FLUID MECHANICS AND HYDRAULIC MACHINERY

LAB MANUAL

Academic Year	**:**	**2018 - 2019**
Subject Code	**:**	**ACE107**
Regulations	**:**	**IARE – R16**
Class	**:**	**V Semester (CE)**

Prepared By

R. Suresh kumar

&

CH. VSS. Sudheer

ASSISTANT PROFESSOR

DEPARTMENT OF CIVIL ENGINEERING

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal – 500 043, Hyderabad

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Dundigal, Hyderabad - 500 043

DEPARTMENT OF CIVIL ENGINEERING

Program: Bachelor of Technology (B. Tech)

VISION OF THE DEPARTMENT

To produce eminent, competitive and dedicated civil engineers by imparting latest technical skills and ethical values to empower the students to play a key role in the planning and execution of infrastructural & developmental activities of the nation.

MISSION OF THE DEPARTMENT

To provide exceptional education in civil engineering through quality teaching, state-of-the-art facilities and dynamic guidance to produce civil engineering graduates, who are professionally excellent to face complex technical challenges with creativity, leadership, ethics and social consciousness.

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DEPARTMENT OF CIVIL ENGINEERING

Program: Bachelor of Technology (B. Tech)

PROGRAM OUTCOMES (PO's)	
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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The Program Specific outcomes (PSO's) listed below were developed specifically to meet the Program Educational Objectives (PEO's). The focus of these PSO's is consistent with the set of required PO's identified in the NBA accreditation guidelines.

The Civil Engineering PSO's require that graduates receiving a Bachelor of Technology in Civil Engineering degree from IARE demonstrate the following.

PROGRAM SPECIFIC OUTCOMES (PSO's)	
PSO1	**ENGINEERING KNOWLEDGE:** Graduates shall demonstrate sound knowledge in analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good foundation in mathematics, basic sciences and technical communication
PSO2	**BROADNESS AND DIVERSITY: Graduates** will have a broad understanding of economical, environmental, societal, health and safety factors involved in infrastructural development, and shall demonstrate ability to function within multidisciplinary teams with competence in modern tool usage.
PSO3	**SELF-LEARNING AND SERVICE:** Graduates will be motivated for continuous self-learning in engineering practice and/or pursue research in advanced areas of civil engineering in order to offer engineering services to the society, ethically and responsibly.

FLUID MECHANICS AND HYDRAULIC MACHINERY LAB SYLLABUS

Exp No.	NAME OF THE EXPERIMENT
1.	Calibration of venturimeter and Orificemeter
2.	Determination of coefficient of discharge for a small orifice/Mouth piece by constant head method
3.	Calibration of contracted rectangular notch / triangular notch
4.	Determination of friction factor of a pipe
5.	Determination of coefficient for minor losses
6.	Verification of Bernoulli's equation
7.	Impact of jet on vanes
8.	Performance test on Pelton wheel turbine
9.	Study of Hydraulic jump
10.	Performance test on Francis turbine
11.	Performance test on centrifugal pump
12.	Performance test on reciprocating pump

ATTAINMENT OF PROGRAM OUTCOMES (PO's) & PROGRAM SPECIFIC OUTCOMES (PSO's)

Exp No.	Name of Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1.	Calibration of venturimeter and Orificemeter	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
2.	Determination of coefficient of discharge for a small orifice/Mouth piece by constant head method	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
3.	Calibration of contracted rectangular notch and triangular notch	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
4.	Determination of friction factor of a pipe	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
5.	Determination of coefficient for minor losses	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
6.	Verification of Bernoulli's equation	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
7.	Impact of jet on vanes	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
8.	Performance test on Pelton wheel turbine	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
9.	Study of Hydraulic jump	PO1(H), PO2(M), PO4(M), PO6(L), PO10(M)	PSO1(H), PSO2(M)
10.	Performance test on Francis turbine	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
11.	Performance test on centrifugal pump	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)
12.	Performance test on reciprocating pump	PO1(H), PO2(M), PO4(M),PO6(L), PO10(M)	PSO1(H), PSO2(M)

MANDATORY INSTRUCTIONS

1. Students should report to the labs concerned as per the timetable.

2. Record should be updated from time to time and the previous experiment must be signed by the faculty in charge concerned before attending the lab.

3. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.

4. After completion of the experiment, certification of the staff in-charge concerned in the observation book is necessary.

5. Students should bring a notebook of about 100 pages and should enter the readings/observations/results into the notebook while performing the experiment.

6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate previous session should be submitted and certified by the staff member in-charge.

7. Not more than FIVE students in a group are permitted to perform the experiment on a set up.

8. The group-wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.

9. The components required pertaining to the experiment should be collected from Lab-in-charge after duly filling in the requisition form.

10. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.

11. Any damage of the equipment or burnout of components will be viewed seriously either

by putting penalty or by dismissing the total group of students from the lab for the semester/year.

12. Students should be present in the labs for the total scheduled duration.

13. Students are expected to prepare thoroughly to perform the experiment before coming to Laboratory.

14. Procedure sheets/data sheets provided to the students groups should be maintained neatly and are to be returned after the experiment.

15. DRESS CODE:

1. Boys - Formal dress with tuck in and shoes.

2. Girls - Formal dress (salwarkameez).

3. Wearing of jeans is strictly prohibited

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EXPERIMENT NO. 1(A)

CALIBRATION OF VENTURIMETER

AIM: To determine the co-efficient of discharge of the given Venturimeter by establishing the relationship between discharge and pressure head difference.

APPARATUS:

1. Venturimeter with pressure tapings at the entrance and the throat installed in a horizontal pipeline.
2. U-tube manometer to measure the difference across the tapings
3. A constant steady supply of water with a means of varying discharge
4. Measuring tank and stop watch to measure the actual discharge.

THEORY:

A Venturimeter is a device used to measure the rate of flow of a liquid in a pipe line. It consists of a converging cone, throat section (cylindrical) and a diverging cone. The principle (Bernoulli's theorem) used is to measure the difference of head between two sections and computing the average flow velocity from which the discharge is computed using discharge continuity equation.

Coefficient of discharge (Cs) is the ratio of actual discharge to the corresponding theoretical discharge.

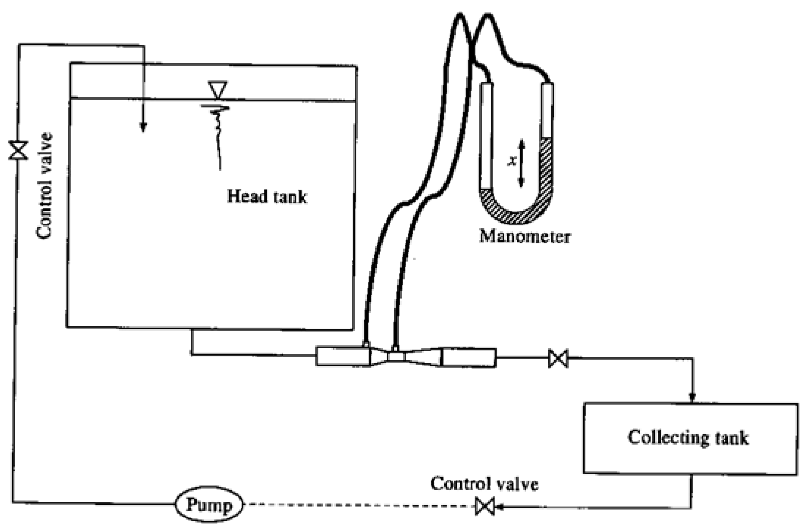


Fig.No.1 Experimental setup of Venturimeter

PROCEDURE:

1. Select a Venturimeter set-up.
2. Note down diameter of the pipe.
3. Connect the two limbs of manometer to inlet and throat of the Venturimeter.
4. Allow the water to flow in the pipe by opening the gate valve.
5. Vent the manometer by removing the air bubbles in the tube.
6. Note down the manometer readings4ifference in elevation of manometric fluid in left and right limbs
7. Note down the time required to collect a known height of water in collecting tank.
8. Repeat Steps 6 to 7 for various discharges by varying the gate valve for four more trails.

TABULAR COLUMN:

S. No.	Manometer reading $x = (x_1 - x_2)$	Equivalent water head h=12.6x	Time for ------mm Rise in tank (t)	$Q_a = \frac{A \times r}{t}$	Q_t	$C_d = \frac{Q_a}{Q_t}$
	M	M	S	m^3/s	m^3/s	
1						
2						
3						
4						
5						

SPECIMEN CALCULATION:

$Q_a = \frac{A \times r}{t}$ = …………………; A = …………….. × ………………… = …………….. m^2;

$Q_a = \frac{(\qquad\qquad)}{(\qquad)}$ = …………………….. m^3/s

$Q_t = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh}$ = ………………. m^3/s

$h = x\left[\frac{s_m}{s} - 1\right]$ = ………………….. ; $x = (x_1 - x_2)$ m; g = 9.81 (m/s^2)

$a_1 = \frac{\pi d_1^2}{4}$ = ……………….. m^2 d_1= diameter of the pipe

$a_2 = \frac{\pi d_2^2}{4}$ = ……………….. m^2 d_2= diameter of the pipe

$C_d = \frac{Q_a}{Q_t}$

PRECAUTIONS

1. The venturimeter should be fixed in the pipeline such that the pipe, on both Sides, is long enough and does not affect the flow in venturimeter.

2. Sufficient time should be given for the flow to become steady-uniform.

3. The air bubbles should be completely removed in the pipe connecting the Manometer. This should be achieved only by opening the valves provided at the top of the manometers simultaneously. If they are opened separately, the manometric fluid (usually mercury, which is very costly) will spill out of

POSSIBLE ERRORS

1. The manometric reading (head) for the flow through the pipe before and after taking readings of volumetric measurements (actual discharge) should be the same. If they are not same, take the average of the two readings for volumetric readings.

2. Reading errors may occur at manometer and volumetric piezometer scale by not recording the readings at the eye level.

3. Synchronize stopwatch operations for volumetric measurements.
 Note: Typical experimental results are worked out in Excel File-Venturimeter.xis given in the accompanying CD.

