DEPARTMENT OF

MECHANICAL ENGINEERING

FLUID MECHANICS & MACHINERY LAB

2019-20

(*18MEL57*)

Pradeep N R

Faculty Incharge

Jagadesh A S

Instructor

BAPUJI INSTITUTE OF ENGINEERING AND TECHNOLOGY

DAVANGERE- 577 004

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As per VTU Syllabus CBCS scheme for V Semester

Name : ....

USN : ....

Semester: .... Batch No......................

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VISION OF THE INSTITUTE

To be center of excellence recognized nationally and internationally, in distinctive areas of engineering education and research, based on a culture of innovation and invention.

MISSION OF THE INSTITUTE

BIET contributes to the growth and development of its students by imparting a broad based engineering education and empowering them to be successful in their chosen field by inculcating in them positive approach, leadership qualities and ethical values.

VISION OF THE DEPARTMENT

The department endeavors to be a center of excellence, to provide quality education leading the students to become professional mechanical engineers with ethics, contributing to the society through research, innovation, entrepreneurial and leadership qualities.

MISSION OF THE DEPARTMENT

1. To impart quality technical education through effective teaching-learning process leading to development of professional skills and attitude to excel in Mechanical Engineering.

2. To interact with institutes of repute, to enhance academic and research activities.

3. To inculcate creative thinking abilities among students and develop entrepreneurial skills.

4. To imbibe ethical, environmental friendly and moral values amongst students through broad based education

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

1. Enable to understand mechanical engineering systems those are technically viable, economically feasible and socially acceptable to enhance quality of life.
2. Apply modern tools and techniques to solve problems in mechanical and allied engineering streams.
3. Communicate effectively using innovative tools, to demonstrate leadership and entrepreneurial skills.
4. Be a professional having ethical attitude with multidisciplinary approach to achieve self and organizational goals.
5. Utilize the best academic environment to create opportunity to cultivate lifelong learning skills needed to succeed in profession.

PROGRAM SPECIFIC OUTCOMES (PSO'S)

PS01:-Apply the acquired knowledge in design, thermal, manufacturing and interdisciplinary areas for solving industry and socially relevant problems.

PS02:-To enhance the abilities of students by imparting knowledge in emerging technologies to make them confident mechanical engineers.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – V

Fluid Mechanics & Machinery Lab

Course Code	**18MEL57**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.
- Energy conversion principles, analysis and understanding of hydraulic turbines and pumps will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.

Sl. No.	Experiments

PART A

1. Determination of coefficient of friction of flow in a pipe.
2. Determination of minor losses in flow through pipes.
3. Determination of force developed by impact of jets on vanes.
4. Calibration of flow measuring devices
   a. Orifice Plate meter
   b. Nozzle
   c. Venturimeter
   d. V-notch

PART B

5. Performance testing of Turbines
   a. Pelton wheel
   b. Francis Turbine
   c. Kaplan Turbines
6. Performance testing of Pumps
   a. Single stage / Multi stage centrifugal pumps
   b. Reciprocating pump
7. Performance test of a two stage Reciprocating Air Compressor
8. Performance test on an Air Blower`

PART – C (Optional)

9. Visit to Hydraulic Power station/ Municipal Water Pump House and Case Studies
10. Demonstration of cut section models of Hydraulic turbines and Pumps;

Course Outcomes: At the end of the course, the student will be able to:

CO1. Perform experiments to determine the coefficient of discharge of flow measuring devices.
CO2. Conduct experiments on hydraulic turbines and pumps to draw characteristics.
CO3. Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.
CO4. Determine the energy flow pattern through the hydraulic turbines and pumps, Exhibit his competency towards preventive maintenance of hydraulic machines

DO's

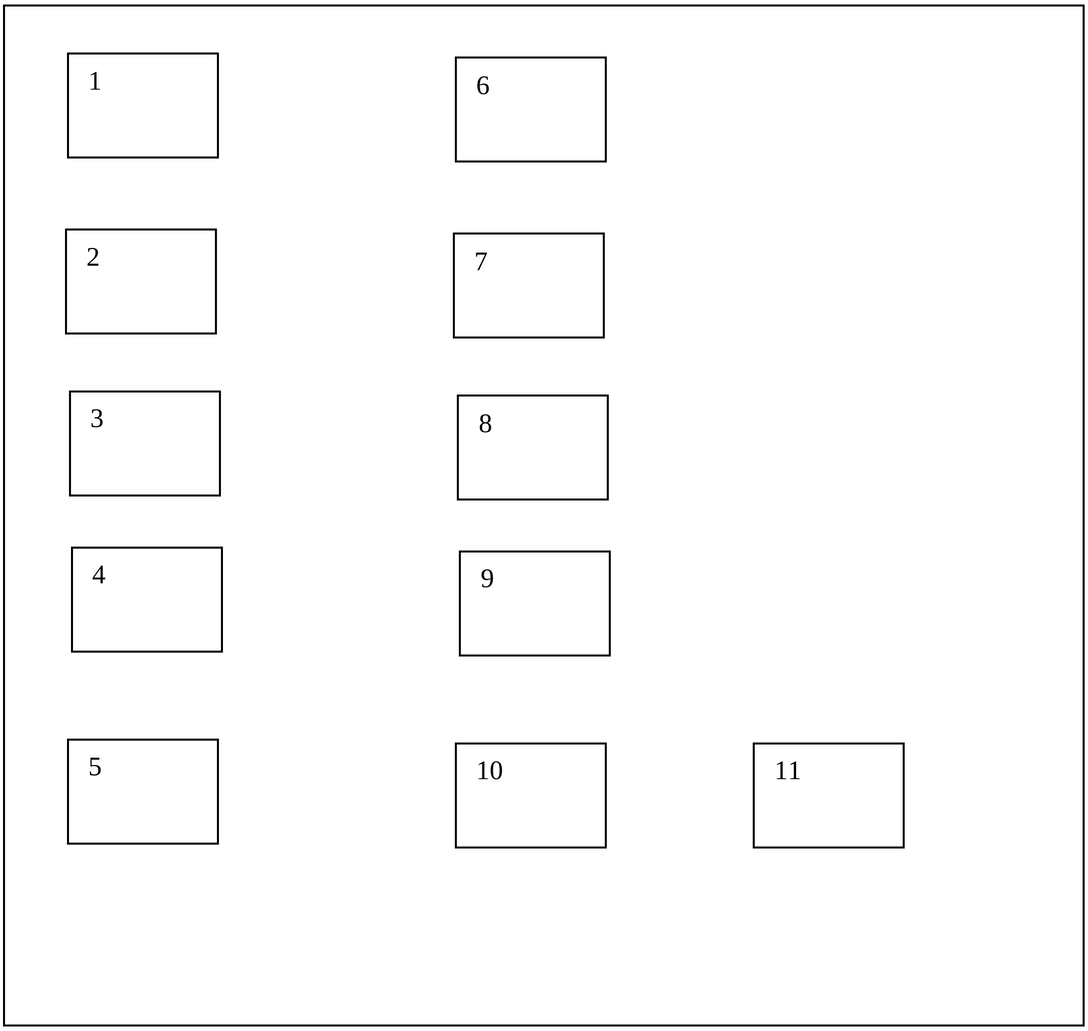
1. Students must always wear uniform and shoes before entering the lab.
2. Proper code of conduct and ethics must be followed in the lab.
3. Windows and doors to be kept open for proper ventilation and air circulation.
4. Note down the specifications of the experimental setup before performing the experiment.
5. Check for the electrical connections and inform if any discrepancy found to the attention of lecturer/lab instructor.
6. Perform the experiment under the supervision/guidance of a lecturer/lab instructor only.
7. After the observations are noted down switch off the electrical connections.
8. In case of fire use fire extinguisher/throw the sand provided in the lab.
9. In case of any physical injuries or emergencies use first aid box provided.
10. Any unsafe conditions prevailing in the lab can be brought to the notice of the lab in charge.

DONT's

1. Do not operate any experimental setup to its maximum value.
2. Do not touch/ handle the experimental setups/Test Rigs without their prior knowledge,
3. Never overcrowd the experimental setup/Test Rig, Leave sufficient space for the person to operate the equipment's.
4. Never rest your hands on the equipment or on the display board, because it has fragile measurement devices like thermometers, manometers, etc.

CONTENTS

Layout of Fluid Mechanics & Machinery Lab



INDEX

1. Friction Factor Measuring Apparatus
2. Minor Losses Measuring Apparatus
3. Impact of Jet Apparatus
4. Orifice Plate meter
5. Nozzle meter
6. Venturimeter
7. Notches Apparatus
8. Pelton Turbine Test Rig, Francis Turbine Test Rig and Kaplan Turbine Test Rig
9. Single stage, Multi stage centrifugal pumps and Reciprocating Pump
10. Two Stage Reciprocating Air Compressor
11. Centrifugal Air Blower

Experiment NO: 1

FRICTION FACTOR IN PIPE

AIM:
To determine the loss of head of water flowing in a pipe due to friction.

APPARATUS:
A number of horizontal pipes of different diameters connected at two sections (a known as Distance apart), to the limbs of a V-tube Hg manometer, a valve fitted with each pipe to Regulate the flow, a measuring tank fitted with a piezometer tube and a graduated scale.

THEORY:
The head lost due to friction in given by the Darcy- Weibach equation.

$h_f = (4\ f\ L\ V^2)/(2\ g\ d)$

or

$f = (h_f\ g\ d)/(2\ L\ V^2)$

Where f = friction factor

L = length of pipe section (connected to U-tube manometer), m

V = velocity of flow in pipe, m/s

d = inside diameter of pipe, m

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

PROCEDURE:
After noting carefully the diameter of pipe and the length between the section attached to the limbs of U-tube manometer, the valve is opened to allow water to flow in that pipe only. Vent the manometer. Note down the manometer readings. Record the rise in water level in the measuring tank for a known interval of time(t = 60s) and the discharge is determined. Velocity of flow in the pipe is calculated using the discharge and cross sectional area of pipe.

Thus the head lost due to friction can be calculated using the above fom1ula. The above procedure is repeated for different velocities of flow and different diameter of the
Horizontal pipes

OBSERVATIONS

1. Length of measuring tank, l = -----m
2. Breadth of measuring tank, b = -----m
3. Area of the measuring tank, A = ------m^2
4. Inside diameter of pipe, d = -----------m
5. Inside area of the pipe (cross section), a = (π x $d^2/4$) = ---------- m^2
6. Length between sections connected to U-tube manometer, L = ----m
7. Time Taken for collecting water, t =--------sec.

TABULAR COLUMN

Sl No.	Hg Manometer Reading in mm			h_f of water (mts)	ln h_f	Measuring tank reading in mm			Discharge (Q)m^3/s	Velocity (V) m/s	ln V	Theoretical friction factor f_{the}	Actual Friction factor f_{actual}
	Left limb head h_1 (mts)	Right limb head h_2 (mts)	Total Head $h=h_1+h_2$ (mts)			IR	FR	H = FR-IR					
12.5 mm Dia. 1 2 3													
20 mm Dia. 1 2 3													

SPECIMEN CALCULATIONS:

(1) Head loss due to friction (h_f)

Monometer reading in left limb, h_1 =- -------m

Monometer reading in right limb, h_2 =- -------m

Difference, $h = h_2 + h_1$ =- -------m

$h_f = (12.6 \times h)$ = ----------m of water

(2) Discharge (Q)

Time duration of water collection in the measuring tank,

t = ------- seconds

Initial water level = IR = ------- m

Final water level = FR = ------- m

Difference of water levels, H = FR - IR = --------- m

$Q = (l \times b \times H/t)$ =--------------m^3/s

3) Velocity of flow, (V)

