency	Speed of the pump, N, rpm

GRAPHS:

- Discharge Vs Head
- OP Vs Head
- Efficiency Vs Head

DISCUSSIONS ON THE RESULTS :

General Possibilities of Errors if occurred.
Outcome of Results - applications

CONCLUSIONS OF THE RESULTS TABULATED:

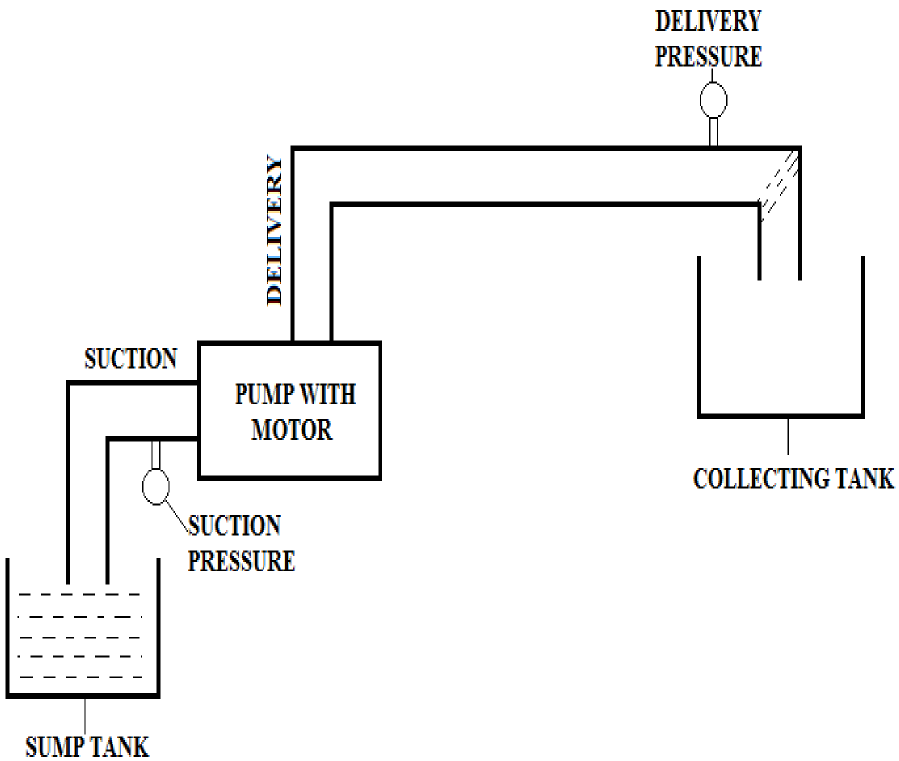
Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

Viva Questions:

1. What is the Centrifugal pump?
2. How do you classify the Centrifugal pumps?
3. What are the main parts of Centrifugal pumps?
4. What is the priming in Centrifugal pump?
5. What is the function of spiral casing in Centrifugal pump?
6. Name the different types of efficiencies Centrifugal pump?
7. Name the different types of casings for the impeller of Centrifugal pump?
8. What do you understand by the term multistage pump?
9. How the water enters in to the Centrifugal pump?
10. What is the discharge of Centrifugal pump when compared with Reciprocating pump

SINGLE- STAGE CENTRIFUGAL PUMP



Exp No: Date:

MULTI – STAGE CENTRIFUGAL PUMP TEST RIG

AIM:

e) Study the Performance Characteristics of the pump.

f) Draw Characteristics curves of the pump at different head.

g) Comparative analysis of the curves.

h) To Study the Stage wise built in pressure of the pump.

DESCRIPTION OF APPARATUS;

The Centrifugal Pump Test Rig comes with the following two versions along with the standard specifications:

b. DC Version.

This version has a Centrifugal pump coupled to a DC Motor with Thyrister control drive for desirable speed setting.

b. AC Version- YOUR EQUIPMENT.

This version has a Centrifugal pump coupled to an AC Motor with Stepped Cone Pulley arrangement for operating the pump at Three different speeds.

Standard Specifications:

12. The pump is of **KIRLOSKAR** make of 1hp capacity with the head of 11m head.
13. The Motor coupled is of **MEGHA ELECTRICALS** make of 2hp capacity with Thyristor control drive.
14. The above two are fitted on the Base frame.
15. Water from the sump tank is sucked by the pump and is delivered through the delivery pipe to the collecting tank.
16. **Overflow** arrangement is provided to the collecting tank.
17. **Butterfly valve** is provided in the measuring tank for instant close and release.
18. The suction and delivery can be controlled by means of **control valves**.
19. **Piezometer** with Vinyl sticker scale (For better readability) is provided to measure the height of the water collected in the measuring tank.

20. The apparatus comes with a separate **NOVAPAN** board control panel with standard accessories such as **Digital RPM Indicator**, Energy meter, Delivery and Vacuum gauges.
21. The equipment has been designed for closed circuit operation.
22. The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS angle with all the provisions for holding the tanks and accessories.

PREPARATION OF EQUIPMENT:

8. Fill in the sump tank with clean water.
9. Set the operation to be studied by operating the valves in the equipment.
10. Prime the pump. (in case of multi stage)
11. Keep the delivery valve in closed condition and suction valve in open condition of the pump in study.
12. Connect the power cable to 1Ph, 230V, 10 Amps with proper earth connection.
13. Press the green button on the Starter and set the Vacuum gauge reading to 100mm of Hg if needed.
14. Press the Red button to stop the operation

LIMITATIONS

- Check and note the Maximum and minimum Delivery head by fully opening and closing the Delivery Valve.
- Operate within the range of this head only.

PROCEDURE FOR MANUAL OPERATION:

5. Press the green button switch on the starter.
6. Now slowly open to vary the discharge (delivery valve) and note down the following:

   f. Vacuum gauge reading
   g. Delivery Pressure gauge reading.
   h. Voltmeter & Ammeter Reading.
   i. Time taken for 10 cm rise in measuring tank
   j. Speed of the pump

7. Change the discharge using the discharge valve and repeat the above step.
8. Once the experiment is done, Close the delivery valve completely and Press the Red button on the starter to stop the operation.

OBSERVATIONS:

SL. No	Delivery Pressure 'P'		Vacuum 'Pv' mm of Hg		Water flow rate(or) Discharge 'Q'		Power input		Speed of the pump, N, rpm
	bar	x10m	bar	x10m	lpm	m^3/sec	Voltage 'Volts'	Current 'Amps'	

PROCEDURE FOR COMPUTERIZED

13. Switch on the computer
14. Open the corresponding Software of the instrument.
15. Specify the username.
16. Select the "COMPORT" and "TYPE OF METER" under test, once selected the connectivity is created.
17. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.
18. Now, Switch on the pump by pressing the green button and slowly operate the delivery valve to set the pressure.
19. Adjust the flow through the control valve of the pump.
20. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.
21. Repeat the Step 7 to 8 for different flow rates.
22. Once experiment is completed, press "STOP" button on the screen to stop the experiment.
23. Close the delivery valve completely and press the red button on the starter to stop the operation of the pump.
24. For report follow the procedure given in ANNEXURE – 1.

