Annexure-A

Fluid Mechanics and Machinery Lab

Lab Manual

Mechanical Engineering Department

Sant Longowal Institute of Engineering and Technology

(Deemed to be University, Established by MHRD, Government of India)

PREFACE

Fluid mechanics is an important subject for Mechanical engineers. This subject basically deals with fluids (water). Different equations and formulae are used to measure different fluid and flow properties like discharge, velocity, and viscosity etc. of fluids by employing various techniques, in line, discussed under this subject. This Lab manual mainly deals with the common and universal laboratory tests of fluid (water) i.e., Verification of Bernoulli's theorem, Flow through Venturimeter, Flow through orifice, Flow over V-notch, determine pressure by pressure measuring devices like piezometer, U-Tube differential manometer and bourdon gauge, Determine the meta centric height of given model, Determine the efficiency of gear oil pump and hydraulic ram. This knowledge and its practice shall ensure them mastering over the lab skills- an indispensable ingredient of employability for survival in the competitive market of employment.

It is believed that this laboratory manual covers the requirements of laboratory exercise requirements for students undergoing the course of fluid mechanics as per course curriculum of undergraduate level study in Mechanical Engineering. For better understanding of the course enough schematic diagrams and line sketches has been compiled from sources in the form of the laboratory books, internet etc.

Although the experiments and activities detailed in the Laboratory manual have been subjected to trial and testing, care should be taken to perform experiments in the specified manner and follow safety norms.

Motivation given, support extended, and facilities provided by Prof. (Dr.) A.S.Shahi, Head of Mechanical Engineering Department to bring this manual in the present form is thankfully acknowledged.

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Developed by

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FOREWORD

The Laboratory Manual of Fluid Mechanics Lab intended to serve the need of students pursuing Diploma and Undergraduate courses in Mechanical Engineering Department of Sant Longowal Institute of Engineering and Technology, Longowal. It is expected that the manual will facilitate students in undergoing smooth conduct of practical classes.

I wish to put on record my sincere appreciation to the highly motivated team of laboratory including its in-charge, Technician and attendant for compilation and making the manual in presentable form for the benefit of students.

Dr. A.S.Shahi
Head of Department
Mechanical Engineering Department

GENERAL INSTRUCTIONS

1. All the students are instructed to wear identity card, protective uniform, and shoes before entering the laboratory.
2. Students should have a clear idea about the principle of the exercise to be performed.
3. All the students are advised to come with a complete record and correct observation book of the previous experiment.
4. Do not operate any instrument/machine without getting prior permission from technical staff.
5. The entire instrument is costly. Hence, handle them carefully, to avoid penalties for any breakage.
6. The utmost care must be taken to avert any possible injury while performing Laboratory work. In case anything uneven occurs, report it immediately to the staff members.
7. One student from each batch should put his/her signature during receiving the instrument in instrument issue Register.

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SYLLABUS

Subject Code : ME-313

Title of the course : Fluid Mechanics and Machinery

L	T	P	Credits	Weekly Load
2	0	4	3	6

Experiments (ME-313)

1. To determine the viscosity of a Liquid by Redwood viscometer.
2. To verify Bernoulli's Theorem.
3. To determine the coefficient of discharge of Venturimeter.
4. To determine the coefficient of discharge of orifice meter.
5. To determine the pressure by Bourdons Pressure Gauge.
6. To study the constructional details of a Pelton turbine and measure its efficiency.
7. To study the constructional details and working principle of a Francis turbine.
8. To study different components of centrifugal pump in dismantled condition.
9. To determine the efficiency of a Gear oil pump.
10. To determine the efficiency of a Hydraulic Ram.

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1. AIM: - TO DETERMINE THE VISCOSITY OF A LIQUID BY REDWOOD VISCOMETER.

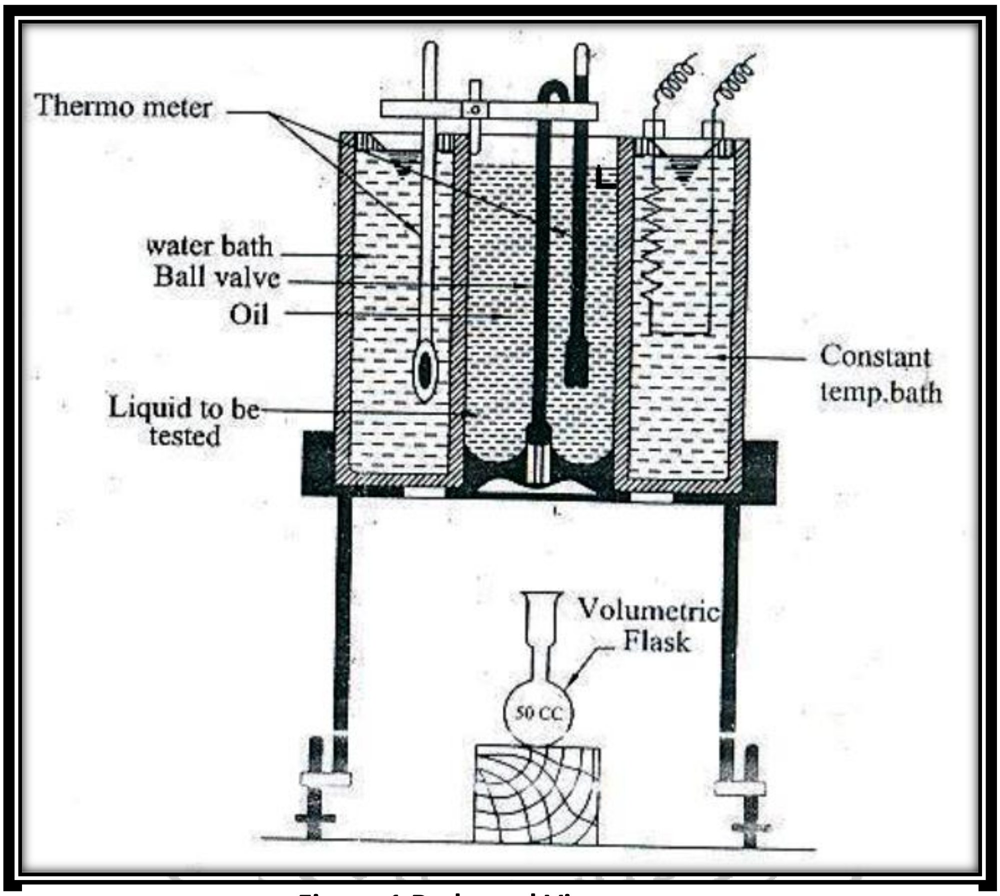


Figure 1 Redwood Viscometer.

Aim: -TO DETERMINE VISCOSITY OF A LIQUID BY REDWOOD VISCOMETER.

Apparatus: - Redwood apparatus, thermometer, heater, measuring cylinder, ball valve.

Theory:

The Redwood apparatus is used for determining the viscosity of oil which expresses flow as a time to flow in seconds through specified hole made in a metallic piece. The Red wood apparatus measures the viscosity from empirical relation. The method is primarily applicable for viscosity determination of oil, which flow in a Newtonian manner, i.e., it possesses a linear relationship between shear stress and velocity gradient under the test conditions.

Mode of operation: -

The flow time measurements for given sample products should be made at the flowing temperatures:- 21°C, 37.8°C, 50°C, 93°C, 121°C, 149°C & 204°C

For fuel oils the minimum temperature is 49°C & for flux oils the temperature test to be 93°C. The apparatus Redwood No. 1 will indicate the viscosity flow time between 30 seconds to 2000 seconds if the flow time measured for any oil exceeds 2000 seconds. The test should be repeated with red wood viscometer No 2, which will give the correct value of viscosity for such highly viscous oils.

Experimental procedure: -

1 Clean the apparatus and properly dry it.

2 Fill the bath with water to obtain different temperatures. Heat the viscometer bath to few degrees above the desired test temperature.

3 By using the ball valve, close the jet.

4 50 ml of oil collected in measuring cylinder.

5 Place the clean & dry flask centrally below the jet.

6 For proper heating of the oil remove the stirrer.

S No	Temperature (˚C)	Time (Sec.)	Volume (ml.)
1			
2			
3			
4			

7 Lift the ball valve & simultaneously start stopwatch, then oil will flow through the jet. Stop the stopwatch at the instant when the viscometer is completely empty.

8 Measure the volume in the measuring cylinder.

9 Repeat the experiment at different temperatures.

Observations: —

Calculations: -

Y1 = (0.0026t-1.95/t) x sp. Gravity of sample. (If time is up to 100 sec.)
Y2= (0.0022t -1.6/t) x sp. Gravity of sample. (If time is more than 100 sec.)