$V = Q/a$ = -------- m/s

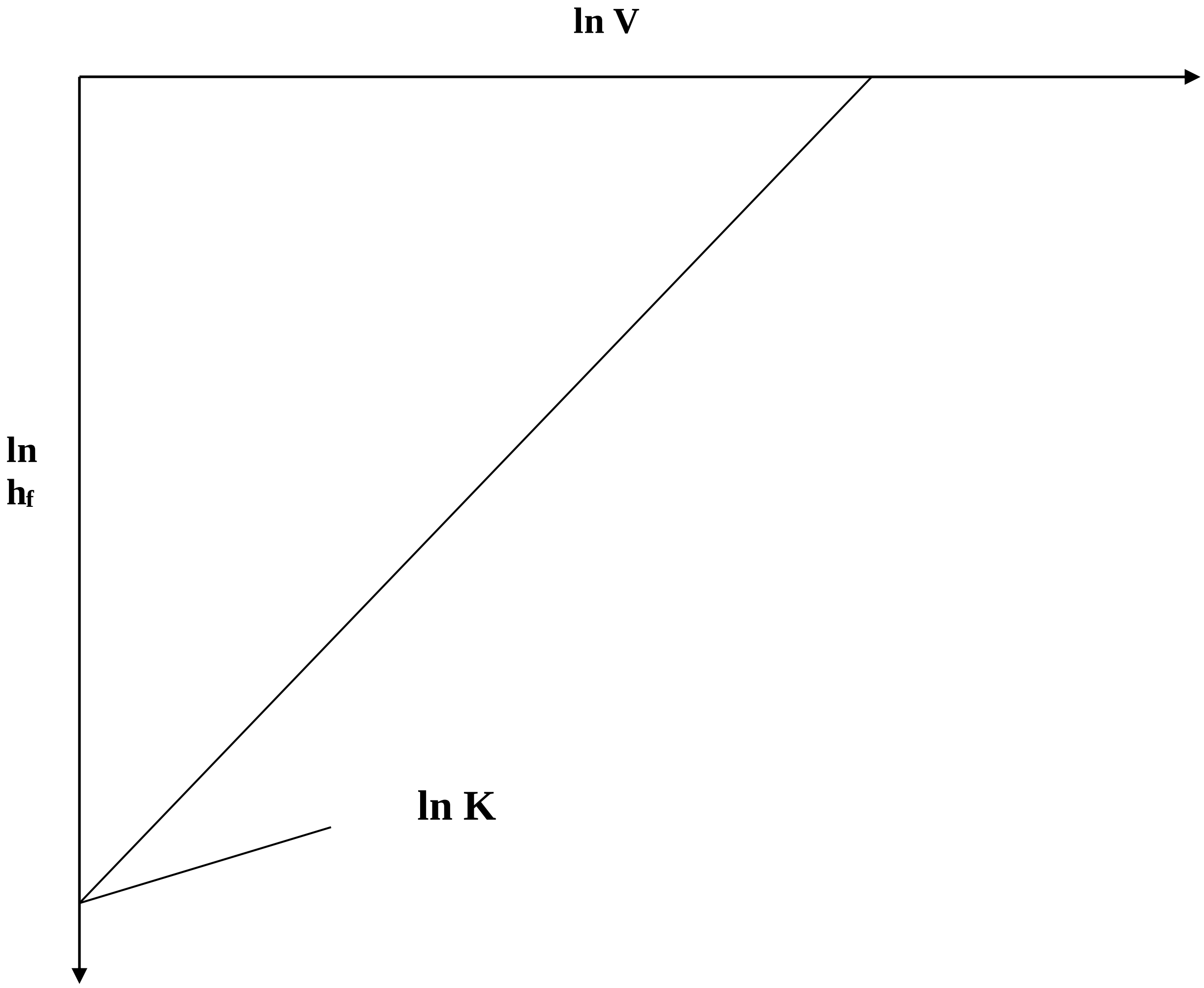
4) Theoretical friction factor, (f_{the})

$f_{the} = (h_f\, g\, d)/(2\, LV^2)$

5) Actual friction factor, (f_{actual})

$f_{graph} = (2 \times g \times d \times K) / 4L$

Nature of graph



RESULT:

1. Theoretical friction factor, f_{the}= --------
2. Actual friction factor, f_{actual}= --------
3. The coefficient of friction K=-----------

Experiment NO. 2

MINOR LOSSES IN PIPES

AIM :

To find the loss of head due to sudden contraction, expansion, elbow and bend during flow through a pipe.

APPARATUS:

An arrangement for uniform supply of water, pipe fittings consisting of sudden enlargement, sudden contraction, elbow and bend , measuring tank with a piezometer and a scale, manometer .

THEORY:

(a) Loss of head due to sudden enlargement is given by

$$h_e = \frac{K_e \times (V_1 - V_2)^2}{2\,g}$$

where

V_1 = Velocity at inlet.

V2 = Velocity at outlet.

K_e = Coefficient of enlargement.

g = Acceleration due to gravity.

(b) Loss of head due to sudden contraction is given by

$$h_c = \frac{0.5 \times K_c \times (V_2^2)}{2\,g}$$

where

K_c = coefficient of contraction

V_2 = velocity of exit.

(c) Loss of head due to elbow is given by

$$h_{el} = \frac{K_{el} \times V^2}{2\,g}$$

where

V = velocity of flow.

K_{el} = coefficient of elbow

(d) Loss of head due to bend is given by

$$h_b = \frac{K_b \times V^2}{2\,g}$$

where

V = velocity of flow.

K_b = coefficient of bend

PROCEDURE:

Uniform water flow through a pipe fitting is made. The outlet through the pipe fitting is collected in a measuring tank. The amount water collected during a definite period of time (t = 60 s) is noted. Manometer readings in the two limbs connected on either side of the pipe fitting is noted. Calculate the velocity of flow and head loss due to various fittings, calculate the different coefficients of various fittings. The above procedure is repeated for different flow rates and for different diameter of the pipe for different pipe fittings.

OBSERVATION SUDDEN EXPANSION :

Length of the measuring tank , l = ...mm

Breadth of the tank, b = ...mm

Pipe diameter, d_1 = ... mm,

Pipe diameter, d_2 = ... mm,

area, a_1 = ... m^2

area, a_2 = ... m^2

TABULAR COLUMN FOR SUDDEN ENLARGEMENT

Sl. No	Hg manometer Reading (mm)			h_{fe} m H_2O	Measuring tank Reading in cms			Q m^3/s	V_1 m/s	V_2 m/s
	h_1	h_2	$h=h_1 + h_2$ (mts)		IR	FR	H =FR-IR (mts)			
1										
2										
3										

(a) SPECIMEN CALCULATIONS FOR SUDDEN ENLARGEMENT

1. Manometer head (h_f) in m of water

   h_{fe} = (12.6) × h = ………….m

   $h = h_1 + h_2$

Where

2. Discharge, Q = l × b × H / 60 = ………..m^3/s

3. Velocity at inlet of sudden enlargement pipe =

   V_1 = Q / a_1 = ……… m/s

4. Velocity at exit of sudden enlargement pipe =

   V_2 = Q/ a_2 = ……….m/s

5. Coefficient of enlargement(K_e)

$$K_e = \frac{h_{fe} 2 g}{(V_1 - V_2)^2}$$

OBSERVATION SUDDEN CONTRACTION :

Length of the measuring tank, L = ...mm

Breadth of the tank, B = ...mm

Pipe diameter, d_1 = ... mm,

Pipe diameter, d_2 = …………. mm,

area, a_1 = ………….. m^2

area, a_2 = ………….. m^2

TABULAR COLUMN FOR SUDDEN CONTRACTION

Sl. No	Hg manometer Reading (mm)			h_{fc} m H_2O	Measuring tank Reading in cms			Q m^3/s	V_2 m/s
	h_1	h_2	$h=h_1+h_2$ (cms)		IR	FR	H =FR-IR (cms)		
1									
2									
3									

(b) SPECIMAN CALCULATIONS FOR SUDDEN CONTRACTION

1.Manometer head (h_f) in m of water

h_{fc} = (12.6) × h = ...m

Where $h = h_1 + h_2$

2.Discharge, Q = l × b × H / 60 = ...m^3/s

3.Velocity of flow, V = Q / a_2 = ... m/s

4.Coefficient of contraction(K_c)

$$K_c = \frac{2g\, h_{fc}}{0.5\,(V_2^2)}$$

Observation for an Bend :

Length of the measuring tank, L = ...mm

Breadth of the tank, B = ...mm

Bend diameter, d = ... mm,

Area of the bend a = ... m^2

TABULAR COLUMN FOR SUDDEN BEND

Sl. No	Hg manometer Reading (mm)			h_{fb} m H_2O	Measuring tank Reading in cms			Q m^3/s	V m/s
	h_1	h_2	$h=h_1+h_2$ (cms)		IR	FR	H =FR-IR (cms)		
1									
2									
3									

(a) SPECIMAN CALCULATIONS FOR AN BEND

1. Manometer head (h_{be}) in m of water

h_{fb} = (12.6) × h = …………..m

Where $h = h_1 + h_2$

2. Discharge, Q = l × b × H / 60 = ………..m^3/s

3. Velocity of flow, V = Q / a = ……… m/s

4. Coefficient of bend (K_b)

$$K_b = \frac{h_{fb}\, 2\, g}{V^2}$$

OBSERVATION FOR AN ELOBW :

Length of the measuring tank, l = ...mm

Breadth of the tank, b = ...mm

Elbow diameter, d = ... mm,

Area of the elbow a = ... m^2

TABULAR COLUMN FOR SUDDEN ELBOW

Sl. No	Hg manometer Reading (mm)			h_{fel} m H_2O	Measuring tank Reading in cms			Q m^3/s	V m/s
	h_1	h_2	$h=h_1+h_2$ (cms)		IR	FR	H =FR-IR (cms)		
1									
2									
3									

SPECIMEN CALCULATIONS FOR AN BEND

1.Manometer head (h_{fel}) in m of water

$h_{fe1} = (12.6) \times h = \ldots\ldots\ldots\ldots\ldots m$

Where $h = h_1 + h_2$

2.Discharge, $Q = l \times b \times H / 60 = \ldots\ldots\ldots\ldots m^3/s$

3.Velocity of flow, $V = Q / a = \ldots\ldots\ldots m/s$

4. Coefficient of elbow(K_{el})

$$K_{el} = \frac{h_{fel} 2g}{V^2}$$

RESULTS:

1. Coefficient of Contraction = K_c = …………
2. Coefficient of enlargement = K_e = …………
3. Coefficient of elbow = K_{el} = ……………
4. Coefficient of bend = K_b = ………………

Answer the following:

1. What do you mean by major energy loss?
2. List down the type of minor energy losses.
3. What is compound pipe?
4. What do you mean by equivalent pipe
5. Derive Darcy -weisback's equation.

Experiment No: 3

IMPACT OF JET ON VANES

AIM:

To determine the coefficient of impact of jet on

- Flat,
- Inclined
- Hemispherical vanes

APPARATUS:

Nozzle, different types of vanes, a stop watch, dead weights, a measuring tank and a lever arm with a hanger.

THEORY:

The impact of jet vanes has a wide range of applications in rotodynamic machines .Theoretical impact force on different vanes is

a) For a flat vane:

$$F_{th} = \rho\, a\, V^2 \ldots\ldots\ldots \quad N$$

b) For an inclined vane

(at an angle θ to the direction of flow of jet)

$$F_{th} = \rho\, a\, V^2 \sin^2 \theta \ldots\ldots\ldots \quad N$$

c) For a symmetrical conical vane

$$F_{th} = \rho\, a\, V^2 \,(1 + \cos\theta)$$

Where ρ = density of water

a = area of jet (nozzle) in m^2

V = jet velocity in m/s

d) For a hemispherical vane

$$F_{th} = \rho\, a\, V^2 \,(\cos\alpha + \cos\beta)$$

$$= 2\rho\, a\, V^2$$

PROCEDURE:

The nozzle is fixed in position. The vane under test is fixed above the nozzle. The weight is adjusted such that the arm is in horizontal position, when there is no load on the hanger. Find the lever ratio by measuring the distance between the hanger and fulcrum (L1) and distance between the vane support and the fulcrum (L2). Weight of about (50 to 100 grams) is put on the hanger and the control valve is opened. Flow rate is adjusted such that the impact of jet makes the lever horizontal.

Calculate the actual force on the vane due to jet by multiplying the weight placed on the hanger and the lever ratio.

The discharge water is collected for 60 seconds time duration.

Calculate the actual and theoretical force of impact in the direction of jet.

Then calculate the coefficient of impact.

Repeat the experiment for different weights and different types of vanes.

