LAB MANUAL FOR

FLUID MECHANICS & HYDRAULIC MACHINES LAB

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GENERAL INSTRUCTIONS

Rough record and Fair record are needed to record the experiments conducted in the laboratory. Rough records are needed to be certified immediately on completion of the experiment. Fair records are due at the beginning of the next lab period. Fair records must be submitted as neat, legible, and complete.

Instructions to Students for Writing the Fair Record:

In the fair record, the index page should be filled properly by writing the corresponding experiment number, experiment name, date on which it was done and the page number.

On the **right-side** page of the record following has to be written:

1. **Title**: The title of the experiment should be written in the page in capital letters.
2. In the left top margin, experiment number and date should be written.
3. **Aim**: The purpose of the experiment should be written clearly.
4. **Apparatus/Tools/Equipment/Components used:** A list of the Apparatus/Tools/ Equipment/Components used for doing the experiment should be entered.
5. **Principle**: Simple working of the circuit/experimental set up/algorithm should be written.
6. **Procedure:** steps for doing the experiment and recording the readings should be briefly Described.
7. **Observations:**

i) Data should be clearly recorded using Tabular Columns.
ii) Unit of the observed data should be clearly mentioned
iii) Relevant calculations should be shown.

8. **Results**: The results of the experiment must be summarized in writing and should be fulfilling the aim.
9. **Inference**: Inference from the results is to be mentioned.

On the **Left side** page of the record experimental set up should be drawn neatly.

GENERAL RULES FOR PERSONAL SAFETY

1. Always wear tight shirt/lab coat, pants and shoes inside workshops.
2. Make sure that equipment working on electrical power are grounded properly.
3. Avoid standing on metal surfaces or wet concrete. Keep your shoes dry.
4. Never handle electrical equipment with wet skin.
5. Hot soldering irons should be rested in its holder. Never leave a hot iron unattended.
6. Avoid use of loose clothing and hair near machines and avoid running around inside lab.
7. INFORM YOUR INSTRUCTOR about faulty equipment so that it can be sent for repair.
8. Do not MOVE EQUIPMENT around the room except under the supervision of an instructor.

COURSE OUTCOME

Course Outcome	Descriptions (Students will be able to)
CO1	Understand the basic properties of fluids and apply Newton's Law of Viscosity in solving practical problems.
CO2	Understand the significance of basic principles of fluid statics and application of hydrostatic law in determining forces on surfaces and hydraulic structures, floatation and stability of floating bodies like boats, ships, naval vessels etc.
CO3	Understand the principles of kinematics with specific emphasis on application of continuity equation, stream function etc.
CO4	Apply the principles of Bernoulli's equation in measurement of discharge in pipes, and in other pipe flow problems.
CO5	Computation of friction loss in laminar and turbulent flows.
CO6	Understand the working principle of pumps and turbines.

CONTENTS

Chapter 1

Determination of Metacentric Height

1.1. Aim of the Experiment

To determine the metacentric height of a floating body.

1.2. Theory

A body floating in a fluid is subjected to the following system of force. The downward force of gravity acting on each particle that goes to make up the weight of body, we acting through center of gravity G. The upward buoyant force of the fluid acting on the various elements of the submerged surface of the floating body FB, acting through center of buoyancy B. For a body to be in equilibrium on the liquid surface, the two forces Wc and FB must lie in the same vertical line i.e. these must be collinear, equal and opposite.

When the pontoon has been titled through an angle, the center of gravity of body G, usually remain unchanged in its position, but B i.e. center of buoyancy will generally change its position, thus Wc and Fb in the new position cuts the axis of the body at M, which is called the metacentre and the distance GM is called the metacentric height. The metacentric height is a measure of the static stability of the floating bodies. The metacentric height can be obtained by equating righting couple and applied moment. The metacentric height is given by

$$GM = w\,x/W \tan\theta$$

where, GM = metacentric height in mm, w is the mass of the slider in kg, x is the distance to the movable weight from the central position in mm, W is the mass of the trough and the slider in kg, θ is the angle of inclination

1.3. Apparatus used

A pontoon floating in a tank. Removable strips, graduated arc with pointer, movable, hangers, set of weight.

1.4. Procedure

i) Weigh the adjustable transversal mass as well as the floating prismatic base and assembly.
ii) Displace the sliding mass up to upper part of the mass in such a way that the gravity center be in the upper part of the floating assembly.
iii) Fill the volumetric tank with water.

iv) Move the adjustable mass to the right of the center in 10mm steps of x, until the end of the scale, recording the angular displacement for every position.

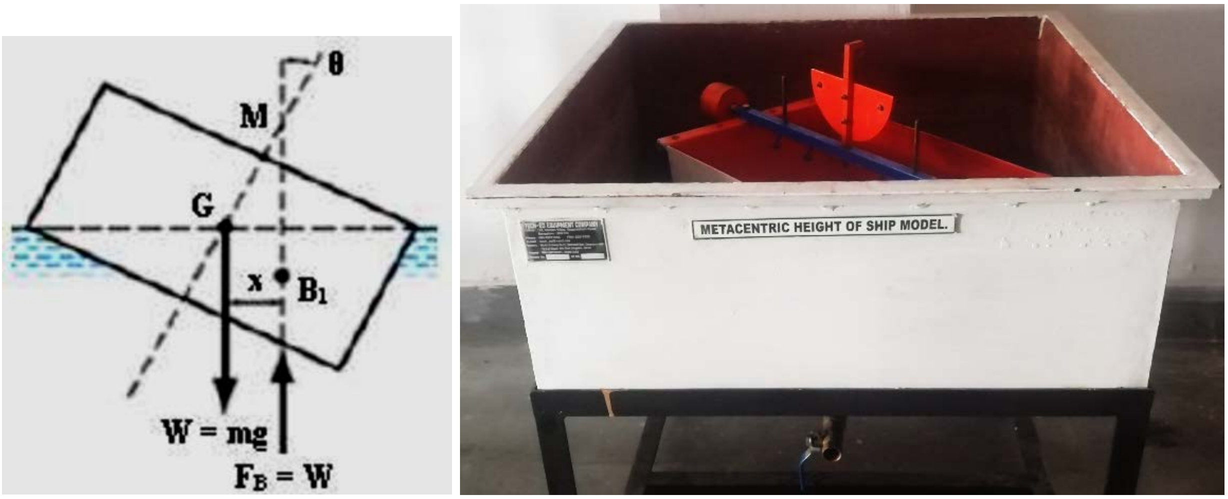


Fig. 1.1. Experimental set up of metacentric height apparatus.

1.4. Observation

Mass of movable slider w =

Mass of trough W_t=

Mass of slider and trough W = 1.951

Sl. No.	Distance from the movable mass to the right of the center, x (cm)	Inclination angle (θ)	tan θ	Metacentric Height $\left(GM = \frac{wx}{Wtan\theta}\right)$ (cm)

1.5 Sample calculation

For observation Sl. No. ___

Distance from the movable mass to the right of the center, x=

Metacentric Height, $GM = \frac{wx}{Wtan\theta}$=

1.6.Result

The average metacentric height (GM) is found to be_______.

Chapter 2

Verification of Bernoulli's equation

2.1. Aim of the Experiment

To Verify the Bernoulli's Theorem.

2.2. Theory

Considering friction less flow along a variable are duct, the law of conservation of energy states "for and Inviscid, incompressible, Irrotational and steady flow along a stream line the total energy (or Head) remains the same". This is called Bernoulli's equation. The total head of flowing fluid consist of a pressure head, velocity head and elevation head remain constant.

Mathematically, Bernoulli's equation is given by

$$\frac{P}{\rho g}+\frac{v^2}{2g}+z=constant$$

where P, V and Z refer to the pressure, velocity and position of the relative to some datum at any section.

2.3. Apparatus used

Inlet supply tank with overflow arrangement, outlet supply tank with means of varying flow rate, Perspex duct of varying cross-section and a series of piezometric tubes installed along its length.

2.4. Procedure

i) Open the inlet valve slowly and allow the water to flow from the supply tank.

ii) Now adjust the flow to get a constant head in the supply tank to make flow in and out flow equal.

iii) Under this condition the pressure head will become constant in the piezometer tubes.

iv) Measure the height of water level "h" (above the arbitrarily selected plane) in different piezometric tubes.

v) Compute the area of cross-section under the piezometer tubes.

vi) Note down the quantity of water collected in the measuring tank for a given interval of time.

vii) Change the inlet and outlet supply and note the reading.

viii) Take at least three reading as described in the above steps.

Fig. 2.1. Experimental set up of Bernoulli's theorem apparatus.

2.5. Observation

Area of collecting tank (A)=

Increase in depth=

Time =

Discharge=

Section	1	2	3	4	5
Cross-sectional area of pipe (a)					
Velocity of Flow (v=Q/a)					
$\frac{v^2}{2g}$					
Piezometer reading $\left(\frac{P}{\rho g}\right)$					
$\frac{P}{\rho g}+\frac{v^2}{2g}+z$					

2.6.Sample calculation

2.7. Result

The total energy head is found to be _______. Hence the Bernoulli's theorem is verified.

Chapter 3

Determination of Coefficient of Discharge for V-notch

3.1. Aim of the Experiment

To Determine the Co-efficient of discharge of a flow through V-notch

3.2. Theory

A notch is a device used for measuring the rate of flow of liquid through a small channel (or) a tank. It is used to estimate discharge and velocity of flowing water. Notches are those overflow structure whose length of crest in the direction of low is accurately shaped. There may be rectangular, trapezoidal, V notch etc. the V-notch is one of the most precise discharge. A v-notch is having a V-shaped opening provided in its body so that water is discharged through this opening. This line which bisects the angle of notch should be vertical and the same distance from both sides of the channel. The discharge coefficient C_d of a v-notch given by

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

In which Q_{act}=the actual discharge flowing in the pipe and Q_{th}=theoretical discharge of V-notch given by

$$Q_{th} = \frac{8}{15}\tan\frac{\theta}{2}\sqrt{2g}H^{5/2}$$

Where θ=apex angle of V-notch, H=water head

3.3. Apparatus used

Approach channel with baffle plate fitted with notch, A Surface level gauge to measure head over notch, a measuring tank to measure flow rate and a constant steady supply of water with using pump.