Result: -

Precautions: -

1. The temperature should be kept constant throughout the experiment.
2. The viscometer should be cleaned with alcohol before starting the experiment.
3. With the help of the spirit level, the viscometer should be properly leveled.
4. The experiment should be carried out in a closed room.
5. The ball valve should be lifted gently.
6. The liquids whose viscosity is to be determined should be free from particles & suspended impurities

2. AIM: - TO VERIFY BERNOULLI'S THEOREM.

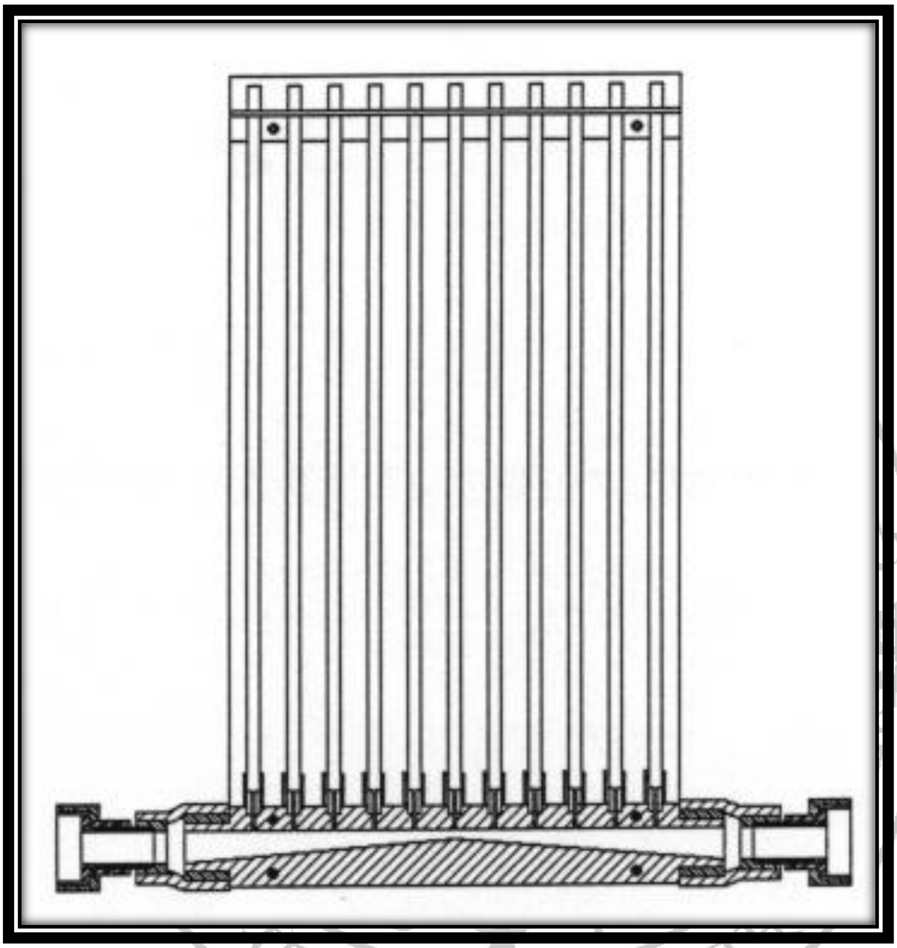


Figure 2. Bernoulli's Theorem apparatus.

AIM: - TO VERIFY BERNOULLI'S THEOREM

Apparatus: -

Bernoulli test rig, stopwatch, meter rod.

Theory: -

The principle of conservation of energy gives rise to Bernoulli's theorem which states

that if an incompressible ideal fluid flow through closed passage, the total head' i.e. sum of datum head (z), pressure head (p/ w) & velocity head ($v^2/2g$) will remains constant at all points in flow field.

$$H = \frac{P}{W} + z + \frac{v^2}{2g} = \text{constant}$$

But the validity of the above theorem is subject to the following conditions:

(1) The flow is steady,
(2) Fluid is frictionless, i.e., non-viscous.
(3) Fluid is irrigational.
(4) No external work is done on the flow system by any external machine.

Experimental set up: -

The apparatus consists of a converging diverging duct issuing out of a cylindrical water container & discharging another. Piezometric connections made at small at equal intervals to show pressure heads at different sections. This is measured by collecting a known volume of water in time t. The water is supplied to the apparatus from the laboratory storage tank which can be regulated by inlet valve. Another valve is fitted at the end of the duct to get sufficiently low pressure at the central tube. A graph is attached on a vertical board to take the piezometric reading. Alternatively, a scale may be used for same purpose.

Procedure —

1. Open the inlet valve to obtain a steady flow, collect water in a tank for certain time t.
2. Consider the base of apparatus as base datum; measure the height of water, level above the tube base (p/w +z) in all the tubes.

Note: — p/w is pressure head & z is the datum head and the sum of these two quantities, is called piezometric head. By proper adjustment of outlet valve, sufficiently deep curve can be obtained.

Observations: -

Width of passage, b' = --- cm.

Tube no.	Discharge Q= (h2 – h1) X a/t	Depth of Passage 'b'	Area of Passage 'a'	Velocity. (V)	Velocity Head $v^2/2g$	P/w+z (H.G.L)	Total head (H) (T.E.L)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

Calculations —

1. Calculate the area of cross section 'a, at given section = bd
.
2. Discharge Q = a/t ($h_2 - h_1$)
3. Velocity of flow v $=Q/a$
4. Velocity of head = $v^2/2g$

Where A is the area of x-section of outlet tank

($h_2 - h_1$) is net rise in level in outlet tank in time t.

b is the width of duct below tube.

d is the depth of duct below respective tube.

Result: -

1. Now again open the inlets valve by few more turns and then repeat the above procedure by 3-4 times.
2. Note down the width ‘b’ and depth ‘d’of the duct at various x- sections.

Precautions —

1. Reading should be recorded under steady condition of flow.

2. There should be no bubble in piezometric tube

3. AIM: -TO DETERMINE THE COEFFICIENT OF DISCHARGE OF VENTURIMETER.

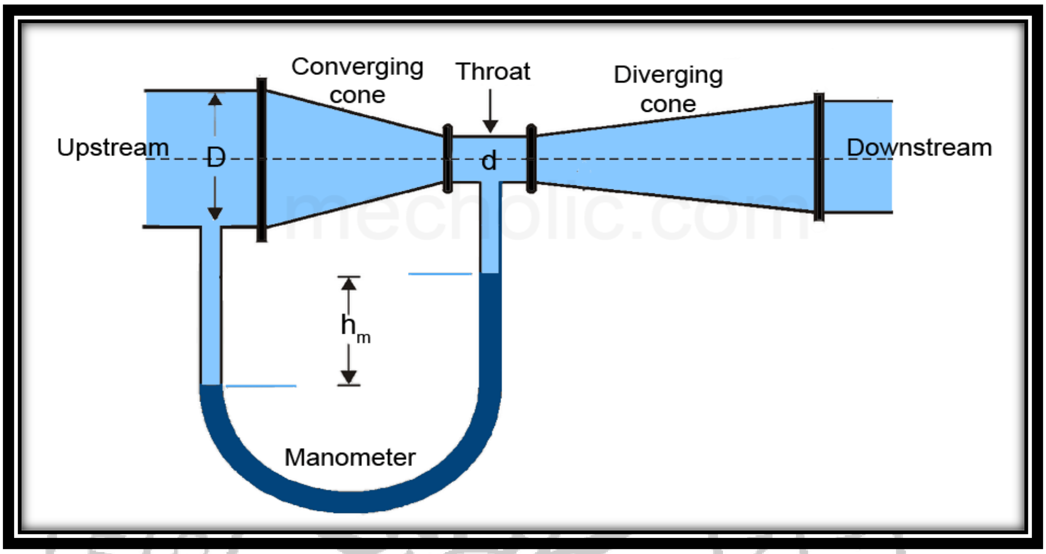


Figure 3. Venturimeter connected with manometer.

Figure 4. Venturimeter

AIM: -TO DETERMINE THE COEFFICIENT OF DISCHARGE OF VENTURIMETER.

Apparatus: -Venturimeter, Stopwatch, measuring tank, differential manometer, etc.

Theory: -Venturimeter is a device used for measuring the rate of flow of fluid flowing through the pipe. It basically consists of flowing three parts.

1. A short covering parts.
2. Throat.
3. Long diverging part.

It is based on the principle of Bernoulli theorem. Coefficient of discharge (C_d) is given by

$$C_d = \frac{Q_{act}\sqrt{a_1^2 - a_2^2}}{a_1 a_2 \sqrt{2gh}} = Q_{act}/Q_{th}$$

Where a_1 = area of pipe

a_2= area of throat.

Q_{th} & Q_{act} are theoretical and actual discharges respectively.

h is calculated by the relation,

$h = X\left[\frac{S_h}{S_o} - 1\right]$

S_h = Specific gravity of Mercury (13.6)

S_o= Specific gravity of water (1)

Q_{act}= $\frac{\text{area of measuring tank x net rise of water level in tank}}{\text{Time taken.}}$

Observations: -

Throat diameter =…….mm.