OBSERVATIONS:

Length of measuring tank, l = _______ m

Breadth of measuring tank, b = _______ m

Area of measuring tank, A = _______ m^2

Diameter of nozzle, d = _______ m

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

Length from hanger to fulcrum, L_1 = _______ m

Length from vane support to fulcrum, L_2 = _______ m

Lever arm ratio, L_1/L_2 = 2

Weight used in experiments, W=50gm and W=75gm

TABULAR COLUMN

Type of vane	Sl No.	Lever arm reading		Measuring tank readings (cms)			Discharge	Velocity	F_{th}	Coefficient of impact = F_{act}/F_{th}
		Wt. added to hanger w kg	F_{act} = W (L_1/L_2) N	IR	FR	H =FR-IR (cms)	Q m^3/s	V m/s	N	
Flat	1									
	2									
Inclined at 30^0	1									
	2									
Inclined at 60^0	1									
	2									
Symmetrical Conical	1									
	2									
Hemispherical	1									
	2									

SPECIMEN CALCULATIONS:

1. Actual force(F_{act})

$F_{act} = W_1 (L_1/L_2) =$ ______N

where W_1 = weight in N

2. Discharge(Q)

$Q = A\,h/60$ = ______ m^3/s

3. Velocity of jet(V)

$V = Q/a$ = ______ m/s

4. Theoretical force(F_{theory})

For flat vane

$F_{th} = \rho\, a\, V^2$ ……… N

For inclined vane

$F_{th} = \rho\, a\, V^2 \sin^2 \theta$ …….. N

For symmertrical conical vane

$F_{th} = \rho a V^2 \ (1+ \ \cos \theta)$

Where ρ = density of water

a = area of jet (nozzle) in m^2

V = jet velocity in m/s

For hemispherical vane

$F_{th} = \rho a V^2 \ (\cos \alpha + \ \cos \beta)$

$= 2\rho a V^2$

7. Coefficient of impact **=** F_{act}/F_{th} = ______

RESULT:

Coefficient of impact of jet on

1. Flat vane = ________
2. Inclined vane(30^0) = ________
4. Hemispherical vane = ________
5. Conical vane =________

Experiment No. 4

ORIFICEMETER

AIM:

To find the coefficient of discharge of a given orificemeter fitted in a pipe

APPARATUS:

An orificemeter, an arrangement for regulated supply of water, a measuring tank with a piezometer tube and a scale, a U-tube mercury manometer, and a stop watch.

THEORY:

Discharge through an venturimeter is given by

$$Q = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where C_d = Coefficient of discharge,

a_1 = cross sectional area of inlet pipe, m^2

K = venturimeter constant,

a_2 = cross sectional area of throat, m^2

h = manometer reading in m of water.

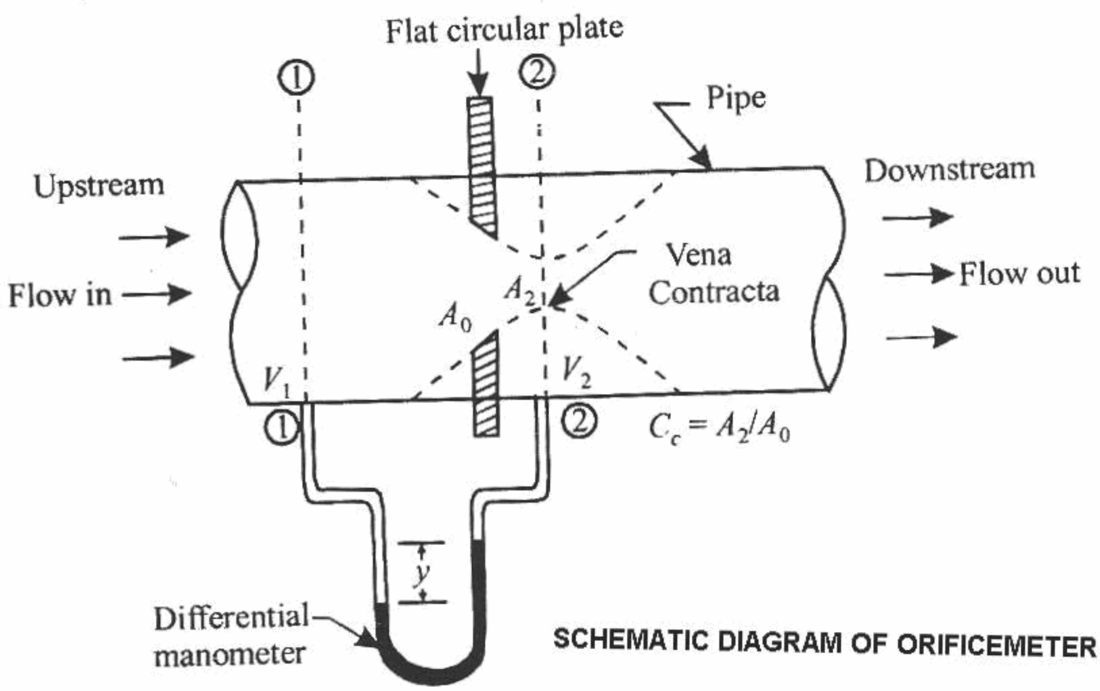
PROCEDURE:

Note the diameters at inlet and the throat section of the venturimeter, and find out the corresponding areas. Measure the dimensions of the measuring tank. Record rise in water level in the measuring tank for definite period of time (60 s), and calculate the discharge of water.

connect the two tapping at the inlet and the throat of the venturimeter to the two limbs of U-tube mercury manometer, and vent the air bubbles. For particular discharge the difference of the mercury level in the two limbs of the manometer is noted (R) Experiment is repeated for different values of discharge.

OBSERVATIONS

1. Diameter at inlet of the venturimeter , d_1 = ------------ mm
2. Diameter of the throat of the venturimeter d_2 = ------------ mm
3. Cross sectional area of the inlet, a_1 = ------------ m^2
4. Cross sectional area of the throat, a_2 = ------------ m^2
5. Length of measuring tank, l = ------------ mm
6. Breadth of measuring tank, b = ----------- mm
7. Area of the measuring tank, A = lxb=-------- m^2
8. Time duration of water collection t = 60 s



SCHEMATIC DIAGRAM OF ORIFICEMETER

TABULAR COLUMN

Sl No.	Hg Manometer Reading in mm			h_f of water (mts)	$\ln(h_f)$	Measuring tank reading in m			Q_{act} m^3/s	ln (Q_{act})	Q_{theo} m^3/s	Theoretical C_d	Actual C_d
	h_1	h_2	$h=h_1+h_2$			IR	FR	H = FR-IR					

SPECIMEN CALCULATION

(1) Monometer head (h_f)

h_f = 12.6 x h = ----------- m of water.

where

h = Difference in level of monometer reading in

(2) Actual discharge (Q_{actual})

Q = (A x H/60) = ------------- m^3 /s

where

A = area of measuring tank in m^2

H = rise in water level in m

(3) Theoretical discharge($Q_{theoretical}$)

$$Q_{theoretical} = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where Cd=Coefficient of discharge

(4) Theoretical Co-efficient of discharge (C_d)

$$\text{Theoretical } C_d = \times \frac{\text{Actual discharge}}{\text{Theoretical discharge}}$$

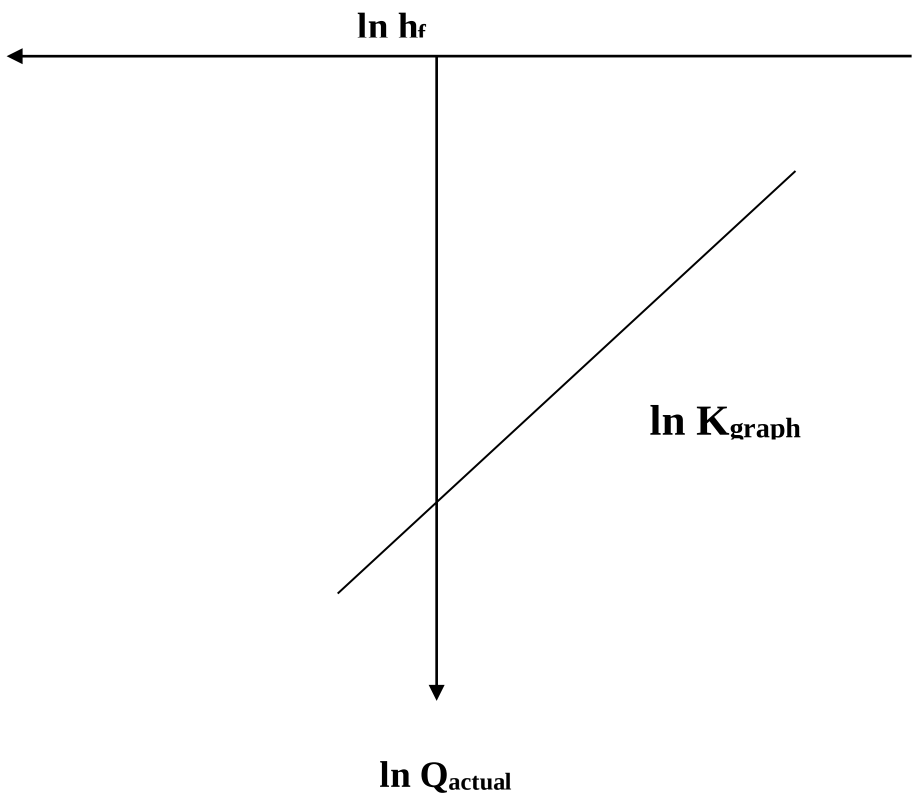
(5) Actual Co-efficient of discharge (C_d)

$$\text{Actual } C_d = \frac{K_{graph}}{K}$$

Where K = venturimeter constant

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

Nature of graph



RESULT

1. Plot the following graph.

   ln Q_{actual} Vs ln h_f

2. Theoretical Co-efficient of discharge (C_d) =

3. Actual Co-efficient of discharge (C_d) =

Answer the following:

1. Mention two pressure measuring instruments
2. How manometers are classified
3. State Newton's law of viscosity
4. Define stream line.
5. Define path line

Experiment No. 5

NOZZLE METER

AIM:

To find the coefficient of discharge of a given nozzlemeter fitted in a pipe

APPARATUS:

An nozzlemeter, an arrangement for regulated supply of water, a measuring tank with a piezometer tube and a scale, a U-tube mercury manometer, and a stop watch.

THEORY:

*Discharge through an **nozzlemeter** is given by*

$$Q_{theoritical} = C_d \times \frac{a_1 \times a_2 \sqrt{(2ghf)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where C_d = Coefficient of discharge,

a_1 = cross sectional area of inlet pipe, m^2

K = venturimeter constant,

a_2 = cross sectional area of nozzle throat, m^2

h_f = manometer reading in m of water.

PROCEDURE:

Note the diameters at inlet and the throat section of the nozzlemeter, and find out the corresponding areas. Measure the dimensions of the measuring tank. Record rise in water level in the measuring tank for definite period of time (60 s), and calculate the discharge of water.

connect the two tapping at the inlet and the throat of the nozzlemeter to the two limbs of U-tube mercury manometer, and vent the air bubbles. For particular discharge the difference of the mercury level in the two limbs of the manometer is noted (R) Experiment is repeated for different values of discharge.

OBSERVATIONS

1. Diameter at inlet of the pipe , d_1 = ------------ mm
2. Diameter of the throat of the nozzle d_2 = ------------ mm
3. Area of the pipe, a_1 = ------------ m^2
4. Cross sectional area of the nozzle, a_2 = ------------ m^2
5. Length of measuring tank, l = ------------ mm
6. Breadth of measuring tank, b = ----------- mm
7. Area of the measuring tank, A = lxb=-------- m^2
8. Time duration of water collection t = 60 s

TABULAR COLUMN

Sl No.	Hg Manometer Reading in mm			h_f of water (mts)	$\ln(h_f)$	Time taken for 10cm rise of water in sec.	Q_{act} m^3/s	$\ln(Q_{act})$	Q_{theo} m^3/s	Theoretical C_d	Actual C_d
	h_1	h_2	$h=h_1+h_2$								

SPECIMEN CALCULATION

(1) Monometer head (h_f)

h_f = 12.6 x h = ----------- m of water.

where

h = Difference in level of monometer reading in

(2) Actual discharge (Q_{actual})

Q = (A x H/60) = ------------- m^3 /s

where

A = area of measuring tank in m^2

H = rise in water level in m

(3) Theoretical discharge($Q_{theoretical}$)

$$Q_{theoretical} = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where Cd=Coefficient of discharge

(4) Theoretical Co-efficient of discharge (C_d)

$$\text{Theoretical } C_d = \times \frac{\text{Actual discharge}}{\text{Theoretical discharge}}$$

(5) Actual Co-efficient of discharge (C_d)

$$\text{Actual } C_d = \frac{K_{graph}}{K}$$

Where K = venturimeter constant

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

RESULT

1. Plot the following graph.

   $\ln Q_{actual}$ Vs $\ln h_f$

2. Theoretical Co-efficient of discharge (C_d) =

3. Actual Co-efficient of discharge (C_d) =

Experiment No: 6

VENTURIMETER

AIM:

To find the coefficient of discharge of a given venturimeter fitted in a pipe

APPARATUS:

An venturimeter, arrangement for regulated supply of water, measuring tank with a piezometer tube and a scale, U-tube manometer, stop watch.