3.4. Procedure

i) The notch under test is positioned at the end of the tank, in a vertical plane and with the sharp edge on the upstream side.

ii) The tank is filled with water up to crest level and subsequently note down the crest level of the notch by the help of a point gauge.

iii) The flow regulating valve is adjusted to give the maximum possible discharge without flooding the notch.

iv) Conditions are allowed to steady before the rate of discharge and head H were recorded.

v) The flow rate is reduced in stages and the reading of discharge and H were taken.

vi) The procedure is repeated for other type of notch.

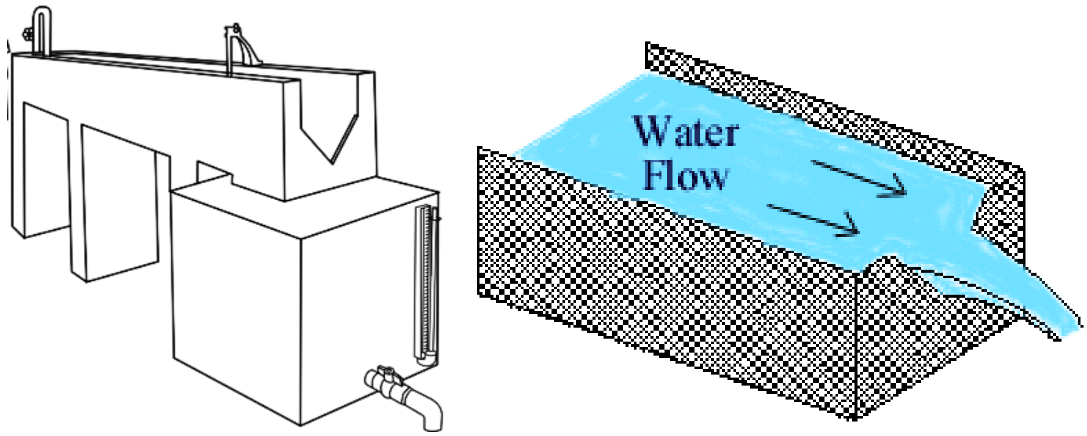


Fig. 3.1. Experimental set up of V-notch apparatus.

3.4. Observation

Area of collecting tank (A)=

Apex angle of V-notch(θ)=

Crest Level of trapezoidal notch (H_0)=

Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q_{act} = \frac{Ah}{\Delta t}\right)$	Final Water level above notch (H_1)	Water head ($H=H_1-H_0$)	Q_{th}	$C_d = \frac{Q_{act}}{Q_{th}}$

3.5.Sample calculation

$Q_{act} = \frac{Ah}{\Delta t}$=

$Q_{th} = \frac{8}{15}\tan\frac{\theta}{2}\sqrt{2g}H^{5/2}$=

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

3.6. Result

The average co-efficient of discharge of the V-notch is found to be ________.

Chapter 4

Calibration of rectangular notch

4.1. Aim of the Experiment

To Determine the Co-efficient of discharge of a flow through rectangular notch

4.2. Theory

A notch is a device used for measuring the rate of flow of liquid through a small channel (or) a tank. It is used to estimate discharge and velocity of flowing water. Notches are those overflow structure whose length of crest in the direction of low is accurately shaped. There may be rectangular, trapezoidal, V-notch etc. A rectangular notch, symmetrically located in a vertical thin plate, which is placed perpendicular to the side and bottom of a straight channel, is defined as a rectangular sharp-crested notch. The discharge coefficient C_d of a rectangular notch given by

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

In which Q_{act}=the actual discharge flowing in the pipe and Q_{th}=theoretical discharge of rectangular notch is given by

$$Q_{th} = \frac{2}{3}\sqrt{2g}BH^{3/2}$$

Where Q=discharge over a rectangular notch, B=width of notch and H=head over the crest of the notch.

4.3. Apparatus used

Approach channel with baffle plate fitted with notch, A Surface level gauge to measure head over notch, a measuring tank to measure flow rate and a constant steady supply of water with using pump.

4.4. Procedure

vii) The notch under test is positioned at the end of the tank, in a vertical plane and with the sharp edge on the upstream side.

viii) The tank is filled with water up to crest level and subsequently note down the crest level of the notch by the help of a point gauge.

ix) The flow regulating valve is adjusted to give the maximum possible discharge without flooding the notch.

x) Conditions are allowed to steady before the rate of discharge and head H were recorded.

xi) The flow rate is reduced in stages and the reading of discharge and H were taken.

xii) The procedure is repeated for other type of notch.

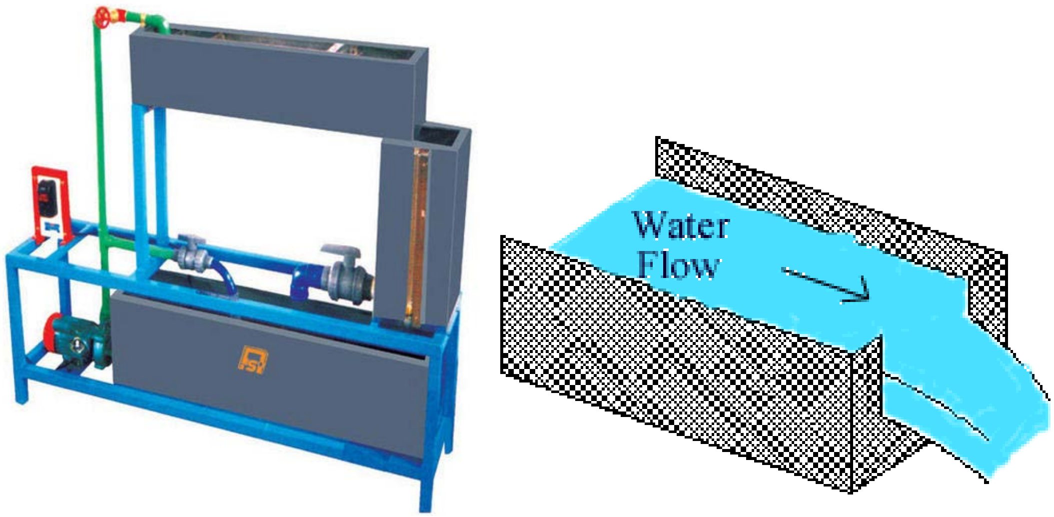


Fig. 4.1. Experimental set up of rectangular notch apparatus.

4.4. Observation

Area of collecting tank (A)=

Width of notch (B) =

Crest Level of trapezoidal notch (H_0) =

Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q_{act} = \frac{Ah}{\Delta t}\right)$	Final Water level above notch (H_1)	Water head ($H=H_1-H_0$)	$Q_{th} = \frac{2}{3}\sqrt{2g}BH^{3/2}$	$C_d = \frac{Q_{act}}{Q_{th}}$

4.5.Sample calculation

$Q_{act} = \frac{Ah}{\Delta t}$=

$Q_{th} = \frac{2}{3}\sqrt{2g}BH^{3/2}$=

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

4.6. Result

The average co-efficient of discharge of the rectangular notch is found to be ________.

Chapter 5

Determination of coefficients of an orifice (C_d, C_C, C_v)

5.1. Aim of the Experiment

To determine the value of coefficient of discharge, coefficient of velocity and coefficient of contraction for the given orifice.

5.2. Theory

Orifice meter is a device used to measure discharge in a pipeline or a closed conduit. Orifice is a hole through which liquid is made to pass through. It works on Bernoulli's principle or venturi effect and continuity equation. Orifice meter consists of a flat plate with a circular hole at the centre. The circular hole is called orifice. The edges of the orifice are bevelled. The orifice plate is fixed using flanges. The section of flow where the area is minimum is called vena-contracta. At vena-contracta the velocity is maximum.

Merits and Demerits of orifice meter over venturimeter.

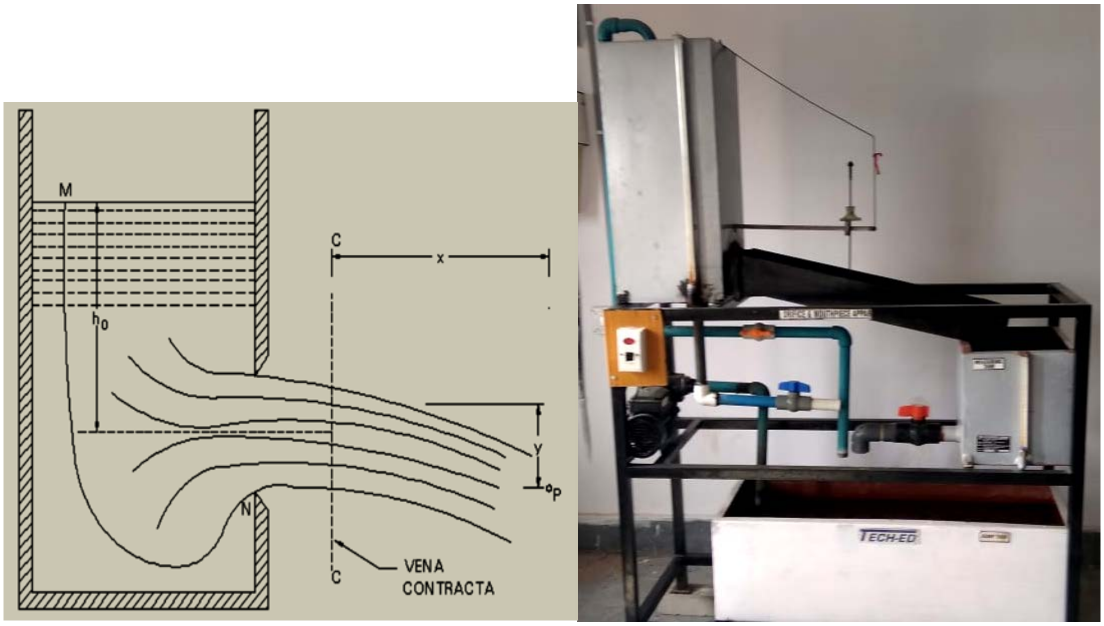
a. Orifice meter occupies less space than venturimeter.
b. Simple in construction and hence cheaper than venturimeter.
c. In case of orifice meter expansion and contraction are sudden and hence loss of energy is more.
d. The co-efficient of discharge of venturimeter is high (about 0.9) where as that of orifice meter is low (about 0.6).

