FLUID MECHANICS AND HYDRAULIC MACHINERY

LABORATORY MANUAL

B.TECH
(II YEAR – I SEM)
(2019-20)

Department of Mechanical Engineering

MALLA REDDY COLLEGE
OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

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Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – ‘A’ Grade - ISO 9001:2015 Certified)

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LIST OF EXPERIMENTS

S.No.	NAME OF THE EXPERIMENT
1	Calibration of Venturi meter
2	Calibration of Orifice meter
3	Performance Test on Centrifugal Pump
4	Performance Test on Reciprocating Pump
5	To calculate Friction Factor for a given Pipe Line
6	Impact of jet of water on Vane
7	Performance Test on Pelton Wheel
8	Bernoulli's experiment
9	Performance Test on Francis Turbine
10	Performance Test on Kaplan Turbine

Objectives:

- Student able to learn about different measuring devices, working Principles and their performances
- To calculate Cd, c_c, c_v and Coefficient of impact of varioushydraulic systems
- Student able to learn about different characteristics of Turbines.
-

Outcomes:

-

Student's exposure to study various operating characteristics of Centrifugal pump and Reciprocating pump.

Student's exposure to study various operating characteristics of Kaplan, Francis and Pelton Wheel Turbines.

- Get Exposure to verification of Bernoulli's Theorem.

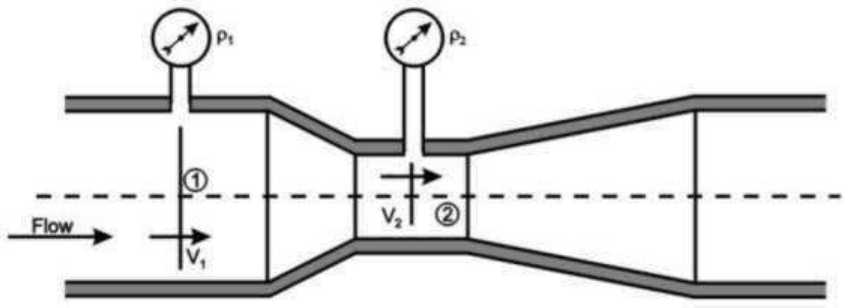
EXPERIMENT: 1

CALIBRATION OF VENTURIMETER

Aim: - To calibrate a given venture meter and to study the variation of coefficient of discharge of it with discharge.

Apparatus: -.

(1) Venturi Meter
(2) Piping System
(3) Supply Pump Set
(4) Measuring Tank
(5) Differential Manometer
(6) Sump
(7) Stop Watch



Theory: - A venture meter is a device that is used for measuring the rate of flow of fluid through a pipeline. The basic principle on which a venture meter works is that by reducing the cross - sectional area of the flow passage, a pressure difference is created between the inlet and throat & the measurement of the pressure difference enables the determination of the discharge through the pipe. A Venturi meter consists of an inlet section followed by a convergent cone, a cylindrical throat, and gradually divergent cone.

The inlet section of the venture meter is of the same diameter as that of the pipe, which is followed by a convergent one. The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the throat of the venturi meter. The throat of the venturi meter is a short parallel side tube having its cross – sectional area smaller than that of the pipe. The divergent cone of the venturi meter is a gradually diverging pipe with its cross – sectional area increasing from that of the throat to the original size of the pipe. At the inlet and the throat, of the venture meter, pressure taps are provided through pressure rings.

Specifications:-

Flow Meters: Consists of venture meter of size 25 mm provided for experiments. The meter has the adequate cocks also with them

Piping System: Consists of a set of G.I. piping of size 25 mm with sufficient upstream and downstream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and downstream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common Pipe for easy operation.

Supply Pump Set: Is rigidly fixed on sump. The mono block pump with motor, operating on single phase 220/240 volts 50 Hz AC supply.

Measuring Tank: Measuring tank with gauge glass and scale arrangement for quick and easy measurement.

Differential Manometer: Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.

Sump: Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Procedure:-

1. Check whether all the joints are leak proof and water tight. Fill the manometer to about half the height with mercury

2. Close all the cocks, pressure feed pipes and manometer to prevent damage and overloading of the manometer. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water height and vertically.

3. Check proper electrical connections to the switch, which is internally connected to the motor. First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.

4. The actual discharge is measured with the help of the measuring tank. The differential head produced by the flow meter can be found from the manometer for any flow rate.

5. Start the motor keeping the delivery valve close. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.

6. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometers upper part and the connecting pipes with water by venting the air from the pipes.

7. Note down the difference of head "h" from the manometer scale, and time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch.

Sample Calculations:-

1. Calculate actual discharge using below formula.
   Discharge: - The time taken to collect some, R cm of water in the collecting tank in m^3/sec.

$$Q_{act} = \frac{A \times R}{t}$$

Where,

A = area of the collecting tank in m^2 (0.3m X 0.3m)

R = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to rise, „R" in„t" seconds.

2. Using difference in mercury level "h" calculate the theoretical discharge of venturimeter by using following expression

$$Q_{the} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

Where ,

h= difference of head in meters = (h1 -h2) x $\frac{S_m}{S_w} - 1)$

= $(h_1 – h_2)$ x 12.6 m

a_1= Area of venture at inlet = $(\prod /4)\ d_1^2$ m^2

a_2= Area of venture at throat = $(\prod /4)\ d_2^2$ m^2

g =Acceleration due to gravity

d_1 =Inlet diameter in meters. d2 =Throat diameter in meters.

S_m = Specific gravity of mercury =13600

S_w = Specific gravity of water = 1000

3. Calculate the coefficient of discharge of orifice meter (**C_d**): $\frac{Q_{Act}}{Q_{Theo}}$

S. No	Venturi inlet diameter d_1	Throat Diameter d_2
1	25 mm	13.5 mm

Viva- Voce Questions:

1. What is a venturi meter?
2. What are the main parts of a venturi meter?
3. Define coefficient of Discharge (C_d)?
4. What is the value of coefficient of Discharge (C_d)?
5. What is a nozzle? Is there any relation between nozzle and venturi meter?
6. Define coefficient of Velocity?

EXPERIMENT: 2

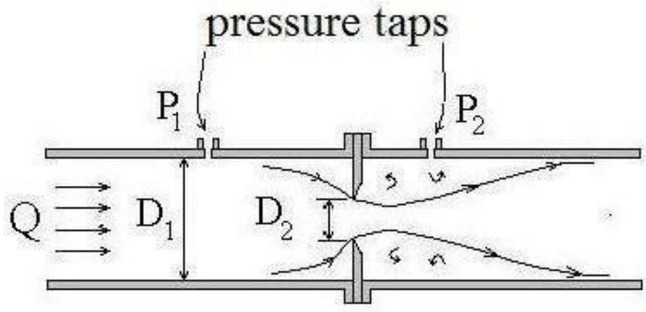
CALIBRATION OF ORIFICE METER

Aim: - To calibrate a given Orifice meter and to study the variation of coefficient of discharge.

Apparatus:-

The apparatus consists of (1) Orifice meter (2) Piping system (3) supply pump set (4) Measuring tank (5.) Differential manometer (6) Sump

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



Specification:-

1. **Flow Meters:** Consists of Orifice meter of size 25 mm provided for experiments. The meter has the adequate cocks also with them.
2. **Piping System:** Consists of a set of G.I. piping of size 25 mm with sufficient upstream and downstream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and downstream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common plate for easy operation.
3. **Supply Pump Set:** Is rigidly fixed on sump. The mono block pump with motor. Operating on single phase 220/240 volts 50 Hz AC supply.
4. **Measuring Tank:** Measuring tank with gauge glass and scale arrangement for quick and easy measurement.
5. **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.
6. **Sump:** Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Procedure:-

1. First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.
2. Check whether all the joints are leak proof and water tight. Fill the manometer to about half the height with mercury.

3. While taking readings, close all the cocks in the pressure feed pipes except the two (Down-stream and upstream) cocks which directly connect the manometer to the required flow meter, for which the differential head is to be measured. (Make sure while taking reading that the manometer is properly primed. Priming is the operation of filling the manometer upper part and the connecting pipes with water and venting the air from the pipes).

Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.

4. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
5. Check proper electrical connections to the switch, which is internally connected to the motor.
6. Start the motor keeping the delivery valve close. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
7. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).
8. Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometer s upper part and the connecting pipes with water by venting the air from the pipes. Note down the difference of head "h" from the manometer scale.
9. Note down the time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch.

Sample calculations:-

1. Calculate actual discharge using the formula

   Discharge: - The time taken (t) to collect some R cm of water in the collecting tank

   $Q_{act} = A \times R/t$

   Where:

   A = Area of the collecting tank in m² (0.3m X 0.3m)

   R = Rise of water level taken in meters (say 0.1m or 10cm)

   t = Time taken for rise of water level to rise "R" cm in t seconds.

2. Using difference in mercury level "h" calculate the theoretical discharge of venturimeter

$$Q_{th} = \frac{a_1 * a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

Where,

a_1= Area of venture at inlet = $(\prod /4)\, d_1^2$ m^2

a_2= Area of venture at throat = $(\prod /4)\, d_2^2$ m^2

h = difference of head in meters = $(h_1-h_2) \times (\frac{S_m}{S_w} - 1)$= (h_1-h_2) X 12.6 m

g =Acceleration due to gravity.

d_1 =Inlet diameter in meters.

d_2 =Throat diameter in meters.

S. No.	Time for (10 cm) raise of water level in sec.	Actual discharge = Q_{act}	Differential head in mm of mercury			Theoretical discharge = Q_{the}	$C_d = Q_{act}/Q_{the}$
			h_1	h_2	H		
1							
2							
3							
4							
5							
6							
7							

3. Calculate the coefficient of discharge of orifice meter (C_d): $C_d = \frac{Q_{Act}}{Q_{Theo}}$

4. Repeat the steps 3 to 8 for different sets of readings by regulating the discharge valve.

Assume:

S.No.	Orifice inlet diameter d_1	Orifice diameter d_2
1.	25mm	13.0mm

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
6. Control valve should be in closed position.
7. Do not attempt to alter the equipment as this may cause

Results and Conclusions:-

Graphs: Draw the graphs between Q_{act} Vs Q_{the} Draw the graphs between C**d** Vs Q_{act}

Applications of Orifice meter: It is used as a flow measuring device.

Viva-Voce questions:-

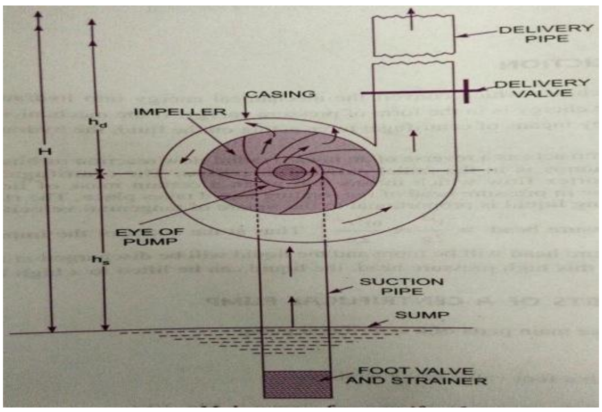
1. What is an Orifice meter?
2. What are the main parts of a orifice meter?
3. Define coefficient of Discharge (C_d)?
4. What is the value of coefficient of Discharge (C_d)?
5. What is the difference between Orifice meter and venturimeter?
6. What is the difference between Orifice meter and Orifice plate?

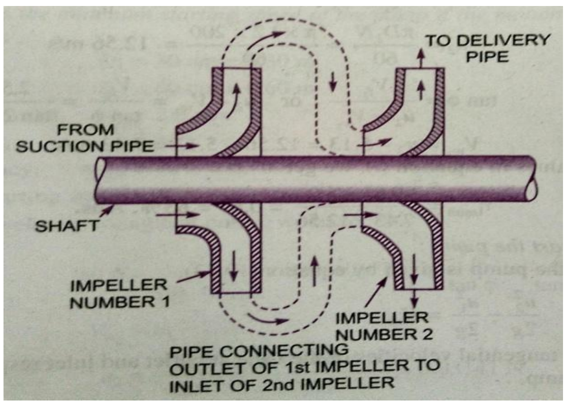
EXPERIMENT: 3
PERFORMANCE TEST ON CENTRIFUGAL PUMP

Aim: - To conduct a test at various heads of given centrifugal pump find its efficiency.

Apparatus: - The Test Rig mainly consists of (1) centrifugal pump set (2) Panel Board (3) Pressure and vacuum gauges to measure the head (4) Measuring Tank to measure the discharge (5) Energy meter to measure the input to the motor (6) Sump.

Theory: In general, a pump may be defined as mechanical device when connected in a pipe line, can convert the mechanical energy into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential. Pumps are of major concern to most Engineers and Technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, Reciprocating, Axial flow (stage pumps), air jet, diaphragm and Turbine pumps. Most of these pumps fall mainly into a class namely Rotodynamic, Reciprocating (positive displacement) and fluid operated pumps. In a Centrifugal pump, pressure head is developed by centrifugal action. The pump consists of an impeller, which rotates in a casing. Fluid enters through the eye of the pump and discharges radially outwards to the delivery pipe. Centrifugal Pumps also come based on the type of vanes: Backward curved blades, Radial Type and Forward Curved Type. Centrifugal pumps are commercially available as Single stage and Multi-stage pumps. In this pump, the liquid is made to rotate in a closed chamber (volute casing), thus creating the centrifugal action, which gradually builds the pressure gradient towards outlet thus resulting in the continuous flow. These pumps compared to Reciprocating pumps are simple in construction, more suitable for handling viscous, turbid (muddy), liquids can be directly coupled to high speed electric motors (without any speed reduction), easy to maintain. But, their hydraulic heads at low flow rates is limited and hence not suitable for very high heads compared to reciprocating pump of same capacity. But, still in most cases, this is the only type of pump, which is being widely used for agricultural applications because of its practical suitability. The present test rig allows the students to understand and draw the operating characteristics at various heads, flow rates and speeds.





Specifications:-

1. **Centrifugal Pump Set:** The pump set is of special design, horizontal spindle, and vertical split case. The pump is of such a size, type & design that 1) The total head 2) Discharge and 3) Power requirements at normal speed is well suited for the experimental purposes in technical institutions.

2. **A.C. Motor:** The electric motor suitable for operation on 50 cycles A.C. Supply is provided.

3. **Gauges:** Suitable range of pressure and vacuum gauges to measure the total head on the pump with reasonable accuracy.

4. **Measuring Tank:** Is provided to measure the discharge of the pump with overflow arrangement. The tank is complete with gauge glass and scale arrangement.

5. **Piping System:** Suitable piping system with pipes, bends and valves are provided. A Simple strainer valve is provided on the suction side to prevent any foreign matter entering into the pump. The gate valve is provided in the delivery side to control the head on the pump. While starting the motor always keep the valve in close position.

6. **Panel Board:** The Panel Board houses all the necessary electrical items, like switch, starter for the above pump set and an energy meter to read the power input and it is fitted with the unit on a strong iron base with sufficient height.

Procedure:-

1. Start the motor keeping the delivery valve close.

2. Note down the pressure gauge and vacuum gauge reading by adjusting the delivery valve to require head say 0 meters. Now calculate the total head (H).

   Pressure Head = Kg/cm^2 x 10 = meters.

   Vacuum Head = (mm of Hg X 13.6) / 1000 meters

   Datum head = Distance between pressure and vacuum gauge in meter

   Total Head (H) = Pressure Head + Vacuum head + Datum Head

3. Note down the time required for the rice of 10cm (i.e 0.1) Water in the collecting tank by using stop watch. Calculate discharge using below formulae.

Discharge: The time taken collect some 'R'cm of water in the collecting tank

$$Q_{act} = \frac{A * R}{t}$$

Where:

A = area of the collecting tank in m^2
R = rise of water level taken in meters (say 0.1m or 10cm)
t = Time taken for rise of water level to height 'R' in seconds.