GRAPHS:

Draw the graph of *log* Q_a vs *log h*

$$Q_a = \frac{a_1 a_2}{\sqrt{a_1{}^2 - a_2{}^2}}\sqrt{2gh^n} = Kh^n$$

Where, $K = C_d \frac{a_1 a_2}{\sqrt{a_1{}^2 - a_2{}^2}}\sqrt{2g}$

$log\ Q_a = logK + n \log h$, at $h = 1:\ Q_a = k$

Hence, $C_d = \frac{K}{\left(\frac{a_1 a_2}{\sqrt{a_1{}^2 - a_2{}^2}}\right)\sqrt{2g}}$

General values of venturimeter co-efficients: C_d → 0.95 to 0.98

CALCULATIONS:

FORMULAE:

The discharge through a venturimeter is given by

$$Q_a = C_d \frac{a_1 a_2}{\sqrt{a_1{}^2 - a_2{}^2}}\sqrt{2gh}$$

Coefficient of discharge, $C_d = \frac{Q_a}{Q_t}$

Actual discharge, $Q_a = \frac{A \times r}{t}$

Where, a = Area of measuring tank; r = Rise of water level in the measuring tank, and t = Time for r mm rise in measuring.

The theoretical discharge through venturimeter is given by

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

Where,

a_1 = Cross-section area of inlet of venturimeter

a_2 = Cross-section area of throat of venturimeter

h = Equivalent water head = $x\left[\frac{s_m}{s} - 1\right]$

s_m = Specific gravity of manometric fluid i.e. mercury = 13.60

s = Specific gravity of flowing fluid i.e. water =1

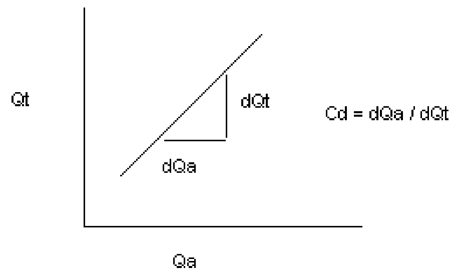
x = difference in levels of manometric fluid in the two limbs of manometer.

CALCULATIONS:

RESULT

The co-efficient of discharge of Orifice meter = ……………. From Calculation The co-efficient of discharge of Orifice meter = ……………. From Graph

NORMAL GRAPH:



Draw Q_a Vs Q_t .

Find C_d value from the graph and compare it with calculated C_d value from table.

LOG GRAPH:

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRE-LAB QUESTIONS

1. Write continuity equation for incompressible flow?
2. What is meant by flow rate?
3. What is the use of orifice meter?
4. What is the energy equation used in orifice meter?
5. List out the various energy involved in pipe flow.

POST-LAB QUESTIONS

1. How do you find actual discharge?
2. How do you find theoretical discharge?
3. What do you meant by co-efficient of discharge?
4. Define vena-contracta?
5. List out the Bernoulli’s applications.

FLOW MEASUREMENT BY ORIFICEMETER 1(B)

AIM: To determine the co-efficient of discharge of the orifice meter

EQUIPMENTS REQUIRED: Orifice meter test rig, Stopwatch

PREPARATION THEORY

An orifice plate is a device used for measuring the volumetric flow rate. It uses the same principle as a Venturi nozzle, namely Bernoulli's principle which states that there is a relationship between the pressure of the fluid and the velocity of the fluid. When the velocity increases, the pressure decreases and vice versa. An orifice plate is a thin plate with a hole in the middle. It is usually placed in a pipe in which fluid flows. When the fluid reaches the orifice plate, with the hole in the middle, the fluid is forced to converge to go through the small hole; the point of maximum convergence actually occurs shortly downstream of the physical orifice, at the so-called *vena contracta* point. As it does so, the velocity and the pressure changes. Beyond the *vena contracta*, the fluid expands and the velocity and pressure change once again. By measuring the difference in fluid pressure between the normal pipe section and at the *vena contracta*, the volumetric and mass flow rates can be obtained from Bernoulli's equation. Orifice plates are most commonly used for continuous measurement of fluid flow in pipes. This experiment is process of calibration of the given orifice meter.

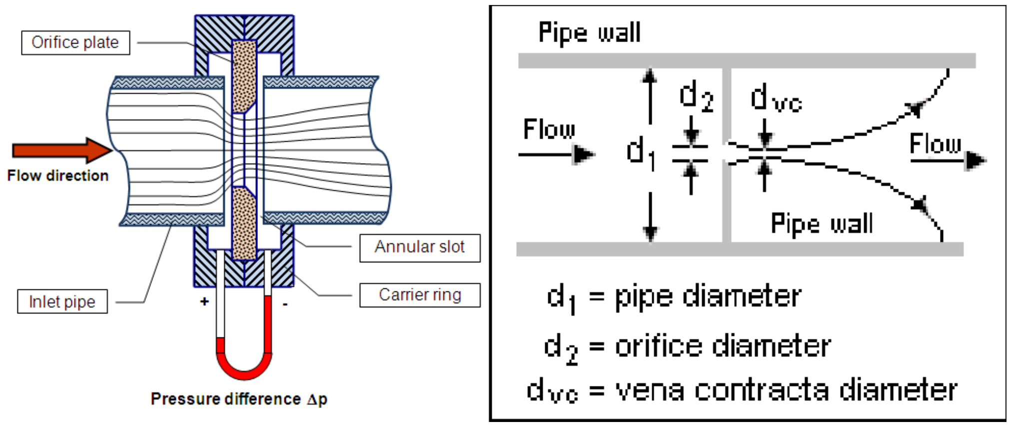


Fig.2. Orifice Plate

PROCEDURE:

N.B.: Keep the delivery valve open while start and stop of the pump power supply.

Switch on the power supply to the pump Adjust the delivery flow control valve and note down manometer heads (h1, h2) and time taken for collecting 10 cm rise of water in collecting tank (t). (i.e. Initially the delivery side flow control valve to be kept fully open and then gradually closing.) Repeat it for different flow rates.

1.4.4. Switch off the pump after completely opening the delivery valve.

l. No.	Manometer Reading (cm)			Manometer Head H	Time for 10 cm rise t	Actual Discharge Q_a	Theoretical Discharge Q_t	Co-eff. of discharge C_d
	h_1	h_2	$h_m = h_1 - h_2$	m	sec	m^3/sec	m^3/sec	
1.								
2.								
3.								
4.								
5.								
6								
							Average $\mathbf{C_d}$ value	

OBSERVATIONS

FORMULAE / CALCULATIONS

The actual rate of flow, $Q_a = A \times h / t$ (m^3/sec)

Where A = Area of the collecting tank = lengh x breadth (m^2) h = Height of water(10 cm) in collecting tank (m),

t = Time taken for 10 cm rise of water (sec)

The Theoretical discharge through orifice meter, Q_t =

$(a_1 a_2 \sqrt{2g H}) / \sqrt{(a_1^2 - a_2^2)}\ m^3/sec$

Where, H = Differential head of manometer in m of water = $12.6 \times h_m \times 10^{-2}$ (m)

g = Acceleration due to gravity ($9.81 m/sec^2$) Inlet Area of rifice meter in m^2 , $a_1 = d_1^2/ 4$

Area of the throat or orifice in m^2 , $a_2 = d_2^2/ 4$

The co-efficient of discharge,

$\mathbf{C_d}$ = Actual discharge / Theoretical discharge = Q_a/Q_t

TABULATION

Size of Orifice meter :

Inlet Dia. d_1 = 25 mm ,

Orifice dia d_2 = 18.77 mm,

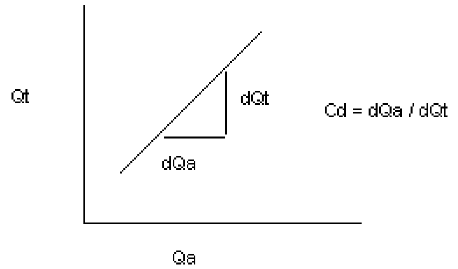
Measuring area in collecting tank A = 0.3 x 0.3 m^2

RESULT

The co-efficient of discharge of orifice meter = ……………. From Calculation

The co-efficient of discharge of orifice meter = ……………. From Graph

GRAPH:



Draw Q_a Vs Q_t .

Find C_d value from the graph and compare it with calculated C_d value from table

PRE-LAB QUESTIONS

1. Write continuity equation for incompressible flow?
2. What is meant by flow rate?
3. What is the use of orifice meter?
4. What is the energy equation used in orifice meter?
5. List out the various energy involved in pipe flow.

POST-LAB QUESTIONS

1. How do you find actual discharge?
2. How do you find theoretical discharge?
3. What do you meant by co-efficient of discharge?
4. Define vena-contracta?
5. List out the Bernoulli’s applications.

EXPERIMENT: 02

COEFFICIENT OF DISCHARGE FOR A SMALL ORIFICE BY CONSTANT HEAD METHOD

AIM:

To determine the.coefficient of discharge for a small orifice by constant head method

APPARATUS:

1. Orifice
2. Stop clock
3. Collecting Tank

PROCEDURE

1. Open the valve and let the water in to the balancing tank
2. Adjust the inlet valve such that the water fremains constant at particular head.
3. Record the head orifice(H cm) ie the height of water surface from the center of orifice
4. At a particular head collect water flowing through the orifice in a collecting tank and note the time taken for collection of water
5. Repeat the experiment for six different heads.

CALCULATIONS

Theoretical discharge through an orifice

$$Qth = a\sqrt{2gH}$$

$$Qth = K\sqrt{H}$$

Where a= Area of cross section of orifice

H= Head of the orifice

g= acceleration due to gravity

Actual discharge through orifice is given by C_a=C_d $\times$Qth

Determination of coefficient of discharge by constant head method for an orifice

Diameter of an orifice= 3.0 cm

C/s area of an orifice=……………….