CALCULATION:

TOTAL HEAD, H

$$H = \left(P + \frac{P_v}{760}\right) * 10\ m\ of\ Water$$ **MANUAL**

$$H = (P + P_v) * 10\ m\ of\ Water$$ **DIGITAL**

Where,

P = Delivery Pressure, kg/cm²
Pv = Vacuum Pressure, kg/cm²

1. DISCHARGE, Q

OR

$$Q = \frac{A\ x\ R}{t\ x\ 100}\ m^3/s$$ **MANUAL**

$$Q_A = \frac{LPM}{60000}\ m^3/s$$ **DIGITAL**

Where,

A	= Area of collecting tank = 0.16 m².
R	= Rise in water level of the collecting tank, cm.
t	= time for ‘R’ cm rise of water, sec
100	= Conversion from cm to m.
LPM	= Flowrate in digital indication, lpm

3. INPUT POWER, IP (Electrical)

$$IP = \frac{V\ x\ I}{1000}\ kW$$ **Single Stage**

$$IP = \frac{V * I * Pf}{1000}\ kW$$ **Multi Stage**

Where,

V = Voltage in Volts
I = Current in Amps
Pf = Power Factor of the motor= 0.8

6. **OUTPUT POWER, OP (Hydraulic)**

$$OP = \frac{WQH}{1000}\ kW$$

Where,

W = 9810 N/m^3
Q = Discharge, m^3/sec
H = Total Head.

7. **Efficiency of the pump, η%**

$$\eta\% = \frac{OP\ x\ 100}{IP}$$

TABULATIONS :

SL. No	Total Head 'H' m of water	Discharge. Q, m^3/sec	Input power, IP, hp	Output Power, OP, hp	Efficiency	Speed of the pump, N, rpm

GRAPHS:

- Discharge Vs Head
- OP Vs Head
- Efficiency Vs Head

DISCUSSIONS ON THE RESULTS :

General Possibilities of Errors if occurred.
Outcome of Results - applications

CONCLUSIONS OF THE RESULTS TABULATED:

Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

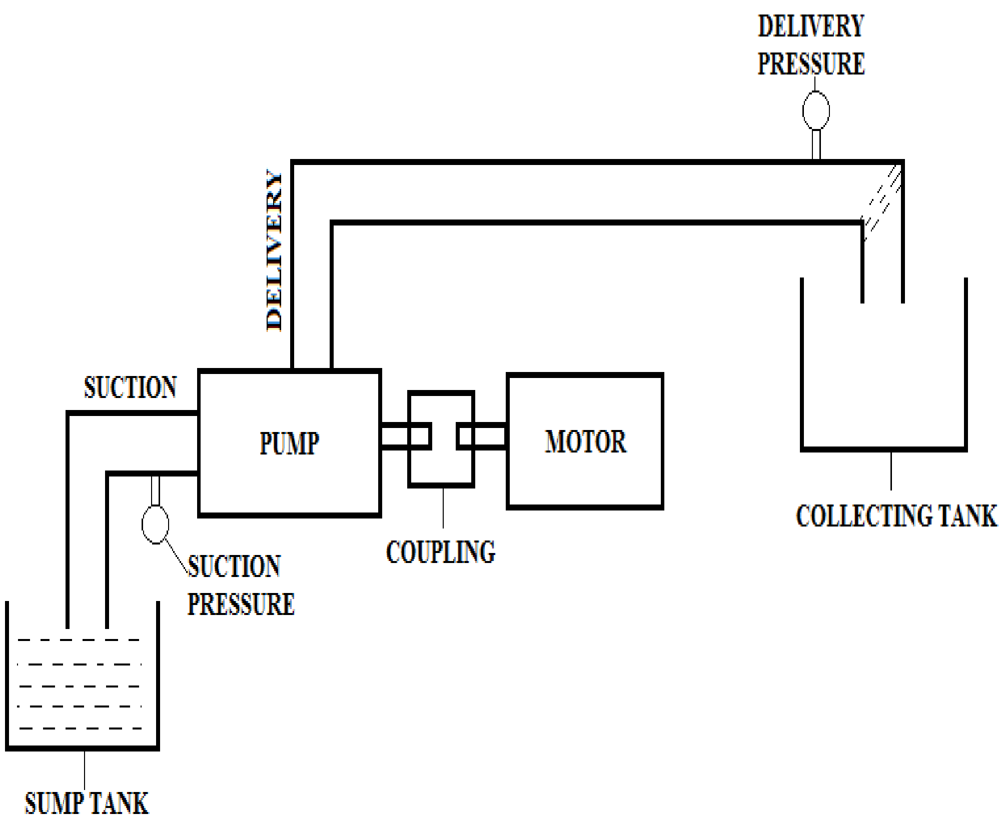
DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

Viva Questions:

1. What is the Centrifugal pump?
2. How do you classify the Centrifugal pumps?
3. What are the main parts of Centrifugal pumps?
4. What is the priming in Centrifugal pump?

5. What is the function of spiral casing in Centrifugal pump?
6. Name the different types of efficiencies Centrifugal pump?
7. Name the different types of casings for the impeller of Centrifugal pump?
8. What do you understand by the term multistage pump?
9. How the water enters in to the Centrifugal pump?
10. What is the discharge of Centrifugal pump when compared with Reciprocating pump

MULTI-STAGE CENTRIFUGAL PUMP



Exp No: Date:

RECIPROCATING PUMP TEST RIG

AIM:

a. Study the Performance Characteristics of the pump.
b. Draw Characteristics curves of the pump at different head.
c. Comparative analysis of the curves.
d. To Study the Stage wise built in pressure of the pump.

DESCRIPTION OF APPARATUS

The Reciprocating Pump Test Rig comes with the following two versions along with the standard specifications:

a. DC Version.

This version has a Reciprocating pump coupled to a DC Motor with Thyrister control drive for desirable speed setting.

b. AC Version– YOUR EQUIPMENT.

This version has a Reciprocating pump coupled to an AC Motor with Stepped Cone Pulley arrangement for operating the pump at Three different speeds.

Standard Specifications:

1. The pump is of **SUGUNA** make of 1hp capacity with the head of 36m head.

2. The Motor coupled is of **CROMPTON GREAVES** make of 1.5hp capacity with Stepped Cone pulley arrangement for speed change.

3. The above two are fitted on the Base frame.

4. Water from the sump tank is sucked by the pump and is delivered through the delivery pipe to the collecting tank.

5. **Overflow** arrangement is provided to the collecting tank.

6. **Valve** is provided in the measuring tank for instant close and release

7. The suction and delivery can be controlled by means of **control valves**.

8. **Piezometer** with Vinyl sticker scale (For better readability) is provided to measure the height of the water collected in the measuring tank.

9. The apparatus comes with a separate **NOVAPAN** board control panel with standard accessories such as **Digital RPM Indicator**, Energy meter, Delivery and Vacuum gauges.

10. The equipment has been designed for closed circuit operation.

11. The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS angle with all the provisions for holding the tanks and accessories.