4. Note down the time taken for n revolutions of energy meter disk and calculate the Input power.

$$\text{Input power} = \frac{n \times 3600 \times \eta}{EMC \times t}$$

η = Motor efficiency = 0.70

n = No. of revolutions of energy meter disc

t = Time for Energy meter revolutions of disc. in seconds

EMC = Energy meter constant

Single stage Centrifugal pump EMC = 3200

Multi stage Centrifugal pump EMC = 75

5. Now calculate the output power

$$\text{Output power} = \frac{w Q_{act} H}{1000} \quad kW$$

Where; w = Sp. Wt. of water (9810 N/m³)

Q_{act} = Discharge

H = Total Head

6. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve. A Typical tabular form is given below for convenience during experiments

S.No.	Pressure gauge reading	Vacuum gauge reading	Time taken for 5rev of energy meter disc	Time taken for collecting 10cm rise of water In collecting tank	Total head ($P+P_v$) meter	Discharge Q	Input Power kW	Output Power kW	Efficiency
1									
2									
3									
4									
5									

Sample Calculations:-

Total Head, H

$$H = (P + P_V/760) \times 10m \text{ of water}$$

Where,

P = Delivery Pressure P_v = Vacuum Pressure

$$\text{Input Power} = \frac{K \times 3600 \times \eta}{EMC \times t}$$

IP (Electrical)

$\acute{\eta}_m$ = 0.70 (70% assumed)
K = No ofrevolutions of energy meter
EMC =Energy Meter Constant
t= Time taken for „K_1 revolutions of Energy meter

$$\text{Output Power, OP (Hydraulic)} = \frac{WQ_{act} \quad H}{1000} Kw$$

Where,

W=1000 kg/m³

Q = Discharge, (A×R/**t)** **m³/sec**

H =Total Head in **m**

Graphs:-

1. Discharge Vs Head

2. Discharge Vs Input power
3. Discharge Vs Efficiency

Precautions:-

1. Don't start the pump if the voltage is less than 380 V
2. Don't forget to give Electrical neutral and earthing connections to the main plug
3. At least once in 3 months grease/oil the rotating parts
4. Initially put the clean water free from foreign material, and change the water once in 3 months.
5. At least every week, operate the unit for five minutes to prevent clogging of moving parts

Results and conclusions:-

Applications of a Centrifugal pump: It is used in Agriculture purpose.

It is used in Industrial purpose.

It is used in Agriculture purpose.

Viva questions:-

1. What is a pump?
2. Define centrifugal force?
3. Classify different types of pumps?
4. Differentiate single stage and multi stage pumps?
5. Define pressure head and Vacuum head?
6. Differentiate positive and non positive displacement pumps?

EXPERIMENT: 4
RECIPROCATING PUMP TEST RIG

Aim: - To conduct a test at various heads of given reciprocating pump finds its efficiency.
Apparatus: -The Reciprocating Pump Test Rig mainly consists of

1. A Reciprocating Pump
2. A Single phase 2.0 HP 1440 RPM AC Motor
3. Piping system & collecting tank
4. Input power Measuring arrangement and
5. SS Sump tank
6. Stop watch
7. Scale

Theory:- In general, a pump may be defined as mechanical device when connected in a pipe line, can convert the mechanical energy into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential. Pumps are of major concern to most engineers and technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, reciprocating, axial flow (stage pumps), air jet, diaphragm and turbine pumps. Most of these pumps fall mainly into a class namely roto dynamic, reciprocating (positive displacement) and fluid operated pumps. Reciprocating pump is based purely on mechanical concepts, since the liquid is displaced by a piston (plunger) moving in a cylinder. They discharge a definite quantity of liquid irrespective of the head on the pump i.e., positive displacement. However, in a single acting pump, water is sucked into the cylinder in the suction stroke and delivered out of the cylinder in the delivery stroke that is the discharge only on alternate strokes, where as in double acting pump there is suction and delivery in each stroke that is the discharge is continuous.

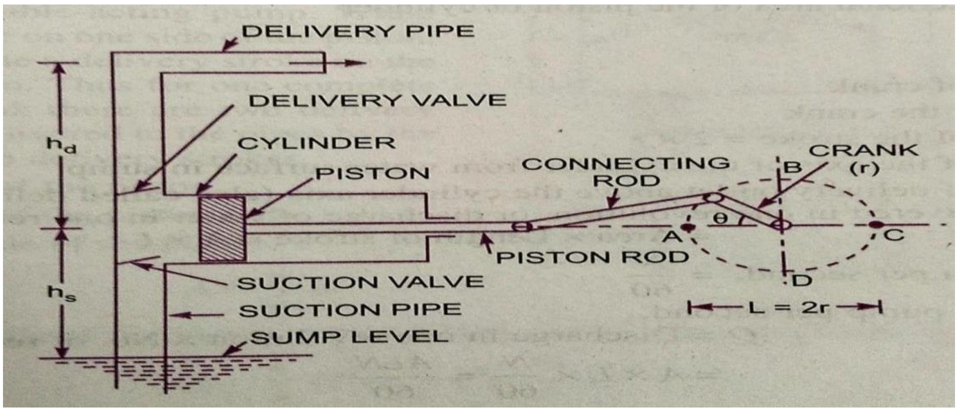
Pour the lubricating oil SAE 40 in the crankcase of the reciprocating pump to the required level once in a year. This will require about 250 cc of oil prime the pump before starting see that the V belt are in proper tension. Start the Motor keeping the delivery valve in fully open position. Open the gauge cocks, and see the pressure developed by the pump. Delivery control valve may be closed up to about 30 meters of the water head on the delivery side. Under any circumstances the valve should not be closed beyond 40 meters head on the delivery side. If the pressure exceeds this valve (40 Kg/sq.cm) the cylinder head gasket joints, piston, pressure gauge etc. would be damaged. To stop the pump set, first close the gauge cocks. Do not close the delivery valve on the other hand it may open fully. Then switch off the motor.

Specifications:-

1. **Reciprocating Pump:** The Reciprocating pump is of single acting type. The suction & Delivery size are 1" x 3/2" respectively. Bore: 38 mm, Stroke: 48 mm.
2. **Motor:** The Motor supplied is of 2 HP 1440 RPM. It can be operated on AC 50 cycles 220/ 230 V, through mains. A smaller HP motor can be used for normal working conditions, a higher power motor is selected to test the pump at higher speed, high pressure combinations, without over loading it.
3. **Piping System:** Suitable piping system with pipes, bends valves etc. Arrangement with Cocks is , also provided for connecting pressure and vacuum gauges to the delivery and Suction pipes.
4. A simple strainer valve is provided on the suction side to prevent any foreign matter from entering into the pump. The gate valve is provided on the delivery side to control the Head of the pump. Note that the delivery valve should never be closed when the pump is working.

   While starting the motor always keep the valve in open position. Otherwise the pump parts will be damaged. Collecting Tank: A Collecting tank is provided to measure the discharge water through piezo meter arrangement.
5. **Input Power Measurement:** A Kilowatt-hour meter is provided to measure the power input to the motor. The energy meter constant (The Number of Revolutions per minute of the energy meter Disc) is stamped on the meter. From this the input power can be easily calculated.
6. **Sump**: A Sump is provided compactly within the (Floor space of the main unit to store adequate water for circulation through the unit for experimentation)

Procedure:-



1. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically. Check whether all the joints are leak proof and water tight.
2. Check whether all the electric connection is correct. See that the gauges are mounted on the correct position and their cocks closed.
3. Delivery valve should be in fully open condition. Start the motor keeping the delivery valve fully open.
4. Note down the pressure gauge and vacuum gauge reading by adjusting the delivery valve to require head say in meters. Now calculate the total head (H).

Pressure Head = Kg/cm² x 10 = meters.

$$\text{Vacuum Head - } \frac{mm\ of\ Hg\ X\ 13.6}{1000} meters$$

Datum head = Distance between pressure and vacuum gauge in meters

Total head (H) = Pressure Head + Vacuum Head + Datum Head

5. Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by using stop watch. Calculate discharge using below formula.