THEORY:

Discharge through an venturimeter is given by

$$Q = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where C_d = Coefficient of discharge,

a_1 = cross sectional area of inlet pipe, m^2

K = venturimeter constant,

a_2 = cross sectional area of throat, m^2

h = manometer reading in m of water.

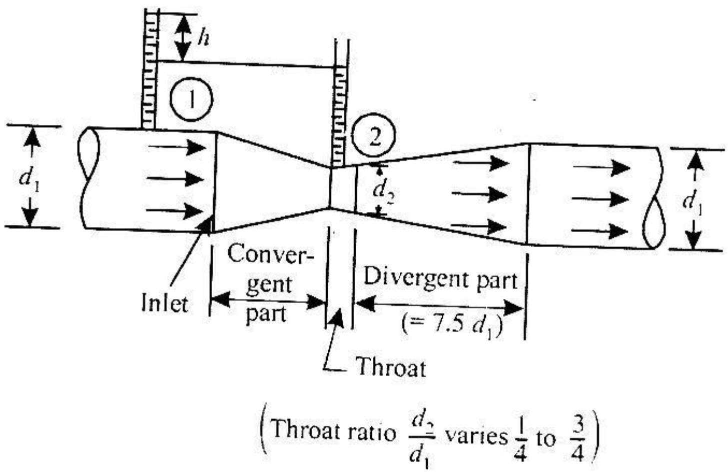
PROCEDURE:

Note the diameters at inlet and the throat section of the venturimeter, and find out the corresponding areas. Measure the dimensions of the measuring tank. Record rise in water level in the measuring tank for definite period of time (60 s), and calculate the discharge of water.

connect the two tapping at the inlet and the throat of the venturimeter to the two limbs of U-tube mercury manometer, and vent the air bubbles. For particular discharge the difference of the mercury level in the two limbs of the manometer is noted (R) Experiment is repeated for different values of discharge.

OBSERVATIONS

1. Diameter at inlet of the venturimeter , d_1 = ------------ mm
2. Diameter of the throat of the venturimeter d_2 = ------------ mm
3. Cross sectional area of the inlet, a_1 = ------------ m^2
4. Cross sectional area of the throat, a_2 = ------------ m^2
5. Length of measuring tank, l = ------------ mm
6. Breadth of measuring tank, b = ----------- mm
7. Area of the measuring tank, A = lxb=-------- m^2
8. Time duration of water collection t = 60 s



SCHEMATIC DIAGRAM OF VENTURIMETER

TABULAR COLUMN

<table>
<tr><th rowspan="2">Sl No.</th><th colspan="3">Hg Manometer Reading in mm</th><th rowspan="2">h_f of water (mts)</th><th rowspan="2">ln(h_f)</th><th colspan="3">Measuring tank reading in m</th><th rowspan="2">Q_{act} m^3/s</th><th rowspan="2">ln (Q_{act})</th><th rowspan="2">Q_{theo} m^3/s</th><th rowspan="2">Theoretical C_d</th><th rowspan="2">Actual C_d</th></tr>
<tr><th>h_1</th><th>h_2</th><th>$h=h_1 + h_2$</th><th>IR</th><th>FR</th><th>H = FR-IR</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

SPECIMEN CALCULATION

(1) Monometer head (h_f)

h_f = 12.6 x h = ----------- m of water.

where h = Difference in level of monometer reading in

(2) Actual discharge (Q_{actual})

Q = (A x H/60) = ------------- m^3 /s

where

A = area of measuring tank in m^2

H = rise in water level in m

(3) Theoretical discharge($Q_{theoretical}$)

$$Q_{theoretical} = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where C_d=Coefficient of discharge

(4) Theoretical Co-efficient of discharge (C_d)

$$\text{Theoretical } C_d = \times \frac{\text{Actual discharge}}{\text{Theoretical discharge}}$$

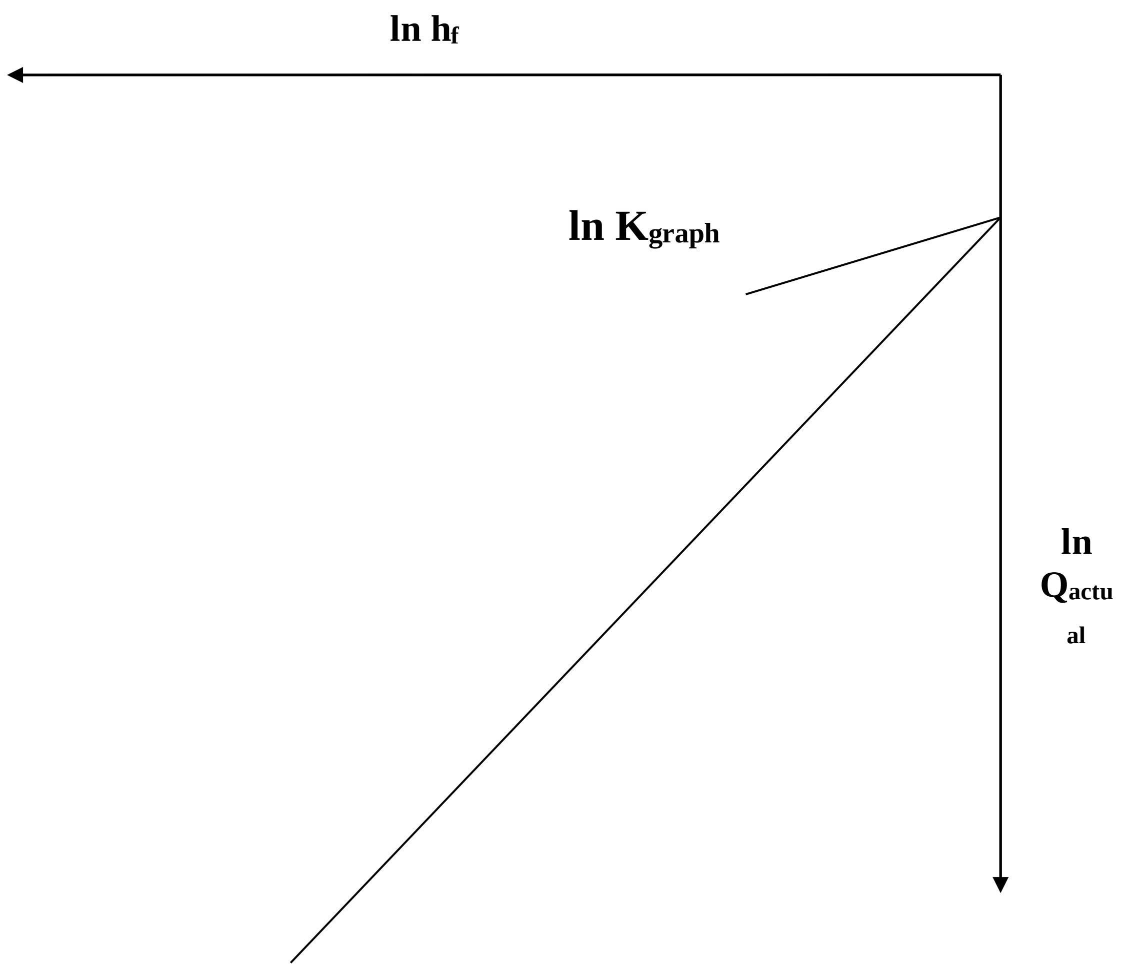
(5) Actual Co-efficient of discharge (C_d)

$$\text{Actual } C_d = \frac{K_{graph}}{K}$$

Where K = venturimeter constant

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

Nature of graph



RESULT

1. Plot the following graph.

   ln Q_{actual} Vs ln h_f

2. Theoretical Co-efficient of discharge (C_d) =

3. Actual Co-efficient of discharge (C_d) =

Answer the following:

1. What is peizometer?
2. Define the following terms.
   - _ Fluid.
   - _ Specific volume
   - _ Specific gravity.
   - _ Viscosity.
   - _ Compressibility.
   - _ Vapour pressure.
   - _ Capillarity.
   - _ Surface tension.
3. Differentiate the following terms.
   - o Fluid and solid.
   - o Newtonian and non Newtonian fluid.
   - o Ideal and real fluid.
4. Derive continuity equation for compressible and incompressible fluid.
5. Differentiate between Absolute and gauge pressures

Experiment No: 7

DETERMINATION OF COEFFICIENT OF DISCHARGEOF 60^0 and 45^0 V - NOTCH

AIM :

To calibrate a given 60^0 and 45^0V- Notch.

APPARATUS:

A Notch tank fitted with vertical perforated plates to decrease the velocity of approach and with arrangements for a regulated supply of water, a bucket for water collection, a measuring jar, a stop watch, a piezometer with a graduated scale, and a 90^0 V- notch.

THEORY :

Notches are overflow structure where length of crest along the flow of water is accurately shaped to calculate discharge.

$$Q_{\text{thoritical}} = \frac{8}{15} C_d \times \tan\frac{\theta}{2} \times \sqrt{2g} \times H^{5/2}$$

Where H = Head of water causing flow over notch in meters,

C_d = coefficient of discharge,

θ = angle of notch,

g = acceleration due to gravity in m/s^2

PROCEDURE:

By means of the supply cock, allow the water into the tank till it just starts passing over the notch. Now stop the supply of water and when no water passes over the notch, note the level of water in the piezometer. Next adjust the supply of water till the head over the sill of the notch remains constant. At this instant, again note the level of water in the piezometer. The difference between the two-piezometer readings gives the head of water (H) causing flow over notch.

Collect the water flowing over the notch in a bucket for a particular time (15 seconds). Measure the amount of water collected using measuring jar to find the actual discharge (Q). The above formula is used to calculate the value of C_d. Take a number of readings by varying the discharge.

OBSERVATIONS :

Length of the measuring tank l = …………m

Breadth of the measuring tank b = ………. m

Area of the measuring tank A = …….. m2

Least count of hook gauge = …………

Coefficient of discharge, C_d =0.6

TABULAR COLUMN

Notch	Hook Gauge reading			Hook Gauge reading for 90^0			Q_{act} m^3/s	Q_{the} m^3/s	ln (h)	ln (Q_{act})	K_{gra}	K_{the}	$C_d = \frac{Q_{actual}}{Q_{theoritical}}$	$C_d = \frac{K_{graph}}{K_{theoritical}}$
	IR	FR	h = FR-IR	IR	FR	H = FR-IR								
60^0														
45^0														

SPECIMEN CALCULATION:

$$Q_{actual} = (8/15)\, C_d \times \tan(\theta/2) \times \sqrt{2g} \times H^{5/2}$$

$$Q_{theoretical} = (8/15)\, C_d \times \tan(\theta/2) \times \sqrt{2g} \times h^{5/2}$$

Theoretical Co-efficient of discharge (C_d)

$$C_d = \frac{Q_{actual}}{Q_{theoretical}}$$

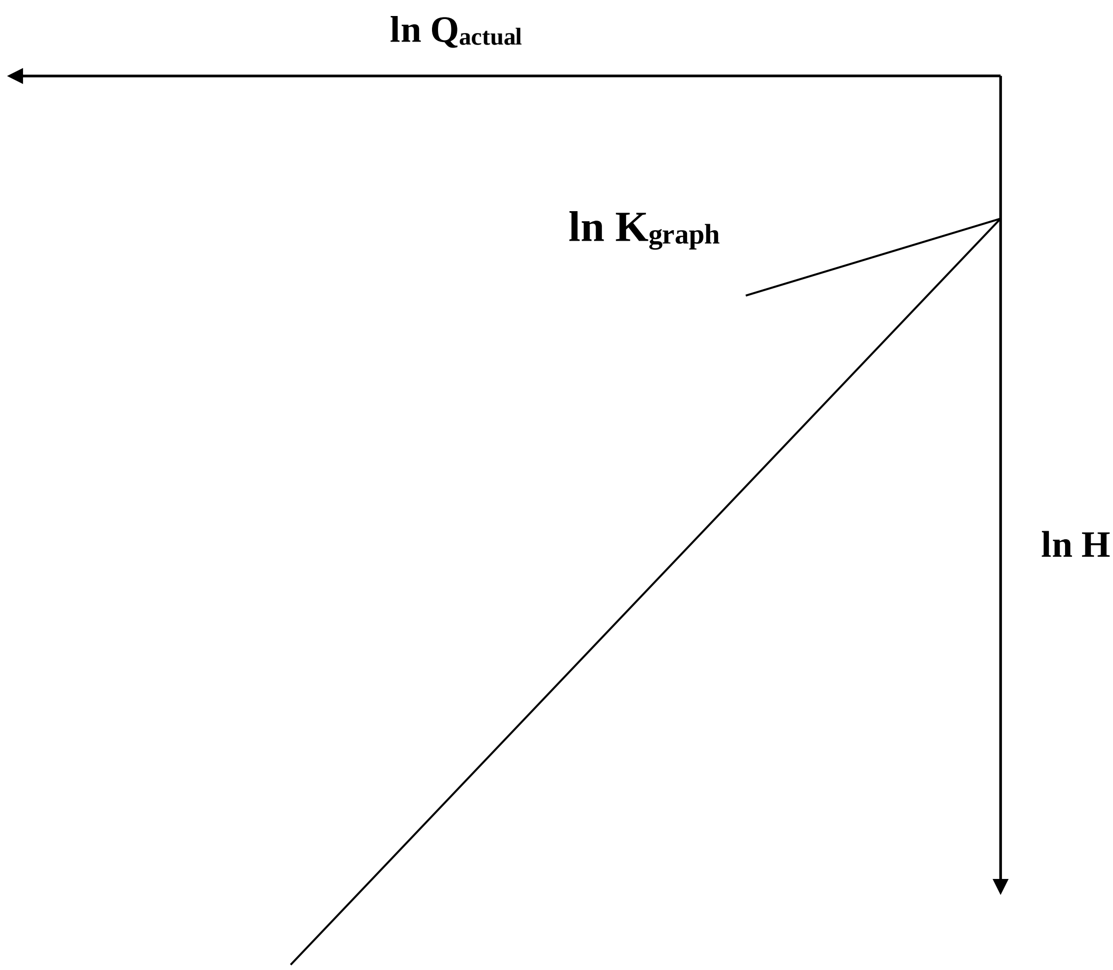
Actual Co-efficient of discharge (C_d)