PANEL DETIALS:

MAINS ON INDICATOR: To indicate the Power given to the system.
STARTER : Provided to activate the pump.
CHANGE OVER SWITCH : Provided to interchange with the operation of the pump.
DIGITAL RPM INDICATOR : Provided to indicate the speed of pump
DIGITAL DATA SCANNER : Provided to indicate the Delivery & Vacuum Pressure, Voltage and current.
ANALOGUE PRESSURE INDICATORS : Provided to measure Pressure at different stages of the pump

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Set the operation to be studied by operating the valves in the equipment.
3. Prime the pump. (in case of multi stage)
4. Keep the delivery valve in **OPEN** condition and suction valve in open condition of the pump in study.
5. Connect the power cable to 1Ph, 230V, 10 Amps with proper earth connection.
6. Press the green button on the Starter and set the Vacuum gauge reading to 100mm of Hg if needed.
7. Press the Red button to stop the operation

LIMITATIONS

- Check and note the Maximum and minimum Delivery head by fully opening and closing the Delivery Valve.
- Operate within the range of this head only.

PROCEDURE FOR MANUAL OPERATION:

1. Press the green button switch on the starter.

2. Now slowly open to vary the discharge (delivery valve) and note down the following:

    c. Vacuum gauge reading

    d. Delivery Pressure gauge reading.

    e. Voltmeter & Ammeter reading.

    f. Time taken for 10 cm rise in measuring tank

    g. Speed of the pump

3. Change the discharge using the discharge valve and repeat the above step.
4. Once the experiment is done, Close the delivery valve completely and

    Press the Red button on the starter to stop the operation.

AFTERMATH

OBSERVATIONS:

SL. No	Delivery Pressure 'P'		Vacuum 'Pv' mm of Hg		Water flow rate(or) Discharge 'Q'		Power input		Speed of the pump, N, rpm
	bar	x10m	bar	x10m	lpm	m^3/sec	Voltage 'Volts'	Current 'Amps'	

PROCEDURE FOR COMPUTERIZED

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the "COMPORT" and "TYPE OF METER" under test, once selected the connectivity is created.
5. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump by pressing the green button and slowly operate the delivery valve to set the pressure.
7. Adjust the flow through the control valve of the pump.
8. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.
9. Repeat the Step 7 to 8 for different flow rates.
10. Once experiment is completed, press "STOP" button on the screen to stop the experiment.
11. Close the delivery valve completely and press the red button on the starter to stop the operation of the pump.
12. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS

1. **TOTAL HEAD, H**

$$H = \left(P + \frac{P_v}{760}\right) * 10\ m\ of\ Water \quad \text{MANUAL}$$

$$H = (P + P_v) * 10\ m\ of\ Water \quad \text{DIGITAL}$$

Where,

P = Delivery Pressure, kg/cm²

Pv = Vacuum Pressure, kg/cm²

2. **DISCHARGE, Q**

$$Q = \frac{A\ x\ R}{t\ x\ 100}\ m^3/s \quad \text{MANUAL}$$

OR

$$Q_A = \frac{LPM}{60000}\ m^3/s \quad \text{DIGITAL}$$

Where,

A = Area of collecting tank = 0.16 m².

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

LPM = Flowrate in digital indication, lpm

3. INPUT POWER, IP (Electrical)

$$IP = \frac{V x\, I\, x\, \eta_T\, x\, P_f}{1000}\ kW$$

Where,

V = Voltage in Volts

I = Current in Amps

η_T = transmission = 0.90

P_f = Power Factor = 0.8

4. OUTPUT POWER, OP (Hydraulic)

$$OP = \frac{WQH}{1000}\ kW$$

Where,

W = 9810 N/m^3

Q = Discharge, m^3/sec

H = Total Head.

5. Efficiency of the pump, η%

$$\eta\% = \frac{OP\ x\ 100}{IP}$$

TABULATIONS :

SL. No	Total Head 'H' m of water	Discharge. Q, m^3/sec	Input power, IP, hp	Output Power, OP, hp	Efficiency	Speed of the pump, N, rpm

GRAPHS:

- Discharge Vs Head
- OP Vs Head
- Efficiency Vs Head

DISCUSSIONS ON THE RESULTS :

General Possibilities of Errors if occurred.
Outcome of Results - applications

CONCLUSIONS OF THE RESULTS TABULATED:

Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

Precautions:

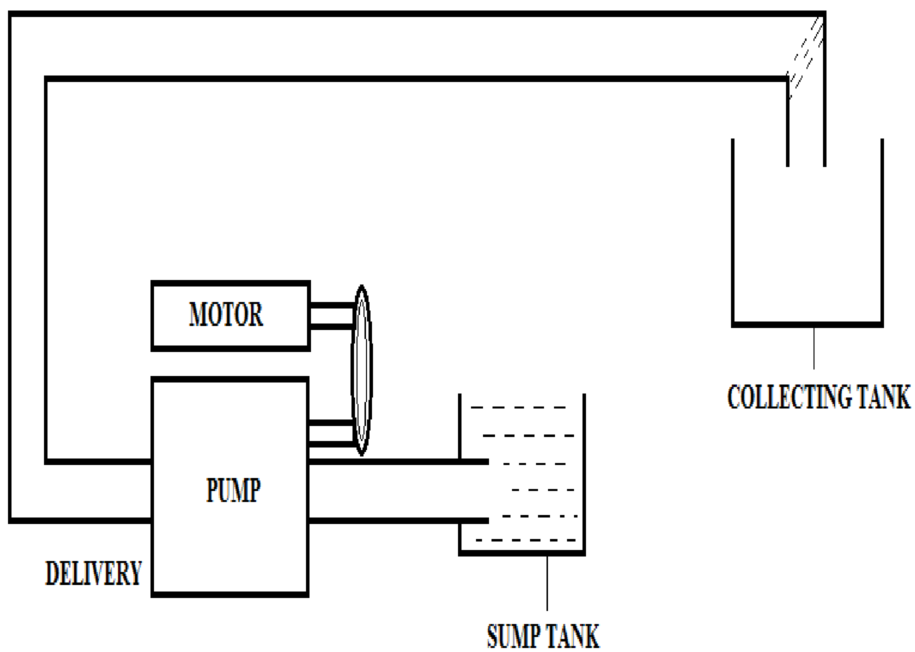
1. Never close the delivery valve completely.'
2. Do not start the pump if there is no water in the sump tank.
3. Care should be taken while measuring the time taken for 'N_e' revolutions of energy meter disc.

Result: The performance test has been conducted and thus the characteristic curves are obtained.

Viva Questions:

1. What is the Reciprocating pump?
2. How do you classify the Reciprocating pumps?
3. What are the main parts of Reciprocating pumps?
4. Why the Air vessels are fitted in Reciprocating pumps?
5. What are the functions of Air vessels?
6. What is the slip of Reciprocating pump?
7. What is the separation of Reciprocating pump?
8. How much power is saved by fitting Air vessels in single acting Reciprocating pump?
9. How much power is saved by fitting Air vessels in double acting Reciprocating pump?
10. What is the discharge of Reciprocating pump when compared with Centrifugal pump?