Size of collecting tank 50*50 cm2

OBSEVATIONS

S.NO.	Head (H cm)	Rise of water in collecting Tank (R cm)	Volume of collecting Tank(cm3)	Actual discharge Qa =V/T	Theoretical discharge Qth = $K\sqrt{H}$	Coefficient of discharge K= Qa/Qth

RESULTS:

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

EXPERIMENT:03

CALIBRATION OF CONTRACTED RECTANGULAR AND TRIANGULAR NOTCH NOTCHES

AIM:

To calibrate notches, and thereby establish the relationship between the head over weir and discharge.

APPARATUS:

1. Approach channel fitted with the notch or weir
2. A point gauge to measure head over the weir
3. A constant steady supply of water with a means of varying discharge
4. Measuring tank and stop watch to measure the actual discharge

THEORY:

A notch or sharp crested weir is a device used to measure the discharge flowing through the open channel. The general types of notches according to their geometric shapes are rectangular, triangular and trapezoidal.

End contraction: Due to the constriction of flow as it flows through the weir, the actual flow decreases. In case of rectangular weir, the flow through the weir including end contraction is given by

$$Q = \frac{2}{3} C_d \sqrt{2g}(L - 0.2h)h^{\frac{3}{2}} = \frac{2}{3} C_d \sqrt{2g}\, L h^{\frac{3}{2}} - \frac{2}{15} C_d \sqrt{2g}\, h^{\frac{5}{2}}$$

As can be seen reduction in flow is triangular portion

$$\frac{8}{15} \times \frac{1}{4} C_d \sqrt{2g}\, h^{\frac{5}{2}} = \frac{8}{15} C_d \sqrt{2g} \tan\theta\ h^{\frac{5}{2}}$$

C_d = Coefficient of discharge

L= Crest length of rectangular notch=…………………………..

θ = Half-angle of the triangular portion=…………………………..

h= difference between crest reading to gauge reading (head of water over the notch)

g= 9.81 m/s^2

$\tan\theta = 1/4$

Rectangular Notch

S. No.	Head over Notch	Time for____mm rise in tank	$Q_a = \frac{A \times r}{t}$	Q_t	$C_d = \frac{Q_a}{Q_t}$
	M	S	m^3/s	m^3/s	
1					
2					
3					
4					
5					

SPECIMEN CALCULATION:

Crest reading = ……………………………m

$Q_a = \frac{A\times r}{t}$=……………… A=…………………………×………………..=……………………….m^2

$Q_t = \frac{2}{3}\sqrt{2g}\,Lh^{\frac{3}{2}}$ m^3/s

L=……………m

$g=9.81\ m/s^2$

$C_d = \frac{Q_a}{Q_t}$=…………………………

Hence the triangular portion by the side of rectangular weir with crest width L is having slopes as 1H:4V.then the additional flow in the triangular portion of trapezoidal weir will be compensating for the end contraction and the flow through Cippoletti weir will be same as rectangular weir.

Coefficient if discharge is the ratio of actual discharge to the corresponding theoretical discharge to the weir crest is the point about which the flow is just about to begin.

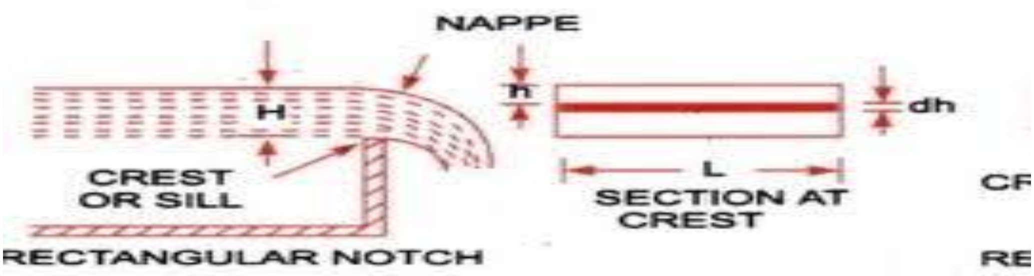


Fig.1 Rectangular Notch

Procedure:

1) Select the given notch set-up.
2) Note down the type of notch by using point gauge.
3) Note down the crest reading of the notch by using pint gauge.
4) Allow the water by opening the gate valves.
5) Note down the final reading by using point gauge.
6) Note down the time required to fill the particular height of water in the collecting tank
7) Repeat steps 5to 6 for various discharge by varying the gate valve for four more trails.

Precautions:

1) The weir / notch should be fixed exactly in the vertical plane perpendicular to the flow axis.
2) The weir should be fixed in a position such that it is symmetrical over vertical axis.
3) Sufficient time should be given foe the flow to become steady-uniform.
4) Gauge readings should be measured only in peizometre attached to the channel and not on the free surface.

Possible Errors:

1. Head should be constant in the head tank and the point gauge measurements before and after taking the readings of volumetric measurements (actual discharge) should be the same. If the measurements are not the same, take the average of the two readings.
2. Reading error may occur at gauge and volumetric peizometre scale by not recording the readings at the eye level.
3. Synchronize the stop watch operations for volumetric measurement

NOTE:

Typical experimental results are worked out in Excel File-Rectangle.xls, triangle.xls, trapezoidal.xls, Broad crested.xlsa, ogeeweir.xls, given in the accompanying CD.

Triangular Notch:

S. No.	Head over Notch	Time for____mm rise in tank	$Q_a = \frac{A \times r}{t}$	Q_t	$C_d = \frac{Q_a}{Q_t}$
	M	S	m^3/s	m^3/s	
1					
2					
3					
4					
5					

SPECIMEN CALCULATION:

Crest reading = ………………………………m

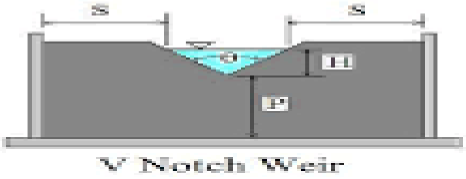
$Q_a = \frac{A \times r}{t}$=……………… A=……………………×………………..=……………………..m^2

$Q_t = \frac{8}{15}\, C_d \sqrt{2g}\, \tan\theta\;\, h^{\frac{5}{2}}$ m^3/s

$g=9.81\ m/s^2$ $\theta = 30^0$ or 45^0

Q_t =………………………

$C_d = \frac{Q_a}{Q_t}$ =…………………………



Graphs:

Draw the graph of *log* Q_a *vs log h*

Rectangular weir and Cipoletti weir

$$Q_a = \frac{2}{3} C_d \sqrt{2g}\, L\, h^n = K h^n$$

$$K = \frac{2}{3}\; C_d \sqrt{2g}$$

Where,

log Q_a = *log K* + *n log h* *at h=1;* $Q_a = K$

hence $C_d = \frac{k}{\frac{2}{3}\sqrt{2g}\, L}$ and *n* is the slope of the line

Triangular weir

$$Q_t = \frac{8}{15}\; C_d \sqrt{2g}\, \tan\theta\;\; h^{\frac{5}{2}} = K h^n$$

$$\mathrm{K} \;= \frac{8}{15}\; C_d \tan\theta\; \sqrt{2g}$$

Where,

log Q_a = *log K* + *n log h* at h =1; $Q_a = K$

hence,

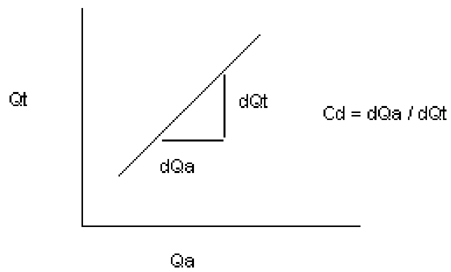
$C_d = \frac{k}{\frac{8}{15}\tan\theta\,\sqrt{2g}}$ and *n* is the slope of the line

General values of the C_d varies in between 0.60 to 0.62 depending on the type of notch

Calculations:

Results

Normal graph



PRE LAB QUESTIONS

1. Derive expression for theoretical discharge?
2. Sketch and explain flow through notch apparatus?
3. What are the applications of square notch?
4. What is the application of flow through notch?
5. What are the units of discharge?

PRE LAB QUESTIONS

1. How do understand by theoretical discharge

2. Explain different types notches

3. Which one is maximum discharge in all Notches

4. How do you calculate the Co-efficient of Discharge

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

EXPERIMENT: 04

DETERMINATION OF FRICTION FACTOR IN PIPES

AIM:

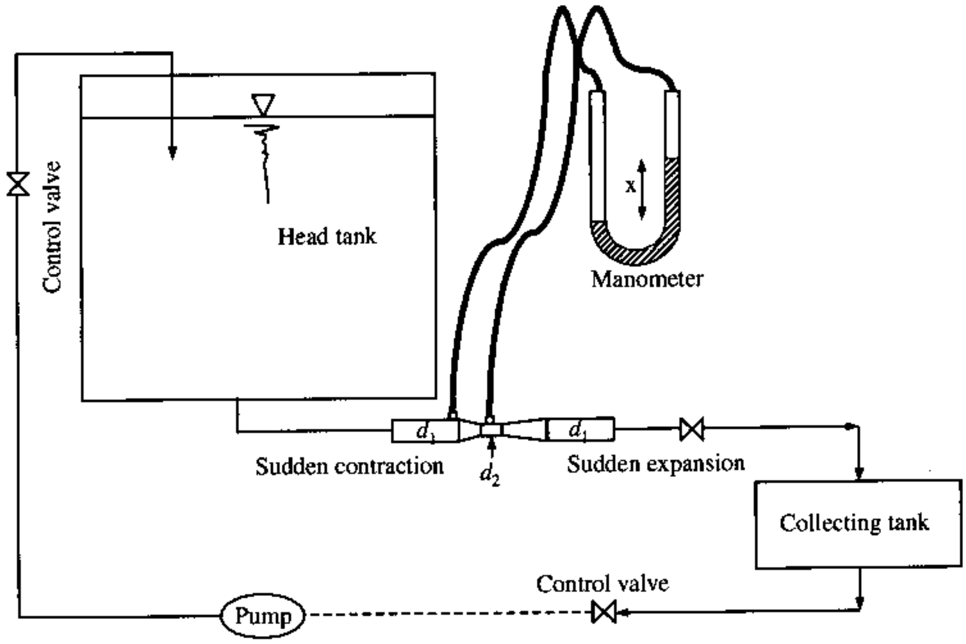
To determine Darcy friction co-efficient.