$$C_d = \frac{K_{graph}}{K_{theoretical}}$$

Where

$$K_{theoretical} = 8/15 \times \tan(\theta/2) \times \sqrt{2g}$$

Nature of graph



RESULT:

1. Plot the following graph for ln (Q) vs. ln (H)
2. Theoretical Co-efficient of discharge for 60^0 v-notch C_d.=_______
3. Actual Co-efficient of discharge for 60^0 v-notch C_d.=_______
4. Theoretical Co-efficient of discharge for 45^0 v-notch C_d.=_______
5. Actual Co-efficient of discharge for 45^0 v-notch C_d.=_______

Experiment No : 8

PELTON WHEEL

AIM:

To study the characteristics of Pelton wheel at constant head and constant speed.

APPARATUS:

Pelton turbine, pressure gauge, Venturimeter, manometer, tachometer, weights, etc.

THEORY:

Pelton turbine is a tangential type impulse turbine . In such turbine

$P_1 = P_2$ P_1 = pressure at inlet of turbine

P_2 = pressure at exit of turbine

$V_1 >> V_2$ V_1 = velocity at inlet of turbine

V_2 = velocity at exit of 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 the outlet of the turbine is atmospheric. This type of turbine is used for high heads.

PROCEDURE:

Keep the gate opening at the required position i.e. full, 3/4, 1/2, 1/4, etc. Start the water supply. Allow the water to fall on the buckets by opening the valve. Note the readings in the right and left limbs of the Hg manometer, the pressure gauge reading, speed of turbine.

Repeat the experiment for different loads and for a particular head, for obtaining the main characteristics of the pelton turbine.

Experiment is repeated for different heads while keeping the speed constant for obtaining the operating characteristics.

OBSERVATIONS:

a) Diameter of brake drum, d_1 = ………mm

b) Diameter of rope, d_2 =………mm

c) Effective diameter of the brake drum, $D = d_1 + d_2$ = ……….mm

d) Dead weight , T_1 =………….N

e) Spring balance reading, T_2 =………….N

f) Weight of hanger, T_o = ………..N

g) Load on turbine, $T = T_1 - T_2 + T_O$ = ………….N

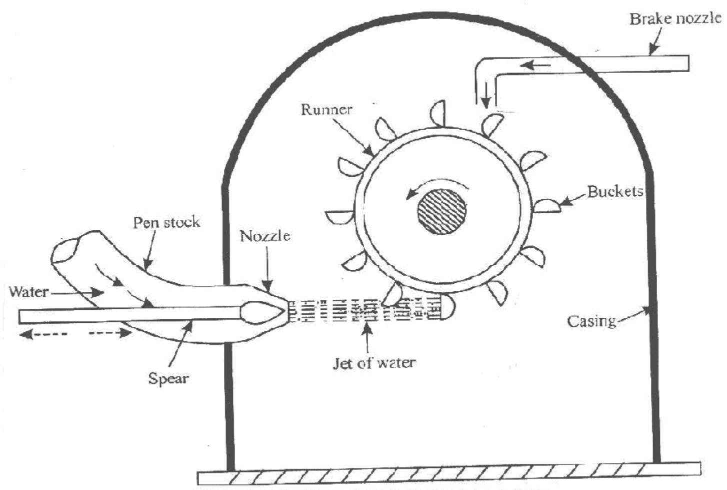
h) Circumfrance of brake drum = $C_b = \pi \times D$ = ………..m

i) Diameter at inlet of the venturimeter , d_1 = ------------ mm

j) Diameter of the throat of the venturimeter d_2 = ------------ mm

k) Cross sectional area of the inlet, a_1 = ------------ m^2

l) Cross sectional area of the throat, a_2 = ------------ m^2



SCHEMATIC DIAGRAM OF PELTON WHEEL TURBINE

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a) Speed Varying- Head constant - (Main Characteristics):

Sl No.	% of gate opening	Pressure Head		Manometer reading in mm			h_f m in m	Q m^3/s	Spring Balance Reading				Speed N r/min	Input P_i kW	Output kW	Efficiency η %
		P kg/cm^2	H=PX10 m	h_1 cm	h_2 cm	$h' = h_2+h_1$			T_o N	T_1 N	T_2 N	T N				
1	100%															
2	75%															
3	50%															

b)Head Varying- Speed constant-(Operating Characteristics):

Sl No.	% of gate opening	Pressure Head		Manometer reading in mm			h_f in m	Q m^3/s	Spring Balance Reading				Speed N r/min	Input P_i kW	Output kW	Efficiency η %
		P kg/cm^2	H=PX10 m	h_1 cm	h_2 cm	$h' = h_1+h_2$			T_o N	T_1 N	T_2 N	T N				
1	100%															
2	75%															
3	50%															

SPECIMEN CALCULATION:

1. Monometer head (h_f)

h_f = 12.6 x h = ----------- m of water.

where h = Difference in level of monometer reading in m

2. Theoretical discharge($Q_{theoretical}$)

$$Q_{theoretical} = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where C_d=Coefficient of discharge

3. Input power, P_i = ρgQH Watts

Q = discharge in m^3/s.

H = pressure head in m of water.

4. Output power, P_o = πDNT/60 Watts

5 Overall Efficiency,

η_o = (Output power/ Input power) × 100.

Graphs

1.For constant speed:

(a) Efficiency vs Speed

(b) Output power vs speed

2. For constant head:

(a) Efficiency vs discharge

(b) Output power vs discharge

Result:

Answer the following:

1. What are the main parameters in designing a Pelton wheel turbine?
2. What is breaking jet in Pelton wheel turbine?
3. What is the function of casing in Pelton turbine
4. Draw a simple sketch of Pelton wheel bucket.
5. What is the function of surge tank fixed to penstock in Pelton turbine?

Experiment No: 9

FRANCIS TURBINE

AIM:

To study the performance characteristics of Francis turbine for constant speed and constant head.

APPARATUS:

Francis turbine, pressure gauges, manometer, tachometer, weights, Venturimeter.

THEORY:

Francis turbine is a mixed flow type reaction turbine. Water enters the runner of the turbine in the radial direction at inlet and leaves in the axial direction at outlet of the runner.

PROCEDURE:

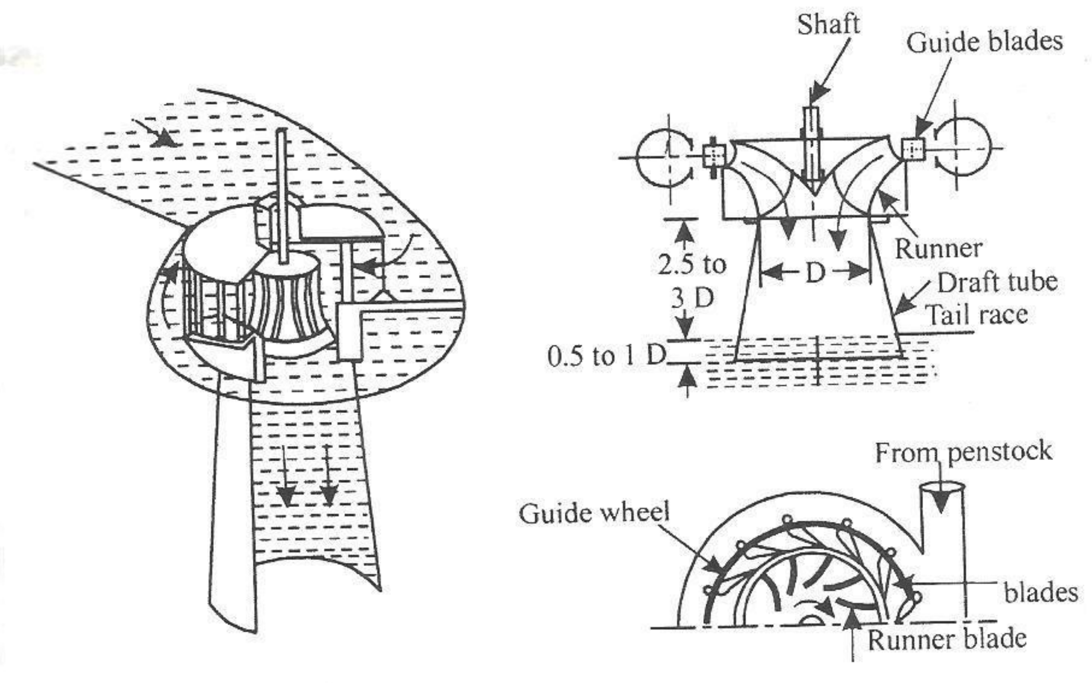
Open the gate valve fully. Start the water supply. Place the weights on the hanger. Note down the pressure gauge (P) and vacuum gauge (V) readings in kgf/cm^2. Record the mercury manometer readings in the left and right limbs. (connected to the venturimeter) in mm of Hg. Note down the speed using tachometer. Record the spring balance reading and dead weights placed on the hanger.

Repeat the experiment for different loads and constant head to obtain main characteristics.

Experiment is repeated for varying head while keeping speed constant to obtain the operating characteristics.

OBSERVATIONS:

1. Diameter of rope D_1 = …….mm
2. Diameter of brake drum D_2 = …….mm
3. Effective diameter of brake drum = $D = D_1+D_2$ = ……….mm
4. Dead weight , T_1 =………….N
5. Spring balance reading, T_2 =………….N
6. Weight of hanger, T_o = ………..N
7. Load on turbine, T = $T_1 - T_2 + T_O$ = ………….N
8. Circumfrance of brake drum C_b = $\pi \times D$ = ………..m
9. Diameter at inlet of the venturimeter ,d_1 = ------------ mm
10. Diameter of the throat of the venturimeter d_2 = ------------ mm
11. Cross sectional area of the inlet, a_1 = ------------ m^2
12. Cross sectional area of the throat, a_2= ------------ m^2



SCHEMATIC DIAGRAM OF FRANCIS TURBINE

TABULAR COLUMN FOR CONSTANT HEAD

Sl No.	% of gate opening	Pressure Head		Vacuum Head		Total Head $H = H_1 + H_2$	Manometer reading in mm			Q m^3/s	h_f m	Spring Balance Reading				Speed N r/min	Input P_i kW	Output P_{i0} kW	Efficiency η %
		P kg/cm^2	$H_1 = px10$ kg/cm^2	V kg/cm^2	$H_2 = Vx10$ kg/cm^2		h_1 cm	h_2 cm	$h' = h_1 + h_2$			T_o N	T_1 N	T_2 N	T N				
1	100%																		
2	75%																		
3	50%																		

TABULAR COLUMN FOR CONSTANT SPEED

Sl No.	% of gate opening	Pressure Head		Vacuum Head		Total Head H= H_1 + H_2	Manometer reading in mm			Q m^3/s	H_1 m	Spring Balance Reading				Speed N r/min	Input P_i kW	Output P_{i0} kW	Efficiency η %
		P kg/cm^2	H_1=px 10 kg/cm^2	V kg/cm^2	H_2=Vx 10 kg/cm^2		h_1 cm	h_2 cm	h' = h_2+h_1			T_o N	T_1 N	T_2 N	T N				
1	100%																		
2	75%																		
3	50%																		

SPECIMEN CALCULATIONS FOR CONSTANT HEAD:

1. Monometer head (h_f)

   h_f = 12.6 x h = ----------- m of water.

   where h = Difference in level of monometer reading in

   Theoretical discharge($Q_{theoretical}$)

$$Q_{theoretical} = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where C_d=Coefficient of discharge

2. Input power, $P_i = \rho gQH$ Watts

   Q = discharge in m^3/s.