RECIPROCATING PUMP TEST RIG



Exp No: Date:

CALIBRATION OF VENTURI METER

AIM:

a. **Calibrate the given Venturi meter** at different flow rate.

b. Determination of **Co-efficient** of **Discharge** through all these meters.

DESCRIPTION OF THE APPARATUS:

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

PANEL DETIALS:

MAINS ON INDICATOR: To indicate the Power given to the system.

STARTER: Provided to activate the system.

PRESSURE INDICATOR: To indicate the Pressure in digital format.

WATERFLOW INDICATOR: To indicate the Flow rate in digital format.

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.

2. Keep the delivery valve and all other ball valves in closed position except the manometer valves. If it is Digital Version there will be no Manometer hence closes all other valves.

3. Connect the power cable to 1Ph, 220V, 10 Amps with proper earth connection.

LIMITATIONS

1. Venturi meter - Maximum Pressure Range 10m of Water Column

PROCEDURE FOR MANUAL

1. Switch on the pump & open the delivery valve.
2. Open the corresponding Ball valve of the pipeline in test.
3. Adjust the flow through the control valve of the pump.
4. Open the corresponding Teflon Ball valves fitted to meter tappings.
5. Note down the differential head reading.
6. Note down time for collection of “R cm” rise of water in collecting tank by operating the Ball Valve. OR Directly take the readings from the indicator.
7. Change the flow rate and repeat the experiment.

OBSERVATIONS:

Sl. No	TYPE OF METER	MANOMETER READING Or Differential Head		Time for ‘R’ cm rise in water ‘T’ sec Or Flow meter reading in	
		bar	x10m	lpm	m^3/sec
1	Venturi				
2					
3					
4					

PROCEDURE FOR COMPUTERIZED

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the “COMPORT” and “TYPE OF METER” under test, once selected the connectivity is created.
5. Press “START” button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump & open the delivery valve.
7. Open the corresponding Ball valve of the pipeline in test.
8. Adjust the flow through the control valve of the pump.
9. Open the corresponding Teflon Ball valves fitted to meter tappings.
10. For the adjusted valve position, all the values will be displayed on the screen, now, press “STORE” button to store the required data.
11. Repeat the Step 8 to 10 for different flow rates.
12. Once experiment is completed, press “STOP” button on the screen to stop the experiment.
13. Repeat the Step 2 to 11 for different meter.
14. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS

1. **Pressure Head, H**

H = (Reading in digital meter x 10) m of water

2. **Theoretical discharge of Venturi, Orificemeter and Flow Nozzle, QT**

$$Q_{TH} = \frac{A1 * A2 * \sqrt{2gH}}{\left(\sqrt{A1^2 - A2^2}\right)} \; m^3/s$$

Where,

A1 = cross sectional area of pipe, m^2

A2 = cross sectional area of throat/orifice, m^2

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

H = Total head (Digital Reading)

d1 = diameter at the inlet pipe

= 0.025 for Venturimeter & Orifice meter

d2 = throat/orifice

= 0.0125 for Venturimeter & Orifice meter

Cross sectional Area is calculated based on the following formula

$$A_{suffix} = \frac{\pi \, x \, (d_{suffix}{}^2)}{4} \quad m^2$$

Actual Discharge, QA

$$Q_A = \frac{A \, x \, R}{t \, x \, 100} \, m^3/s \quad \textbf{MANUAL}$$

OR

$$Q_A = \frac{LPM}{60000} \, m^3/s \quad \textbf{DIGITAL}$$

Where,

A = Area of collecting tank = m^2.

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

LPM = Water flow reading, LPM

1. **Co – efficient of discharge, Cd**

$$C_d = \frac{Q_A}{Q_{TH}}$$

TABULATIONS :

Loss of Head, m of water column	Actual Discharge, QA m^3/sec	Theoretical Discharge, QA m^3/sec	Co – efficient of Discharge, cd	Average, cd

GRAPHS:

a. **Head Vs Discharge**

b. **Theoretical Discharge Vs Actual Discharge**

DISCUSSIONS ON THE RESULTS :

General Possibilities of Errors if occurred.
Outcome of Results

CONCLUSIONS OF THE RESULTS TABULATED:

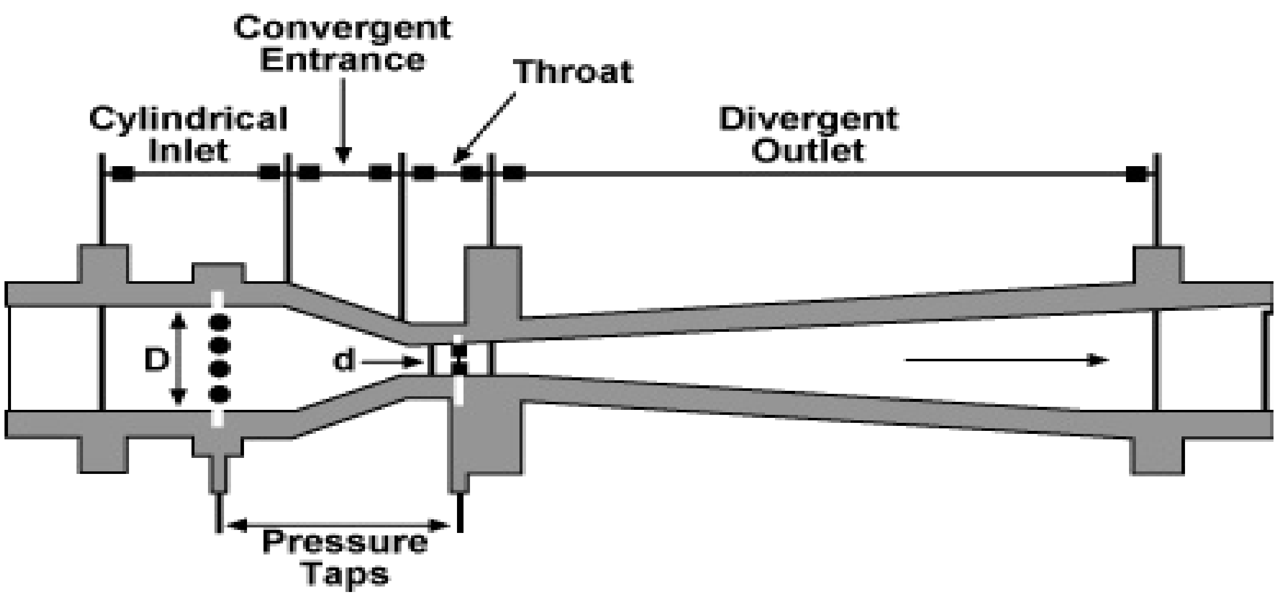
Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e., from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