Diameter of pipe =.............mm.

Sr. No.	Manometer reading (X) in cm.	$h = X\left[\frac{S_h}{S_o} - 1\right]$	$Q_{th} = \frac{a_1 a_2\sqrt{2gh}}{\sqrt{{a_1}^2 - {a_2}^2}}$	$Q_{act} = \frac{volume\ of\ water\ colle}{time\ taken}$	$C_d = \frac{Q_{act}}{Q_{th}}$

Calculations —

1. The value of h is given by

   $h=X\left[\frac{S_h}{S_o} - 1\right]$

   Where

   S_h — Specific gravity of mercury =13.6

   S_o — Specific gravity of water = 1

2. Actual discharge Q_{act} is calculated by volumetric method i.e., $Q_{act} = \frac{volume\ of\ water\ collected}{time\ taken}$

3. Theoratical discharge Q_{th} is calculated by using the eq. i.e.

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

4. The coefficient of discharge is calculated for different sets i.e.

$$C_d = \frac{Q_{act}}{Q_{th}}$$

Result:

Procedure: -

1. Connect the Differential manometer across throat & Inlet pipe as shown in figure.
2. Start the pump & regulate the inlet valve to allow the steady flow through venturimeter.
3. Took the reading of the actual flow i.e., water collected in measuring tank for a specific time period.
4. Note down the deflection ' X, of mercury columns in the differential manometer.
5. Readjust the inlet valve for other rate of flow.
6. Repeat the above procedure & obtain 3-4 readings.

Precautions-

1. Pipe& fitting should be leaking proof.
2. A manometer should be handled carefully.
3. Before taking the reading remove all entrapped air from two limbs of manometer.

4. AIM: -TO DETERMINE THE COEFFICIENT OF DISCHARGE OF AN ORIFICE METER.

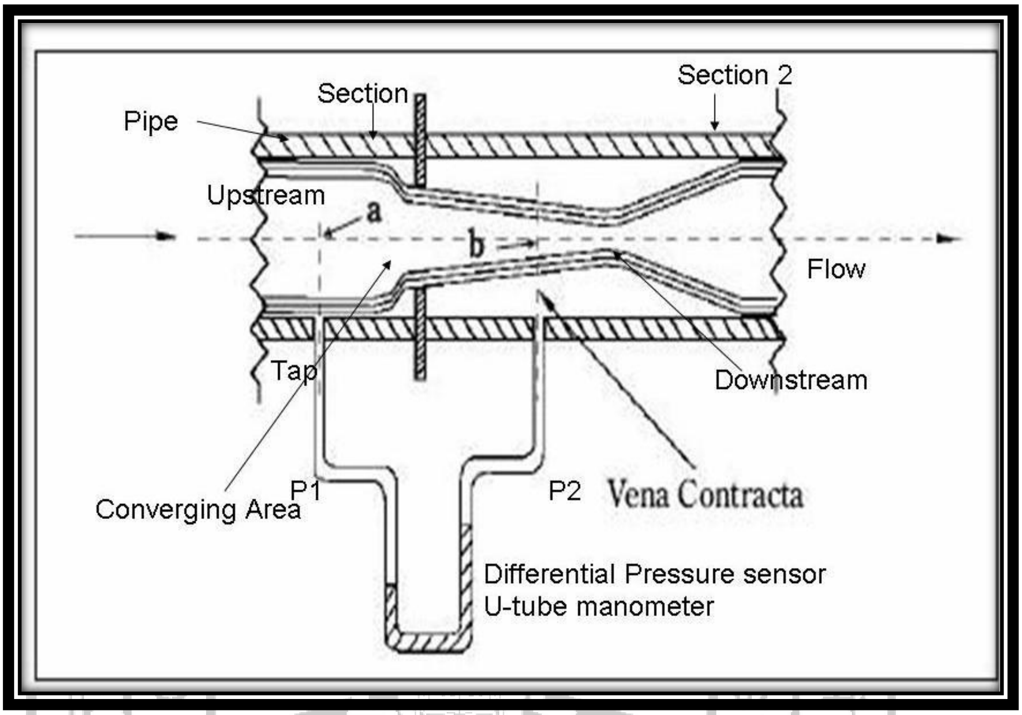


Figure 5. Flow measurement by Orifice meter.

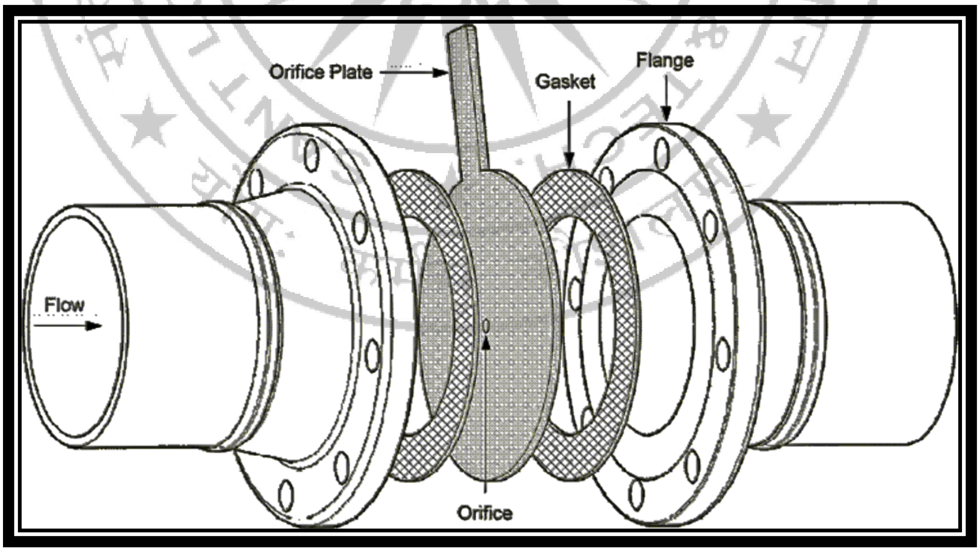


Figure 6. Orifice meter in dismantled condition

AIM: - TO DETERMINE THE COEFFICIENT OF DISCHARGE OF AN ORIFICE METER.

Apparatus: -Orifice meter, stop- watch, differential manometer, measuring scale etc.

Theory: -Orifice meter is a device used for measuring the rate of flow of liquid through a pipe. It consists of flat circular plate which has circular edge, the hole- called orifice, which is concentric with the pipe. The orifice diameter is generally kept 0.5 time the diameter of the pipe, although it may vary from 0.4 to 0.8 times the pipe dia. A differential manometer is connected between across orifice meter to measure the pressure difference between two sections. The discharge by orifice meter is given by following equation.

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

Where a_1 - area of orifice

a_2-area of pipe

Difference in pressure head $h = X\left[\frac{S_h}{S_o} - 1\right]$

X - Reading of manometer

S_h-specific gravity of mercury [13.6]

S_o - specific gravity of water [1]

Actual discharge (Q_{act}) = area of measuring tank X net rise of water level / Time taken

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

Procedure: -

1. Connect the differential manometer across orifice meter.

2. Open the water supply with the help of gate valve& allow the steady discharge flow through orifice meter.

3. Note the deflection 'x, of mercury in the manometer.

4. Note the net rise of water level in measuring tank for known time.

5. Now again open the inlet valves by few more turns and repeat the above procedure.

6. Repeat the experiment several times.

Observations: -

Throat diameter =…….mm.

Diameter of pipe =.............mm.

Sr. No.	Manometer reading (X) in cm.	$h = X\left[\frac{S_h}{S_o} - 1\right]$	$Q_{th} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1{}^2 - a_2{}^2}}$	$Q_{act} = \frac{volume\ of\ water\ colle}{time\ taken}$	$C_d = \frac{Q_{act}}{Q_{th}}$

Calculations —

2. The value of h is given by

   $h = X\left[\frac{S_h}{S_o} - 1\right]$

   Where

   S_h — Specific gravity of mercury =13.6

   S_o — Specific gravity of water = 1

5. Actual discharge Q_{act} is calculated by volumetric method i.e. $Q_{act} = \frac{volume\ of\ water\ collected}{time\ taken}$
6. Theoretical discharge Q_{th} is calculated by using the eq. i.e.

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

7. The coefficient of discharge is calculated for different sets i.e.

$$C_d = \frac{Q_{act}}{Q_{th}}$$

Result: -

Precautions: -

1. Remove all entrapped air from two limbs of manometer.
2. Note the reading of manometer very carefully by removing the parallax error.