APPARATUS:

1. A small diameter pipe line
2. U-tube manometer to measure the difference across the tapings
3. A constant steady supply of water with a means of varying discharge
4. Measuring tank and stop watch to measure the actual discharge

THEORY:

Due to the viscous resistance between the layers of flowing fluid and the layer and boundary, friction is developed, which opposes the motion. This co-efficient of friction can be obtained from Darcy– Weisbach equation.



PROCEDURE:

1. Note down diameter of the pipe.
2. Connect the two limbs of manometer to the two gauge pints.
3. Allow the water to flow into the pipe by opening the gate valve.
4. Vent the manometer by removing the air bubbles in the tube.
5. Note down the difference in the level of manometric fluid in the left and right limb.
6. Note down the time required to fill particular height of water in the collecting tank.
7. Repeat Steps 3 to 5 for various discharges by varying the gate valve for four more trials.

PRECAUTIONS:

1. The pipeline should be long enough such that the sufficient head loss is recorded in the manometer.
2. Sufficient time should be given for the flow to become steady – uniform.
3. The air bubbles should be completely removed in the pipe connecting the manometer. This should be achieved only by opening the valves provided at the top of the manometers simultaneously. If they are opened separately, the manometric fluid (usually mercury, which is very costly) will spill out of manometer.

CALCULATIONS:

FORMULAE:

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

where,

h_f = Head loss due to friction = $x\left(\frac{s_m}{s} - 1\right)$

m = Specific gravity of manometric fluid, i.e. water = 13.60

s = Specific gravity of flowing fluid, i.e. water = 1.00

x = Difference in levels of the manometric fluid in the two limbs of manometer

f = Coefficient of friction.

l = Length of the pipe; d = Diameter of the pipe.

V = velocity of water in the pipe = $\frac{Q_a}{a}$

Q_a= Actual discharge

a = Cross section area of the pipe

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

Actual discharge, $Q_a = \frac{A \times r}{t}$

A = Area of measuring tank

r = Rise of water level in the measuring tank

t = Time for r cm rise in measuring

SPECIMEN CALCULATION:

$Q_a = \frac{A \times r}{t}$ = ……..; A = ………. × ……….. = ……….. m^2;

$Q_a = \frac{(\quad \times \quad)}{(\quad)}$ = ………….. m^3/s

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

$h = x\left[\frac{s_m}{s} - 1\right] = 12.6x$ =…………..m

$g = 9.81\ m/s^2$

$V = \frac{Q_a}{a} =$ ……………….. $a = \frac{\pi d^2}{4}$ = ……………… m^2; d = diameter of the pipe

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

$R_e = \frac{16}{f}$ for $R_e < 2000$

$f = \frac{0.079}{(R_e)^{1/4}}$ for $2000 < R_e < 10^6$

$R_e = \frac{3.895 \times 10^{-5}}{f^4}$

POSSIBLE ERRORS:

1. The manometric reading (head) for the flow through the pipe before and after taking readings of volumetric measurements (actual discharge) should be the same. If not, take the average of the two readings for volumetric readings.
2. Reading errors at manometer and volumetric piezometer scale may occur by not recording the readings at the eye level.
3. Synchronize the stopwatch operations for volumetric measurements.
4. U-tube mercury manometer records very low head difference by showing small readings. Using inverted U-tube manometer will have better sensitivity.

GRAPH: Draw R_e *vs f* graph

CALCULATIONS:

TABULAR COLUMN:

S. No.	Manometer reading $x = (x_1 - x_2)$	Equivalent water head h=12.6x	Time for ------mm Rise in tank (t)	$Q_a = \frac{A \times r}{t}$	Velocity of Water $V = \frac{Q_a}{a}$	F	R_e
	M	M	S	m^3/s	m/s		
1							
2							
3							
4							
5							

CALCULATIONS:

RESULTS

NORMAL GRAPH

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRE-LAB QUESTIONS

1. List out the various types of pipe fittings?
2. What do you meant by minor losses?
3. What are the types of losses in pipe flow?
4. What do you meant by entry loss?
5. What do you meant by exit loss?

1.

POST-LAB QUESTIONS

1. What is the equation for head loss due to sudden enlargement?
2. What is the equation for head loss due to sudden contraction?
3. What is the equation for head loss due to bend?
4. What is the equation for head loss at entry of pipe?
5. What is the equation for head loss at exit of pipe?
6. Which Newton’s law is applicable to impulse turbine?

EXPERIMENT:5

DETERMINATION OF COEFFICIENT FOR MINOR LOSSES

AIM:

Determination of coefficients due to sudden enlargement and sudden contraction.

APPARATUS:

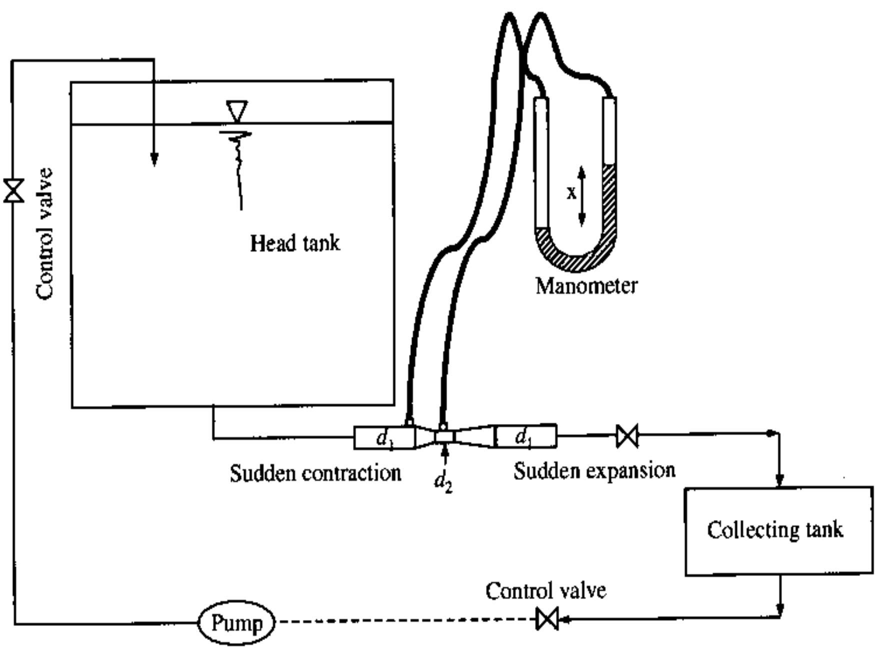
A small diameter pipe line consisting of sudden expansion and sudden contraction sections

1. U-tube manometer to measure the difference across the tapings
2. A constant steady supply of water with a means of varying discharge
3. Measuring tank and stop watch to measure the actual discharge

THEORY:

Head losses in flow through pipes are classified into major and minor losses. Minor losses include head loss due to sudden enlargement and sudden contraction. As the stream line leaves the boundary, due to sudden expansion, lot of eddy currents and flow reversals are generated and head loss occurs in the pipe. Even in head loss due to sudden contraction, mainly loss is due to the sudden expansion from Veena- contracta to the pipe diameter.

Veena- contracta: It is the minimum cross-sectional area of flow attained by the contracting fluid jet before it starts to expand again.



PROCEDURE:

1. Note down the diameter of the pipe.
2. Connect the manometer to the gauge points of the apparatus.
3. Allow the water by opening the gate valve.
4. Note down the difference in the level of manometric fluid in the left and right limb.
5. Note down the time required to fill particular height of water in the collecting tank.
6. Repeat steps 4 and 5 for various discharges by varying the gate valve for four more trials.

PRECAUTIONS:

1. The pipeline should be long enough before and after the device (bends expanded and contracted pipes such that the head loss recorded in the manometer is not affected due to the other losses.
2. Sufficient time should be given for the flow to become steady- uniform.
3. The air bubbles should be completely removed in the pipe connecting the manometer. This should be achieved only by opening the valves provided at the top of the manometers simultaneously. If they are opened separately, the manometric fluid (usually mercury, which is very costly) will spill out of manometer.

Tabular column:

S.No.	Head loss due to	Manometer reading x	Equivalent water head h = 12.6x	Time for ____ mm rise in tank(t)	$Q_a = \frac{A \times r}{t}$	Velocity of water $V_1 = \frac{Q_a}{a_1}$	Velocity of water $V_2 = \frac{Q_a}{a_2}$	k_e or k_c
		m	M	S	m^3/s	m/s	m/s	
1								
2								
3	Sudden Enlargement							
4								
5								
1								
2								
3	Sudden contraction							
4								
5								

CALCULATIONS:

FORMULAE:

$$h_e = k_e \frac{(V_1 - V_2)^2}{2g} \quad \text{and} \quad h_c = k_c \frac{V^2}{2g}$$

where,

h_e = Head loss due to sudden contraction = $x\left[\frac{s_m}{s} - 1\right]$

s_m = Specific gravity of manometric fluid i.e. mercury = 13.60

s = Specific gravity of flowing fluid i.e. water = 1.00

x = Difference in levels of the manometric fluid in the two limbs of manometer

V, V_1 = Velocity of water in the pipe (smaller diameter) = $\frac{Q_a}{a_1}$

V_2 = Velocity of water in the pipe (larger diameter) = $\frac{Q_a}{a_2}$

Q_a = Actual discharge in m^3/s

$a_1\ and\ a_2$= Cross- sectional areas of the pipe (larger and smaller diameter respectively)

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

$d_1\ and\ d_2$ = Diameter of the pipe (larger and smaller diameter, respectively)

Actual discharge, $Q_a = \frac{A \times r}{t}$

A = Area of measuring tank.

r = Rise of water level in the measuring tank.

t = Time for r mm rise in measuring tank

POSSIBLE ERRORS:

1. The manometric readings (head) for the flow through the pipe before and after taking readings of volumetric measurements (actual discharge) should be the same. If they are not same, take the average of the two readings for volumetric readings.
2. Reading errors may occur at manometric piezometer scale by not recording the readings at the eye level.
3. Synchronize the stopwatch operations for volumetric measurements.
4. U-tube mercury manometer records very low head difference by showing small readings. Using inverted U-tube manometer will have better sensitivity.