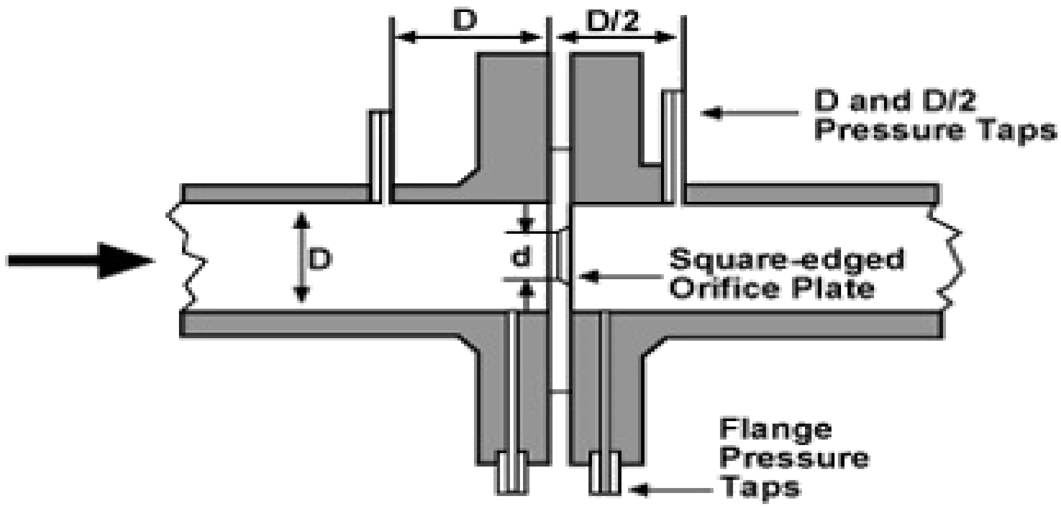
Viva Questions:

1.. What are the parts of Venturimeter ?
2. What is the angle of convergent part ?
3. What is the angle of divergent part ?
4. What is the length of convergent part ?
5. What is the length of divergent part ?
6. What is the diameter of throat ?
7. What is the main purpose of venturimeter ?
8. What is the co-efficient of discharge of venturimeter ?
9. Differentiate between simple manometer and differential manometer.
10. What is the difference between pitot-tube and u-tube manometer.

PICTORIAL REPRESENTATION METERS



VENTURI METER



ORIFICE METER

Exp No: Date:

CALIBRATION OF ORIFICEMETER

AIM:

c. **Calibrate the given orifice meter** at different flow rate.

d. Determination of **Co-efficient** of **Discharge** through all these meters.

DESCRIPTION OF THE APPARATUS:

1. The apparatus consists of a **orifice meter** made of **clear ACRYLIC** fitted to specially made separate pipelines which are interchangeable.
2. **Tappings** with **Ball Valves** are provided at appropriate positions which is connected to a **Manometer**.
3. **ACRYLIC Piezometer** is provided to measure the height of the water collected in the **measuring tank**.
4. **Mercury filled Manometer** made of Acrylic is provided to measure the pressure difference.
5. **Butterfly valve** is provided in the measuring tank for instant close and release.
6. **Overflow arrangement** is also provided to the tanks.
7. A **supply pump (Kirloskar/Sharp make)** with starter is provided for supplying the water and a supply tank is provided to store the water.
8. **Vinyl sticker scale** is provided for both Manometer and Piezometer for better readability.

PANEL DETIALS:

MAINS ON INDICATOR: To indicate the Power given to the system.
STARTER: Provided to activate the system.
PRESSURE INDICATOR: To indicate the Pressure in digital format.
WATERFLOW INDICATOR: To indicate the Flow rate in digital format.

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Keep the delivery valve and all other ball valves in closed position except the manometer valves. If it is Digital Version there will be no Manometer hence closes all other valves.
3. Connect the power cable to 1Ph, 220V, 10 Amps with proper earth connection.

LIMITATIONS

1. **orifice meter -** Maximum Pressure Range 10m of Water Column

PROCEDURE FOR MANUAL

1. Switch on the pump & open the delivery valve.
2. Open the corresponding Ball valve of the pipeline in test.
3. Adjust the flow through the control valve of the pump.
4. Open the corresponding Teflon Ball valves fitted to meter tappings.
5. Note down the differential head reading.
6. Note down time for collection of "R cm" rise of water in collecting tank by operating the Ball Valve. OR Directly take the readings from the indicator.
7. Change the flow rate and repeat the experiment.

OBSERVATIONS:

Sl. No	TYPE OF METER	MANOMETER READING Or Differential Head		Time for 'R' cm rise in water 'T' sec Or Flow meter reading in	
		bar	x10m	lpm	m^3/sec
1	Orifice				
2					
3					
4					

PROCEDURE FOR COMPUTERIZED

1. Switch on the computer
2. Open the corresponding Software of the instrument.
3. Specify the username.
4. Select the "COMPORT" and "TYPE OF METER" under test, once selected the connectivity is created.
5. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.
6. Now, Switch on the pump & open the delivery valve.
7. Open the corresponding Ball valve of the pipeline in test.
8. Adjust the flow through the control valve of the pump.
9. Open the corresponding Teflon Ball valves fitted to meter tappings.
10. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.
11. Repeat the Step 8 to 10 for different flow rates.
12. Once experiment is completed, press "STOP" button on the screen to stop the experiment.
13. Repeat the Step 2 to 11 for different meter.
14. For report follow the procedure given in ANNEXURE – 1.

CALCULATIONS

1. **Pressure Head, H**

H = (Reading in digital meter x 10) m of water

2. **Theoretical discharge of Venturi, Orificemeter and Flow Nozzle, QT**

$$Q_{TH} = \frac{A1 * A2 * \sqrt{2gH}}{\left(\sqrt{A1^2 - A2^2}\right)} \; m^3/s$$

Where,

A1 = cross sectional area of pipe, m^2

A2 = cross sectional area of throat/orifice, m^2

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

H = Total head (Digital Reading)

d1 = diameter at the inlet pipe

= 0.025 for Venturimeter & Orifice meter

d2 = throat/orifice

= 0.0125 for Venturimeter & Orifice meter

Cross sectional Area is calculated based on the following formula

$$A_{suffix} = \frac{\pi \, x \, ({d_{suffix}}^2)}{4} \quad m^2$$

Actual Discharge, QA

MANUAL

$$Q_A = \frac{A \, x \, R}{t \, x \, 100} \; m^3/s$$

OR

$$Q_A = \frac{LPM}{60000} \; m^3/s$$

DIGITAL

Where,

A = Area of collecting tank = m^2.