Discharge:- The time taken to collect some (R) cm of water in the collecting tank in m^3/sec.

$$Q = \frac{A \times R}{t}$$

A = area of the collecting tank in m^2 (0.3m X 0.3m)

R = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to height R in seconds

6. Note down the time taken for „n‟ revolutions of energy meter disk and calculate the Input power.

$$\text{Input power} = \frac{V \times I}{\eta_t \times 1000} \text{ kW}$$

Where, η_t = Motor efficiency = 0.70

n = No. of revolutions of energy meter disc

t = Time for Energy meter revolutions of disc. in seconds

C = Energy meter constant

7. Output Power, OP (Hydraulic) = $\frac{WQH}{1000}$

W= Sp .Wt. of water (9810 N/m) Q =Discharge, m^3/sec

H = Total Head

1. Efficiency Of The Pump, η%
2. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve

Note: -- Maximum head should not exceed 2.5m (i.e. 2.5kg/sq. cm)

Graphs :

1. Discharge Vs Head
2. OP Vs Head
3. Efficiency Vs Head

Tabular Form

S. No.	Pressure gauge reading	Vacuum gauge reading		Time taken for collecting 10cm rise of water In collecting tank (t)	Total head (P + V) meters	Discharge Q	Input Powe r Kw	Output Power Kw	efficiency
1									
2									
3									
4									

Precautions:-

1. Don’t Start the pump if the voltage is less than 180V
2. Don’t forget to give Electrical neutral and earthling connections to the main plug.
3. At least once in 3 months grease/oil the rotating parts.
4. At least every week, operate the unit for five minutes to
5. prevent clogging of moving parts

Results and Conclusions:-

Viva Questions:

1) Difference between reciprocating and centrifugal pump
2) What is cavitation of a pump
3) What is priming of a pump
4) What is air vessel
5) What is the difference between vacuum head and datum head

EXPERIMENT: 5

FRICTION FACTOR FOR A GIVEN PIPE LINE

Aim: - To calculate the friction factor for a given pipe line.

Apparatus: - The unit consists mainly of 1) Piping System 2) Measuring Tank 3) Differential Manometer 4) Supply pump set 5) Sump.

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

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

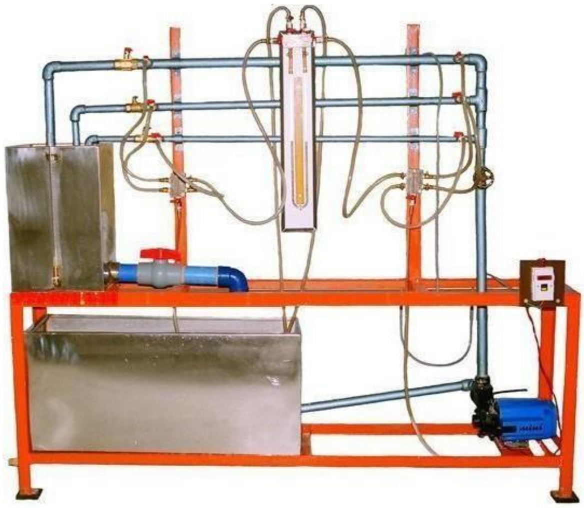
- Major Losses.
- Minor Losses.

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

Minor losses can be due to various reasons such as Inlet and Outlet of the pipe, bends, gates, sudden expansions and contractions. The apparatus is designed to study the friction losses that appear in long pipes and the obstructions that are encountered in the way of flow by various types of fittings.

The apparatus is primarily designed for conducting experiments on the frictional losses in pipes of different sizes. Three different sizes of pipes are provided for wide range of experiments. Each individual pipe can be connected to the Manometer through the pressure feed pipes having individual quick operating cocks. While taking reading close all the cocks in the pressure feed pipe except the two (upstream and downstream) cocks, which directly connect the manometer to the required pipe for which the loss in head has to be determined. (Make sure while taking readings, that the manometer is properly primed. Priming is the operating of filling the Manometer upper part and the connecting pipes with water venting the air from the pipes). First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.

Specifications:-



Piping System: Piping System of size 12.7 mm, 20 mm and 20 mm (S.S.) dia. With tapings at 1 meter distance and a flow control valve.

Measuring Tank: Measuring tank is provided to measure the discharge of water from the unit.

Differential Manometer: Differential manometer with 1 mm scale graduations to measure the loss of head in the pipe line.

Supply Pump Set: Supply pump set is rigidly fixed on the sump. The pump set is mono block pump with 0.5 HP motor operating on single phase 220 volts 50 Hz AC supply.

Sump: Sump is provided to store sufficient waters for independent circulation through the unit for experimentation and arranged within the floor space of the main unit

Procedure:-

1. Check whether all the joints are leak proof and water tight. Close all the cocks on the pressure feed pipes and Manometer to prevent damage and overloading of the manometer.
2. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertical. Check proper electrical connections to the switch, which is internally connected to the motor.
3. Start the motor keeping the delivery valve close.
4. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
5. By regulating the valve control the flow rate and select the corresponding pressure tapings.
6. Make sure while taking readings, that the manometer is properly primed. Priming is the operating of filling the Manometer upper part and the connecting pipes with water venting the air from the pipes. Note down the loss of head "hf" from the manometer scale.

7. Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by using stop watch. Calculate discharge using below formula.
8. The actual discharge is measured with the help of the measuring tank. For each size of the pipe the area of cross section of flow can be calculated from the known diameter of the pipes. From these two valves and the average velocity of stream through the pipe can be calculated.
9. The actual loss of head is determined from the Manometer readings. The frictional loss of head in pipes is given by the Darcy's formula. The friction coefficient indicates 'f '.
10. Repeat the steps 4 to 9 for different sets of readings by regulating the discharge valve

Sample calculations:-

Discharge: - The time taken to collect some 'R' cm of water in the collecting tank in m^3/sec.

$$Q = \frac{AxR}{t}$$

A = area of the collecting tank in m^2 (0.3m X 0.3m)
R = rise of water level taken in meters (say 0.1m or 10cm)
t = time taken for rise of water level to rise „r‟ in „t‟ seconds.

1. Calculate the velocity of the jet by following formula

$$V = \frac{\text{Discharge}}{\text{Area of the pipe}} = Q/A \text{ m/sec}$$

A = cross sectional area of the pipe= $\Pi d^2/4$
d = pipe diameter

2 . Calculate the coefficient of friction for the given pipe by

$$h_f = \frac{4fLV^2}{2gd}$$

Where,

h_f - Loss of head of water = $(h_1-h_2)(S_m/S_o - 1)$ = (h1-h2) 12.6 m

f - Co-efficient of friction for the pipe

L - Discharge between sections for which loss of head is measured (1 meter)

v - Average velocity of flow in m/sec

g - Acceleration due to gravity 9.81m/sec d - Pipe diameter in meters.

S. No.	Diameter of pipe	Area (a)	Manometer reading	Time for rise of 10 cm water	Discharge (Q)	Velocity (v)	Co-efficient of friction f

Calculation:-

1 Total Head, H

Where,

H = (h1 ± h2) x 12.6 m of water

12.6 = conversion factor from mercury to water head

2.Discharge, Q

$$Q - \frac{A \pm R}{t\,x\,100}\ m^3/s$$

Where,

A = Area of collecting tank = 0.125 m^2.

R = Rise in water level of the collecting tank, 10cm

T = Time taken for collecting tank

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

Where, A = area of the pipe/fitting in use

3 Friction Factor,

(Major Losses) F:

$A' = \frac{\pi x D^2}{4} m^2$

$F = \frac{2gd h_f}{4LV^2}$

Where, h_f = Head loss of the friction

d= Diameter of the pipe

H = Total head, m of water,

V = Velocity, m

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

L = Distance between tapping =1.5 m

K= Head loss due to fittings

(Minor Losses)

Loss of head due to sudden contraction = $0.5V_2^2/2g$

Loss of head due to sudden contraction = $(V_1 - V_2)^2/2g$

g = acceleration due to gravity, 9.81m/s^2

Precautions:-

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

Result and Conclusions:-

Applications of friction factor for a given pipe line:-

1. It is used to calculate the losses

Viva- Questions:-

1. What is friction factor?
2. Define Darcy's Wiezbach equation.
3. Classify different Major Losses.?
4. Classify different Minor losses.
5. Difference between ideal fluid and real fluid.
6. What is the value of friction factor?