5. AIM: -TO DETERMINE THE PRESSURE BY BOURDONS PRESSURE GAUGE

- **PIEZOMETER TUBE**
- **U-TUBE DOUBLE COLUMN MANOMETER**
- **BOURDAN GAUGE**

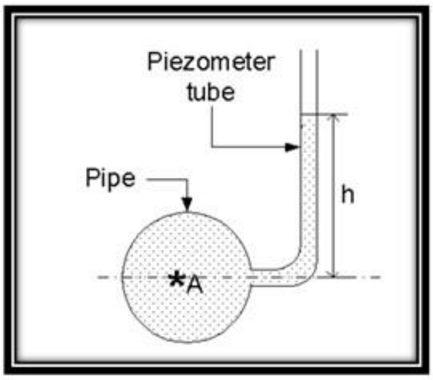


Figure 07. Piezometer Tube

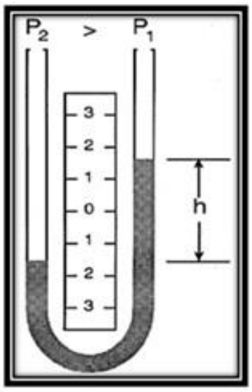
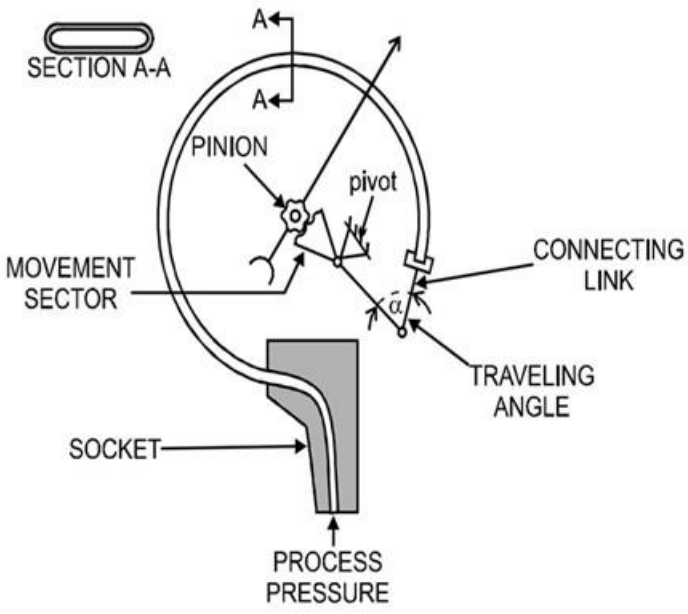


Figure 08. U-Tube Double Column Manometer



C-Bourdon pressure element

Figure 09. C-Bourdon Pressure Gauge Element

AIM: - TO DETERMINE THE PRESSURE BY BOURDONS PRESSURE GAUGE

- **PIEZOMETER TUBE**
- **U-TUBE DOUBLE COLUMN MANOMETER**
- **BOURDAN GAUGE**

Apparatus: -

Piezoelectric tube, double column u-tube MANOMETER, BOURDAN GAUGE

Theory: -

Piezoelectric tube: -

It is a vertical glass tube tapped into the wall of a container or pipe for the purpose of measuring the pressure head. The liquid rises into the tube to a certain height which gives the pressure head from the relationship.

$$P=\rho gh$$

The intensity of pressure P is calculated.

Double column U-tube manometer: -

Piezoelectric tube has its limited utility in that a small pressure can be measured by it and that gas pressure cannot be measured. Fir a large pressure, a very long tube is required which is difficult to obtain and handle. Gas, if allowed to enter the tube, would expose to atmosphere. To overcome these difficulties a tube double column MANOMETER is used. It contains a liquid heavier than the liquid of which the pressure is to be measured. Generally, it is Hg. The pressure head of the liquid in the p is given by equation.

$h=x\ (S_h/S_l-1)$

Where h is pressure head

X is the difference of level of heavier liquid in two limbs.

S_h is the specific gravity of heavier liquid.

S_l is the specific gravity of light liquid.

Bourdon pressure gauge: -

The bourdon tube is curved, elliptical shape metallic tube, which tends to straighten as the fluid pressure in the tube increases and to curl tighter as pressure decreases. Any change in the curvature of the tube is transmitted to a system of gears to the pointer which rotates over a printed dial the direction and magnitude of the pointer movement depends upon the direction and magnitude of the change in the curvature of the tube. Bourdon tube gauges are very rugged and will measure pressure either above or below atmosphere. Those designs to measure the pressure above atmosphere are known as pressure gauges and those designs to read pressure below atmosphere are known called vacuum gauges. In many cases, a single gauge known as compound gauge is designed to measure the pressure both above and below atmosphere. Such a gauge is calibrated in kg/cm² above atmosphere and mm of Hg below atmosphere.

Precautions: -

1. Piezometer and U-tube should enter the pipe at right angle to the motion of the flow.

2. If the pressure is to be measured in U-tube heavier liquid generally Hg is used, the liquid in the U-tube should be little heavier than that in the pipe.

6. **AIM: - TO STUDY THE CONSTRUCTIONAL DETAILS OF A PELTON TURBINE AND MEASURE ITS EFFICIENCY**

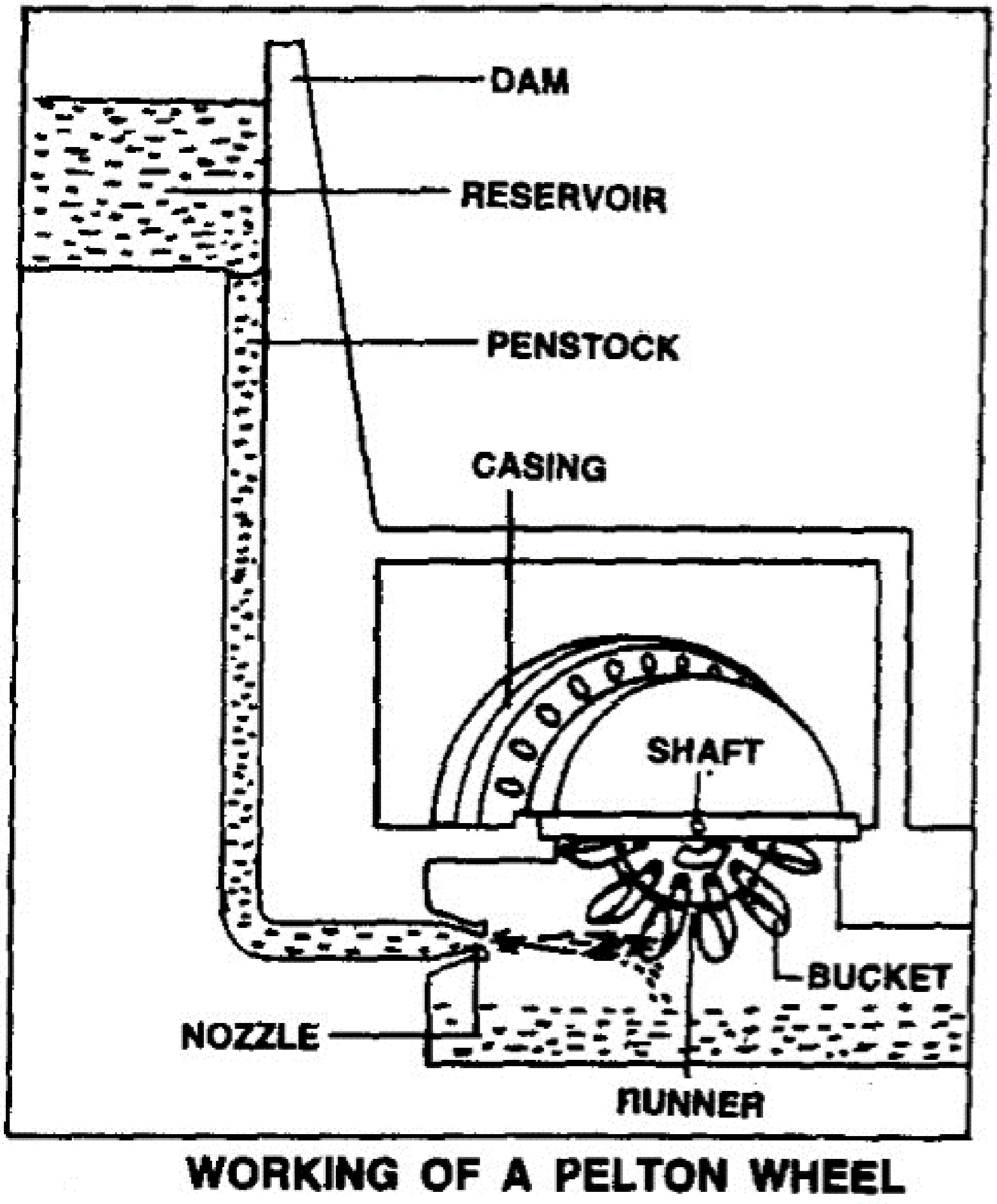


Figure10: - Working of a Pelton Wheel

AIM: - TO STUDY THE CONSTRUCTIONAL DETAILS OF A PELTON TURBINE AND MEASURE ITS EFFICIENCY

OBJECTIVE:

To Study the operation of a Pelton Turbine.