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

LPM = Water flow reading, LPM

2. **Co – efficient of discharge, Cd**

$$C_d = \frac{Q_A}{Q_{TH}}$$

TABULATIONS :

Loss of Head, m of water column	Actual Discharge, QA m^3/sec	Theoretical Discharge, QA m^3/sec	Co – efficient of Discharge, cd	Average, cd

GRAPHS:

a. **Head Vs Discharge**
b. **Theoretical Discharge Vs Actual Discharge**

DISCUSSIONS ON THE RESULTS :
General Possibilities of Errors if occurred.
Outcome of Results

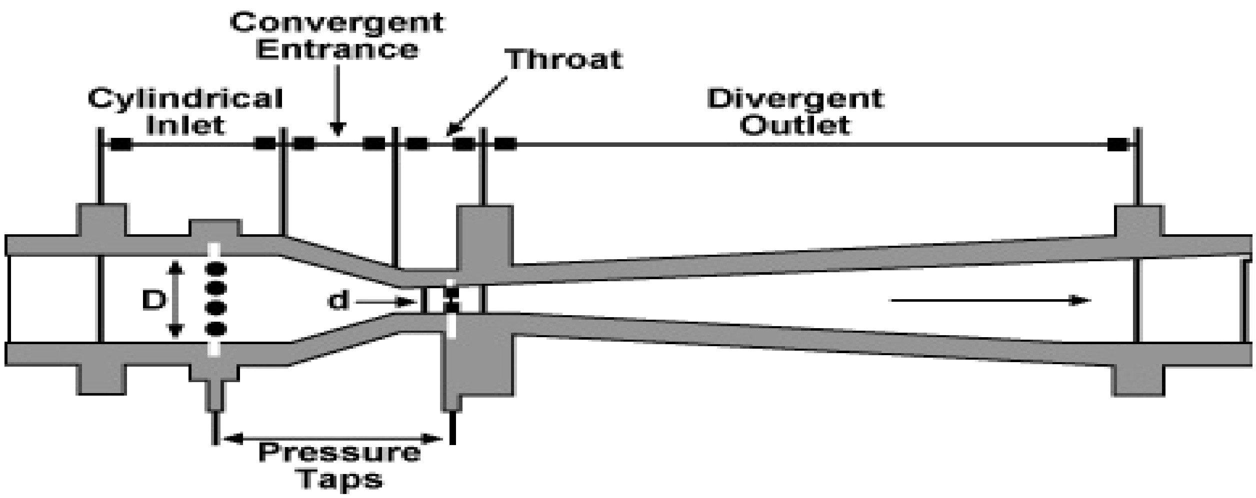
CONCLUSIONS OF THE RESULTS TABULATED:
Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e., from startup to end.
DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

PRECAUTIONS:

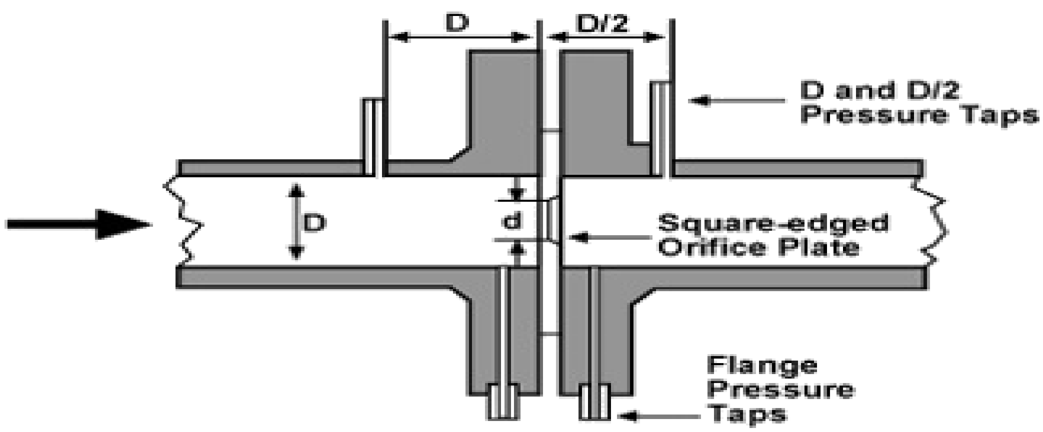
1. Do not run the pump dry.
2. Clean the tanks regularly, say for every 15days.
3. Do not run the equipment if the voltage is below 180V.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main
    a. control valve should be in close position.
6. Do not attempt to alter the equipment as this may cause
    b. damage to the whole system.

Viva Questions:

1.. What do you understand by the term intensity of pressure ?
2. What is meant by pressure head ?
3. Distinguish between gauge pressure and absolute pressure.
4. State the different principles of measurement of pressure.
5. What is the specific gravity of mercury ?
6. What is the ratio of diameter of Orifice and diameter of pipe ?
7. What is the main purpose of Orificemeter ?
8. What is the co-efficient of discharge of Orificemeter ?
9. Differentiate between simple manometer and differential manometer.
10. What is the difference between u-tube manometer and inverted manometer ?



VENTURI METER



ORIFICE METER

Exp No: Date:

MAJOR LOSSES IN PIPES

AIM:

The experiment is conducted to determine:

a. Determination of Pressure drop across different pipes.
b. Comparative analysis of different type of pipes.
c. Friction factor for different pipe fittings.
d. Comparative analysis of friction factor through different pipe fittings.

DESCRIPTION OF THE APPARATUS:

1. The apparatus has 4 different **specially made pipelines** comprising of
   a. **1" G.I**
   b. **1/2" G.I**
   c. **1" PVC**
   b. **1"G.I** pipe with Reducing Collar, Enlarging collar, Union and Collar
   d. **1"G.I** pipe with 90° BENDS
2. All these are mounted on **interchangeable** lines for operation with necessary **Pressure tappings** at appropriate positions and **Ball valves** which is connected to a Manometer.
3. A measuring tank is provided to measure the flow rate.
4. **Piezometer** is provided to measure the height of the water collected in the measuring tank.
5. **Mercury filled Manometer** made of **Acrylic** is provided to measure the pressure difference.
6. **Ball valve** is provided in the measuring tank for instant close and release.
7. **Overflow arrangement** is also provided to the tanks.
8. A **supply pump (Kirloskar/Sharp make)** with starter is provided for supplying the water.
9. A **supply tank** is provided to store the water.
10. **Vinyl sticker scale** is provided for both **Manometer** and **Piezometer** for better readability.
11. The whole arrangement is mounted on an **Aesthetically designed sturdy frame** made of **MS angle** with all the provisions for holding the tanks and accessories.

THEORY BEHIND:

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

Here, we are going to consider two important losses that occur during flow,

1. Major Losses.
2. Minor Losses.

Major losses occur due to friction. This friction may be due to viscosity or roughness in the pipe.

Minor losses can be due to various reasons such as Inlet and Outlet of the pipe, bends, gates, sudden expansions and contractions.

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

PANEL DETIALS:

MAINS ON INDICATOR: To indicate the Power given to the system.

STARTER: Provided to activate the pump.

PRESSURE INDICATOR: To indicate the Pressure in digital format.

WATERFLOW INDICATOR: To indicate the Flow rate in digital format.

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Keep the delivery valve and all other ball valves in closed position except the manometer valves. If it is Digital Version there will be no Manometer hence close all other valves.
3. Connect the power cable to 1Ph, 220V, 10 Amps with proper earth connection.

LIMITATIONS

All indicators used are above the range so, there is no problem with the range of operation, however it is duty of person using it to be within the range.

PROCEDURE:

1. Switch on the pump & open the delivery valve.
2. Open the corresponding Ball valve of the pipeline in test.
3. Adjust the flow through the control valve of the pump to the maximum.
4. Open the corresponding Ball valves of the pipe line.
5. Note down the differential head reading.
6. Note down time for collection of “R cm” rise of water in collecting tank by operating the Ball Valve.
7. Change the fittings and repeat the experiment.