EXPERIMENT: 6

IMPACT OF JET OF WATER ON VANE

Aim: To find the coefficient of impact of jet on flat circular and hemispherical vanes.

Apparatus: - The apparatus consists of mainly (1) Nozzle housing, (2) Nozzle, (3) Vane,

(4) Transparent Tank (5) Measuring Tank (6) Sump and (7) Stop watch.

Theory:-When a jet of water is directed to hit a vane of any particular shape, the force is exerted on it by the fluid in the opposite direction. The amount of force exerted depends on the diameter of the jet, shape of the vane and flow rate of water. The force also depends on whether the vane is moving or stationary. The current experiment deals with the force exerted on stationary vanes.

The following are the theoretical formulae for calculating the force for different shapes of vanes based on the flow rate.

Spherical Plate: $F_t = 2 \rho A V^2 / g$

Flat Plate: $F_t = \rho A V^2 / g$

Inclined plate $F_t = \rho A V^2 \sin\theta / g$

Where,

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

A= Area of jet in m

ρ = Density of water = 1000 Kg/m^3

V = Velocity of jet in m/s

Θ = Angle the deflected jet makes with the axis of the striking jet = 60°

Ft = Theoretical force acting parallel to the direction of the jet.

Nozzle housing

It is of M.S rigidly fixed to the bottom of the tank having transparent tube and suitable to accommodate nozzle.

Nozzle: It is of Gun Metal machined and polished nozzle of 8 mm is supplied.

Vane: It is of Gun Metal machined all over and interchangeable. Flat vane with normal input. Hemispherical vane with normal input.

Transparent Tank: To observe the flow and jet deflection the tank is fitted with transparent tube.

Measuring Tank: It is of suitable size and provided with gauge glass, scale arrangement for quick and easy measurements. A Ball valve is provided to empty the tank.

Sump: It is of suitable size with a supply pump set of 1 HP operating on single phase 220-240V 50Hz AC Supply, and a drain plug to drain the water when the unit is not in use.

The jet of water impinging on vane exerts force on it. The force exerted on it is derived by applying impulse momentum equation to control volume of water. The force exerted by a jet of fluid on symmetric vane is given by

$$F_{the} = \rho a V^2$$

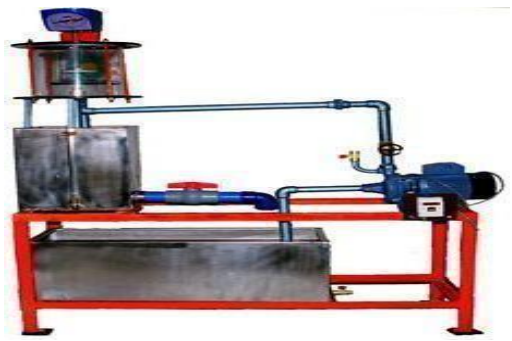
The apparatus is primarily designed for measuring the force on vane due to the impact of jet of water. Aluminum Vane is supplied to study the effect of the deflection of the impinging jet on the vane. The actual discharge is measured by using the measuring tank, by noting the time for a definite rise of water level when the water is collected in the tank. One gunmetal Nozzle of diameter 8 mm is provided. The *Co*-efficient of contraction of the nozzle can be taken as 0.67. The actual impinging jet velocity (V) in meters per second be calculated from the above flow rate and the area of the nozzle (a) in square mm.. The theoretical force (F_1 in Kg) on the vane in the direction of the jet is equal to the change of momentum per second.

Fix the transparent tube on the measuring tank with the help of four bolts and nuts provided. Make sure that the discharge spout is exactly center of the vane and connect the necessary piping to the apparatus. A typical tabular form for use during experiments is attached herewith.

For flat vane $F_{the} = \rho a V^2$

For hemispherical vane $F_{the} = 2\rho a V^2$

F_{act} = (Observed reading in 'gm' + 250 'gm') x 9.81 Newton



Procedure:-

1. Check whether the nozzle housing, discharge pipe flange etc are fitted with gaskets to prevent water leakage.
2. Check the gauge glass and meter scale assembly of the Measuring tank and see that it is Fixed water tight and vertical.
3. Start the motor keeping the delivery valve close.
4. The water is allowed to flow through the pipe by regulating the flow control valve up to some extent of actual force say 100gm. Convert the 100gm into Newton's and note down as actual force.

Q = A x R5. Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by Using stop watch. Calculate discharge using below formula.

Sample calculations:-

1. Discharge**:** The time taken to collect some 'R' cm of water in the collecting tank in m^3/sec.

$$Q_{act} = \frac{A \times R}{t}$$

Where,

A = area of the collecting tank in m^2 (0.3m X 0.3m)

R = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to rise 'R' in t seconds.

2. Calculate the velocity of the jet by following formula

$$V = \frac{\text{Rotometer reading}}{60000 \times \text{Area of the jet}} = \quad \text{m/sec}$$

A = cross sectional area of the jet = $\Pi d^2/4$

D = diameter of the nozzle = 5mm = 0.005m

3. Calculate the theoretical force by the momentum equation $F_{th} = \rho a V^2$

ρ = Density of water =1000 kg/m^3

Ø = angle made by the velocity of the jet with outlet tangent of the vane, which is zero in our case.

For flat vane F_{the} = $\boldsymbol{\rho a V^2/g}$.

For hemispherical vane F_{the} = $\boldsymbol{2\rho a V^2/g}$.

For inclined vane F_{the} = $\boldsymbol{\rho a V^2 \sin\theta/g}$.

Fact = (observed reading in „gm" + 250 „gm") x 9.81 **N**ewton

4. Repeat the steps from 2 to 4 for various heads by regulating the delivery valve.
5. A Typical tabular form for use during experiments is attached here with.

S.No	Type of vane	F_{act}	Velocity	F_{the}	Vane Co- eff. F_{act}/F_{th}
1					
2					
3					
4					
5					
6					

Precautions:

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

Results and Conclusions:-

Application of impact of jet: This is mainly used in hydraulic turbines.

Viva- Questions:-

1. Define the term jet?
2. What is impact of a jet?
3. Is there any difference between efficiency and vane co-efficient?
4. What is vane?
5. Is there any similarity between jet and nozzle?

EXPERIMENT: 7

PELTON WHEEL TURBINE TEST RIG

Aim: To conduct performance test on the given Pelton wheel turbine

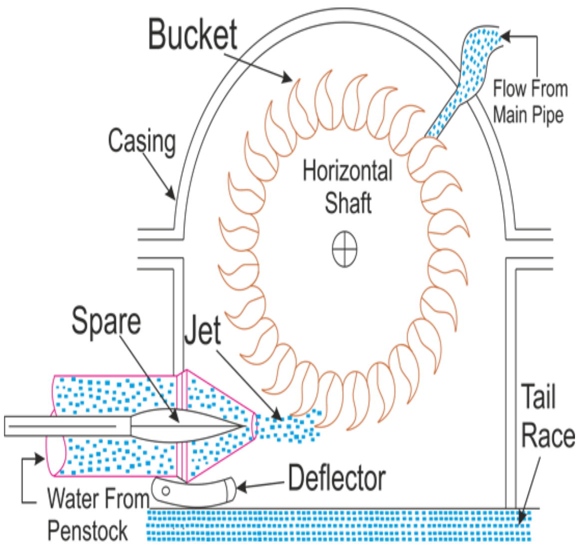
Apparatus: Pelton wheel turbine test rig

Theory:- Hydraulic (or Water) Turbines are the machines that use the Energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the Turbines become the Prime over to run Electrical Generators to produce electricity, Viz., Hydro Electric Power.

Turbines are classified as Impulse and Reaction Types. In Impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Of many types of Turbine, the Pelton Wheel, most commonly used, falls into this category of Impulse Turbine while the Francis & Kaplan fall into the category of Reaction Turbines.