Because of the energy loss which takes place as the water passes down the tank and through the orifice, the actual velocity v_{act} in the plane of vena-contracta will be less than the theoretical velocity, v_{th}.

The coefficient of velocity(C_v) is given by

$$C_v = \frac{v_{act}}{v_{th}} = \frac{\sqrt{gx^2/2y}}{\sqrt{2gh}}$$

where *x* and *y* (measured positive downward) represent the horizontal and vertical coordinates of a point on the trajectory of the jet (origin being taken at the lowest point of the jet at vena-contraction and h= water head.



5.1. Orifice experimental setup

The coefficient of discharge (C_d) is defined as the ratio of the actual discharge to that theoretical discharge given by

$$C_d = \frac{Q_{act}}{Q_{th}} = \frac{Q_{act}}{a_0\sqrt{2gh}}$$

Where $a_0$is the area of vena-contacta=4Q/πd^2 in which d= diameter of vena-contacta.

The coefficient of contraction, (C_c) is defined as the ratio between cross-sectional area of the vena-contracta to the cross-sectional area of the orifice. It can also be defined as given by

$$C_c = \frac{C_d}{C_v}$$

5.3. Apparatus used

i. Orifice meter
ii. Pump and motor for steady supply of water.
iii. Clock to record the time
iv. Measuring tank.

5.4. Procedure

a. Fill up sufficient water in sup tank & supply tank, up to level of orifice fixture
b. Fit the required orifice to the tank.

c. Start the pump. Adjust the supply valve. Wait for some time till the water level in the supply tank becomes steady.
d. When water level becomes steady, note down the time required for 10 litres level rise in measuring tank.
e. Measure X and Y co-ordinates of two points in jet, one of which should be closer to orifice and the other away from the orifice.
f. Repeat the procedure for different heads.

5.4. Observation

Length of the pipe, or the distance between the pressure tappings, L=

Diameter of the pipe (D)=

Cross-sectional area of pipe (a)=$\pi D^2/4$

Area of collecting tank (A)=

Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q_{act} = \frac{Ah}{\Delta t}\right)$	Water head (h_0)	x_1	y_1	x_2	y_2	x= x_2-x_1	y= y_2-y_1

5.5.Sample calculation

For observation Sl. No. ___

Diameter. of orifice (d)=

Area of orifice, a_0=

Head over orifice, h_0 =

$$C_d = \frac{Q_{act}}{a_0\sqrt{2gh_0}}=$$

$$C_v = \frac{\sqrt{gx^2/2y}}{\sqrt{2gh_0}}=$$

$$C_c = \frac{C_d}{C_v}=$$

5.6. Result

The average co-efficient of discharge, co-efficient of velocity and co-efficient of contraction of the orifice are found to be________, ______ and ______ respectively.

Chapter 6

Determination of Coefficient of Discharge for Venturimeter

6.1. Aim of the Experiment

To determine the coefficient of discharge of liquid flowing through venturimeter

6.2. Theory

Venturimeter is a device consisting of a short length of gradual convergence and a long length of gradual divergence. Pressure tapping is provided at the location before the convergence commences and another pressure tapping is provided at the throat section of a Venturimeter. The difference in pressure head between the two tapping is measured by means of a U-tube manometer. On applying the Continuity equation & Bernoulli"s equation between the two sections, the following relationship is obtained in terms of governing variables.

Theoretical Discharge (Q_{th}) is given by

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

Where a_1 and a_2 are Area of inlet pipe and throat respectively,

H=Head loss measured by the manometer is given by

$$H_L = x\left(\frac{S_m}{S_w} - 1\right) = 12.6x$$

In which x= manometric reading, S_m=Specific gravity of manometric liquid (=13.6), and S_w= Specific gravity of water (=1).

The coefficient of discharge (C_d) of venturimeter is defined as the ratio of the actual discharge to that theoretical discharge given by

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

6.3. Apparatus used

Venturimeter, Pump and motor for steady supply of water, stopwatch, Measuring tank.

6.4. Procedure

i) The pipe is selected for conducting experiment.

ii) The motor is switched on; as a result, water flows through pipes.

iii) The time taken for 10cm rise of water in collecting tank is noted.

iv) The experiment is repeated for different discharges in the same pipe.

v) Coefficient of Discharge is calculated

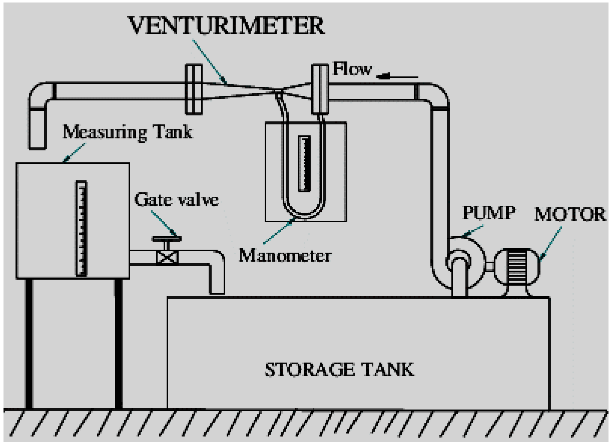


Fig. 6.1. Experimental set up of flow through venturimeter apparatus.

6.4. Observation

Diameter of the inlet pipe =

Diameter of the throat =

Area of collecting tank (A)=

Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q_{act} = \frac{Ah}{\Delta t}\right)$	Manometric reading (x)	Loss of head (H_L)	Q_{th}	$C_d = \frac{Q_{act}}{Q_{th}}$

6.5. Sample calculation

For observation Sl. No. ___

Area of inlet pipe (a_1)=

Area of throat (a_2)=

$H_L = 12.6x$=

$Q_{th} = a_1 a_2 \sqrt{\frac{2gH_0}{a_1^2 - a_2^2}}$=

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

6.6. **Result**

The average co-efficient of discharge of the venturimeter is found to be_______.

Chapter 7

Determination of Reynold's Number

7.1. Aim of the Experiment

Study of different types of flow using Reynold"s apparatus

7.2. Theory

Consider the case of the fluid along a fixed surface such as the wall of a pipe. At some distance y from the surface the fluid has a velocity *(v)* relative to the surface. The relative movement causes a shear stress *(τ)* which tends to slow down the motion so that the velocity close to the wall reduced below u. It can be shown that the shear stress produces a velocity gradient *(∂v/∂y)* which is proportional to the applied stress. The constant of the proportionality is the coefficient of viscosity and the equation is given by

$$\tau = \mu \frac{\partial v}{\partial y}$$

Where μ=coefficient of dynamic viscosity

The inertia force *(F_i)* is directly proportional to density *(p)*, square of the diameter of the pipe *(d^2)* and the velocity.

$$F_i = \rho v^2$$

Reynolds number is the ratio of inertia forces to the viscous forces given by

$$R_e = \frac{\rho v d}{\mu}$$

In which ρ=fluid density and d= diameter of pipe

The flow type is classified using the R_e number

$$R_e = \begin{Bmatrix} < 2000, & flow\ is\ laminar \\ 2000 < R_e < 4000, & flow\ is\ in\ transition \\ R_e > 4000, & flow\ is\ turbulent \end{Bmatrix}$$

7.3. Apparatus used

Reynolds number and Transitional Flow Demonstration Flow Apparatus

7.4. Procedure

i) Set the apparatus, turn on the water supply and partially open the discharge valve at the base of the apparatus.

ii) Adjust the water supply until the level in the constant head is just above the overflow pipe and is maintained at this level by a small flow down the overflow pipe.

iii) Open and adjust the dye injector valve to obtain a fine filament of dye in the flow down the glass tube. A laminar condition should be achieved in which the filament of dye passes down the complete length of the tube without disturbance.

iv) Slowly increase the flow rate by opening the discharge valve until disturbances of the dye filament are noted. This is regarded as the starting point of the transition to turbulent flow. Increase the water supply as required maintaining the constant head conditions.

v) Record the temperature of the water using the thermometer then measure the flow rate by timing the collection of the known quantity of water from the discharge pipe.

vi) Further increase the flow rate as described above until the disturbances increase such that the dye filament becomes rapidly diffused. Small eddies will be noted just above the point where dye filament completely breaks down. This is regarded as the onset of fully turbulent flow. Record the temperature and flow rate.

vii) Now decreases the flow slowly until the dye returns to a steady filament laminar flow and again record the temperature and flow rate.

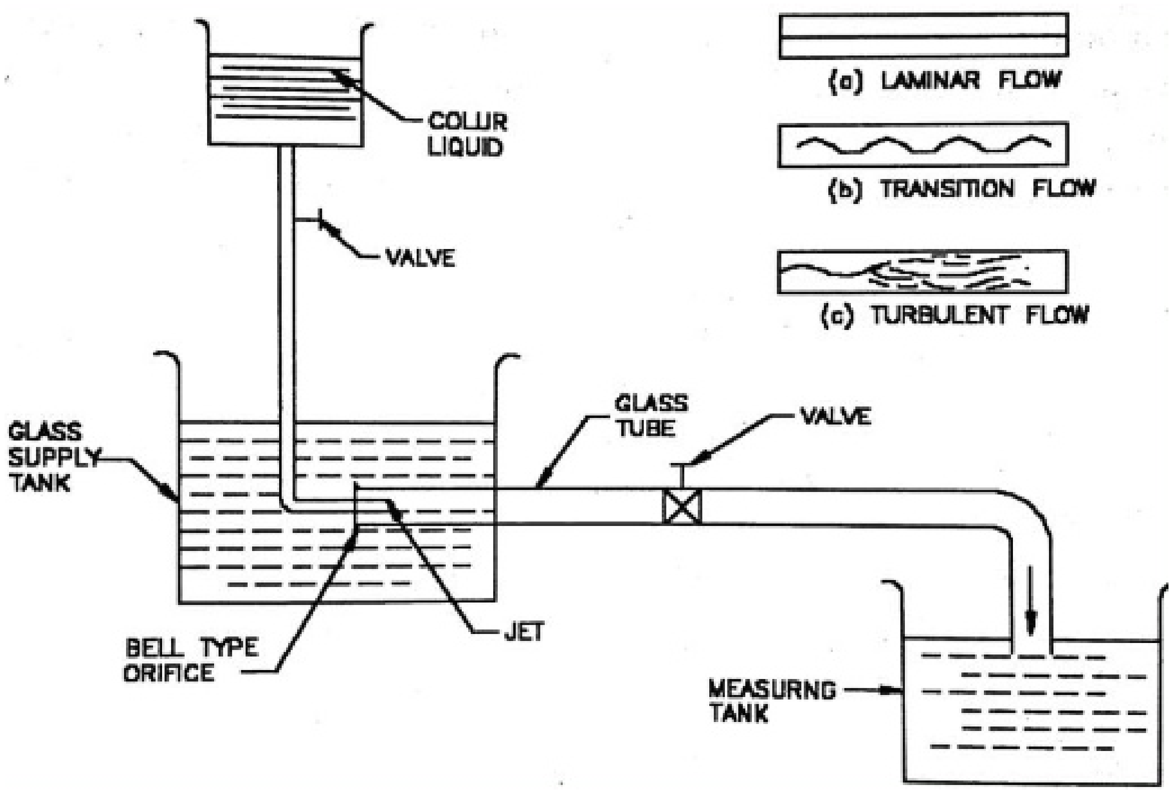


Fig. 7.1. Experimental set up of Reynolds number apparatus.