NOTE: Typical experimental results are worked out in Excel File-Minorlosses.xls given in the accompanying CD.

SPECIMEN CALCULATION:

$Q_a = \frac{A \times r}{t}$ = …………………; A = …………….. × ………………… = …………….. m^2;

$Q_a = \frac{(\qquad\qquad)}{(\qquad\qquad)}$ = …………………….. m^3/s

SUDDEN ENLARGEMENT:

$h_e = x\left[\frac{s_m}{s} - 1\right]$= ………………….. ; g = 9.81 (m/s^2)

$V_1 = \frac{Q_a}{a_1}$ = ……………..; $a_1 = \frac{\pi d_1^2}{4}$ = ……………….. m^2 d_1= diameter of the pipe

$V_2 = \frac{Q_a}{a_2}$ = ……………..; $a_2 = \frac{\pi d_2^2}{4}$ = ……………….. m^2 d_2= diameter of the pipe

$$h_e = k_e \frac{(V_1 - V_2)^2}{2g}$$

SUDDEN CONTRACTION:

$h_e = x\left[\frac{s_m}{s} - 1\right]$= ………………….. ; g = 9.81 (m/s^2)

$V = \frac{Q_a}{a_2}$ = …………….. = m^2; $a_2 = \frac{\pi d_2^2}{4}$ = ………….; d_2= diameter of the pipe (Smaller diameter)

$$h_c = k_c \frac{V^2}{2g}$$

RESULTS

Normal graph:

Evaluation Sheet

S.No.	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRE-LAB QUESTIONS

1.List out the various types of pipe fittings?

2.What do you meant by minor losses?

3.What are the types of losses in pipe flow?

4.What do you meant by entry loss?

5.What do you meant by exit loss?

2.

POST-LAB QUESTIONS

1.What is the equation for head loss due to sudden enlargement?

2.What is the equation for head loss due to sudden contraction?

3.What is the equation for head loss due to bend?

4.What is the equation for head loss at entry of pipe?

5.What is the equation for head loss at exit of pipe?

6.Which Newton's law is applicable to impulse turbine?

EXPERIMENT:06

VERIFICATION OF BERNOLLI'S THEROM

AIM:

To Verify Bernoulli's Therom

APPARATUS:

1. Bernoulli's apparatus
2. Collecting tank
3. Stop watch to measure the time of collection
4. Meter scale to measure the internal dimensions of the collecting tank

THEORY:

The Bernoulli's theorem states that for steady, uniform and laminar flow of an incompressible fluid,the total energy unit weight or total head of each particle remains same along a stream line provided no energy is gained or lost.

Most of the hydraulic structures are based on the principle of Bernoulli's theorem. Verification of the above principle experimentally helps in better understanding of the principles of hydraulics. Mathematically, Bernoulli's theorem can be expressed as

Total head (or) total energy per unit weight,

$$H_t = z + \frac{v^2}{2g} + \frac{p}{w} = constant$$

Where,

Z = datum head =position of conduit with respect to datum

$\frac{v^2}{2g}$ = Velocity head

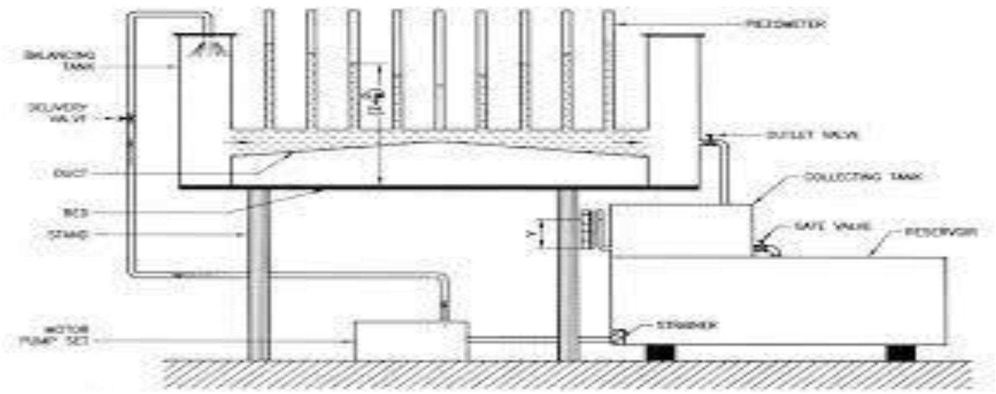
V= Velocity of flow $=\frac{Q}{A} = \frac{Actual\ discharge}{Cross\ sectional\ area}$

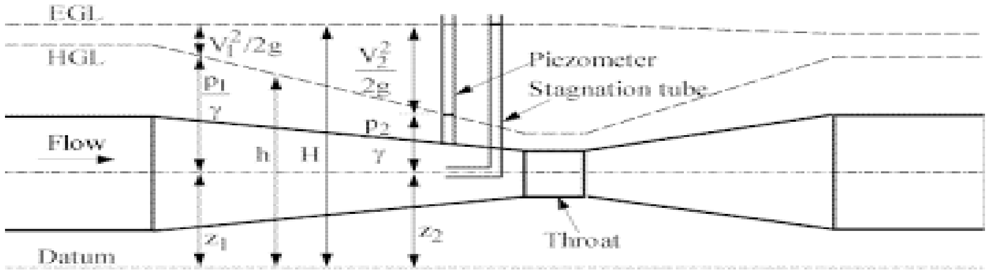
g = Acceleration due to gravity

$\frac{p}{w}$ = piezometric head or pressure head

W= Specific weight i.e., weight per unit volume = $\rho \times g = 9810\ N/m^3$

ρ = Mass density is the mass per unit volume of water.





Observations and Tabulations									
Cross section		**Time for H mm rise 't'in**	**Avg time 't'**	**Discharge Q= AH/t**	**Velocity V= Q/a**	**Velocity head V^2/2g**	**Pressure head h= P/W**	**Datum head z**	**Total head H**
		s	**S**	**mm^3/s**	**mm^3/s**	**mm/s**	**mm**	**mm**	
No.	Area	Trail							
1	a1	1	2						
2	a2								
3	a3								
4	a4								
5	a5								
6	a6								
7	a7								

Note:

The head in S.I units is meters or m. however, in this experimental setup , since the dimensions are small, it is taken in “mm”. the pressure head in this experiment is obtained directly as the head in each peizometer tube. in case pressure gauges are used the head is calculated as $\frac{P}{w}$

Specimen calculations:

Area of collecting tank $A = L \times B$ = mm^2

Discharge $Q = \frac{AH}{T}$ = mm^3

Velocity $V = \frac{Q}{a}$ = mm/s

Velocity head $\frac{v^2}{2g}$ = mm

Pressure head $h = \frac{p}{w}$ = mm

Datum head z = mm

Therefore total head at each station $H_t = z + \frac{v^2}{2g} + \frac{p}{w} =$ mm

$$H_t = z_1 + \frac{{v_1}^2}{2g} + \frac{p_1}{w} = z_2 + \frac{{v_2}^2}{2g} + \frac{p_2}{w} = constant$$

Description of Equipment:

The experimental setup consists of a convergent- divergent passage of rectangular cross section made out of clear transparent sheet to facilitate visual observation of the flow. The passage walls are so made that the top of the wall is horizontal and the side walls are vertical and mutually parallel to each other. The lower wall is so constructed that it gives passage to the required convergence and divergence. The total length of test section of the passage is divided into number of equal lengths, where the peizometric tubes are fitted. Each of these peizometric tubes is provide with scale to measure the pressure energy or pressure heads.

At both the ends of the passage tanks are provided, which help to stabilize the flow. The calibrated scale is provided to measure the volume of water in the measuring tank based on the water level in the gauge glass.

The setup is provided with an arrangement for injecting a dye into the passage at its entrance through a fine nozzle with the help of which usual observation of the flow can be made.

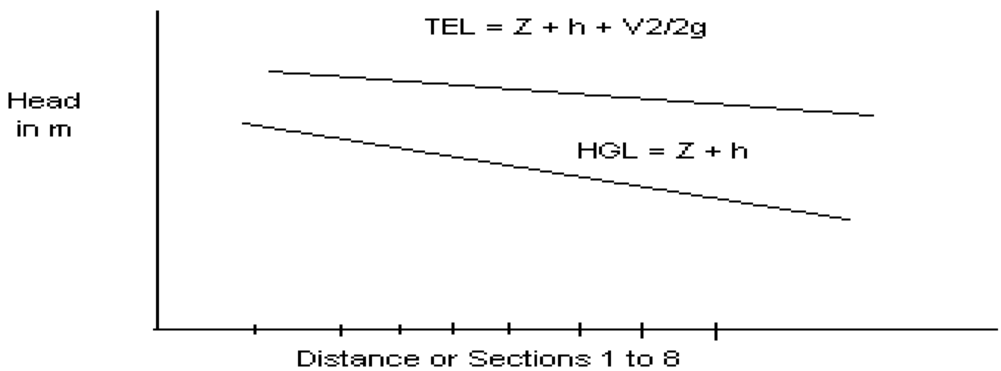
Procedure:

The experiment is conducted with datum line taken at the center line of the rectangular channel of varying cross sections and the same at all sections and considered ‘zero’ as its value.

1. Open the inlet valve to allow the flow from sully tank through the conduit. Also admit the dye into the passage.
2. Adjust the outlet valve of the apparatus, so that a constant head is maintained in the supply tank of apparatus.
3. Remove air bubbles in the peizometer tubes. Measure the pressure heads of various sections of the conduit with peizometers placed at each section.
4. Note the time‘t’ for collection of water to know rise ‘H’ of water level in the collecting tank.
5. Calculate the velocity and hence velocity head.
6. Tabulate the observations and calculate the total heads.