   H = pressure head in m of water.

3. Output power, $P_o = \pi DNT/60$ Watts

4. Overall Efficiency, η_o = (Output power/ Input power) × 100.

5. Efficiency η =…………………%

RESULTS:

The performance characteristics of Francies Turbine are as shown graph.

The efficiency of Francies Turbine for

a. Constant head= η =------- %
b. Constant speed=η = ------ %

GRAPHS

1. Unit discharge ,	(Q_u)	Vs	Unit speed ,	(N_u)
2 .Unit Power,	(P_u)	Vs	Unit speed , (N_u)	
3 .Overall efficiency ,	(η_o)	Vs	Unit speed ,	(N_u)
4 .Power developed ,	(P_o)	Vs	Discharge,	(Q)
5. Overall efficiency,	η_o	Vs	Discharge,	(Q)

Answer the following:

1. What is the difference between Francis turbine and Modern Francis turbine?
2. What is the difference between outward and inward flow turbine?
3. What is mixed flow reaction turbine? Give an example.
4. Why draft tube is not required in impulse turbine?
5. How turbines are classified based on head. Give example.

Experiment No: 10

KAPLAN TURBINE

AIM:

To study the characteristics of Kaplan turbine.

APPARATUS:

Kaplan turbine, manometer, Venturimeter, weights pressure and vacuum gauges.

THOERY:

Kaplan turbine is an axial flow reaction turbine. The turbine consists of,

1. Runner with adjustable vanes
2. A ring of adjustable vanes
3. A volute casing.
4. A draft tube
5. Brake dynamometer.

Kaplan turbine converts hydraulic energy of water into mechanical energy. Kaplan turbines are best suited for low heads (10 to 50 m). The specific speed ranges from 400 to 1000.

PROCEDURE:

1. Keep the guide vane at 4/8 opening.
2. Keep the runner vane at 4/8 opening.
3. Prime the pump, close the gate valve.
4. Start the pump.
5. Open the gate valve slowly.
6. Note the pressure gauge reading (G).
7. Note the vacuum gauge reading (V).
8. Vent the manometer.
9. Note the manometer reading.
10. Measure the speed of the turbine by using the tachometer

11. Load the turbine by placing dead weight in the hanger. Take all readings.
12. Repeat the experiment for various loads.
13. Experiment is repeated for different guide and runner and runner vane openings.

OBSERVATIONS:

1. Diameter of rope D_1 = …….mm
2. Diameter of brake drum D_2 = …….mm
3. Effective diameter of brake drum = $D = D_1+D_2$ = ……….mm
4. Dead weight , T_1 =………….N
5. Spring balance reading, T_2 =………….N
6. Weight of hanger, T_o = ………..N
7. Load on turbine, $T = T_1 - T_2 + T_O$ = ………….N
8. Circumfrance of brake drum $C_b = \pi \times D$ = ………..m
9. Diameter at inlet of the venturimeter ,d_1 = ------------ mm
10. Diameter of the throat of the venturimeter d_2 = ------------ mm
11. Cross sectional area of the inlet, a_1 = ------------ m^2
12. Cross sectional area of the throat, a_2= ------------ m^2

TABULAR COLUMN FOR CONSTANT HEAD

Sl No.	% of gate opening	Pressure Head		Vacuum Head		Total Head H= H_1 + H_2	Manometer reading in mm			Q m^3/s	h_f m	Spring Balance Reading				Speed N r/min	Input P_i kW	Output P_{i0} kW	Efficiency η %
		P kg/cm²	H_1=px 10 kg/cm²	V kg/cm²	H_2=Vx 10 kg/cm²		h_1 cm	h_2 cm	h' = h_1+h_2			T_o N	T_1 N	T_2 N	T N				
1	100%																		
2	75%																		
3	50%																		

TABULAR COLUMN FOR CONSTANT SPEED

Sl No.	% of gate opening	Pressure Head		Vacuum Head		Total Head	Manometer reading in mm			Q m^3/s	H_1 m	Spring Balance Reading				Speed N r/min	Input P_i kW	Output P_{i0} kW	Efficiency η %
		P kg/cm^2	H_1=px 10 kg/cm^2	V kg/cm^2	H_2=Vx 10 kg/cm^2	H= H_1 +H_2	h_1 cm	h_2 cm	h' = h_2+h_1			T_o N	T_1 N	T_2 N	T N				
1	100%																		
2	75%																		
3	50%																		

SPECIMEN CALCULATIONS FOR CONSTANT HEAD:

2. Monometer head (h_f)

h_f = 12.6 x h = ----------- m of water.

where h = Difference in level of monometer reading in

Theoretical discharge($Q_{theoretical}$)

$$Q_{theoretical} = C_d \times \frac{a_1 \times a_2 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

Where C_d=Coefficient of discharge

2. Input power, $P_i = \rho gQH$ Watts

Q = discharge in m^3/s.

H = pressure head in m of water.

3. Output power, $P_o = \pi DNT/60$ Watts

4. Overall Efficiency, η_o = (Output power/ Input power) $\times$ 100.

5. Efficiency η =…………………%

RESULTS:

The performance characteristics of Francies Turbine are as shown graph.

The efficiency of Francies Turbine for

c. Constant head= η =------- %

d. Constant speed=η = ------ %

GRAPHS

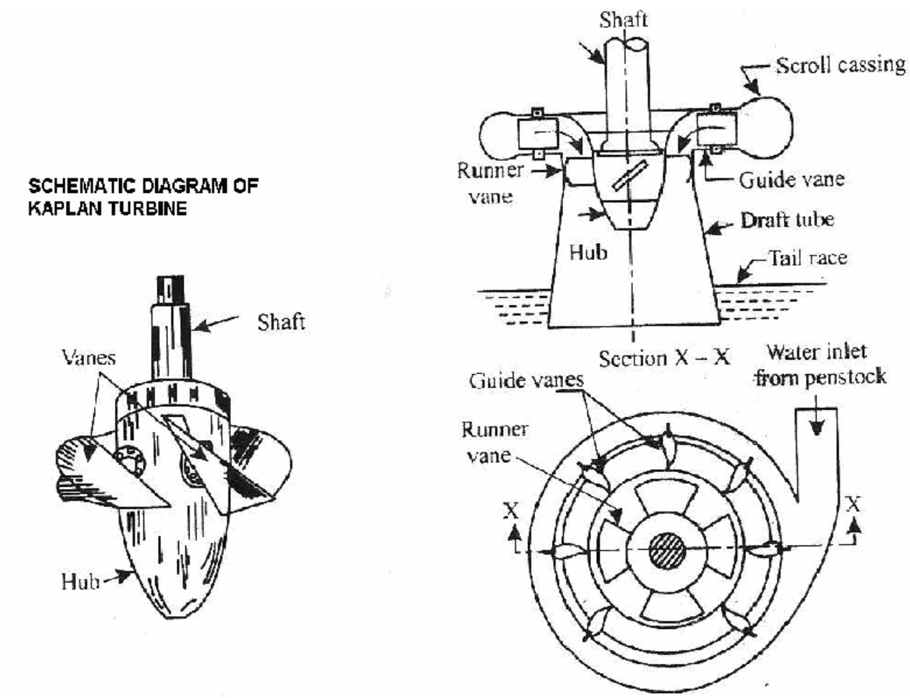
1. Unit discharge , (Q_u) Vs Unit speed , (N_u)

2 .Unit Power, (P_u) Vs Unit speed , (N_u)

3 .Overall efficiency , (η_o) Vs Unit speed , (N_u)

4 .Power developed , (P_o) Vs Discharge, (Q)

5. Overall efficiency, η_o Vs Discharge, (Q)



Answer the following:

1. What is the difference between propeller and Kaplan turbine?
2. Mention the parts of Kaplan turbine.
3. Differentiate between inward and outward flow reaction turbine.
4. Define impulse turbine.
5. Define reaction turbine

Experiment No: 11

CENTRIFUGAL PUMP

AIM :

To study the performance of the single stage centrifugal pump for constant & variable speed.

APPARATUS:

Centrifugal pump, tachometer, stop clock, pressure gauges, energy meter and a measuring tank with a piezometer with a scale.

THEORY :

Centrifugal pump is similar to Francis turbine in construction except that the fluid flow direction is opposite to that of turbine. The pump is often used to rise the water from low head to high head. The pump consists of an impeller revolving in a casing. The rotation of the impeller increases the pressure of water due to dynamic action (centrifugal force). The casing around the impeller converts the dynamic head into static head of water.

PROCEDURE:

a) **Constant Speed :**

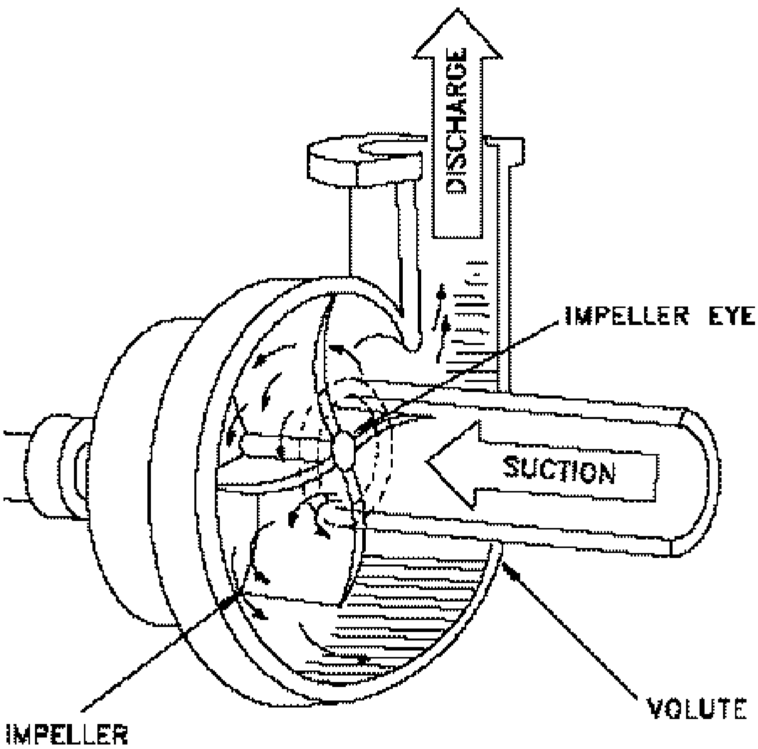
1. Open the delivery valves and starts the motor.
2. adjust the delivery valve and adjust the pressure gauge reading .
3. Measure the length and breadth of the measuring tank.
4. Note down the following readings.
    a. Pressure & vacuum gauge readings (G & V).
    b. Time for 0.220 m rise of water
    c. Time for 10 revolutions of energy meter.
5. Take the above readings for different values of head.
6. Calculate the input power, output power and overall efficiency.
7. Plot the relevant graphs.

b) Variable Speed:

1. Open the delivery valve and start the motor.
2. Keep head constant and take the readings as explained above.
3. Repeat the experiment for different heads.
4. Calculate the input power, output power and overall efficiency.
5. Plot the relevant graphs.