Normally, Pelton Wheel requires high Heads and Low Discharge while the Francis & Kaplan (Reaction Turbines) requires relatively low Heads and high Discharge. These corresponding Heads and Discharges are difficult to create in a laboratory size Turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understating of various elements associated with any particular Turbine is possible with this kind of facility. The unit essentially consists of casing, with a circular transparent window kept at the front for the visual inspection of the impact of the Jet on buckets. a bearing pedestal, a rotor assembly of shaft, Runner & brake drum, all mounted on a suitable sturdy iron base plate,

A rope brake arrangement is provided to load the turbine. The input to the turbine can be controlled by adjusting the spear position by means of a hand wheel fitted. The water inlet pressure is measured by a pressure gauge and for the measurement of speed a digital tachometer is used. An Optimum size sump is provided to store sufficient water from independent circulation through the unit for experimentation



Pour adequate water in the sump. Make sure before starting that the pipe lines are free from foreign matter. Also note whether all the joints are water tight and perfectly matched. Prime the pump and start it with closed gate valve. Then slowly open the gate valve situated above the turbine and open the cock fitted to the pressure gauge and so that the pump develops the rated head. If the pump develops the required head, slowly open the turbine spear by rotating the hand wheel until the turbine attains the normal rated speed (1000 RPM). Run the turbine at the normal speed for about 10 minutes and carefully note the following:

- Operation of the bearings, temperature rise, noise etc
- Vibration of the unit.
- Steady constant speed and speed fluctuations if any.

In addition to this, on the sump side note the operation of the stuffing box. (The stuffing box should show an occasional drip of water. If the water through the brake drum when the turbine runs under load, so that the heat generated by the brake drum is carried away by the cooling water. Do not suddenly load the turbine, load the turbine gradually and at the same time open the spear to run the turbine at normal speed.

Water turbines are tested in the hydraulic laboratory to demonstrate the principles of water turbines, to study their construction, and to give the students a clear knowledge about the different types of turbines and their characteristics. Turbines shall be first tested at constant net supply head by varying the load, speed and spear setting. However the net supply head on the turbines tested in which case the power developed by the turbine and the best efficiently speed will also be reduced. The output power from the turbine is calculated from the readings taken on the brake and the speed of the shaft. The input power supplied to the turbine is calculated from the net supply head on the turbine and discharge through the turbine. Efficiency of the turbine being the ratio between the output and input and can be determined from these two readings. The discharge is measured by the 50mm Venturi meter and with the Pressure Gauges. Supply Head is measured with the help of the pressure gauge. The speed of the turbine is measured with digital tachometer fitted to the turbine. After starting and running the turbine at normal speed for the sometime, load the turbine and take readings.

Specifications:-

Casing: of an iron having a large circular transparent Window.
Runners: of electroplated MS disc fitted with accurately finished electroplated buckets.
Shaft: of Stainless steel for rust free operation and for high strength.
Nozzle: designed for smooth flow and efficient operation.
Pelton Turbine:-

	1. Power output	:	1 KWatt
	2. No. of Buckets	:	17Nos.
Supply Pump set:-	1. Capacity	:	5 HP
	2. Type	:	Centrifugal

Flow Measuring Unit:-

1. Size of Venturi meter : 50 mm.
2. Diameter of inlet : 50 mm
3. Diameter of throat : 25 mm.

Procedure:-

1. Connect the supply water pump-water unit to 3 ph, 440V, 30A, electrical supply, with neutral and earth connections and ensure the correct direction of the pump motor unit.
2. Check whether all the joints are perfectly matched, and all the electric connections are connected correctly.
3. Keep the Gate Valve and Sphere valve closed position and the Brake Drum loading at zero.
4. Press the green button of the supply pump starter. Now the pump picks-up the full speed and becomes operational.
5. Slowly open the Sphere Valve so that the turbine rotor picks the speed and conduct experiment on constant speed. Note down the readings of speed, load and pressure gauges readings and tabulated below.
6. Press the green button of the supply pump starter. Now the pump picks-up the full speed and becomes operational.
7. Slowly open the Sphere Valve so that the turbine rotor picks the speed and conduct experiment on constant speed.
8. Note down the readings of speed, load and pressure gauges readings and tabulated below.
9. For any particular setting of the spear first run the turbine at light load and then gradually load it. The net supply head on the turbine shall be maintained constant at the rated value and this can be done by adjusting the gate valve fitted just above the turbine. A typical tabular form is givenbelow for the convenience during experiment.

Sample Calculations :-

$$\text{Efficiency} = \frac{\text{Output power}}{\text{Input Power * Frictional efficiency}} \times 100$$

Input Power = 9810 x Supply head in meters (H) x Discharge(Q) $= \frac{W \times Q \times H}{1000}$ kw

Frictional efficiency=85%= 0.85 Q = Discharge = $K\sqrt{h}$ m^3/sec

Where, $h = (P_1 - P_2) \times 10$ m

$$K = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where, a_1 = Diameter of the venturimeter inlet = 50 mm = 0.05m

a_2 = Diameter of the Venturimeter throat = 25 mm =0.025m

P_1 =Inlet pressure,

P_2 =Throat pressure

Output Power = $\frac{2\Pi NT}{60000\ N}$ Kw.

$$OP = \frac{2\pi NT}{60000\ x\ \eta_T}\ kW$$

N = RPM of the turbine shaft
T= Torque of the turbine shaft
T= (W_1-W_2) x R x 9.81
W = Load applied on the turbine.
R = Radius of the brake drum with rope in meters = 0.12 meters

Where, P = Pressure gauge readings in Kg/Cm^2
H =Total Head of Turbine in meters of water,

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

Pv = Vacuum ~~P~~ress~~s~~ure gauge m of water readings in mm of hg
Discharge, Q from the below equation

$$Q = \frac{Cd * A1 * A2 * \sqrt{2gh}}{\left(\sqrt{A1^2 - A2^2}\right)}\ m^3/s$$

Where, h = $(P_1 - P_2)$ x 10 meters
A_1 = Area of the Inlet $= \pi d_1^2/4$
Where, d_1 = Inlet diameter = 50 mm
A_2 = Area of the Inlet = $\pi d_2^2/4$
d_2 = Inlet diameter = 25 mm

C_d = 0.95 (Constant) for Venturimeter or
C_d = 0.62 (Constant) for Orifice enter
Input to the turbine, IP (Hydraulic) is

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

Where, W = 9810 Kg/m^3
Q =Discharge in m^3/s
H =Total Head in m of water
Output from turbine, OP (Mechanical Work done)
Where,
N = Turbine Speed in rpm
T = Torque in N-m T= F X R X 9.81 N m
η_T = Transmission Efficiency =0.8

Where $F = F_1 \sim F_2$

R = Radius of Brake Drum=0.125m

Turbine Efficiency, $\eta_t = \frac{OP \times 100}{IP}$

Unit Quantities – Under Unit Head

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

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

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

$$N_S = \frac{N\sqrt{P}}{H^{(5/4)}}$$

Tabular form:

S.No	Speed	Supply head	pressure Gauges Reading			Discharge m³/sec	Break weight W_1-W_2	Input Power	Output Power	Efficiency OP / IP
			P_1	**P_2**	**$P_1 - P_2$**					
1.										
2.										
3.										
4.										
5.										
6.										
7.										

Precautions:

1 Do not start Pump set if the supply voltage is less than 300V (Phase to Phase voltage)

2 Do not forget to give electrical earth and neutral connections correctly; otherwise the RPM indicator gets burnt.

3. Initially, fill in the tank with clean water free from foreign material, change the water every six months.

4. Frequently, at least once in three months, grease all visual moving parts.

5. At least every week, operate the unit for five minutes to prevent any clogging of moving parts.

6. To start and stop supply pump, always keep Gate Valve closed.

7. It is recommended to keep Sphere Rod setting at close positions before starting the turbine. This is to prevent racing of the propeller shaft without load.

8. In case of any major faults, Please write to the manufacturers and do not attempt to repair.

Results and Conclusions:-

Viva-Questions:-

1. Difference Between Impulse & reaction turbine
2. Which type of blade used in Pelton turbine
3. What is maximum head of Pelton Turbine?
4. How many number of runners used in Pelton turbine
5. What is the purpose of draft tube in turbines

Applications of Pelton Wheel Turbine:

It is used for maximum discharge and high head (<= 250m)

EXPERIMENT: 8

BERNOULLI'S EXPERIMENT

Aim : The experiment is conducted to study of Pressure gradient at different ones, verification of Bernoulli's equation, and Comparative analysis under different flow rates.