7.5. Observation

Coefficient of dynamic viscosity of fluid (μ) =

Diameter of the pipe (d) =

Area of collecting tank (A)=

Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q_{act} = \frac{Ah}{\Delta t}\right)$	Flow velocity $(v = 4Q_{act}/\pi d^2)$	$R_e = \frac{\rho v d}{\mu}$	Flow type

7.6.Sample calculation

For observation Sl. No. ___

$v = 4Q_{act}/\pi d^2$=

$R_e = \frac{\rho v d}{\mu}$=

7.7. **Result**

The flow in the pipe is found to be ________.

Chapter 8

Friction Loss in Flow through Pipes

8.1. Aim of the Experiment

To determine the Co-efficient of friction in flow through pipes of various sizes.

8.2. Theory

When a fluid is flowing through a pipe, the fluid experiences some resistance due to which sme of the energy of fluid is lost. The major factor contributing to the energy loss in any pipe flow is through the boundary shear. Estimation of frictional losses is important from engineering point of view as the design of pipe mains carrying water from any reservoir to the township over a long distance mainly depends upon the friction factors. Booster pumps at places are to be provided to add additional energy needed to maintain the required quantity of flow. The loss of energy due to friction and it is calculated by the following Darcy-Weisbach formulae:

$$h_f = \frac{4fLv^2}{2gD}$$

Where, h_f = loss of head due to friction, f = co-efficient of friction., L = length of pipe

v = mean velocity of flow=Q/a, Q=Discharge, a= Cross-sectional area of pipe=$\pi D^2/4$

D = diameter of pipe, Discharge (Q) is measured as: $Q = \frac{Ah}{\Delta t}$

In which A= Area of collecting tank

h= rise of water level in collecting tank in time interval Δt.

Actual head loss calculated using the manometer reading can be estimated as given by

$$h_f = x\left[\frac{S_{Hg}}{S_w} - 1\right] = 12.6x$$

Where x=manometer reading

8.3. Procedure

i) Switch on the pump and open the delivery valve.

ii) Open the corresponding ball valve of pipe under consideration.

iii) Keep the ball valve of other pipeline closed.

iv) Note down the differential head readings in the manometer. (Expel if any air is present by opening the drain cocks provided to the manometer).

v) Close the butterfly valve and note down the time taken for known water level rise.

vi) Change the flow rate and take the corresponding reading

vii) Repeat the experiment for different diameter of pipelines.

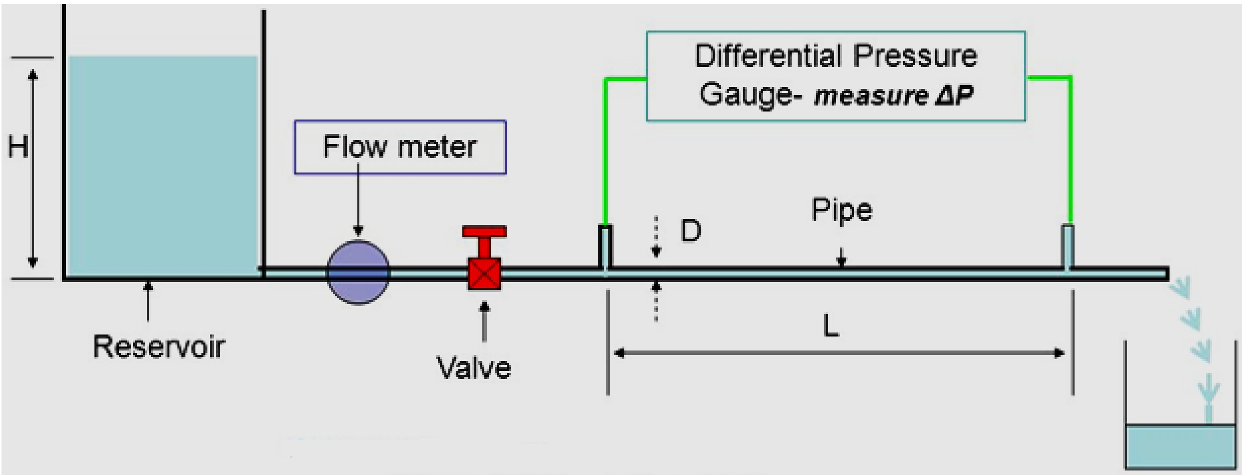


Fig. 8.1. Experimental setup of friction loss in pipe flow.

8.4. Observation

Length of the pipe, or the distance between the pressure tappings, L=

Diameter of the pipe (D)=

Cross-sectional area of pipe (a)=$\pi D^2/4$

Area of collecting tank (A)=

Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q = \frac{Ah}{\Delta t}\right)$	Velocity of flow, v=Q/a	Differential manometer reading (x)	$h_f = 12.6x$	Co-efficient of friction $\left(f = \frac{gDh_f}{2Lv^2}\right)$

8.5.Sample calculation

For observation Sl. No. ___

Discharge, $Q = \frac{Ah}{\Delta t} =$

Velocity of flow, v=Q/a=

Head loss, $h_f = 12.6x$

Co-efficient of friction, $f = \frac{gDh_f}{2Lv^2} =$

8.6.Result

The average co-efficient of friction of the pipe is found to be_______.

Chapter 9

Determination of minor losses in flow through pipes

9.1. Aim of the Experiment

To determine coefficient of various minor losses of energy in flow through pipes.

9.2. Theory

When a fluid flows through a pipe, certain resistance is offered to the flowing fluid, which results in causing a loss of energy. The various energy losses in pipes may be classified as:

(i) Major losses.

(ii) Minor losses.

The major loss of energy as a fluid flows through a pipe, is caused by friction. It may be computed mainly by Darcy-Weisbach equation. The loss of energy due to friction is classified as a major loss because in case of long pipelines. It is usually much more than the loss of energy incurred by other causes. The minor losses of energy are those, which are caused on account of the change in the velocity of flowing fluid (either in magnitude or direction). In case of long pipes these losses are usually quite small as compared with the loss of energy due to friction and hence these are termed 'minor losses' which may even be neglected without serious error. However, in short pipes these losses may sometimes outweigh the friction loss. Some of the losses of energy that may be caused due to the change of velocity are indicated below

(a) Loss of head due to sudden enlargement

$$h_L = K\left(\frac{v_1^2 - v_2^2}{2g}\right)$$

(b) Loss of head due to sudden contraction

$$h_L = K\left(\frac{v_2^2}{2g}\right)$$

(c) Loss of head at 90˚ Elbow

$$h_L = K\left(\frac{v^2}{2g}\right)$$

(d) Loss of head at 90˚ Bend

$$h_L = K\left(\frac{v^2}{2g}\right)$$

(e) Loss of head due to pipe fitting

$$h_L = K\left(\frac{v^2}{2g}\right)$$

Where h_L=head loss,

K=coefficient of pipe,

g= acceleration due to gravity

v_1=flow velocity at contraction=Q/a_1,

a_1=cross-sectional area= $\pi D_1^2/4$

v_2=flow velocity at expansion=Q/a_2,

a_2=cross-sectional area= $\pi D_2^2/4$

v= flow velocity = Q/a

a=cross-sectional area= $\pi D^2/4$

D_1, D_2, and D= pipe diameter at contraction, expansion, and at elbow, bend and fitting of pipe respectively.

9.3. Procedure

a. Switch on the pump and open the delivery valve.
b. Open the corresponding ball valve of pipe under consideration.
c. Keep the ball valves of other pipelines closed.
d. Note down the differential head readings in the manometer (expel if any air is present by opening the drain cocks provided to the manometer).
e. Close the butterfly valve and note down the time taken for known water level rise.
f. Change the flow rate and take the corresponding reading

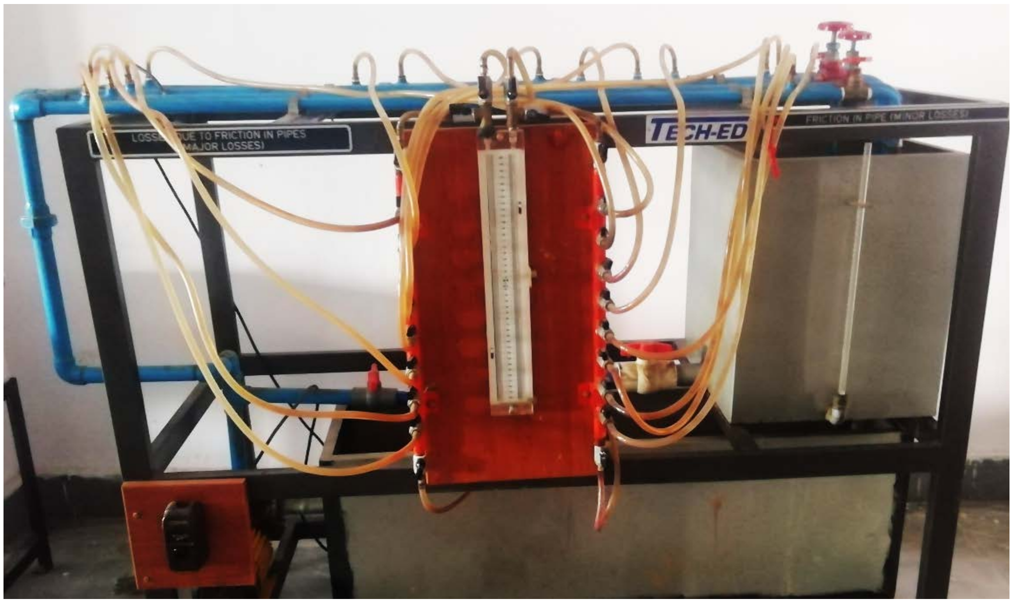


Fig. 9.1. Experimental setup of minor losses in pipe flow apparatus.