PROCEDURE FOR COMPUTERIZED

1. Switch on the computer
2. Open the corresponding Software of the instrument.

3. Specify the username.

4. Select the "COMPORT" and "TYPE OF METER" under test, once selected the connectivity is created.

5. Press "START" button on the menu bar, Now, all the indications will be showing on the monitor.

6. Now, Switch on the pump & open the delivery valve.

7. Open the corresponding Ball valve of the pipeline in test.

8. Adjust the flow through the control valve of the pump to the maximum.

9. Open the corresponding Teflon Ball valves fitted to tappings.

10. For the adjusted valve position, all the values will be displayed on the screen, now, press "STORE" button to store the required data.

11. Repeat the Step 8 to 10 for different fittings.

12. Once experiment is completed, press "STOP" button on the screen to stop the experiment.

13. Repeat the Step 2 to 11 for different meter.

14. For report follow the procedure given in ANNEXURE – 1.

OBSERVATIONS:

<table>
<tr><th rowspan="2">Sl. No</th><th rowspan="2">TYPE OF FITTING</th><th colspan="2">MANOMETER READING</th><th colspan="2">Time for 'R' cm rise in water
't' sec
Or
Flow meter reading in</th></tr>
<tr><th>bar</th><th>X10m</th><th>LPM</th><th>m^3/sec</th></tr>
<tr><td>1</td><td rowspan="4"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td><td></td><td></td></tr>
</table>

CALCULATIONS

1. **Pressure Head, H**

H = (Reading in digital meter x 10) m of water

2. **Actual Discharge, QA**

$$Q_A = \frac{A \, x \, R}{t \, x \, 100} \; m^3/s$$

Where,

A = Area of collecting tank = m².
R = Rise in water level of the collecting tank, cm.
t = time for 'R' cm rise of water, sec
100 = Conversion from cm to m.

3. **VELOCITY, V**

$$V = \frac{Q}{A'} \quad m/s$$

Where,

A' = area of the pipe/fittings in use= $A' = \frac{\pi \, x \, D^2}{4} \; m^2$

Where,

Sl No.	Type of Fittings	Diameter to be considered, 'D' in	
		mm	m
1	1" GI Pipe	25.4	0.0254
2	1/2 " GI Pipe	12.7	0.0127
3	Contraction	12.7	0.0127
4	Expansion	12.7	0.0127
5	Union	25.4	0.0254
6	Collar	25.4	0.0254
7	Bends	25.4	0.0254

4. **FRICTION FACTOR, F:**

$$F = \frac{2gHD}{4LV^2}$$

5. LOSS DUE TO FITTINGS, K:

$$K = \frac{2gH}{V^2}$$

Where,

H = total head, m of water column
D = Diameter of the Pipe considered, m
V = velocity, m/s
g = acceleration due to gravity, 9.81 $1/s^2$
L = Distance b/w tapping = 1.5m

TABULATIONS :

Loss of Head, m of water column	Actual Discharge, QA m^3/sec	Velocity, V m/s	Co – Efficient of Friction, F or Loss due to fitting, K	Remarks

DISCUSSIONS ON THE RESULTS :
General Possibilities of Errors if occurred.
Outcome of Results

CONCLUSIONS OF THE RESULTS TABULATED:
Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS

PRECAUTIONS

1) Do not run the pump dry.
2) Clean the tanks regularly, say for every 15days.
3) Do not run the equipment if the voltage is below 180V.
4) Check all the electrical connections before running.
5) Before starting and after finishing the experiment the main control valve should be in close position.
6) Do not attempt to alter the equipment as this may cause damage to the whole system.

RESULTS:

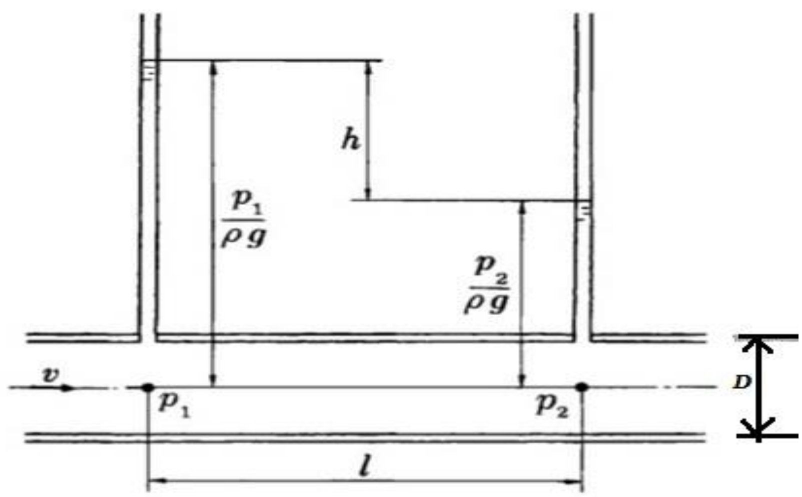
1. The average coefficient of friction for the pipe of 1.5 cm diameter, f =

   From graph hf Vs $V^2/2g$, the coefficient of friction, f =
2. The average coefficient of friction for the pipe of 2.0 cm diameter, f =

   From graph hf Vs $V^2/2g$, the coefficient of friction, f=

Viva Questions:

1. What are the minor losses in pipe flow?
2. What are the major losses in pipe flow?
3. What is the Darcy's frictional factor?
4. What are the forces consider in pipe flow?
5. What do you understand by total energy line?
6. What do you understand by hydraulic gradient line?
7. What do you understand by pipes in series?
8. What do you understand by pipes in parallel?
9. What is an equivalent pipe?
10. What is a compound pipe?
11. What will be loss of head when pipes are connected in series?
12. What will be loss of head when pipes are connected in parallel?



MAJOR LOSSES

Exp No: Date:

MINOR LOSSES IN PIPES

AIM:

The experiment is conducted to determine:

a. Determination of Pressure drop across different pipes.
b. Comparative analysis of different type of pipes.
c. Friction factor for different pipe fittings.
d. Comparative analysis of friction factor through different pipe fittings.

DESCRIPTION OF THE APPARATUS:

1. The apparatus has 4 different **specially made pipelines** comprising of
   e. **1" G.I**
   f. **1/2" G.I**
   g. **1" PVC**
   c. **1"G.I** pipe with Reducing Collar, Enlarging collar, Union and Collar
   h. **1"G.I** pipe with 90° BENDS
2. All these are mounted on **interchangeable** lines for operation with necessary **Pressure tappings** at appropriate positions and **Ball valves** which is connected to a Manometer.
3. A measuring tank is provided to measure the flow rate.
4. **Piezometer** is provided to measure the height of the water collected in the measuring tank.
5. **Mercury filled Manometer** made of **Acrylic** is provided to measure the pressure difference.
6. **Ball valve** is provided in the measuring tank for instant close and release.
7. **Overflow arrangement** is also provided to the tanks.
8. A **supply pump (Kirloskar/Sharp make)** with starter is provided for supplying the water.
9. A **supply tank** is provided to store the water.
10. **Vinyl sticker scale** is provided for both **Manometer** and **Piezometer** for better readability.
11. The whole arrangement is mounted on an **Aesthetically designed sturdy frame** made of **MS angle** with all the provisions for holding the tanks and accessories.