Apparatus:-1.

1) Venturimeter, 2) Pizoemeter, 3) Overhead Tank, 4) Sump Tank, 5) Centrifugal Pump

Theory:

Bernoulli's Theorem gives the relationship between pressure head, velocity head and the datum. Here the attempt has been made to study the relationship of the above said parameters using venturimeter.

- The apparatus consist of a specially fabricated clear ACYLIC Venturimeter with necessary tappings connected to a Multibank Pizeometer also made of clear ACRYLIC.
- The apparatus consists of two overhead tanks interconnected with the venturimeter, which is placed in between the tanks.
- The overhead tanks are provided with the head variation mechanism for conducting the experiments at various heads.
- Water in the sump tank is pumped using a Monobloc Centrifugal Pump (Kirloskar make) which passes through the control valve to the overhead tank.
- The height of the water in the collecting tank is measured using the acrylic Piezometer to find the flow rate.
- The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS tubes and Novapan Board with all the provisions for holding the tanks and accessories.

Procedure:

1. Fill in the stump tank with clean water.
2. Keep the delivery valve closed.
3. Check and give necessary electrical connections to the system.
4. Switch on the pump & slowly open the delivery valve.
5. Adjust the flow through the control valve of the pump.
6. Allow the system to attain the steady state. i.e, let the water pass from second overhead tank to the collecting tank.
7. Note down the pressure head at different points of the venture meter on the multi-tube piezometer. (Expel if any air is the by inserting the thin pin into the piezometer openings)
8. Close the ball valve of the collecting tank and measure the time for the known rise of water.
9. Change the flow rate and repeat the experiment.

Observation:

Sl. No	Static Head Loss, h										Time for R cm rise in water 'T' sec
	1	2	3	4	5	6	7	8	9	10	
1											
2											
3											
4											

Discharge, Q_{act}

Where $Q = (A\, X\, R)/t \times 100$

A = Area of collecting tank = 0.045 m².

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

t = time for R cm rise of water, sec

Pressure Head= $P / \rho g = h$ m water

`

ρ = Density of water.

g = Gravitational constant

h = Head measured, m of water column

$$Velocity\ Head = \frac{V^2}{2g} \quad m\ of\ water$$

Where,

V = **Q / a**, a = Area at the particular section* of the venturimeter m².

Verification of BERNOULLI'S EQUATION

Bernoulli" s Equation is given as: After Finding

$$\frac{p}{\rho g} + \frac{V^2}{2g} + z = 0$$

Pressure Head, h

Velocity head, $V^2/2g$ at different cross-section of the Venturimeter.

Put the same in the above equation for different points and verify whether all the values obtained are same.

Note: Consider the datum, z to be constant.

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
6. Control valve should be in close position.
7. Do not attempt to alter the equipment as this may cause
8. Damage to the whole system.

Result and Conclusion:

VIVA QUESTION:

1. State Bernoulli's Theorem
2. Define HGL & TGL
3. Define Pressure head , Suction Head & Velocity head
4. State applications of Bernoulli's Theorem
5. Define Total energy equation

APPLICATIONS OF BERNOULL'S THEORM:

1. Venturi meter
2. Orifice Meter
3. Rota meter
4. Elbow meter
5. Pitot tube.

EXPERIMENT: 9

FRANCIS TURBINE TEST RIG

Aim:-The experiment is conducted to obtain Constant Head and Speed characteristics.

Apparatus:- 1) Monobloc Centrifugal Pump of Kirloskar Make

2) Turbine Unit,

3) Sump Tank,

4) Venturimeter with pressure tappings.

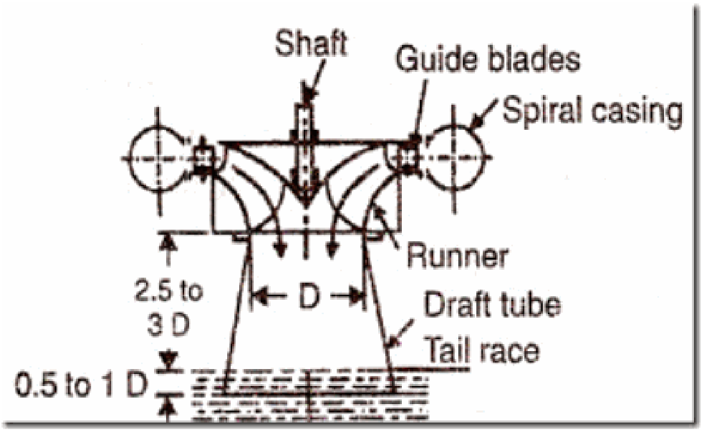
Theory:-

Hydraulic (or Water) Turbines are the machines that use the Energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the Turbines become the Prime over to run Electrical Generators to produce electricity, Viz., Hydro Electric Power.

Turbines are classified as Impulse and Reaction Types. In Impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Of many types of Turbine, the Pelton Wheel, most commonly used, falls into this category of Impulse Turbine while the Francis & Kaplan fall into the category of Reaction Turbines. Normally, Pelton Wheel requires high Heads and Low Discharge while the Francis & Kaplan (Reaction Turbines) requires relatively low Heads and high Discharge. These corresponding Heads and Discharges are difficult to create in a laboratory size Turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understating of various elements associated with any particular Turbine is possible with this kind of facility.

The apparatus consists of the following major parts

a) Monobloc Centrifugal Pump of Kirloskar Make.
b) Turbine Unit
c) Sump Tank
d) Venturimeter with pressure tappings.
e) All are arranged in such a way that the whole unit works as a re-circulating water system.
f) Centrifugal pump set supplies water from Sump Tank to the Turbine through control valve.
g) Water re - enters the Sump Tank after passing through the Turbine unit.
h) Loading of the Turbine is achieved by a rope brake drum connected to spring balance.
i) Provisions for measurement of Turbine speed (digital RPM indicator), Head on Turbine (Pressure gauge) are built in on the control panel.
j) 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.



Procedure:

To obtain constant head characteristics:

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

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

Performance under unit head – unit quantities:

In order to predict the behavior of a turbine working under varying conditions and to facilitate comparison between the performances of the turbines of the same type but having different outputs and speeds and working under different heads, it is often convenient to express the test results in terms of certain unit quantities. From the output of the turbine corresponding to different working heads (Tabular Column - 1), it is possible to compute the output, which would be developed if the head was reduced to unity (say 1 Meter): the speed being adjustable so that the efficiency remains unaffected.

a) Unit Speed,

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

b) Unit Power,

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

c) Unit Discharge,

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

d) Specific Speed,

The Specific Speed of any Turbine is the speed in rpm of a turbine geometrically similar to the actual turbine but of such a size that under corresponding conditions it will develop 1 metric horse power when working under unit head (i.e. 1 meter). The Specific Speed is usually computed for the operating conditions corresponding to the maximum efficiency.

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

Observation:

Constant Head/Speed

Sl. No	Turbine speed N rpm	Delivery Pressure 'P' Kg/cm²	Vacuum pressure 'P_v' mm of hg	Venturimeter Head		Load Applied	Time for 'n' pulses of energy meter, t sec
				P_1 Kg/cm²	P_2 Kg/cm²		
1							
2							
3							
4							
5							

CALCULATIONS

1. Total Head of Turbine in meters of water, H m of water

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

Where, P = Pressure gauge readings in Kg/Cm²

Pv = vacuum Pressure gauge readings in mm of hg

2. Discharge, Q

Where,
$h = (P_1 \sim P_2) \times 10$
A1 = Area of the Venturimeter

Where, D2 = Flow meter

$$A_1 = \frac{\pi \times D_1^{\,2}}{4} \; m^2$$

Throat diameter = 50mm

Cd = 0.95 for Venturimeter

Cd = 0.62 for Orificemeter

3. Input to the turbine, IP(Hydraulic)

$$IP = \frac{WQH}{1000} \; kW$$

Where, W = 9810 Kg/m³, Q =Discharge in m³/s, H =Total Head in m of water

4. Output from turbine, OP (Mechanical Workdone)

$$OP = \frac{V X I}{\eta t X \eta a}$$

Where, V =Voltmeter reading in volts, I =Ammeter reading in amps, ηT = Transmission Efficiency (Belt Transmission) = 0.75., ηA = Alternator Efficiency = 0.73.