INTRODUCTION:

A turbine is a machine which converts the fluid energy into mechanical energy which is then utilized to run the electric generator of a power plant. Fluid used can be water or steam. The Pelton wheel is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmosphere. The turbine is used for high head.

THEORY:

Pelton turbine is a impulse turbine. In an impulse turbine, all the available energy of water is converted into kinetic energy or velocity head by passing it through a contracting nozzle provided at the end of the penstock. The water coming out of the nozzle is formed into a free jet, which strikes on a series of buckets of the runner thus causing it to revolve. The runner revolves freely in air. The water is contact with only a part of the runner at a time, and throughout its action on the runner.

DESCRIPTION:

The set up consists of centrifugal pump, turbine unit, and sump tank, arranged in such a way that the whole unit works as re-circulating water system. The centrifugal pump supplies the water from sump tank to the turbine. The loading of the turbine is achieved by rope brake drum connected with weight balance. The turbine unit can be visualized by a large circular transparent window kept at the front. A bearing pedestals rotor assembly of shaft, runner, and brake drum, all mounted on suitable cast iron base plate.

UTILITIES REQUIRED:

1. Electricity Supply: Three Phase, 420 V AC, 50 Hz, 5 kW with earth connection.

2. Water supply (Initial fill).
3. Drain Required.
4. Floor Area Required: 1.5 m x 0.75 m.

EXPERIMENTAL PROCEDURE

Starting Procedure:

1. Close all the valves provided.
2. Fill sump tank ¾th with clean water and ensure that no foreign particles are there.
3. Open the by-pass valve and ensure that there is no load on the brake drum.
4. Switch ON the pump with the help of the starter.
5. Close the by-pass valve.
6. Now the turbine is in operation.
7. Load the turbine with the help of hand wheel attached on the top of weight balance.
8. Note the pressure gauge readings installed on venturi-meter and in main pipe to measure the flow rate and initial total water head.
9. Measure the load applied and RPM of the turbine.
10. Repeat the experiment at different load.
11. Repeat the experiment for different discharge by regulating the nozzle position by the hand wheel provided for same.

Closing Procedure:

1. When the experiment is over, first remove the load on turbine.
2. Open the by-pass valve.
3. Switch OFF Pump with the help of starter.
4. Switch OFF main power supply.
5. Drain the sump tank with the drain valve provided.

OBSERVATION & CALCULATIONS:

DATA:

g = 9.81 m/sec^2

ρ_w = 1000 kg/m^3

C_v = 0.98

D_p = 0.068 m

D_v = 0.042 m

d_B = 0.310 m

d_R = 0.019 m

W_3 = _____ kg

OBSERVATION TABLE:

S. No	N, rpm	P, kg/cm^2	P_1, Kg/cm^2	P_2, Kg/cm^2	W_1 kg	W_2 kg

CALCULATION:

Total Head (m of H_2O)

H = 10×P, m of water= ------------m of water.

Manometric Head (m of H_2O)

Hm = $(P_1-P_2)\times 10$, m of water

Discharge (m^3/s)

Area of pipe, $A_p = \pi/4\ (d_P)^2$ = _______ m^2

Area of throat, $A_v = \pi/4\ (d_v)^2$ = _______ m^2

$$Q = C_V \times \frac{A_p A_V \sqrt{2gH_m}}{\sqrt{A_p^2 - A_V^2}}, m^{3/s} = \_\_\_\_\_ m^{3/s}$$

Input Power (Kw)

$E_i = \frac{P_w \times g \times Q \times H}{1000}$, kW = -------------kW

Torque (N-m)

Effective Radius, $R_e = \frac{d_B + 2d_R}{2} = ______$m

Torque, **T = (W_1+W_3-W_2) ×g× R_e, N_m = ---------- N_m**

Output power (KW)

$E_o = \frac{2 \times \pi \times N \times T}{60 \times 1000}$, kW= ---------Kw

Turbine Efficiency (KW)

$\eta_i = \frac{E_o}{E_i} \times 100$ = ______ %

NOMENCLATURE:

A_P = Cross-sectional area of pipe, m^2.

A_V = Cross - sectional area of throat, m^2.

C_v = Co-efficient of venturi-meter

D_P = Diameter of pipe, m.

D_V = Diameter of throat, m.

d_B = Diameter of brake drum, m.

d_R	=	Diameter of rope, m.
E_i	=	Input power, kW.
E_o	=	Output power, kW.
g	=	Acceleration due to gravity, m/sec^2.
H	=	Total head, m.
H_m	=	Manometric Head, m of H_2O
N	=	RPM of runner shaft.
P	=	Pressure gauge reading, kg/cm^2.
P_1	=	Pressure at venturi inlet, Kg/cm^2.
P_2	=	Pressure at venturi throat, Kg/cm^2.
R_e	=	Equivalent Radius, m.
Q	=	Discharge, m3/sec.
T	=	Torque, N m.
V	=	Velocity of water, m/sec.
W_1	=	Spring balance weight, kg.
W_2	=	Adjustable weight, kg.
W_3	=	Weight of Rope, kg.
ρ_w	=	Density of Water, kg/m3.
η_t	=	Turbine efficiency.

PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 390 volts and above 420 volts.
2. To prevent clogging of moving parts, run the pump at least once a fortnight.
3. Always keep apparatus free from dust.

TROUBLESHOOTING:

1. If pump does not lift the water, the revolution of the motor may be reverse.
2. Change the electric connection to change the revolutions.
3. If panel is not showing input, check the main supply.

7. AIM: - TO STUDY THE CONSTRUCTIONAL DETAILS AND WORKING PRINCIPLE OF A FRANCIS TURBINE.

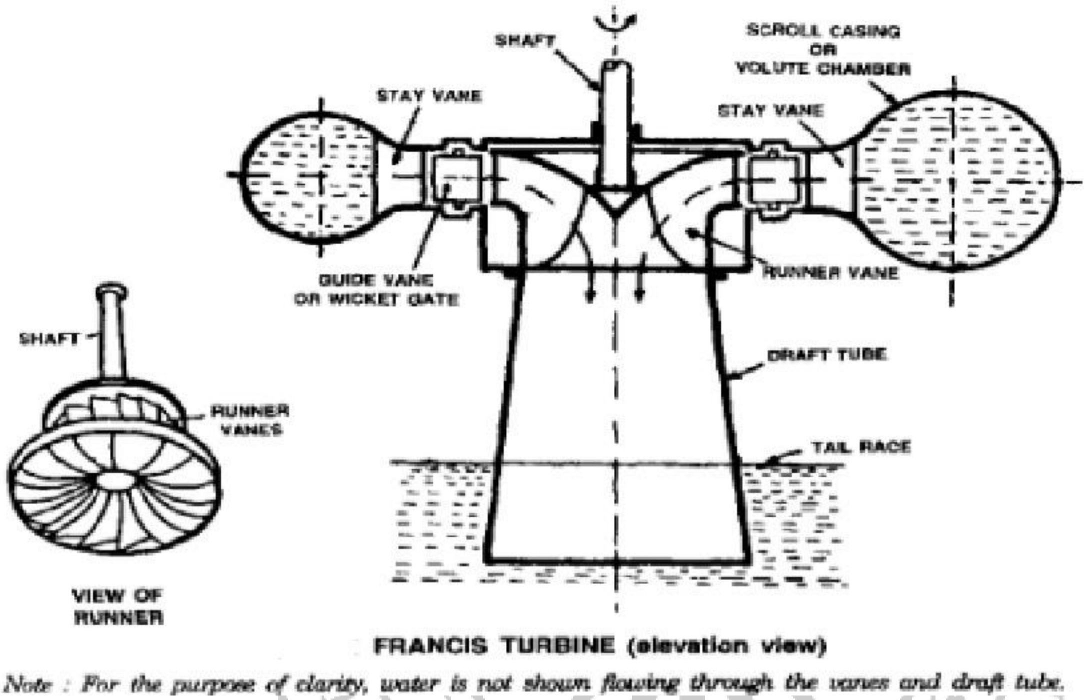


Figure11: - Working of a Pelton Wheel

AIM: - TO STUDY THE CONSTRUCTIONAL DETAILS AND WORKING PRINCIPLE OF A FRANCIS TURBINE

OBJECTIVE:

To Study the operation of a Francis Turbine

INTRODUCTION:

A turbine is a machine which converts the fluid energy into mechanical energy which is then utilized to run the electric generator of a power plant. Fluid used can be water or steam. Kaplan turbine is an axial flow reaction turbine. The reaction turbine operates with its wheel submerged in water. The water before entering the turbine has pressure as well as kinetic energy.