Graphs:

The graphs of pressure head, velocity head, and total head are drawn at various cross sections taking the cross section areas on x-axis.



Calculations:

Results:

Normal Graph:

PRE-LAB QUESTIONS

1.State Bernoulli's theorem?

2.What is continuity equation?

3.What do you meant by potential head?

4. What do you meant by pressure head?

5. What do you meant by kinetic head?

POST-LAB QUESTIONS

1.What do you meant by velocity head?

2.What do you meant by HGL?

3.What do you meant by datum head?

4.What is the use of piezometer?

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

EXPERIMENT: 7
IMPACT ON JET VANES

AIM:

To determine the coefficient of impact of jet by comparing the momentum in a fluid jet with the force generated when it strikes a fixed surface/vane.

APPARATUS:

1. A nozzle of known diameter
2. A flat plate/vane of which the water jet can impinge
3. Weighing pan, weights and lever arm to measure the force of the jet on the flat plate
4. A constant steady supply of water with a means of varying discharge
5. Measuring tank and stop watch to measure the actual discharge

THEORY:

The apparatus consists of a water jet issuing from a nozzle with a high velocity, which is connected to a high head pump main or an over head tank. All the pressure head of water is converted in to velocity head by the nozzle, which discharges the water in to the atmosphere. The jet then strikes the vane. The kinetic energy of the jet is transmitted to the vanes which lifts the vane upwards.

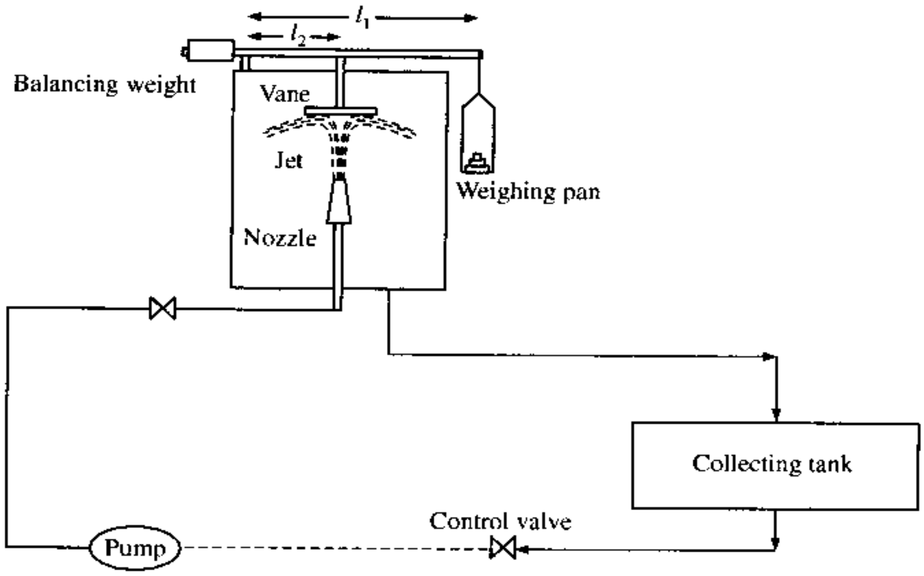
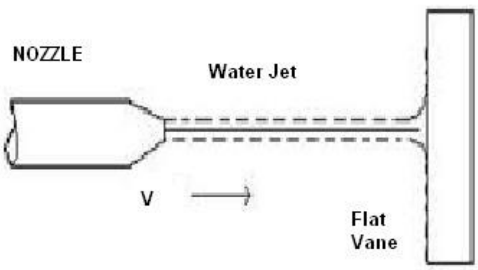


Fig.No.1 Experimental setup of Impact of jet



PROCEDURE:

1. Fit the flat vane into slot and weighing pan to the lever arm.
2. Measure the differential lever arms l_1 and l_2 from pivot to the weighing pan and pivot to the vane, respectively.
3. Note down diameter of the jet/nozzle.
4. Balance the lever arm system by means of counter weight for no load.
5. Open the gate valve by 1 or 2 rotations.
6. Place the weight on the hanger.
7. Start the pump.
8. Adjust the jet so that the weight applied on hanger is balanced.
9. Note down the following readings:
   (i) Weight on the hanger (w)
   (ii) Time for 50 mm rise of water level in the measuring tank (t)
10. Repeat steps 6, 8 and 9 for different weights on hanger for four more trials.

-

CALCULATIONS:

FORMULAE:

Actual force lifted, $F_a = w \times \frac{l_1}{l_2}\, kN$

Theoretical force lifted, $F_t = \rho a v^2 sin\theta\, kN$

Efficiency of the vane, $\eta = \frac{F_a}{F_t} \times 100$

Tabular Column:

S. No.	Weight on hanger (w)	$F_a = \frac{l_1}{l_2} \times w \times 10^{-5}$	Time for -------------mm rise in tank(t)	$Q_a = \frac{A \times r}{t}$	Velocity of water jet $V = \frac{Q_a}{a}$	F_t	Efficiency (η)
	gm	kN	S	m^3/s	m/s	kN	
1							
2							
3							
4							
5							

OBSERVATIONS:

Area of measuring tank $A = l \times b =$ …………….. $\times$ …………….. = ………………. m^2

Angle of the vane = θ = …………………

Lever arm lengths, l_1 = …………….. m; l_2 = ………………….. m

Diameter of the jet = d = ……………… m

SPECIMEN CALCULATION:

Actual discharge, $Q_a = \frac{A \times r}{t}$ = ……………………………………………………..

Actual force lifted, $F_a = \frac{l_1}{l_2} \times w \times 10^{-5}$ …………………………………. kN

Where

w = Weight on hanger = ………………….. gm

l_1 and l_2 = Lever arm lengths

Theoretical force lifted, $F_t = \rho a V^2 \sin\theta$ = …………………………………… kN

ρ = Specific weight of water 9.81 kN/m^3

a = Cross – section area of the jet

V = Velocity of water

θ = Angle of the vane

Efficiency of the vane, $\eta = \frac{F_{act}}{F_{theo}} \times 100 =$

Results:

GRAPHS:

Draw the graph of F_a vs F_t.The slope of the straight line fit gives the efficiency

PRECAUTIONS:

1. Fix the vane exactly symmetrical with the jet axis except for inclined vane. In the case of inclined vane, the fixed vane angle should match with the angle specified on the vane.
2. Sufficient time should be given for the flow to become steady-uniform.
3. The balancing arm should be made near frictionless by proper oiling at the pivot.

4. The balancing drum should be properly placed such that the balancing arm should be horizontal after fixing the vane and weight hanger in position.
5. The weights are too small and should be properly calibrated periodically.
6. Volumetric measurements can be preferred to pressure gauge readings to avoid errors in the computation of the jet velocity.

POSSIBLE ERRORS:

1. Sensitivity of the pressure gauge may effect the computation of velocity of the jet.
2. The horizontal level of the balancing arm should be properly adjusted.
3. The head for the flow through the pipe for the jet before and after taking readings of volumetric measurements (actual discharge) should be the same. If not, take the average of the two readings for volumetric readings.
4. Reading errors at volumetric piezometer scale by not recording the readings at the eye level.
5. Synchronize the stopwatch operations for volumetric measurements.
6.

NOTE: Typical experimental results are worked out in Excel File-Impact.xls given in the accompanying CD.

CALCULATIONS:

Results:

NORMAL GRAPH

Evaluation Sheet

S.No	**Skills of Assessment**	**Marks**	**Score**
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRE-LAB QUESTIONS

1.What is the water jet?

2.What is the effect of water jet on vanes?

3.What do you meant by impact?

4.List out different types of vanes?

POST-LAB QUESTIONS

1.How do you compare different vanes?

2.What do you meant by co-efficient of impact?

3.How do you measure the force of the jet?

4.How do you measure actual flow rate?

5.How do you measure theoretical flow rate?

EXPERIMENT:8

PERFORMANCE TEST ON PELTON WHEEL TURBINE

AIM:

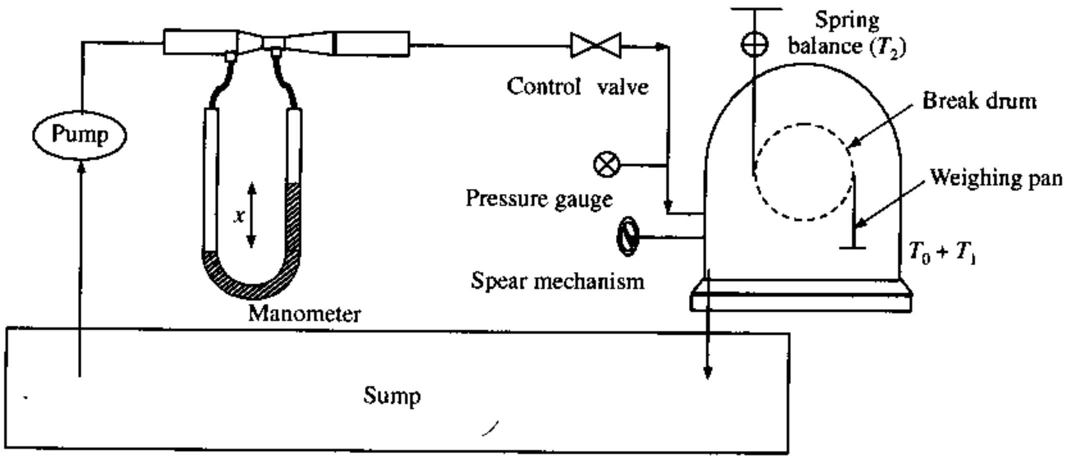
Performance test on Pelton Wheel (Turbine) (a) at constant head and (b) at constant Speed

APPARATUS:

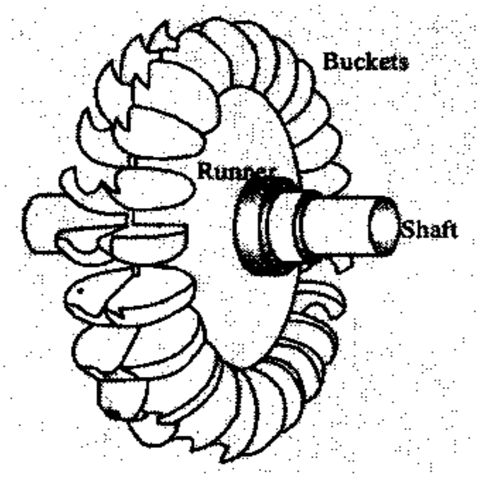
1.Centrifugal pump to supply water at required head
2.Peloton Wheel
3.Pipe network system with necessary control valves
4.Pressure gauge
5.Tachometer to measure the speed of the shaft.
6.Venturimeter along with manometer to measure the discharge
7.Rope brake with spring balance and weighing pan to measure torque

THEORY:

Peloton turbine is a high head, impulse turbine, which is used to generate electricity at high heads of water. All the available head is converted into velocity head by means a nozzle which is controlled by spear and nozzle arrangement.
A venturimeter with a U-tube manometer is provided to calculate the amount of water (discharge) supplied to the turbine. Pressure gauge is fixed to measure the head of water. Using the tachometer the speed of the turbine is measured.