OBSERVATIONS:

1. Length of collecting tank , l = ... m
2. Breadth of collecting tank , b = ... m
3. Area of measuring tank A=
4. Energy meter constant , E = ... rev/kW-hr
5. Distance between pressure gauge and vacuum gauge
   X = ... m



TABULAR COLUMN FOR CONSTANT SPEED AND VARYING HEAD

Sl. No	Vacuum gauge V Kg/cm^2	Section Head H_G Vx10	Delivery Pressure Gauge Red G Kg/cm^2	Delivery Head H_D Gx10	Total Head $H = H_G + H_D + X$ in m	Rise of water H in m	Speed of pump in rpm	Time for collecting water t s	Discharge Q m^3/s	Time for 'n' rev. 'T'sec	Input *Pi* kW	Output P_o kW	Overall efficiency η_o
1													
2													
3													
4													

TABULAR COLUMN FOR VARYING SPEED AND CONSTANT HEAD

Sl. No	Vacuum gauge V Kg/cm^2	Section Head H_G Vx10	Delivery Pressure Gauge Red G Kg/cm^2	Delivery Head H_D Gx10	Total Head $H = H_G + H_D + X$ in m	Rise of water H in m	Speed of pump in rpm	Time for collecting water t s	Discharge Q m^3/s	Time for 'n' rev. 'T'sec	Input Pi kW	Output P_o kW	Overall efficiency η_o
1													
2													
3													
4													

SPECIMEN CALCULATION:

1) Discharge, Q

$$Q = Ah / t = \text{-------------} \ m^3/s$$

2) Input power = $\dfrac{3600 \times \text{No. of revolutions of EM}}{\text{E M constant} \times \text{time in s}}$

$$P_i = \frac{3600 \text{ x } n}{E \text{ x } T} = \ldots\ldots\ldots\ldots\ldots \ W$$

Where E=energy meter constant

3) Output power,

$$P_o = \rho g Q H = \ldots\ldots\ldots \ W$$

4) Efficiency , $\eta = \dfrac{\text{Power output}}{\text{Power input}}$

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

RESULT:

The average efficiency of single stage centrifugal pump =--------

Experiment No: 12

CENTRIFUGAL PUMP

AIM :

To study the performance of the multi stage centrifugal pump for constant & variable speed.

APPARATUS:

Multi stage centrifugal pump with electric motor, tachometer, stop clock, pressure gauges, energy meter and a measuring tank with a piezometer with a scale.

THEORY :

A centrifugal pump containing two or more impellers is called a Multi stage centrifugal pump .The impellers may be mounted on the same shaft or on different shafts, for higher pressure at the out let impellers can be connected in series for higher flow output impellers can be connected in parallel.

PROCEDURE:

a) **Constant Speed :**

1. Open the delivery valves and starts the motor.
2. adjust the delivery valve and adjust the pressure gauge reading .
3. Measure the length and breadth of the measuring tank.
4. Note down the following readings.
    d. Pressure & vacuum gauge readings (G & V).
    e. Time for 0.220 m rise of water
    f. Time for 10 revolutions of energy meter.
5. Take the above readings for different values of head.
6. Calculate the input power, output power and overall efficiency.
7. Plot the relevant graphs.

b) Variable Speed:

1. Open the delivery valve and start the motor.
2. Keep head constant and take the readings as explained above.
3. Repeat the experiment for different heads.
4. Calculate the input power, output power and overall efficiency.
5. Plot the relevant graphs.

OBSERVATIONS:

1. Length of collecting tank , l = ... m
2. Breadth of collecting tank , b = ... m
3. Area of measuring tank A=
4. Energy meter constant , E = ... rev/kW-hr

TABULAR COLUMN FOR CONSTANT SPEED AND VARYING HEAD

Sl. No	Vacuum gauge V Kg/cm^2	Section Head H_G Vx10	Delivery Pressure Gauge Red G Kg/cm^2	Delivery Head H_D Gx10	Total Head $H = H_G + H_D$ m	Stage Pressure			Rise of water H in m	Speed in rpm	Time for collecting water t s	Discharge Q m^3/s	Time for 'n' rev. 'T'sec	Input *Pi* kW	Output P_o kW	Overall efficiency η_o
						I	II	III								
1																
2																
3																
4																

TABULAR COLUMN FOR CONSTANT SPEED AND VARYING HEAD

SPECIMEN CALCULATION:

1) Discharge, Q

$$Q = Ah / t = \text{-------------}\ m^3/s$$

2) Input power = $\dfrac{3600 \times \text{No. of revolutions of EM}}{\text{E M constant} \times \text{time in s}}$

$$P_i = \frac{3600 \times n}{E \times T} = \ldots\ldots\ldots\ldots\ldots\ W$$

Where E=energy meter constant

3) Output power,

$$P_o = \rho g Q H = \ldots\ldots\ W$$

4) Efficiency , $\eta = \dfrac{\text{Power output}}{\text{Power input}}$

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

RESULT:

The average efficiency of single stage centrifugal pump =--------

Answer the following:

1. Define Positive displacement pump.
2. Differentiate between Roto-dynamic and positive displacement pump.
3. Define cavitation in pump.
4. What is the need for priming in pump?
5. Mention the type of casing used in centrifugal pump

Experiment No: 13

RECIPROCATING PUMP

AIM :

To study the performance of the reciprocating pump for

(1) Variable speed and constant head

(2) Constant speed and variable head

APPARATUS:

Reciprocating pump, stop clock, tachometer, measuring tank with a peizometer, energy meter, and pressure gauges.

THEORY:

Reciprocating pump is a positive displacement pump. It consists of a cylinder with a piston, piston rod, connecting rod and a crank, suction pipe, delivery pipe, suction valve and delivery valve. Reciprocating pumps are classified as single acting and double acting.

PROCEDURE:

(a) For varying head and constant speed :

Select the required speed within the avalable range. Open the gate valve fully in the delivery pipe. Start the motor. Throttle the gate valve to get the required head. Note down the following readings for different heads: 1.Speed of the pump , 2. Pressure and vacuum gauge readings (G& V), 3. Time for 10 revolutions of the energy meter. and 4. The time for 10 cm rise of water in the collecting tank.

Calculate the input power ,output power and overall efficiency.

(b) For constant head and varying speed :

Select a particular speed. Open the delivery valve in delivery pipe. Start the motor. Regulate the gate valve to get the required head . Note down the following readings for different speeds: 1.Speed of the pump , 2. Pressure and vacuum gauge readings (G& V), 3. Time for 10 revolutions of the energy meter. and 4. The time for 10 cm rise of water in the collecting tank.

Calculate the input power ,output power and overall efficiency

OBSERVATION :

Single stage double acting reciprocating pump

(1) Length of the collecting tank , l = ……… m

(2) Breadth of the collecting tank , b = …… . .. m

(3) Area of the measuring tank, A=…… . .. m^2

(4) Height of water collected , h = …….. m

(5) Diameter of suction pipe , d_1 = ……… m

(6) Diameter of delivery pipe , d_2 = …… m

(7) Cross sectional area of suction pipe , a_1 = ……… m^2

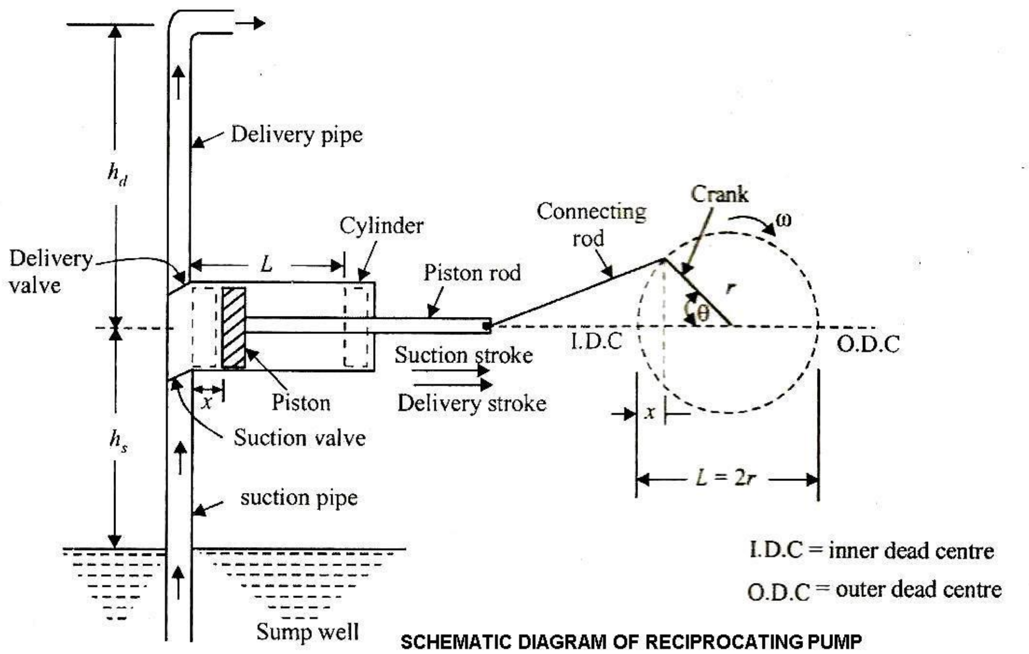
(8) Cross sectional area of delivery pipe , a_2 = …….. m^2

(9) Distance between pressure gauge and vacuum gauge , X = ... m

(10) Energy meter constant E=…………rev/kwhr

(11) Piston stroke length , L = ……… m

(12) Piston diameter , D = ……… m



SCHEMATIC DIAGRAM OF RECIPROCATING PUMP

Tabular Column for constant speed

Sl. No	Speed N r/min	Vacuum gauge V Kg/cm^2	Section Head H_G Vx10	Delivery Pressure Gauge Reding G Kg/cm^2	Delivery Head H_D Gx10	Velocity of discharge in delivery pipe V_D	Velocity of discharge in suction pipe V_S	$C=V_D^2-V_s^2/2g$	Total Head $H= H_G+H_D+X+C$ m	Rise of water H in m	Time for collecting water t in sec	Discharge Q m^3/s		Time for 'n' rev. 'T'sec	Input *Pi* kW	Output P_o kW	Overall efficiency (η) in %	Slip In %
												Q_{th}	Q_{act}					
1																		
2																		
3																		
4																		

Tabular Column for constant Head

Sl. No	Speed N r/min	Vacuum gauge V Kg/cm^2	Section Head H_G Vx10	Delivery Pressure Gauge Red G Kg/cm^2	Head H_D Gx10	Velocity of discharge in delivery pipe V_D	Velocity of discharge in suction pipe V_S	$C=V_D^2-V_s^2/2g$	Total Head $H= H_G+H_D+X+C$ m	Rise of water H m	Time for collecting water t in sec	Discharge Q m^3/s		Time for 'n' rev. 'T'sec	Input *Pi* kW	Output P_o kW	Overall efficiency (η) in %	Slip In %
												Q_{th}	Q_{act}					
1																		
2																		
3																		
4																		

SPECIMEN CALUCULATION:

(1) Theoretical discharge ,

$$Q_{th} = 2 \times (\pi \times d^2)/4 \times L \times (N/60) = \ldots\ldots \; m^3/s$$

(2) Actual Discharge, Q_{act}

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

(3) Velocity of discharge in delivery pipe, V_D

$$V_D = \frac{Q_{actual}}{a_2} \; m/s$$

(4) Velocity of discharge in Section pipe, V_S

$$V_S = \frac{Q_{actual}}{a_1} \; m/s$$

(5) Input power = $\dfrac{3600 \times \text{No. of revolutions of EM}}{\text{E M constant} \times \text{time in s}}$

$$P_i = \frac{3600 \text{ x } n}{E \text{ x } T} = \ldots\ldots\ldots\ldots\ldots \; W$$

Where E=energy meter constant

(6) Output power,

$$P_o = \rho g Q H = \ldots\ldots\ldots \; W$$

(7) Efficiency , $\eta = \dfrac{\text{Power output}}{\text{Power input}}$

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

(8) Slip in percentage

$$\text{Slip} = \frac{Q_{the} - Q_{act}}{Q_{the}} \times 100$$

$$= \ldots\ldots \%$$

- Constant speed and varying head
- Varying speed and constant head

Note: G and V values are multiplied by 10 to correct kgf/cm^2 into m of water.

RESULTS : Plot the following graphs

(a) For constant speed (head varying):

i. η Vs Discharge

ii. head Vs Discharge

(b) For varying speed (head constant):

i. η Vs Discharge

ii. speed Vs Discharge

Answer the following:

1. What is separation in reciprocating pump?
2. How separation occurs in reciprocating pump?
3. Write down the equation for loss of head due to acceleration in reciprocatingpump.
4. Write down the equation for loss of head due to friction in reciprocating pump.
5. Differentiate single acting and double acting reciprocating pump

Experiment No. : 14

TWO STAGE AIR COMPRESSOR

AIM

To conduct performance test on two stage single acting reciprocating air compressor and to determine volumetric efficiency and isothermal efficiency.

APPARATUS

1. Two stage air compressor.
2. Intercooler
3. Dynamometer
4. Orifice meter
5. Tachometer

PROCEDURE :

1. The outlet valve is closed and manometer connections are changed.
2. The compressor is started and pressure develops slowly.
3. At the required pressure i.e. 2 bar, outlet valve is opened slowly and adjusted so that the pressure is maintained constant. In this stage readings are obtained.
    a. Dynamometer reading
    b. speed of motor and compressor
    c. manometer reading
    d. high pressure reading
4. Repeat the experiments at different pressures.