Precautions:

1) Do not start Pump set if the supply voltage is less than 300V (Phase to Phase voltage)
2) Do not forget to give electrical earth and neutral connections correctly; otherwise the RPM indicator gets burnt.
3) Initially, fill in the tank with clean water free from foreign material, change the water every six months.
4) Frequently, at least once in three months, grease all visual moving parts.
5) At least every week, operate the unit for five minutes to prevent any clogging of moving parts.
6) To start and stop supply pump, always keep Gate Valve closed.
7) It is recommended to keep Sphere Rod setting at close positions before starting the turbine. This is to prevent racing of the propeller shaft without load.
8) In case of any major faults, Please write to the manufacturers and do not attempt to repair.

RESULT AND CONCLUSION:

APPLICATIONS OF FRANCIS TURBINE:

1. It is used for power development with a medium head (60 to 250 m) medium discharge

Viva-Questions:-

1. Difference between Impulse & reaction turbine.

2. Which type of blade is used in Francis turbine

3. What is maximum head of Francis turbine?

4. How many number of runners used in Francis turbine?

5. What is the purpose of draft tube in turbines?

EXPERIMENT: 10

KAPLAN TURBINE TEST RIG

Aim: The experiment is conducted to obtain Constant Head and Speed characteristics

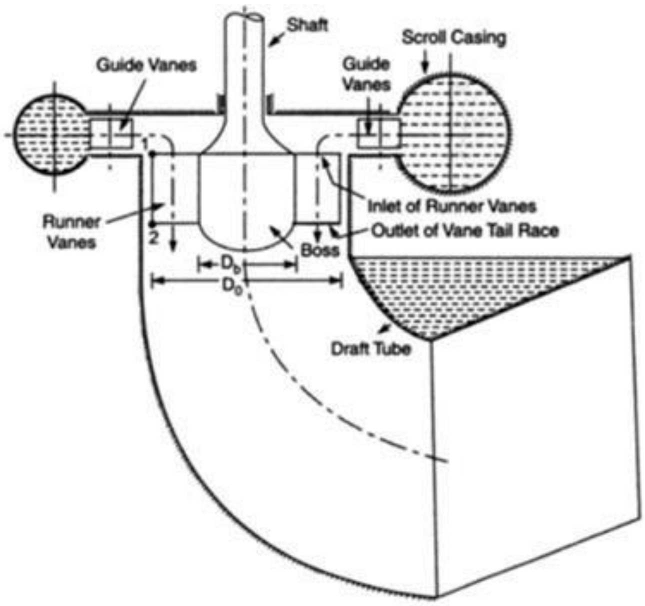
Apparatus:- 1.)Monobloc Centifugal Pump of Kirloskar Make 2) Turbine Unit, 3) Sump Tank,

4) Venturimeter with pressure tappings.

Theory:- Hydraulic (or Water) Turbines are the machines that use the Energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the Turbines become the Primover to run Electrical Generators to produce electricity, Viz., Hydro Electric Power.Turbines are classified as Impulse and Reaction Types. In Impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Of many types of Turbine, the Pelton Wheel, most commonly used, falls into this category of Impulse Turbine while the Francis & Kaplan fall into the category of Reaction Turbines. Normally, Pelton Wheel requires high Heads and Low Discharge while the Francis & Kaplan (Reaction Turbines) requires relatively low Heads and high Discharge. These corresponding Heads and Discharges are difficult to create in a laboratory size Turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understating of various elements associated with any particular Turbine is possible with this kind of facility. The apparatus consists of the following major parts

Monobloc Centrifugal Pump of Kirloskar Make.

a) Turbine Unit
b) Sump Tank
c) Venturimeter with pressure tappings.



- All are arranged in such a way that the whole unit works as a re-circulating water system.
- Centrifugal pump set supplies water from Sump Tank to the Turbine through control

valve.

- Water re - enters the Sump Tank after passing through the Turbine unit.
- Loading of the Turbine is achieved by a rope brake drum connected to spring balance. Provisions for measurement of Turbine speed (digital RPM indicator), Head on Turbine (Pressure gauge) are built in on the control panel.

- 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.

Procedure:-

To obtain constant head characteristics**.**

- Set the Vane position.
- Keep the Delivery valve open at Maximum
- Set the head at required value.
- Now apply the load.
- Operating the delivery valve, maintain the head to the
- Set value.
-

Repeat the steps 4 and 5 till the maximum load the turbine can take.

In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loading

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
6. Set value.
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for each loadings.

Performance under unit head – unit quantities:-

In order to predict the behavior of a turbine working under varying conditions and to facilitate comparison between the performances of the turbines of the same type but having different outputs and speeds and working under different heads, it is often convenient to express the test results in terms of certain unit quantities. From the output of the turbine corresponding to different working heads (Tabular Column - 1), it is possible to compute the output, which would be developed if the head was reduced to unity (say 1 Meter): the speed being adjustable so that the efficiency remains unaffected.

a) Unit Speed,

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

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The Specific Speed of any Turbine is the speed in rpm of a turbine geometrically similar to the actual turbine but of such a size that under corresponding conditions it will develop 1 metric horse power when working under unit head (i.e. 1 meter). The Specific Speed is usually computed for the operating conditions corresponding to the maximum efficiency.

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

Constant Head/Speed

Observation:

Sl. No	Turbine speed N rpm	Delivery Pressure`P" Kg/cm²	Vacuum pressure ‘Pv’ mm of hg	Venturimeter Head		IP	OP	η
				P_1 Kg/cm²	P_2 Kg/cm²			
1								
2								
3								
4								
5								

CALCULATIONS

1. Total Head of Turbine in meters of water, H

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

m of water Where, P = Pressure gauge readings in Kg/Cm²

P_v = vacuum Pressure gauge readings in mm of hg 2. Discharge, Q

Where,

$$Q = \frac{Cd \times A1 * A2 * \sqrt{2gh}}{\left(\sqrt{A1^2 - A2^2}\right)} \ m^3/s$$

h = (P_1 ~ P_2) x 10

A1 = Area of the Venturimeter

$$A_1 = \frac{\pi * D_1^2}{4} \ m^2$$

Where, D1 = Flowmeter Inlet diameter = 100mm

A2 = Area of the throat of the Venturimeter

$$A_2 = \frac{\pi * D_2^2}{4} \ m^2$$

Where, D2 = low meter

Throat diameter 50mm

C_d = .95 for Venturimeter

C_d = 0.62 for Orificemeter

2.Input to the turbine, IP(Hydraulic)

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

Where, W = 9810 Kg/m^3, Q =Discharge in m^3/s, H =Total Head in m of water

3.Output from turbine, OP (Mechanical Work done)

Where,

V =Voltmeter reading in volts,

I =Ammeter reading in amps,

η_T = Transmission Efficiency (Belt Transmission) = 0.75.,

η_a = Alternator Efficiency = 0.73.

Precautions:

1) Do not start Pump set if the supply voltage is less than 300V (Phase to Phase voltage)
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4) Frequently, at least once in three months, grease all visual moving parts.
5) At least every week, operate the unit for five minutes to prevent any clogging of moving parts.
6) To start and stop supply pump, always keep Gate Valve closed.
7) It is recommended to keep Sphere Rod setting at close positions before starting the turbine.
8) This is to prevent racing of the propeller shaft without load.
9) In case of any major faults, Please write to the manufacturers and do not attempt to repair.

Result and Conclusion:

APPLICATIONS OF KAPLAN TURBINE:

1. It is used for power development with a low head (<= 30 m) high discharge

Viva-Questions:-

1) Difference Between Impulse & reaction turbine
2) Which type of blade used in Kaplan turbine
3) What is maximum head of Kaplan turbine
4) How many number of runners used in Kaplan turbine
5) What is the purpose of draft tube in turbines?