9.4. Observation

Area of collecting tank (A)=

Type	Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q = \frac{Ah}{\Delta t}\right)$	Velocity of flow, v=Q/a	Differential manometer reading (x)	$h_L = 12.6x$	Co-efficient (K)
Sudden enlargement					v_1 v_2			
Sudden contraction								
90˚ Elbow								
90˚ Bend								
Pipe fitting								

9.5.Sample calculation

For observation Sl. No. ___

Discharge, $Q = \frac{Ah}{\Delta t} =$

Velocity of flow, v=Q/a=

Head loss, $h_L = 12.6x =$

Co-efficient of pipe in expansion (K)=

9.6.Result

The average co-efficient of the pipe in expansion, contraction, eblow, bend and pipe fitting are found to be________, ________, ________, _________and_______ respectively.

Chapter 10

Experiments on Impact of Jets

10.1. Aim of the Experiment

To determine the co-efficient of impact on vanes.

10.2. Theory

The liquid comes out in the form of a jet from the outlet of a nozzle, which is fitted to a pipe through which the liquid is flowing under pressure. If some plate, which may be fixed or moving, is placed in the path of the jet, the jet on the plate exerts a force. This force is obtained from Newton's second law of motion or from impulse momentum equation. Thus, impact of jet means the force excited by the jet on a plate, which may be stationary or moving. Force (F) exerted by the jet on a stationary plate is given by

$F_{th} = \rho a v^2 (1 - cos\theta)/g$ in kgf.

Where ρ=density of fluid

a= Area of jet=$\pi d^2/4$

v=flow velocity= $4Q/\pi d^2$

d=diameter of jet

θ=angle made by the jet with the surface

$$\theta = \begin{Bmatrix} = 90° \, for \, flat \, surface \\ = 180° \, for \, hemispherical \, surface \end{Bmatrix}$$

At equilibrium condition the impact exerted by the jet is equals to the weight of vane acting downward

The coefficient of impact is estimated as given by

$$K = \frac{F_{act}}{F_{th}} = \frac{m_v}{\rho a v^2 (1 - cos\theta)/g}$$

Where m_v=mass of vane in kg is estimated experimental using momentum theorem about the fulcrum given by

$$m_v = \frac{m_s l_s}{l_v}$$

Where m_s= Mass of sliding weight (kg),

l_s= Distance of sliding weight from fulcrum (m), and l_v= Distance of vane from fulcrum (m)

10.3. Apparatus Required

Vanes (flat, inclined and hemispherical), experimental setup comprising rotameter, nozzles of different diameter, steady supply of water using pump.

10.4. Procedure

a. Fill up clean water in the sump tank up to the mark
b. Fix the flat plate to the fixing rod. Fix the nozzle in perspex box at centre and close the top covers.
c. Adjust the balance weight. Locking bolt is provided so that the vane fixing rod is in horizontal position.
d. Connect the electric supply and hose pipe connection to inlet of the nozzle.
e. Fully open the bypass valve. Start the pump.
f. Slowly close bypass valve. The jet strikes the vane.
g. Now, the vane fixing rod gets unbalanced. Put the sliding weight over the rod and adjust its distance such that vane fixing rod is in balanced position.
h. Note down the balance weight and its distance from the centre of the pivot.
i. Close the discharge valve of the measuring tank. Turn the funnel towards the measuring tank so that the water gets collected in the measuring tank.
j. For next reading use same procedure.
k. After completion of experiment drain all the water and tighten the drain plug.

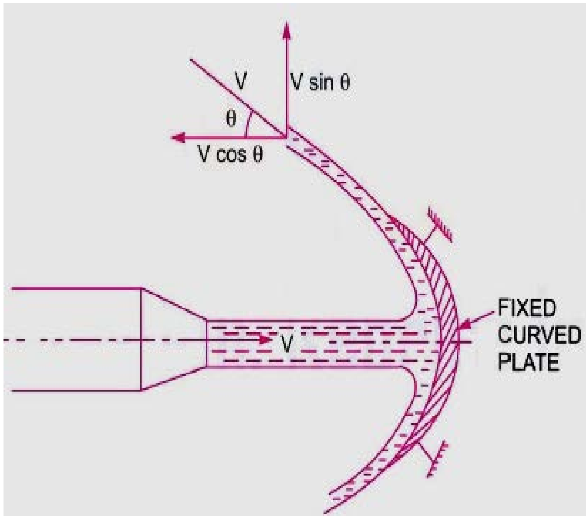


Fig. 10.1. Experimental setup of Impact of jet apparatus.

10.5. Observation

Area of collecting tank (A)=

Type of vane	Sl. No.	Rise of water level in collecting tank (h)	Δt	Discharge $\left(Q = \frac{Ah}{\Delta t}\right)$	Velocity of flow, v=Q/a (m^2/s)	F_{th} (kg)	$F_{act} = m_v$ (kg)	Co-efficient (K=$\frac{F_{act}}{F_{th}}$)
Flat								
Hemispherical								
Inclined								

10.6.Sample calculation

For observation Sl. No. ___

Discharge, $Q = \frac{Ah}{\Delta t} =$

Velocity of flow, v=$4Q/\pi d^2$=

$F_{th} = \rho a v^2 (1 - cos\theta)/g$

$F_{th} = m_v = \frac{m_s l_s}{l_v} =$

The coefficient of impact $(K) = \frac{F_{act}}{F_{th}} =$

10.7.Result

The average co-efficient of impact is found to be ______ respectively.

Chapter 11

Experiments on performance of Pelton turbine

11.1. Aim of the Experiment

To study the performance test of a Pelton wheel.

turbine.

11.2. Theory

Pelton turbine is a impulse turbine. Which uses water available at high heads (pressure) for generation of electricity. All the available potential energy of the water is converted into kinetic energy by a nozzle arrangement. The water leaves the nozzle as a jet and strikes the buckets of the Pelton wheel runner. These buckets are in the shape of double cups, joined at the middle portion in a knife edge. The jet strikes the knife edge of the bucket with the least resistance and shock and glides along the path of the cup, deflecting through an angle of 160° to 170°.This deflection of the water causes a change in momentum of the water jet and hence an impulse force is supplied to the buckets. As a result, the runner attached to the bucket moves, rotating the shaft. The specific speed of Pelton wheel varies from 10 to 100

In the test rig the Pelton wheel is supplied with water under the high pressure by a centrifugal pump. The water flows through the venturimeter to the Pelton wheel. A gate valve is used to control the flow rate to the turbine. The venturimeter with pressure gauges is connected to determine the flow rate in the pipe. The nozzle opening can be decreased or increased by opening the spear wheel at entrance side of the turbine. The turbine is loaded by applying the dead weights on the brake drum. Placing the weights on the weight hanger. The inlet head is read from the pressure gauge. The speed of the turbine is measured with the help of tachometer.

11.3. Apparatus Required

Pelton Turbine, Pressure gauges, Tachometer and Manometer

11.4. Procedure

i) Prime the pump with water and start the pump.

ii) Gradually open the delivery valve of the pump.

iii) Adjust the nozzle at the half of the opening by operating the needle valve by using the spear wheel.

iv) The head should be made constant by operating the delivery valve and the head shows be maintained at constant value.

v) Measure the turbine rpm with the tachometer.

vi) Note the pressure gauge reading at the turbine inlet.

vii) Observe the readings of h 1 and h 2 corresponding the fluid level in the two-manometer links which are connected to venturi meter.

viii) Adjust the load on the break drum and note down the speed of the turbine, using the tachometer and spring balance reading.

ix) Add additional weights and repeat the experiment for other loads.

x) For constant speed tests, the main valve has to be adjusted to reduce or increase the inlet head to the turbine for varying loads spring balance reading.

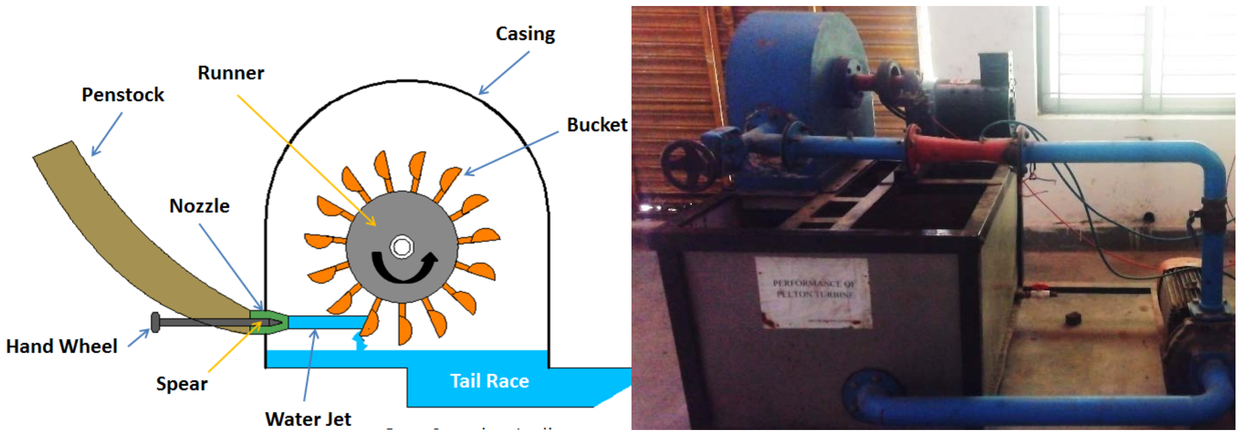


Fig. 11.1. Pelton wheel experimental setup

11.5. Observation

To find discharge the venturi meter and the manometer have been calibrated.