OBSERVATION:

1. Diameter of low pressure cylinder, d_1 = ---------- m
2. Diameter of high pressure cylinder, d_2 = --------- m
3. Stroke length, L = ----------- m
4. Orifice diameter, d = -------- m
5. Area of orifice meter, $a = \pi \times d^2 / 4$, m^2
6. Density of air at NTP , $\rho_{air\ at\ N.T.P} = 1.293\ kg/m^3$
7. Room temp, t = ----------- ^oC
8. Atmospheric air pressure, $P_{atm} = 1 \times 10^5\ N/m^2$
9. Co-efficient of discharge, $C_d = 0.64$

TABULAR COLUMN

Sl. No.	Pressure at outlet in bar	Dynamometer reading W x 9.81 in N	Speed of motor, N in r/min	Speed of the compressor N_c, r/min	Water Manometer reading		
					H_1 m	H_2 m	$H=H_1-H_2$ m
1							
2							
3							
4							

SPECIMEN CALCULATION :

1. Pressure Ratio $r_c = P_a + P_d / P_a$

2. $\rho_{a \text{ at R.T.P.}} = \rho_{air \text{ at N.T.P.}} \times 273 / (273 + t)$, kg/m^3

   where t = room temperature in ^oC

   Head of air , $H_a = (H \times \rho_w / \rho_a)$, m

3. Actual volume of air delivered, $V_a = C_d \times a \times (2 \times g \times H_a)^{1/2}$, m^3/s

4. Swept volume, $Vs = (\pi \times d_1^2 / 4 \times L \times N_c) / 60$, m^3/s

5. Volumetric efficiency, $\eta_{vol} = (V_a/Vs) \times 100\%$

6. Isothermal work , $W = P_a \times V_a \times \ln(r_c)$, W

7. Brake power, $bp = (2 \times \pi \times N \times T) / 60$, kW

8. Isothermal efficiency, = (Isothermal work / brake power) x 100 %

Result:

1. Volumetric efficiency of compressor =

2. Isothermal efficiency of compressor =

Experiment No. : 15

CENTRIFUGAL BLOWER

AIM :
To conduct a test on blower to determine overall efficiency.

APPARATUS

Single stage centrifugal Blower test rig.
Stop watch.

PROCEDURE :

1. Before starting the experiment sluice gate valve should be in closed position.
2. The motor is started to reach its rated speed is 2880 rpm.
3. Note down the first set of reading, while the sluice gate valve is in full closed position.
4. The sluice valve is now opened, for various stages of opening and the readings are taken.

Observation :

TABULAR COLUMN

SL. NO.	Sluice Valve Opening	Load W x 9.81 in N	Speed of motor in RPM	Water Manometer Reading, h in m			Mercury Manometer Reading, H in m		
				h_1 m	h_2 m	$h=h_1-h_2$ m	H_1 m	H_2 m	$H=H_1-H_2$ m
1	Full closed								
2	¼ opening								
3	½ opening								
4	¾ opening								
5	Full opening								

SPECIMEN CALCULATION:

1. Water manometer reading

   Left column = h_1, m

   Right column = h_2, m

   Head of water, $h = h_1 - h_2$, m

2. Mercury manometer reading

   (the readings of venturimeter to measure the discharge)

   Left column = H_1,m

   Right column = H_2, m

   Mercury head, $H = H_1 - H_2$, m

3. Distance between dynamometer axis and motor axis, r =0.35 m

4. K = 0.021, constant for venturimeter.

5. Density of air at RTP, $\rho_{a\ at\ RTP} = (\rho_{a\ at\ NTP} \times 273) / (273 + t)$

   where t = room temperature in ^oC

6. Air head causing flow, $H' = H \times \rho_{hg} / \rho_{air\ at\ R.T.P}$, m

Where ρ_{hg} = 13600 kg/m^3

7. Actual volume of air delivered, $Q_a = k \times H^{1/2}$, m^3/s

8. Head of air at inlet, $H_a = h \times \rho_w / \rho_{a\ R.T.P}$, m

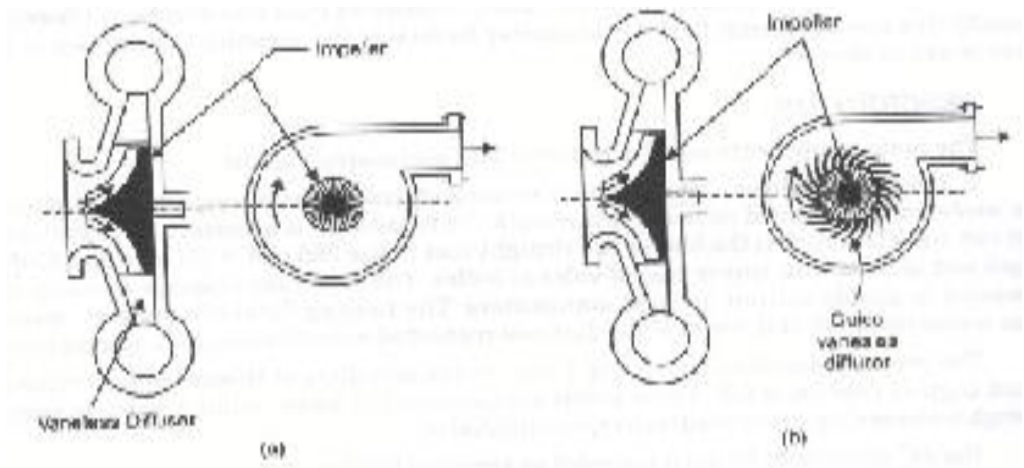
9. Output power, $P_{out} = \rho_{a\ R.T.P} \times H_a \times Qa \times g$, kW

10. Input power, $P_{in} = (2 \times \pi \times N \times T)/60$, kW

Where Torque, $T = W \times r$, Nm

Speed of motor, N in rev/min

11. Overall Efficiency of the blower, $\eta = (P_{out} / P_{in}) \times 100$



Centrifugal blower.

Results: The results are as shown in the tabular column.

EXPERIMENT No. : 08

CENTRIFUGAL BLOWER

Aim : To conduct a test on blower to determine overall efficiency.

Apparatus
1. Single stage centrifugal Blower test rig.
2. Stop watch.

Procedure :

5. Before starting the experiment sluice gate valve should be in closed position.
6. The motor is started to reach its rated speed is 2880 rpm.
7. Note down the first set of reading, while the sluice gate valve is in full closed position.
8. The sluice valve is now opened, for various stages of opening and the readings are taken.

Observation :

SL. NO.	Sluice Valve Opening	Load W x 9.81 in N	Speed of motor in RPM	Water Manometer Reading, h in m			Mercury Manometer Reading, H in m		
				h_1 m	h_2 m	$h=h_1-h_2$ m	H_1 m	H_2 m	$H=H_1-H_2$ m
1									
2									
3									
4									
5									

Specimen Calculation:

6. Water manometer reading

Left column = h_1, m

Right column = $h_{2,}$ m

Head of water, h = h_1-h_2, m

7. Mercury manometer reading

(the readings of venture meter to measure the discharge)

Left column = $H_{1,}$m

Right column = $H_{2,}$ m

Mercury head, H = H_1-H_2, m

8. Distance between dynamometer axis and motor axis, r =0.35 m

9. K = 0.021, constant for venturimeter.

10. Density of air at RTP, $\rho_{a\ at\ RTP} = (\rho_{a\ at\ NTP} \times 273) / (273 + t)$

where t = room temperature in ^oC

6. Air head causing flow, $H' = H \times \rho_{hg} / \rho_{air\ at\ R.T.P,}$ m

Where ρ_{hg} = 13600 kg/m^3

7. Actual volume of air delivered, $Q_a = k \times H^{1/2}$, m^3/s

8. Head of air at inlet, $H_a = h \times \rho_w / \rho_{a\ R.T.P}$, m

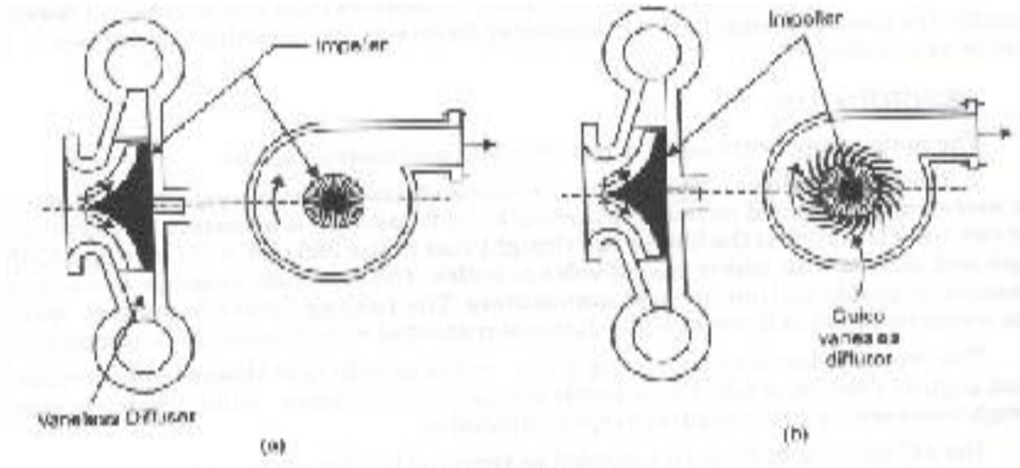
1. output power, $P_{out} = \rho_{a\ R.T.P} \times H_a \times Qa \times g$, kW

10. Input power, $P_{in} = (2 \times \pi \times N \times T)/60$, kW

Where Torque, T = W x r, Nm

Speed of motor, N in rev/min

11. Overall Efficiency of the blower, $\eta = (P_{out}/ P_{in}) \times 100$



Centrifugal blowers

Results: The results are as shown in the tabular column.

EXPERIMENT No. : 09

TWO STAGE AIR COMPRESSOR

Aim To conduct performance test on two stage single acting reciprocating air compressor and to determine volumetric efficiency and isothermal efficiency.

Apparatus

6. Two stage air compressor.
7. Intercooler
8. Dynamometer
9. Orifice meter
10. Tachometer

Procedure :

5. The outlet valve is closed and manometer connections are changed.
6. The compressor is started and pressure develops slowly.
7. At the required pressure i.e. 2 bar, outlet valve is opened slowly and adjusted so that the pressure is maintained constant. In this stage readings are obtained.
   e. Dynamometer reading
   f. speed of motor and compressor
   g. manometer reading
   h. high pressure reading
8. Repeat the experiments at different pressures.

Observation:

10. Diameter of low pressure cylinder, d_1 = ---------- m
11. Diameter of high pressure cylinder, d_2 = --------- m
12. Stroke length, L = ----------- m
13. Orifice diameter, d = -------- m
14. Area of orifice meter, $a= \pi \times d^2 /4$, m^2
15. Density of air at NTP , $\rho_{air\ at\ N.T.P} = 1.293\ kg/m^3$
16. Room temp, t = ----------- ^oC

17. Atmospheric air pressure, $P_{atm} = 1 \times 10^5 \ N/m^2$
18. Co-efficient of discharge, $C_d = 0.64$

Sl. No.	Pressure at outlet in bar	Dynamometer reading W x 9.81 in N	Speed of motor, N in r/min	Speed of the compressor N_c, r/min	Water Manometer reading		
					H_1 m	H_2 m	$H=H_1-H_2$ m
1							
2							
3							
4							

SPECIMEN CALCULATION :

9. Pressure Ratio $r_c = P_a + P_d \ / \ P_a$

10. $\rho_{a \text{ at R.T.P.}} = \rho_{air \text{ at N.T.P.}} \times 273 \ / \ (273 + t)$, kg/m³

    where t = room temperature in ^oC

11. Head of air , $H_a = (H \times \rho_w \ / \ \rho_a)$, m

12. Actual volume of air delivered, $V_a = C_d \times a \times (2 \times g \times H_a)^{1/2}$, m³/s

13. Swept volume, $Vs = (\pi \times d_1^2 / 4 \ \times \ L \times N_c) / 60$, m³/s

14. Volumetric efficiency, $\eta_{vol} = (V_a/Vs) \times 100\%$

15. Isothermal work , $W = P_a \times V_a \times \ln(r_c)$, W

16. Brake power, $bp = (2 \times \pi \times N \times T) / 60$, kW

17. Isothermal efficiency, = (Isothermal work / brake power) x 100 %

Result:

3. Volumetric efficiency of compressor =
4. Isothermal efficiency of compressor =