Experimental Setup of PELTON WHEEL



PROCEDURE:

1. Prime the pump with water.
2. Keep the nozzle – opening to the required position.
   Open the gate valve 1 or 2 rotations.
3. Start the motor
4. Allow the water into the turbine and the turbine will start rotating.
5. Fix the weight hanger to the rope of the brake drum with no load on weight hanger.
6. By varying the gate valve, keep the head constant using the pressure gauge to the required head in case of experiment on constant head or keeps the speed constant using the tachometer to the required speed in case of experiment on constant speed.
7. Note down the following readings :
   (a) Pressure gauge reading, G
   (b) Vacuum gauge reading, V
   (c) Speed of the turbine, N
   (d) Manometer readings, h_1 and h_2
   (e) Load on weight hanger, T_1
   (f) Spring balance reading indicating the frictional loss between the brake drum and rope T_2
   (g) Repeat step 8 for different load conditions by varying the load on the weight hanger either to constant head or for constant speed.
   (h) Note down the above readings G, V, N, $h_1 and\ h_2$, T_1, T_2
   (i) Take at least 5 sets of readings by varying the load.
   (j) Calculate the efficiency of the turbine.

FORMULAE:

$$Q_a = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

Where, $a_1 = \frac{\pi d_1^2}{4}$ and $a_2 = \frac{\pi d_2^2}{4} m^2$

d_1 = Diameter of the inlet of venturimeter and d_2 = diameter of the throat of venturimeter

h = $x\left[\frac{S_m}{S} - 1\right] =$ …………………….. $x = x_1 - x_2$39 m g = 9.81 m/ sec^2

h = Equivalent water head

s_m = Specific gravity of manometric fluid, i.e. mercury = 13.60

S = Specific gravity of flowing fluid, i.e. water = 1.00

x= Difference in levels of the manometric fluid in the two limbs of manometer

Input to the turbine = γQH kW

γ = Specific weight of water 9.81 kN/m^3

Q = Discharge

H = Head (G × 10) m(pressure gauge reading)

Output of the turbine = O.P = $\frac{\pi DNT}{60}$ = $\ldots\ldots\ldots\ldots kW$

D = Equivalent brake drum diameter …………………m

N = Speed of the turbine = ………………………rpm

T = Resultant load = ………………………N

T = $(T_1 - T_2 + T_0) \times 9.81\ N$

T_1 = Load on brake drum in kg

T_2 = Spring balance reading in kg

T_o = Weight of the hanger in kg

Efficiency of the turbine = η = $\frac{Output}{Input} \times 100\ \%$

Tabular Column

S.No.	**Pressure gauge read (G)**	**Total Head (H)**	**Mano Meter reading**	**Equivalent water head**	**Actual discharge Q_a**	**Speed (N)**	**Load T = $T_0 + T_1 - T_2$**			**In put**	**Out put**	**Efficiency (η)**
			X	**h = 12.6x**			**T_1**	**T_2**	**T**			
	Kg / cm^2	**m**	**M**	**m**	**m^3/s**	**rpm**	**Kg**	**Kg**	**N**	**kW**	**kW**	**%**
1												
2												
3												
4												
5												

PRECAUTIONS

1. Check for the priming of the pump so that air bubbles are not developed.
2. Check for the possible leakages at delivery and suction pipes.
3. Sufficient time should be given for the flow to become steady – uniform.
4. Voltage and current input to the pump – motor should be maintained near readings, average values are to be considered.
5. Gauge readings should be maintained constant and if varying during the readings, average values are to be considered.
6. Tachometer used to measure speed of the shaft should be periodically calibrated and for constant speed characteristics, the speed should be checked both at the beginning and end of the trial, and if found to be different, average should be considered.
7. The air bubbles should be completely removed in the pipe connecting the manometer. This should be achieved only by opening the valves provided at the top of the manometers simultaneously. If they are opened separately, the man metric fluid (usually mercury, which is very costly) will spill out of manometer.
8. Diameter of the break drum and the rope should be properly measured and recorded.
9. Weights and spring balance used should be periodically calibrated.

SPECIMEN CALCULATION

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

I.P. = γQH = …………………………kW

O.P. = $\frac{\pi DNT}{60}$ =…………………………kW

Efficiency of the turbine = η = $\frac{Output}{Input} \times 100\%$

Calculations:

Results:

Normal graph

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRE-LAB QUESTIONS

1. Classify turbines.
2. Peloton wheel is which type of turbine.
3. what is input energy given to turbine? What are main components of Pelton turbine?
4. Draw velocity diagrams (at inlet and outlet) for Pelton blade
5. Why is Pelton turbine suitable for high heads?

POST-LAB QUESTIONS

1. How do you Classify turbines
2. How do you Pelton wheel is which type of turbine
3. How do you classified by inlet and outlet
4. What do you understand by specific speed

EXPERIMENT:10

PERFORMANCE TEST ON FRANCIS TURBINE

AIM: Performance test on Francis Turbine (a) at head (b) at constant speed

APPAPATUS:

1.Centrifugal pump to supply water at required head
2.Francis Turbine
3.Pipe network system with necessary control valves
4.Pressure Gauge and Vacuum Gauge
5.Tachometer to measure the speed of the shaft
6.Venturimeter along with manometer to measure the discharge
7.Rope brake with spring balance and weighing pan to measure torque

THEORY:

Francis turbine is a hydraulic machine used to convert hydraulic energy into mechanical energy which in turn is converted to electrical by coupling a generator to turbine.

Francis turbine is medium head, medium discharge, radially inward flow reaction turbine.

A venturimeter with the manometer is provided to calculate the amount of water (discharge) supplied to the turbine. Pressure gauge is fixed to measure the head of water. Using the tachometer, measure the speed of the turbine.

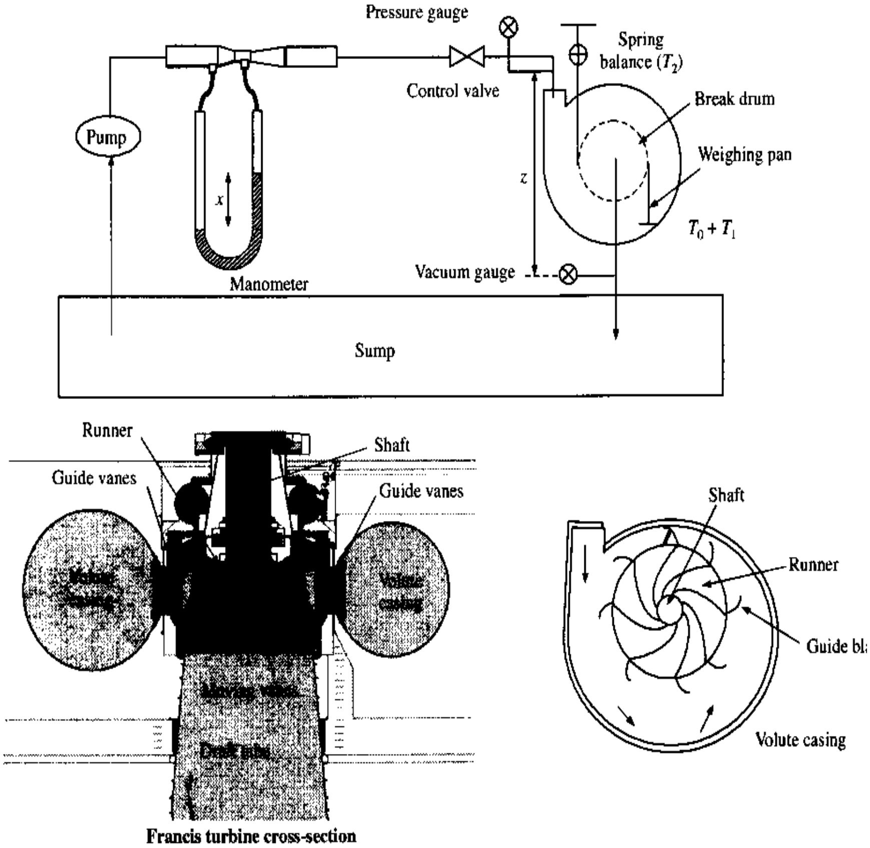


Fig.No.Experimental setup of Francis turbine

PROCEDURE:

1. Prime the pump with water.
2. Keeps the gate opening to the required position.
3. Open the gate valve 1 or 2 rotations.
4. Start the motor.
5. Allow the water into the turbine and the turbine starts to rotate.
6. Fix the weight hanger to the rope of the brake drum with no load on weight hanger.
7. By varying the gate valve, keep the head constant using the tachometer to the required speed in case of experiment on constant speed.
8. Note down the following readings :

(a) Pressure gauge reading, G
(b) Vacuum gauge reading, V
(c) Speed of the turbine, N
(d) Manometer readings, h_1 and h_2
(e) Load on weight hanger, T_1
(f) Spring balance reading indicate the frictional loss between the brake drum and rope, T_2

9. Repeat the step 8 for different load conditions by varying the load on the weight hanger either to constant head or for constant speed.
10. Note down the above readings G, V, N, h_1 and h_2 ,T_1,T_2
11. Take at least 5 sets of readings by varying the load.
12. Calculate the efficiency of the turbine.