Venturimeter: d/D = 0.6, D = 0.065 m,

$$Q_a = C_d \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}} \text{ m}^3/\text{s}$$

The height of mercury column in left arm = h_1 m

The height of mercury column in right arm = h_2 m

Difference of levels = $h_1 - h_2 = h$

Equivalent water column = $(S_m/S - 1)h = (13.6/1-1)h = 12.6h = H_1$

Calculation of Input Power (P_i)

Discharge=Q m^3/s

Head=H m

$$P_i = \rho g Q H$$

Calculation of Output Power:

Dead weight (T_1)=_____Kg

Spring weight (T_2)=_____Kg

Weight of hanger (T_o)=_____Kg

Resultant load (T) =T_1-T_2+T_o=_____Kg

Speed (N)=_____rpm

Dia. of brake drum=0.40 m

Thickness of rope=0.015 m.

Resultant dia., D=0.415 m

$P_o = 2\pi NT/60$

Efficiency of the turbine, $\eta = P_o/P_i$

Sl.No.	Head (m)	Manometer, h (m)	Discharge (m^3/s)	Speed (rpm)	T_1	T_2	T	P_i	P_o	Efficiency

11.6.Sample calculation

For observation Sl. No. ___

11.7.Result

The efficiency of pelton wheel turbine is found to be ______ respectively.

Chapter 12

Experiments on performance of Francis turbine

12.1. Aim of the Experiment

To study the performance test of a Francis turbine.

turbine.

12.2. Theory

Francis turbine is a reaction type hydraulic turbine, used in dams and reservoir of medium height to convert hydraulic energy into mechanical and electrical energy. Francis turbine is radial inward flow reaction turbine. This has the advantage of centrifugal forces acting against the flow, thus reducing the tendency of the turbine to over speed. Francis turbines are best suited for medium heads. The specific speed ranges from 25 to 3oo. The turbine test rig consist of a 1.0 KW (1.34 HP) turbine supplied with water from a suitable 5HP centrifugal pump through suitable pipelines, a gate valve, and a flow measuring venturimeter.

The turbine consists of a cast iron body with a volute casing and gun metal runner consisting of two shrouds with an aerofoil shaped curved vanes in between. The runner is surrounded by a set of brass guide vanes. At the outlet, a draft tube is provided to increase the net head across the turbine. The runner is attached to the output of the shaft with a brake drum to absorb the energy. Water under the pressure from the pump enters the guide vanes into the runner while passing through the spiral casing and guide vanes; a portion of pressure energy is converted into velocity energy. Water thus enters the runner at high velocity and as it passes through the runner vanes, the remaining pressure energy converted into kinetic energy. Due to the curvature of the vanes, the kinetic energy is transformed into mechanical energy. The water head is converted into mechanical energy and hence the runner rotates. The water from the runner is then discharged into the tail race. The discharge through the runner can be regulated also by operating the guide vanes. The flow through the pipeline into the turbine is measured with the venturimeter fitted in the pipeline. The venturimeter is provided with the set of pressure gauges. The net pressure difference across the turbine inlet and outlet is measured with a pressure gauge and a vacuum gauge. The turbine output is torque is determined with a rope brake drum dynamometer. A tachometer is used to measure.

12.3. Apparatus Required

Francis turbine rig, tachometer.

12.4. Procedure

i. Add minimum load to the weight hanger of the brake drum say 1 kg.
ii. Close the main gate valve and start the pump.
iii. Open the gate valve while monitoring the inlet pressure to the turbine. set it for the design value of 1.0 kg/sq.cm
iv. Open the cooling water valve for cooling the brake drum.
v. Measure the turbine rpm with the tachometer.
vi. Note the pressure gauge and vacuum gauge reading at the turbine inlet and outlet.
vii. Note the venturimeter pressure gauge reading, P_1 and p_2.
viii. Add additional weights and repeat the experiment for other loads
ix. For constant speed test, the main valve has to be adjusted to reduce or increase the inlet head to turbine for varying loads.

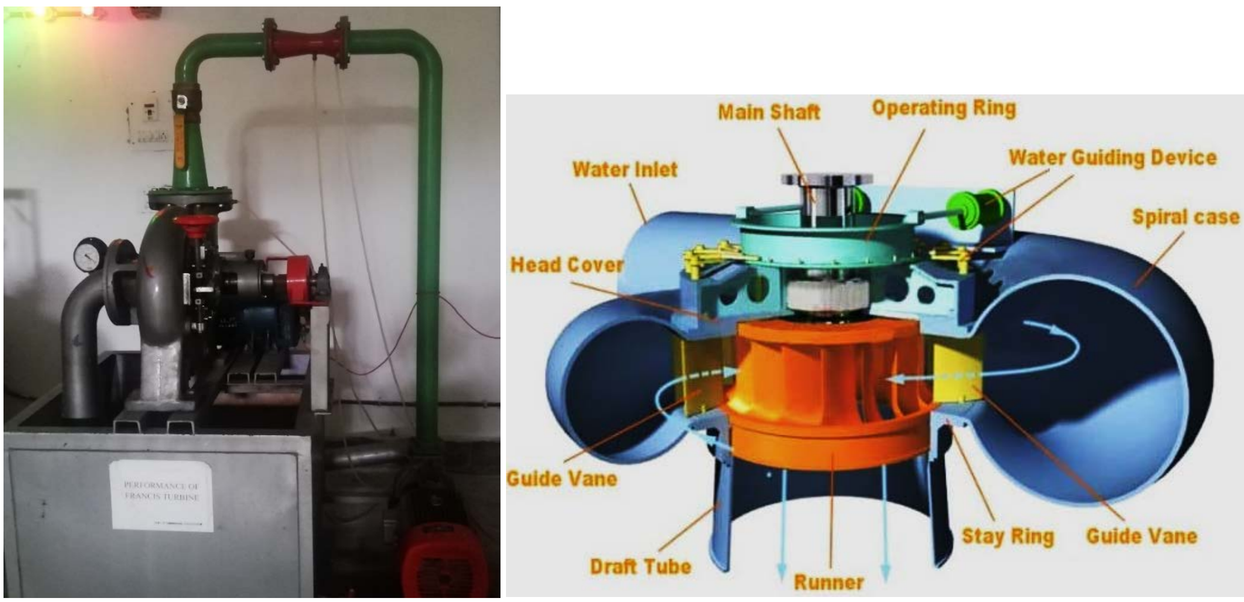


Fig. 12.1. Francis Turbine

12.5. Observation

To find discharge the venturi meter and the manometer have been calibrated.

Venturimeter: d/D = 0.6, D = 0.065 m,

$$Q_a = C_d \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \text{ m}^3/\text{s}$$

The height of mercury column in left arm = h_1 m

The height of mercury column in right arm = h_2 m

Difference of levels = $h_1 - h_2 = h$

Equivalent water column = $(S_m/S - 1)h = (13.6/1-1)h = 12.6h = H_1$

Calculation of Input Power (P_i)

Discharge=Q m^3/s

Head=H m

$$Pi = \rho g Q H$$

Calculation of Output Power (P_o):

Dead weight (T_1)=_____Kg

Spring weight (T_2)=_____Kg

Weight of hanger (T_o)=_____Kg

Resultant load (T) =T_1-T_2+T_o=_____Kg

Speed (N)=_____rpm

Dia. of brake drum=0.40 m

Thickness of rope=0.015 m.

Resultant dia., D=0.415 m

$P_o = 2\pi NT/60$

Efficiency of the turbine, $\eta = P_o/P_i$

Sl.No.	Head (m)	Manometer, h (m)	Discharge (m^3/s)	Speed (rpm)	T_1	T_2	T	P_i	P_o	Efficiency

12.6.Sample calculation

For observation Sl. No. ___

12.7.Result

The efficiency of Francis turbine is found to be ______ respectively.

Chapter 13

Experiments of performance of Kaplan turbine

13.1. Aim of the Experiment

To study the performance test of a Kaplan turbine.

turbine.

13.2. Theory

A Kaplan turbine is a type of reaction turbine. It is an axial flow turbine which is suitable for relatively low heads, and requires a large quantity of water to develop large amount of power. It is a reaction type turbine and hence it operates entirely in a closed conduit from head race to tail race. The test rig consist of a 1 kW Kaplan turbine supplied with water from a suitable 5HP pump through pipe lines, a valve and a flow measuring venturimeter. The turbine consists of a cast iron body with a volute casing, an axial flow gunmetal runner, a ring of adjustable guide vanes and a draft tube. The runner consists of three aerofoil section. The guide is vanes can be rotated about their axis by means of hand wheel. A rope brake drum is mounted on the turbine to absorb the power developed. Suitable dead weight and a hanger arrangement, a spring balance and cooling water arrangement is provided for the brake drum.

Water under pressure from the pump enters through the volute casing and the guide vanes into the runner. while passing through the spiral casing and guide vanes, a portion of the pressure energy (potential energy) is converted into velocity energy (kinetic energy). Water thus enters the runner at high velocity and it passes through the runner vanes, the remaining potential energy is converted into kinetic energy . Due to the curvature of the vanes, the kinetic energy is transformed into the mechanical i.e. the water head is converted into mechanical energy hence the runner rotates. The water from the runner is then discharged into the draft tube. The flow through the pipe lines into the turbine is measured with the venturimeter fitted in the pipe line. Two pressure gauges are provided to measure the pressure difference across venturimeter. The net pressure difference across the turbine inlet and exit is measured with a pressure gauge and vacuum gauge. The turbine output is determined with the rope brake drum. A tachometer is used to measure the speed.

13.3. Apparatus Required

Kaplan turbine test rig, Tachometer

13.4. Procedure

i. Add minimum load to the weight hanger of the brake drum say 1 kg.
ii. Close the main gate valve and start the pump.
iii. open the gate valve while monitoring the inlet pressure to the turbine. set it for the design value of 1.0 kg/sq.cm
iv. Open the cooling water valve for cooling the brake drum.
v. Measure the turbine rpm with the tachometer.
vi. Note the pressure gauge and vacuum gauge reading at the turbine inlet and outlet.
vii. Note the venturimeter pressure gauge reading, P_1 and p_2.
viii. Add additional weights and repeat the experiment for other loads
ix. For constant speed test, the main valve has to be adjusted to reduce or increase the inlet head to turbine for varying loads.