THEORY:

The Francis turbine is a reaction turbine like Kaplan Turbine. It operates in an entirely closed conduit from inlet to tail race. Runner has two major differences. Firstly, in Francis runner, the water enters radically while in Francis type; water strikes on the blades axially. Secondly, the number of blades in Francis runner is 16 to 24 but in the Francis, it is only 3 to 6. This reduces the contact surface with water and hence the frictional resistance. It is used for comparatively low head and large quantity of water is available.

DESCRIPTION:

The horizontal shaft Francis turbine consists mainly of a spiral casing with supporting legs, an outer bearing pedestal, and rotor assembly with blade runner, shaft and brake drum and brake arrangement all mounted on a suitable cast iron base plate. A straight conical draft tube is provided with a draught bend immediately after the runner, for the purpose of regaining the kinetic energy from the exit water and facilitating easy accessibility of the turbine due to its location at a higher level than the tailrace. The operation of regaining the kinetic energy from the exit water by some means of draft tube assumes great importance in high specific speed hydraulic turbines, as the absolute velocity of water leaving the runner is high.

A Venturimeter is installed to measure the flow rate of water. A transparent hollow perspex cylinder is provided in between the draught bend and the casing for observation of flow behind the runner. A rope brake arrangement is provided load the turbine. The output of the turbine can be controlled by adjusting the guide vanes, for which purpose suitable control mechanisms are provided. The net supply head on the turbine is measured by a pressure gauge.

UTILITIES REQUIRED:

1. Electricity Supply: 3 phase, 420 VAC, 50 Hz, 20 kW with earth connection.

2. Water supply (Initial Fill approx 600 Ltrs.)

3. Drain Required.

4. Bench Area Required: 1.5 x 0.75 m

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Close all the valves provided.
2. Fill sump tank ¾th with clean water and ensure that no foreign particles are there.
3. Open the by-pass valve and ensure that there is no load on the brake drum.
4. Switch ON the pump with the help of starter.
5. Close the by-pass valve.
6. Now turbine is in operation.
7. Load the turbine with the help of hand wheel attached on the top of weight balance.
8. Now regulate the guide vanes position with the help of a hand wheel provided for this purpose.
9. Regulate the discharge by regulating the guide vanes position.
10. Note the maximum RPM of the turbine obtained by regulating the position of guide vanes.
11. Note the pressure gauge readings installed on venturi-meter and in main pipe to measure the flow rate and initial total water head.
12. Measure the load applied and RPM of the turbine.
13. Repeat the experiment at different load.

CLOSING PROCEDURE:

1. When the experiment is over, first remove load on dynamometer.
2. Switch OFF pump with the help of starter.
3. Switch OFF main power supply.

OBSERVATION & CALCULATIONS:

DATA:

g = $9.81\ m/s^2$

ρ_w = $1000\ kg/m^3$

C_v = 0.97

D_P = 0.108 m

D_v = 0.068 m

d_B = 0.310 m

d_R = 0.019 m

W_3 = _____ Kg

OBSERVATION TABLE:

Sr. No.	N(RPM)	$P_d(Kg/cm^2)$	P_S(mm of Hg)	P_1 (Kg/cm^2)	P_2 (Kg/cm^2)	$W_1(Kg)$	$W_2(Kg)$

CALCULATION:

Total Head (m of water)

$H = 10\times\left[P_d + \frac{P_s}{760}\right] + H_{pg}$, m of water = ------------m of water

Manometric Head (m of H2O)

H_m = $(P_1-P_2)\times 10$, m of water

Discharge (m3/s)

Area of pipe, $A_p = \frac{\pi}{4}(d_P)^2$ = ________ m^2

Area of throat, $A_v = \frac{\pi}{4}(d_v)^2$ = ________ m^2

$$\mathbf{Q = C_V \times \frac{A_p A_V \sqrt{2gH_m}}{\sqrt{A_p^2 - A_V^2}}}, \mathbf{m^{3/s}} = \_\_\_\_\_\_\mathbf{m^{3/s}}$$

Input Power (Kw)

$E_i = \frac{P_w \times g \times Q \times H}{1000}$, kW = -------------kW

Torque (N-m)

Effective Radius, $R_e = \frac{d_B + 2d_R}{2}$ = ________m

Torque, $\mathbf{T = (W_1+W_3-W_2) \times g \times R_e, N_m}$ **= ---------- $\mathbf{N_m}$**

Output power (KW)

$E_o = \frac{2 \times \pi \times N \times T}{60 \times 1000}$, kW= ---------Kw

Turbine Efficiency (KW)

$\eta_i = \frac{E_o}{E_i} \times 100$ = ________ %

NOMENCLATURE:

A_P = Cross-sectional area of pipe, m^2.

A_V = Cross - sectional area of throat, m^2.

C_v = Co-efficient of venturi-meter

D_P = Diameter of pipe, m.

D_V = Diameter of throat, m.

d_B = Diameter of brake drum, m.

d_R = Diameter of rope, m.

E_i	=	Input power, kW.
E_o	=	Output power, kW.
g	=	Acceleration due to gravity, m/sec^2.
H	=	Total head, m.
H_m	=	Manometric Head, m of H_2O
N	=	RPM of runner shaft.
P_d	=	Discharge Pressure gauge reading, kg/cm^2.
P_S	=	Suction Pressure/ Vacuum gauge reading, mmhg
P_1	=	Pressure at venturi inlet, Kg/cm^2.
P_2	=	Pressure at venturi throat, Kg/cm^2.
Re	=	Equivalent Radius, m.
Q	=	Discharge, m^3/sec.
T	=	Torque, N m.
V	=	Velocity of water, m/sec.
W_1	=	Spring balance weight, kg.
W_2	=	Adjustable weight, kg.
W_3	=	Weight of Rope, kg.
ρ_w	=	Density of Water, kg/m^3.

η_t= Turbine efficiency

PRECAUTION & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 390 volts and above 420 volts
2. Never fully close the delivery line valve.

3. To prevent clogging of moving parts, run pump at least once in a fortnight.
4. Always keep apparatus free from dust.

TROUBLESHOOTING:

1. If pump does not lift the water, the revolution of the motor may be reverse.
2. Change the electric connection of motor to change the revolutions.
3. If panel is not showing input, check the main supply.

REFERENCES:

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2. Dr. P.N. Modi, Dr. S. M. Seth," Hydraulics & Fluid Mechanics", 15th ed., Standard Book House, ND 2005, Page 935-937.

8. **AIM: - TO STUDY THE DIFFERENT COMPONENTS OF CENTRIFUGAL PUMP IN DISMANTLED CONDITION.**

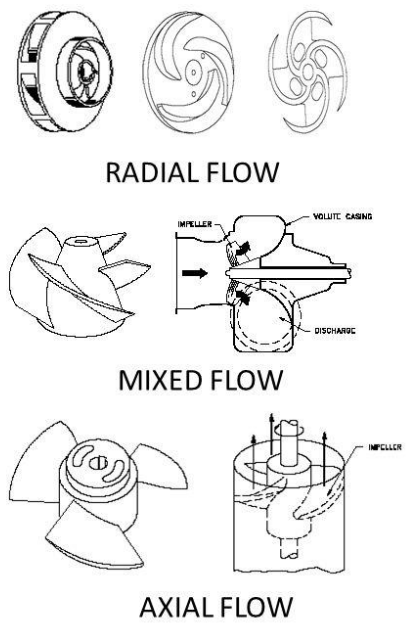


Figure 12: -Types of Centrifugal pumps (acc. To type of flow)

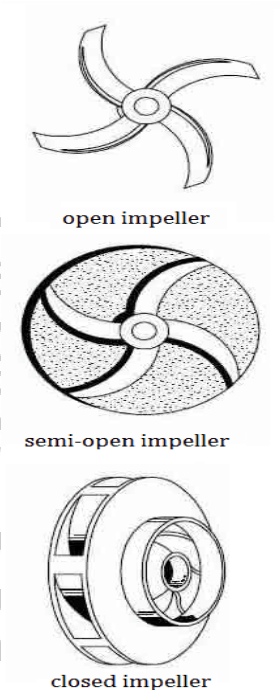


Figure:13 - Types of impellers

AIM: - TO STUDY THE DIFFERENT COMPONENTS OF CENTRIFUGAL PUMP IN DISMANTLED CONDITION.

Apparatus: -

Dismantled centrifugal pump

Theory: -

A pump is a contrivance, which provides energy to a fluid in a fluid system, it is assists to increase the pressure energy or kinetic energy, or both of fluid by converting from mechanical energy. The basis difference between the turbine and the pump, from hydrodynamic point of view, is that in the former flow takes place from the high-pressure side to the low-pressure side, whereas in pump flow takes place from the low pressure towards the higher pressure.