THEORY BEHIND:

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

Here, we are going to consider two important losses that occur during flow,

3. Major Losses.
4. Minor Losses.

Major losses occur due to friction. This friction may be due to viscosity or roughness in the pipe.

Minor losses can be due to various reasons such as Inlet and Outlet of the pipe, bends, gates, sudden expansions and contractions.

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

PANEL DETIALS:

MAINS ON INDICATOR: To indicate the Power given to the system.

STARTER: Provided to activate the pump.

PRESSURE INDICATOR: To indicate the Pressure in digital format.

WATERFLOW INDICATOR: To indicate the Flow rate in digital format.

PREPARATION OF EQUIPMENT:

1. Fill in the sump tank with clean water.
2. Keep the delivery valve and all other ball valves in closed position except the manometer valves. If it is Digital Version there will be no Manometer hence close all other valves.
3. Connect the power cable to 1Ph, 220V, 10 Amps with proper earth connection.

LIMITATIONS

All indicators used are above the range so, there is no problem with the range of operation, however it is duty of person using it to be within the range.

PROCEDURE:

1. Switch on the pump & open the delivery valve.
2. Open the corresponding Ball valve of the pipeline in test.
3. Adjust the flow through the control valve of the pump to the maximum.
4. Open the corresponding Ball valves of the pipe line.
5. Note down the differential head reading.
6. Note down time for collection of “R cm” rise of water in collecting tank by operating the Ball Valve.
7. Change the fittings and repeat the experiment.

PROCEDURE FOR COMPUTERIZED

1. Switch on the computer
2. Open the corresponding Software of the instrument.

3. Specify the username.

4. Select the “COMPORT” and “TYPE OF METER” under test, once selected the connectivity is created.

5. Press “START” button on the menu bar, Now, all the indications will be showing on the monitor.

6. Now, Switch on the pump & open the delivery valve.

7. Open the corresponding Ball valve of the pipeline in test.

8. Adjust the flow through the control valve of the pump to the maximum.

9. Open the corresponding Teflon Ball valves fitted to tappings.

10. For the adjusted valve position, all the values will be displayed on the screen, now, press “STORE” button to store the required data.

11. Repeat the Step 8 to 10 for different fittings.

12. Once experiment is completed, press “STOP” button on the screen to stop the experiment.

13. Repeat the Step 2 to 11 for different meter.

14. For report follow the procedure given in ANNEXURE – 1.

OBSERVATIONS:

Sl. No	TYPE OF FITTING	MANOMETER READING		Time for ‘R’ cm rise in water ‘t’ sec Or Flow meter reading in	
		bar	X10m	LPM	m^3/sec
1					
2					
3					
4					

CALCULATIONS

1. **Pressure Head, H**

H = (Reading in digital meter x 10) m of water

2. **Actual Discharge, QA**

$$Q_A = \frac{A \, x \, R}{t \, x \, 100} \; m^3/s$$

Where,

A = Area of collecting tank = m^2.
R = Rise in water level of the collecting tank, cm.
t = time for 'R' cm rise of water, sec
100 = Conversion from cm to m.

3. **VELOCITY, V**

$$V = \frac{Q}{A'} \quad m/s$$

Where,

A' = area of the pipe/fittings in use= $A' = \frac{\pi \, x \, D^2}{4} \; m^2$

Where,

Sl No.	Type of Fittings	Diameter to be considered, 'D' in	
		mm	m
1	1" GI Pipe	25.4	0.0254
2	1/2 " GI Pipe	12.7	0.0127
3	Contraction	12.7	0.0127
4	Expansion	12.7	0.0127
5	Union	25.4	0.0254
6	Collar	25.4	0.0254
7	Bends	25.4	0.0254

4. **FRICTION FACTOR, F:**

$$F = \frac{2gHD}{4LV^2}$$

5. **LOSS DUE TO FITTINGS, K:**

$$K = \frac{2gH}{V^2}$$

Where,

H = total head, m of water column
D = Diameter of the Pipe considered, m
V = velocity, m/s
g = acceleration due to gravity, 9.81 $1/s^2$
L = Distance b/w tapping = 1.5m

TABULATIONS :

Loss of Head, m of water column	Actual Discharge, QA m^3/sec	Velocity, V m/s	Co – Efficient of Friction, F or Loss due to fitting, K	Remarks

DISCUSSIONS ON THE RESULTS :
General Possibilities of Errors if occurred.
Outcome of Results

CONCLUSIONS OF THE RESULTS TABULATED:
Summarizing the entire operation and graphs if any
Describing the possible error factors and corrections
Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

DISCUSSIONS OF THESE INSTRUMENTS IN VARIOUS INDUSTRIAL APPLICATIONS
Graphs:

1. Head loss due to friction, hf vs Velocity, V.
2. Head loss due to friction, hf vs Velocity head, $V^2/2g$.

PRECAUTIONS

1. Do not run the pump dry.
2. Clean the tanks regularly, say for every 15days.
3. Do not run the equipment if the voltage is below 180V.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main
    a. control valve should be in close position.

6) Do not attempt to alter the equipment as this may cause

damage to the whole system.

<u>RESULTS</u>:

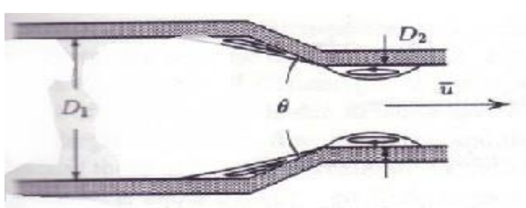
1. The average coefficient of friction for the pipe of 1.5 cm diameter, f =

   From graph hf Vs $V^2/2g$, the coefficient of friction, f =
2. The average coefficient of friction for the pipe of 2.0 cm diameter, f =

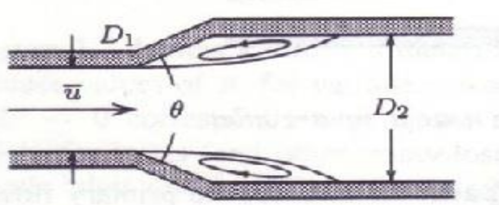
   From graph hf Vs $V^2/2g$, the coefficient of friction, f=

Viva Questions:

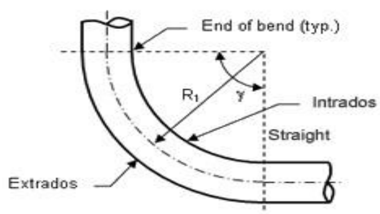
1. What are the minor losses in pipe flow?
2. What are the major losses in pipe flow?
3. What is the Darcy's frictional factor?
4. What are the forces consider in pipe flow?
5. What do you understand by total energy line?
6. What do you understand by hydraulic gradient line?
7. What do you understand by pipes in series?
8. What do you understand by pipes in parallel?
9. What is an equivalent pipe?
10. What is a compound pipe?
11. What will be loss of head when pipes are connected in series?
12. What will be loss of head when pipes are connected in parallel?



CONTRACTION



EXPANSION



ELBOW/BENDS

MAJOR & MINOR LOSSES