Fig. 13.1 Schematic diagram of Kaplan turbine

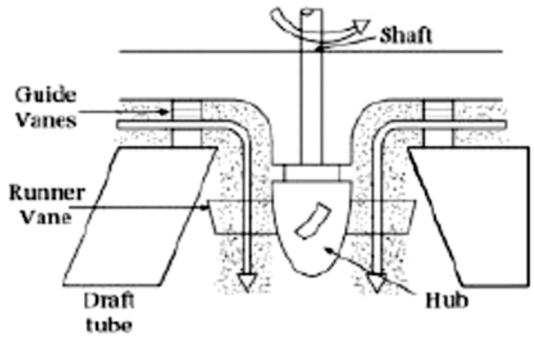


Fig. 13.2. Kaplan Turbine

13.5. Observation

To find discharge the venturi meter and the manometer have been calibrated.

Venturimeter: d/D = 0.6, D = 0.065 m,

$$Q_a = C_d \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \text{ m}^3/\text{s}$$

The height of mercury column in left arm = h_1 m, The height of mercury column in right arm = h_2 m, Difference of levels = $h_1 - h_2 = h$

Equivalent water column = $(S_m/S - 1)h = (13.6/1-1)h = 12.6h = H_1$

Calculation of Input Power (P_i)

Discharge=Q m^3/s,   Head=H m

$Pi = \rho gQH$

Calculation of Output Power (P_o):

Dead weight (T_1)=_____Kg,   Spring weight (T_2)=_____Kg,

Weight of hanger (T_o)=_____Kg,   Resultant load (T) =T_1-T_2+T_o=_____Kg

Speed (N)=_____rpm,   Dia. of brake drum=0.40 m

Thickness of rope=0.015 m.,   Resultant dia., D=0.415 m

$P_o = 2\pi NT/60$

Efficiency of the turbine, $\eta = P_o/P_i$

Sl.No.	Head (m)	Manometer, h (m)	Discharge (m^3/s)	Speed (rpm)	T_1	T_2	T	P_i	P_o	Efficiency

13.6.Sample calculation

For observation Sl. No. ___

13.7.Result

The efficiency of Kaplan turbine is found to be ______ respectively.

Chapter 14

Experiments on performance of Centrifugal Pump

14.1. Aim of the Experiment

To find the efficiency and performance of centrifugal pump.

14.2. Theory

The pump which raises water from a lower level by the action of centrifugal force is known as centrifugal pump. The pump lifts water because of atmospheric pressure acting on the surface of water. A centrifugal pump is Rotodynamic pump that uses a rotating impeller to the pressure of a fluid. It works by the conversion of rotational kinetic energy, typically from an electric motor to an increased static fluid pressure. They are commonly used to move the liquids in pipe system. Fluid enters axially through the hollow middle section of the pump called eye, after which encounters the rotating blades. It acquires tangential and radial velocity by momentum transfer with impeller blades and acquires radial velocity by centrifugal forces.

The performance of a pump is characterized by its net head. which defined as the change in Bernoulli's between the suction and delivery of the pump. H is expressed in equivalent column height of water.

$$H_w = \left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)_{delivery} - \left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)_{suction}$$

Where, P=Absolute water pressure (N/m^2),

V=velocity of water inside the pipe (m/s)

ρ=Density of water (kg/m^3),

g=Acceleration due to gravity (m/s^2) and

Z=Elevation, (m)

The velocity of water can be calculated using discharge and diameter of pipes. The discharge produced by the pump can be determined using the collecting tank and stop watch.

Output of pump (P_i) is estimated as

$$P_o = \rho g Q H_w$$

The external energy supplied to the pump is called brake horse power of pump (P_i)

$$P_i = \frac{3600n}{NT}$$

Where, n= Number of revolutions of energy meter

N=Energy meter constant rev/ kWh

T=Time for 'n' revolutions of energy meter in sec.

Efficiency of pump is estimated as

$$\eta = \frac{P_o}{P_i} \times 100$$

14.3. Apparatus Required

Centrifugal pump test Rig, Stopwatch.

14.4. Procedure

i) Prime the motor, close the delivery valve and switch on the unit

ii) open the delivery valve and maintain the required delivery head. Note the reading.

iii) Note the corresponding suction head.

iv) Measure the area of the collecting tank.

v) Close the drain valve and note down the time for 10 cm rise of water level in the collecting tank

vi) For the different delivery heads repeat the experiment.

vii) For every set of reading note the time taken for 10 revolution of energy meter.

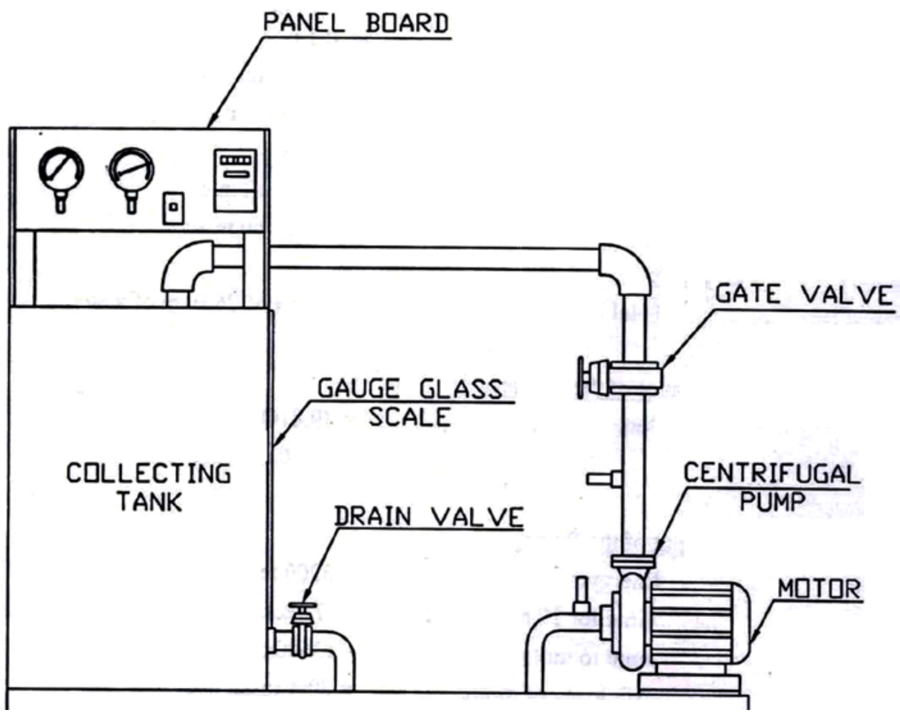


Fig. 14.1 Schematic diagram of centrifugal pump

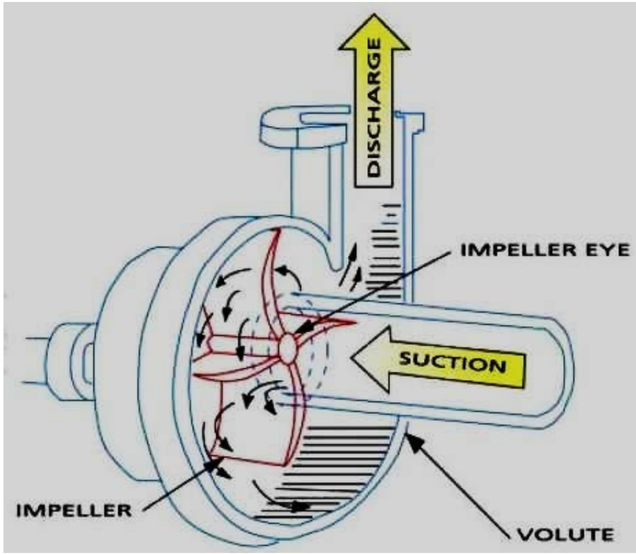


Fig. 14.2. Centrifugal pump

14.5. Observation

Size of the collecting tank = l ×b× h_1

Diameter of the suction pipe, ds = 50 mm

Diameter of the delivery pipe, d_d = 50 mm

Energy meter constant, N = 400 rev / KWH

Difference in the levels of pressure and vacuum gauges, X = 43cm.

Sl. No.	Pressure gauge reading	Vacuum gauge reading	Total Head (m of water)	Time for 0.2m rise in collecting tank, t (sec)	Time for 10 rev. in energy meter, T (sec)	Discharge (m^3/s)	P_i (KW)	P_o (KW)	Efficiency

14.6.Sample calculation

For observation Sl. No. ___

14.7.Result

The efficiency of centrifugal pump is found to be ______ respectively.

Chapter 15

Experiments of performance of reciprocating pump

15.1. Aim of the Experiment

To find the efficiency and performance of reciprocating pump.

15.2. Theory

Reciprocating pump is a positive displacement pump, which causes a fluid to move by trapping a fixed amount of it then displacing that trapped volume into the discharge pipe. The fluid enters a pumping chamber via an inlet valve and is pushed out via a outlet valve by the action of the piston or diaphragm. They are either single acting; independent suction and discharge strokes or double acting; suction and discharge in both directions.

Reciprocating pumps are self-priming and are suitable for very high heads at low flows. They deliver reliable discharge flows and is often used for metering duties because of constancy of flow rate. The flow rate is changed only by adjusting the rpm of the driver. These pumps deliver a highly pulsed flow. If a smooth flow is required then the discharge flow system has to include additional features such as accumulators. An automatic relief valve set at a safe pressure is used on the discharge side of all positive displacement pumps.

The performance of a pump is characterized by its net head. which defined as the change in Bernoulli's between the suction and delivery of the pump. H is expressed in equivalent column height of water.

$$H_w = \left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)_{delivery} - \left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)_{suction}$$

Where, P=Absolute water pressure (N/m^2), V=velocity of water inside the pipe (m/s), ρ=Density of water (kg/m^3), g=Acceleration due to gravity (m/s^2) and Z=Elevation, (m)

The velocity of water can be calculated using discharge and diameter of pipes. The discharge produced by the pump can be determined using the collecting tank and stop watch.