Classification of the pump: - Based on flow of liquid in the impeller pump can be broadly classified as follows: -

1. Radial flow pumps 2. Axial flow pumps 3. Mixed flow pumps

Components of centrifugal pump: -

Refer to the fig. A centrifugal pump consists of the following main components

1. Impeller 2. Casing 3. suction pipe 4. delivery pipe

1. Impeller: - an impeller is a wheel with a series of backward covered vans. It is mounted on the shaft which is usually coupled to an electric motor.

The impellers are of the following types.

a) Closed type: - in this type of impeller vanes are provided with metal cover plates of shrouds both sides. It provides better guidance for the liquid and has high efficiency. It is employed when the liquid to be pumped is pure and relatively free from debris. This type of impeller is shown in fig. A

b) Semi open type: - Semi open type impeller shown in fig. B. This Type of impeller has only one base plate and no crown plate. This type of impeller be used if the liquid contains some debris.

c) Open impeller: - such an impeller is shown in fig. C. The vane neither the crown plate nor the base plate i.e., the vanes are open on both sides. Such impeller and employed for pumping the liquids, which contain suspend solid matter.

2. Casing: - the casing is the airtight chamber surrounding the pump impeller. It contains suction and discharge arrangements, supporting bearings, and facilitates to house the rotor assembly. It has provision to fix stuffing boxes and house packing materials which prevent external leakage. The essential purposes of the casing are: -

- To guide water to and from the impeller
- To partly convert the kinetic energy into pressure energy

The following three types of casing are commonly employed.

A) Volute casing: - Refer the fig. In this type of casing the area of flow gradually increases from the impeller outlet to the delivery pipe so as to reduce the velocity of flow. Thus, increases in pressure occur in Volute casing.

B) Vortex casing: - Refer the fig. If this a circular chamber is provided between the impeller and the volute chamber. The vortex chamber converts some of the kinetic energy into the pressure. The volute chamber further increases the pressure energy. Thus, the efficiency of volute pump fitted with a vortex chamber is more than that of a simple volute pump.

C) Casing with guide blades: - Refer the fig. In this type of casing impeller is surrounded by a series of guides blades mounted on a ring, which is known as diffuser. The liquid leaving the impeller passes through the passage between guide vanes, the velocity of the flow decreases, and the kinetic energy is converted into pressure energy.

3. Suction pipe: - The pipe which connects the central eye of the impeller to sump from which liquid is to be lifted is known as suction pipe. In order to check the formation of air pockets the pipe is made airtight. To prevent the entry of the solids particles debris etc. into the pump the suction pipe is provided with a strainer at the lower end. The lower end of the pipe is also fitted non- return foot valve which does not permit the liquid to drain out from the suction pipe when it is not working, this also help in priming.

4. Delivery pipe: - The pipe which is connected to the outlet of the pump and it delivers the liquid to the required height is known as delivered pipe. A regulating valve provided on the delivery pipe to regulate the supply of water.

Following points, regarding impellers are worth noting:

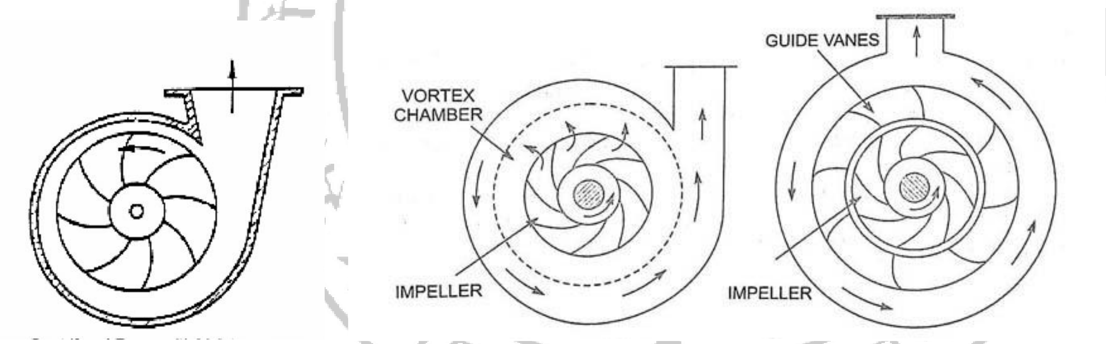
• Where it is required to pump the clear and fresh water, the impeller is wheel casted as single-piece and made-up of cast iron. The cast iron impeller is cheaper.

• Where corrosion due to salt water or chemicals is expected the impellers are made of material such as gunmetal, stainless steel etc.

• Machines (pump) that handle hot water having temperature above 150° C have to be made of cast steel with special type of packing.

• Where acids are to be pumped, the impellers and the side surfaces is contact with liquid should be coated with a suitable material to with stand corrosion.

• Where the pump is used in the milk industry it is made of stainless steel to prevent contamination of liquids being handled.



Vortex Casing Vortex Casing Casing with blades

Figure:14 - Types of casing

Working of a Centrifugal pump: - A centrifugal pump works on the principal that when a certain mass on liquid is rotated by an external force then it is thrown away from the external axis of rotation and a centrifugal head causes it to rise to higher level.

The working operation of a Centrifugal is explained below-

• The delivery valve is closed and then suction pipe, casing and portion of the delivery pipe up to the delivery are completely filled with liquid so that no air pocket is left.

• Keeping the delivery valve still closed the electric motor starts to rotate the impeller. The rotation of the impeller causes strong suction or vacuum just at the eye of the casing.

• The speed of the impeller gradually increased till the impeller rotates its normal speed and develops the normal energy required for pumping the liquid.

• After the impeller attains the normal speed the delivery valve is opened when the liquid is continuously sucked up to the suction pipe, it passes through the eye of the casing and enters the impeller at the centre of it or enter the impeller vanes at their inlet tips. This liquid is impelled out by rotating vanes and it comes out at the outlet tips of the vanes into the casing. Due to impeller action the pressure head as well as velocity head of the liquid are increased.

• From the casing door liquid passes into the pipe and lifted to required height (and discharged from the outlet of the delivery pipe).

• So long as motion is given to impeller and there is supply of liquid to be lifted the process of lifting the liquid to required height remain continuous.

• When pump is to be stopped the delivery valve should be first closed, otherwise there may be some back flow from the reservoir.

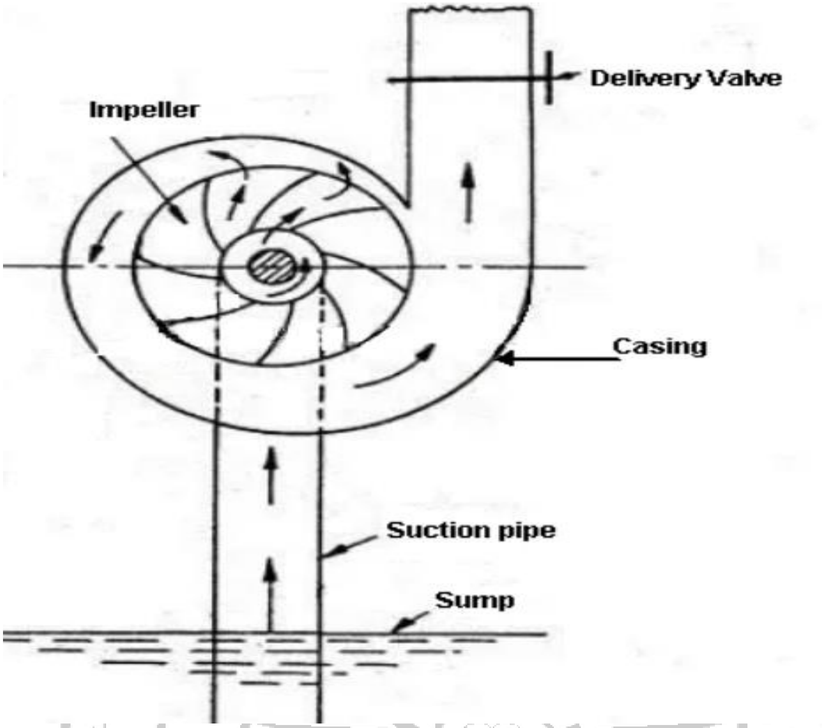


Figure:15- Various parts of centrifugal pump

9. AIM: - TO DETERMINE THE EFFICIENCY OF A GEAR OIL PUMP.

INTRODUCTION: -

The hydraulic machines which convert mechanical energy into hydraulic energy are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.

THEORY: -

GEAR PUMP

A Gear pump is a type of positive displacement pump. It moves a fluid by repeatedly enclosing a fixed volume using interlocking cogs or gears, transferring it mechanically using a cyclic pumping action. It delivers a smooth pulse free-flow proportional to the rotational speed of its gears.