Output of pump (P_i) is estimated as

$$P_o = \rho g Q H_w$$

The external energy supplied to the pump is called brake horse power of pump (P_i)

$$P_i = \frac{3600n}{NT}$$

Where, n= Number of revolutions of energy meter

N=Energy meter constant rev/ kWh

T=Time for 'n' revolutions of energy meter in sec.

Efficiency of pump is estimated as

$$\eta = \frac{P_o}{P_i} \times 100$$

15.3. Apparatus Required

Reciprocating pump test setup, Stop watch, measuring tape, Energy meter

15.4. Procedure

i) Keep the delivery valve open and switch on the pump. Slowly close the delivery valve and maintain a constant head.

ii) Note the delivery and suction gauge reading.

iii) Note the time for 10 rev of Energy meter.

iv) Note the time for 10 cm rise in water level in the collecting tank.

v) Note the speed of the pump (N) rpm.

vi) Repeat the procedure for various openings of the delivery valves.

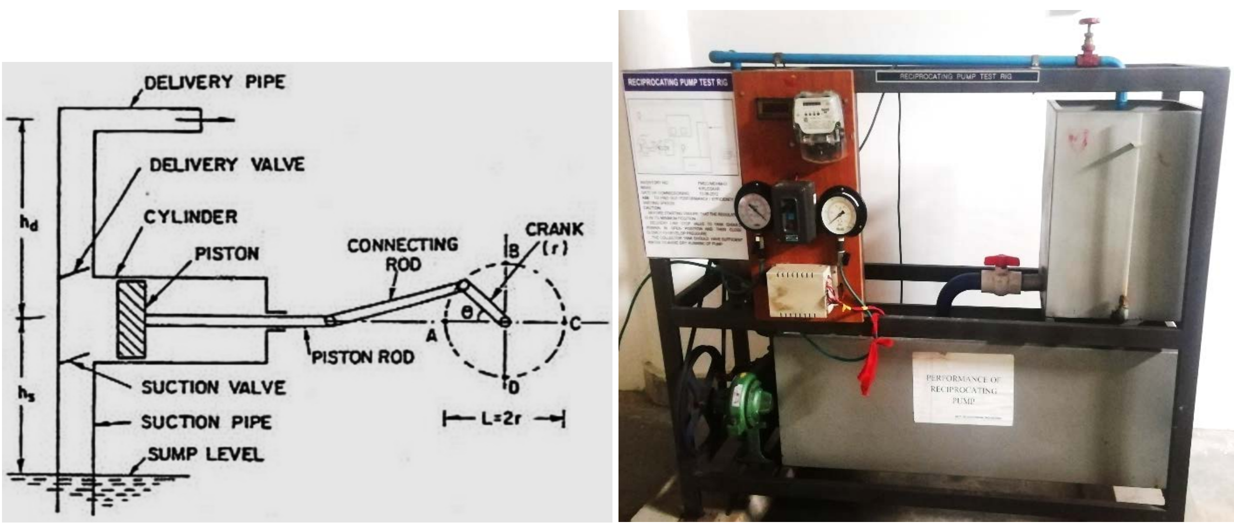


Fig. 15.1 Schematic diagram of Reciprocating pump

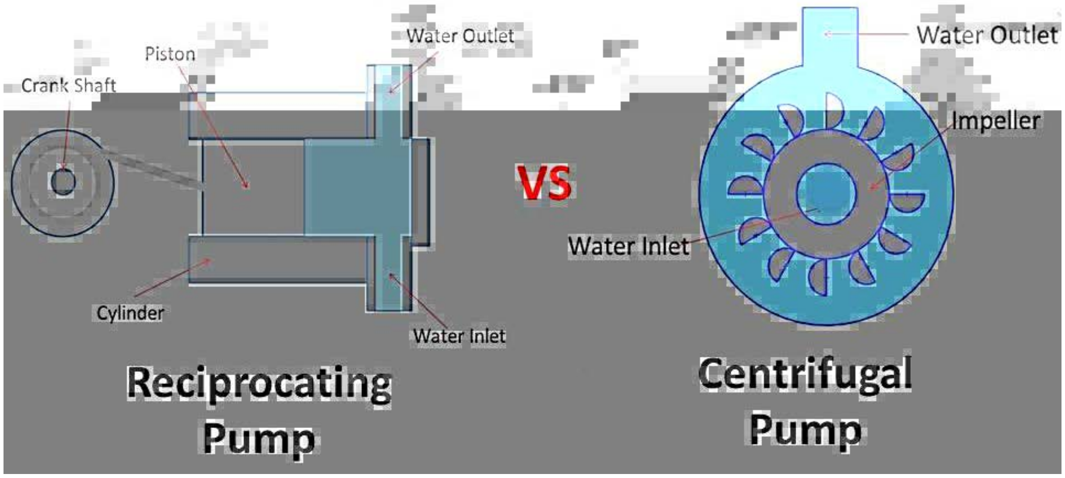


Fig. 15.2. Difference between Reciprocating pump and centrifugal pump

15.5. Observation

Size of the collecting tank = l ×b× h_1

Diameter of the suction pipe, ds = 50 mm

Diameter of the delivery pipe, d_d = 50 mm

Energy meter constant, N = 400 rev / KWH

Difference in the levels of pressure and vacuum gauges, X = 43cm.

Sl. No.	Pressure gauge reading	Vacuum gauge reading	Total Head (m of water)	Time for 0.2m rise in collecting tank, t (sec)	Time for 10 rev. in energy meter, T (sec)	Discharge (m^3/s)	P_i (KW)	P_o (KW)	Efficiency

15.6.Sample calculation

For observation Sl. No. ___

15.7.Result

The efficiency of centrifugal pump is found to be ______ respectively.

Chapter 16

Experiments of performance of Gear pump

16.1. Aim of the Experiment

To find the efficiency and performance of gear pump.

16.2. Theory

A gear pump uses the meshing of gears to pump fluid by displacement. They are one of the most common types of pumps for hydraulic fluid power applications. Gear pumps are also widely used in chemical installations to pump fluid with a certain viscosity. There are two main variations; external gear pumps which use two external spur gears, and internal gear pumps which use an external and an internal spur gear. Gear pumps are positive displacement (or fixed displacement), meaning they pump a constant amount of fluid for each revolution. Some gear pumps are designed to function as either a motor or a pump. The gear oil pump is works based on the squeezing action of the two meshing gears (internal or external gears). The gear pump is one of the positive displacement pumps and the reduction in volume inside the pump results in increase in pressure of fluid.

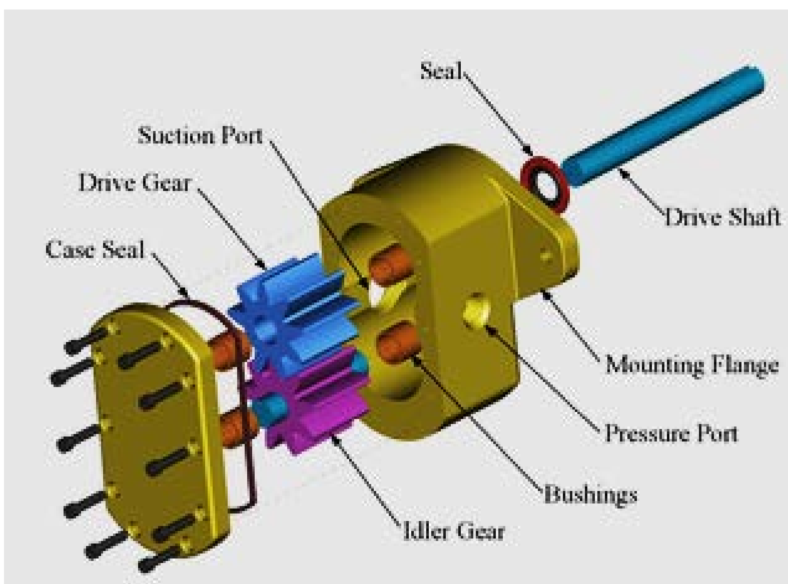


Fig.16.1. Gear pump

The performance of a pump is characterized by its net head. which defined as the change in Bernoulli's between the suction and delivery of the pump. H is expressed in equivalent column height of water.

$$H_w = \left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)_{delivery} - \left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)_{suction}$$

Where, P=Absolute water pressure (N/m^2), V=velocity of water inside the pipe (m/s), ρ=Density of water (kg/m^3), g=Acceleration due to gravity (m/s^2) and Z=Elevation, (m)

The velocity of water can be calculated using discharge and diameter of pipes. The discharge produced by the pump can be determined using the collecting tank and stop watch.

Output of pump (P_i) is estimated as $P_o = \rho g Q H_w$

The external energy supplied to the pump is called brake horse power of pump (P_i)

$$P_i = \frac{3600n}{NT}$$

Where, n= Number of revolutions of energy meter, N=Energy meter constant rev/ kWh

T=Time for 'n' revolutions of energy meter in sec.

Efficiency of pump is estimated as

$$\eta = \frac{P_o}{P_i} \times 100$$

16.3. Apparatus Required

Gear pump test setup, Stop watch, measuring tape, Energy meter

16.4. Procedure

i) The gear oil pump is stated.

ii) The delivery gauge reading is adjusted for the required value.

iii) The corresponding suction gauge reading is noted.

iv) The time taken for 'N' revolutions in the energy meter is noted with the help of a stopwatch.

v) The time taken for 'h' rise in oil level is also noted down after closing the gate valve.

vi) With the help of the meter scale the distance between the suction and delivery gauge is noted. For calculating the area of the collecting tank its dimensions are noted down.

vii) The experiment is repeated for different delivery gauge readings.

16.5. Observation

Size of the collecting tank = l ×b× h_1

Diameter of the suction pipe, ds = 50 mm

Diameter of the delivery pipe, d_d = 50 mm

Energy meter constant, N = 400 rev / KWH

Difference in the levels of pressure and vacuum gauges, X = 43cm.

Sl. No.	Pressure gauge reading	Vacuum gauge reading	Total Head (m of water)	Time for 0.2m rise in collecting tank, t (sec)	Time for 10 rev. in energy meter, T (sec)	Discharge (m^3/s)	P_i (KW)	P_o (KW)	Efficiency

16.6.Sample calculation

For observation Sl. No. ___

16.7.Result

The efficiency of gear pump is found to be ______ respectively.