DESCRIPTION: -

The setup is designed to study the performance of gear pump. The setup consists of a pump coupled with electrical motor PMDC and ACM, supply tank, measuring tank and pipe fittings for closed-loop oil circulation. Pressure and vacuum gauges are connected on delivery and suction side of pumps for the purpose of measurement. The flow rate of water is measured using measuring tank.

UTILITIES REQUIRED: -

1. Electricity supply: Single phase 220 V AC, 50 Hz, 5-15 Amp combined socket with earth connection.
2. Water supply (initial fill)
3. Floor drain required.

EXPERIMENTAL PROCEDURE: -

STARTING PROCEDURE:

1. Clean the apparatus and make tanks free from dust.
2. Close the drain valves provided.
3. Feel sump tank 3/4 with oil and ensure that no foreign particles are there.
4. Open flow control valve given on the water discharge line and control valve given on suction line both of the pumps.
5. Ensure that all on/off switches given on the panel are at off position.
6. Switch on the mains and then motor for pump characteristics perform.
7. Operate the flow control valve to regulate the flow of water discharged by the pumps.
8. Record discharge pressure by means of pressure gauge, provided on discharge line (partially close valve in case of fluctuation)
9. Record section pressure by means of vacuum gauge, provided at suction of the pump (partially close valve in case of fluctuation)
10. Record time for 10-20 pulses of energy meter by stopwatch.
11. Measure the flow of water, discharged by the pump, using stopwatch and measuring tank.
12. Repeat the experiment for different discharge pressures as per choosing pump characteristics.

CLOSING PROCEDURE:

1. When experiment is over open gate valve properly provided on the discharge line.
2. Switch off the selected pump.
3. Switch off power supply to panel.
4. Drain the measuring tank and sump tank buy valve.

SPECIFICATION: -

1. Pumps : Gear pump
2. Gear pump HP : 5L p.m.
3. Motor : PMDC (1500 RPM)
4. Pump : ACM (2800 RPM)

FORMULAS: -

1. E_i $= \frac{P}{t_p} \times \frac{EMC}{3600}\ (KW)$

2. Es $= E_i \times \eta_m \times$ transmission loses (KW)

3. R $= \frac{R_1 - R_2}{100}\ (m)$

4. Q $= \frac{A \times R}{t}\ (m^3/sec)$

5. H $= 10 \times [P_d + \frac{P_s}{760}] + h_{\rho g}\ (m\ of\ water)$

6. E_o $= \frac{\rho \times g \times Q \times H}{1000}$ (kW)

7. η_o $= \frac{E_o}{E_i} \times 100\ (\%)$

8. η_p $= \frac{E_o}{E_s} \times 100\ (\%)$

OBSERVATION AND CALCULATIONS: -

DATA:

Acceleration due to gravity g = 9.81 m/sec^2	Area of measuring tank A= 0.09m^2
Energy meter constant EMC=1600 Pulses/kW hr	Height of pressure gauge from suction of pump $h_{\rho g}$=…..m
Density of water ρ_w= 1000 kg/m^3	Motor efficiency η_m= 0.50 (PMDC) and 0.70 (Crompton)
Transmission losses= 0.55	

OBSERVATION TABLE: -

Sr. No.	N (RPM)	P_d (Kg/cm^2)	P_s (mmHg)	R_1 (cm)	R_2 (cm)	T (sec)	P	T_p (sec)

NOMENCLATURE

Nom	Column Heading	Units	Type
A	Area of measuring tank	m^2	Given
E_i	Pump input	kW	Calculated
EMC	Energy meter constant	Pulses/kW hr	Given
E_o	Pump output	kW	Calculated
E_s	Shaft output	kW	Calculated
G	Acceleration due to gravity	m/s^2	Given
H	Total head	M of water	Calculated
$H_{\rho g}$	Height of pressure gauge from suction of pump	M	Given

N	Speed of pump	RPM	Measured
P	Pulses of energy meter		Measured
P_d	Delivery pressure	Kg/cm^2	Measured
P_s	Suction pressure	mmHg	Measured
Q	Discharge	M^3/s	Calculated
R	Rise of water level in measuring tank	M	Calculated
R_1	Final level of water in measuring tank	Cm	Measured
R_2	Initial level of water in measuring tank	Cm	Measured
T	Time taken by R	Sec	Measured
T_p	Time taken by p	Sec	Measured
P	Density of water	Kg/m^3	Given
η_m	Motor efficiency	%	Given
η_o	Overall efficiency	%	Calculated
η_p	Pump efficiency	%	Calculated
	Transmission losses	%	Given

PRECAUTIONS AND MAINTENANCE INSTRUCTIONS

1. Never run the apparatus if Power supply is less than 200 volts and above 230 volts.
2. Never fully close the delivery valve V1.
3. To prevent clogging of moving parts, run pump at least once in a fourth night.
4. Always use clean water.
5. Always keep apparatus free from dust.

TROUBLESHOOTINGS: -

1. If pump does not lift the water, open the air vent provided on the pump to remove the air from pump.
2. If panel is not showing input, check the men supply.

10. AIM: - TO DETERMINE THE EFFICIENCY OF THE HYDRAULIC RAM.

INTRODUCTION:

The Hydraulic Ram is a contrivance utilizing the water hammer principle. Ram is used when a natural source of water like a spring or stream at low head is available ata nearby place to pump a part of water to higher heads. The Ram requires no externalenergy. The work done by a large quantity of water in falling through a small height is used to raise a small part of water to a greater height.

THEORY:

A quantity of water is first allowed to pass through a long column of pipe connected to the Hydraulic Ram and discharged through a waste valve. The momentum of the water flowing through the pipe is then suddenly destroyed by the automatic closing of the wastevalve which pumps a small quantity of water to the high head tank. When the moving column of water is brought to rest, the waste valve opens, and the cycle is repeated automatically.

Hydraulic Rams are most widely used in hilly regions where natural water streams are available. It requires no external energy, and the running and maintenanceexpenditure is practically nil.

DESCRIPTION:

The experimental set up consists of a Hydraulic Ram having a cylindrical air vessel connected to a small rectangular chamber through a non-returning valve. A waste valve is also provided in the rectangular chamber to discharge the excessive water tothe collecting tank. The chamber is connected to an elevated supply tank. A deliverypipe is connected to the foot of the air chamber to deliver the water to measuring tank tomeasure the discharge delivered by the Ram. A pressure gauge is provided for measuring the pressure.

UTILITIES REQUIRED:

- Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5–15-amp socket with earthconnection.
- Water Supply
- Drain required.

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Clean the apparatus and make it free from dust.
2. Close all the drain valves provided.
3. Fill Sump tank, with clean water and ensure that no foreign particles are there.
4. Close all control valves provided.
5. Ensure that all ON/OFF switches given on the panel are at OFF position.
6. Now switch ON the main power supply.
7. Switch ON the pump.
8. Fill the overhead tank with water.
9. Adjust the ram stroke at minimum.
10. When the overhead tank overflows, open control valve of ram.
11. Now Ram is in operation.
12. Adjust stroke of ram to vary the head developed by the ram.
13. Open slightly the control valve provided at useful water discharge line of Air Vessel.
14. Record pressure gauge reading in air vessel.
15. Measure flow rate of wastewater & useful water discharged by the ram using stopwatch

and measuring tank.

16. Repeat experiment at different flow rates of useful water discharge by the ram by regulating the control valve provided at useful water discharge line of Air vessel.

CLOSING PROCEDURE:

1. When the experiment is over, switch OFF pump first.
2. Switch OFF power supply to panel.

Observation & Calculations:

Data:

h_s = 1 m

A = ______m

Observation Table:

Sr. No.	Useful water		Wastewater			P, kg/cm2
	V, ml	t_1, sec	R_1, cm	R_2, cm	t_2, sec	

Nomenclature:

h_d = Delivery head of ram, m

h_s = Head of water supplied to Ram, m

P = Pressure gauge reading, kg/cm^2

q	=	Discharge of useful water lifted up, m^3/sec
Q	=	Discharge of wastewater, m^3/sec
R	=	Rise in water level in measuring tank of wastewater, m
R_1	=	Final level of water in measuring tank, m
R^2	=	Initial level of water in measuring tank, m
t_1	=	Time taken for collecting useful water, sec
t_2	=	Time taken for R, sec
V	=	Volume of useful water, ml
η_A	=	D' Aubussion's Efficiency
η_R	=	Rankine's Efficiency

PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 180 volts and above 230 volts.
2. To prevent clogging of moving parts, Run Pump at least once a fortnight.
3. Always use clean water.
4. Its apparatus will not be in use for more than one month, drain the water completely.
5. Always keep apparatus free from dust.

TROUBLE SHOOTING:

1. If the pump gets jam, rotate the impeller of the pump by means of a screwdriver.
2. If the panel is not showing input, check the fuse and main supply.