FORMULAE

$Q_a = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$

Where, $a_1 = \frac{\pi d_1^2}{4}$ and $a_2 = \frac{\pi d_2^2}{4} =$ …………… m^2

d_1 = Diameter of the inlet of venturimeter and d_2 = diameter of the throat of venturimeter

h = x $\left[\frac{S_m}{S} - 1\right] =$ …………………….. x = $x_1 - x_2$ m g = 9.81 m/ sec^2

h = Equivalent water head

s_m = Specific gravity of manometric fluid, i.e. mercury = 13.60

S = Specific gravity of flowing fluid, i.e. water = 1.00

X = Difference in levels of the manometric fluid in the two limbs of manometer

Input to the turbine = γQH kW

γ = Specific weight of water 9.81 kN/m^3

Q = Discharge

H = Head (G + V) × 10

Z = Vertical difference between pressure gauges

Output of the turbine = O.P. = $\frac{\pi DNT}{60} =$ …………………………..kW

D = Equivalent brake drum diameter …………………………… m

N = Speed of the turbine = …………………………rpm

T = $(T_1 - T_2 + T_0) \times 9.81N$

T_1 = Load on brake drum in kg

T_2 = Spring balance reading in kg

T_0 = Weight of the hanger in kg

Efficiency of the turbine = $\eta = \frac{Output}{Input} \times 100\%$

TABULAR COLUMN

S. No.	**Pressure Gauge Read (G)**	**Vacuum gauge reading (V)**	**Total head (H)**	**Mano-meter reading**	**Equivalent water head**	**Actual discharge Q_a**	**Speed (N)**	**Load T = $T_0 + T_1 - T_2$**			**Input**	**Output**	**Efficiency (η)**
				x	**H = 12.6x**			T_1	T_2	**T**			
	Kg/cm^2	**M**	**m**		**M**	**m^3/s**	**rpm**	**kg**	**kg**	**N**	**kW**	**kW**	**%**
1													
2													
3													
4													
5													

PRECAUTIONS

1. Check for priming of the pump so that air bubbles are not developed.
2. Check for the possible leakages at delivery and suction pipes.
3. Sufficient time should be given for the flow to become steady – uniform.
4. Voltage and current input to the pump – motor should be maintained near constant during values are to be considered.
5. Gauge readings should be maintained constant, and if varying during the readings, average values are to be considered. Tachometer used to measure speed of the shaft should be periodically calibrated and for constant speed characteristics, the speed should be checked both at the beginning and in the end of the trial, and if found to be different, average should be considered.
6. The air bubbles should be completely removed in the pipe connecting the manometer. This should be achieved only by opening the valves provided at the top of the manometers simultaneously. If they are opened separately, the manometeric fluid (usually mercury, which is very costly) will spill out of manometer.
7. Diameter of the break drum and the rope should be properly measured and recorded.

8. Weights and spring balance used should be periodically calibrated.

POSSIBLE ERRORS

1. Sensitivity of the pressure gauge may affect the computation of the efficiency and analysis of performance of the pump.
2. The manometeric reading (head) for the flow through the pipe before and after taking readings should be the same. If not, take the average of the two readings.
3. Reading errors at manometer and spring balance by not recordings at the eye level.

Note: Typical experimental results are worked out in Excel File – Francis. Xls given in the accompanying CD.

SPECIMAN CALCULATION

$$Q_a = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots \, m^3/S$$

I.P. = γ Q H = ……………………….kW

$$\text{O.P.} = \frac{\pi DNT}{60} = \ldots\ldots\ldots\ldots\ldots\ldots\text{kW}$$

Efficiency of the turbine = $\eta = \frac{Output}{Input} \times 100\%$

Calculations

Results:

Graph normal

Normal graph

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRE LAB QUESTIONS:

1.What is a reaction turbine**?**
2.what is difference between impulse and reaction turbine?
3.Specify the flow of the francis turbine.
4.what head francis turbine used?
5.what is purpose of draft tube in reaction turbine?
6.What is cavitation?

POST LAB QUESTIONS:

1.How do you francis wheel is which type of turbine
2.How do you differenciate between impulse and reaction turbine?
3.What is the use of draft tube
4.What is the use of draft tube

EXPERIMENT:11

PERFORMANCE TEST ON CENTRIFUGAL PUMP

AIM

To conduct the performance test on single stage centrifugal pump.

APPARATUS:

1. Single stage Centrifugal pump with an electric motor device (constant speed)
2. Pipe network system with necessary control valves
3. Vacuum and pressure gauges
4. An energy meter to measure the input power to the motor
5. Measuring tank and stop watch to measure the actual discharge

THEORY:

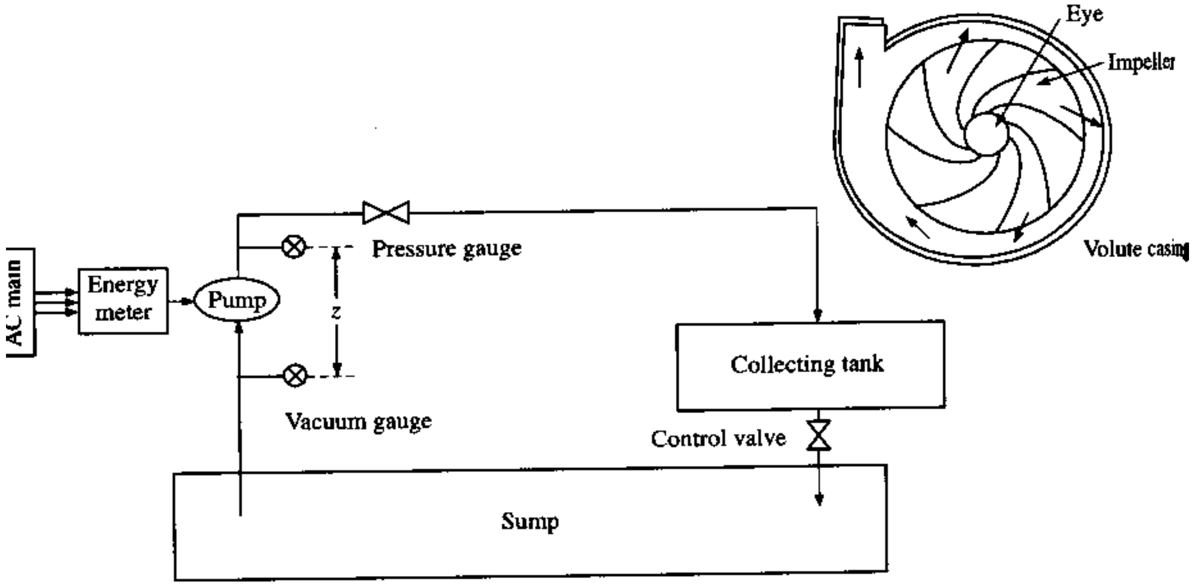
A centrifugal pump is a Hydraulic machine which converts mechanical energy to hydraulic energy, used to lift water from lower level to higher level. A centrifugal pump consists of essentially an impeller rotating inside a casing. The impeller has a number of curved vanes. Due to centrifugal head impressed by the rotation of the impeller, the water enters at the centre and flows outwards to the periphery. There, it is collected in a gradually increasing passage in the casing, known as volute chamber, which serves to convert a part of the velocity head into pressure head. For higher heads, multi stage centrifugal pumps having two or more impellers in series will have to be used.

A single/multistage centrifugal pump is coupled to a motor. In this experiment, the efficiency of the centrifugal pump at constant speed is computed.

An energy meter is provided to measure the input to the motor and a collecting tank is provided to calculate the discharge from the pump. Pressure and vacuum gauges are provided in the delivery and suction sides of the pump to measure the heads, respectively.

Tabular Column:

S. No	Pressure gauge reading (G)	Vacuum gauge reading (V)	Total head (H)	Time for ________ mm rise in tank (t)	Actual discharge (Q)	Time for 10 Revolutions in energy meter (T)	Input	Output	Efficiency
	kg/cm^2	Kg/cm^2	m	S	m^3/s	S	kW	kW	%
1									
2									
3									
4									
5									



Experimental setup

CALCULATIONS:

FORMULAE:

$$Q_a = \frac{A \times r}{t} \; m^3/s$$

$$H = G + V + z + \frac{V_d^2 - V_s^2}{2g} \; m$$

G = Pressure head, V = Vacuum head

z = Vertical difference in level between pressure and vacuum gauges

V_d = Velocity of water in delivery pipe

V_s = Velocity of water in suction pipe

g = Specific gravity = 9.81 m/sec^2

Output from the pump = γQHkW

where, γ is the specific weight of water = 9.81 kN/m^3; Q is the discharge through the pump in m^3/s, and H is the total head in m

Input to the pump = I.P = $\eta_{motor} \times \frac{3600 \times 10}{NT}\; kW$

η_{motor} = Efficiency of the motor = 85% (assumed)

N = Energy meter constant revolutions / kWh

T = Time for 10 revolutions of the disk in energy meter Efficiency = $\eta = \frac{output}{input}$

PROCEDURE:

1. Prime the pump with water
2. Open the gate valve 1 or 2 rotations
3. Start the motor and set the vacuum gauge reading to the required head.
4. Note down the following reading:
   (i) Pressure gauge reading, G
   (ii) Vacuum gauge reading , V
   (iii) Time taken for 10 revolutions in the energy meter, T
   (iv) Time taken to fill up 200 cm rise in the collecting tank, t
   (v) The difference in the levels of the pressure and vacuum gauges, x
5. And then set the vacuum gauge reading to the other heads.
6. Note down the above readings G, V, T and t
7. Take at least 5 sets of readings by varying the head through delivery valve and note down the readings.

PRECAUTIONS:

1. Check for the priming of the pump so that air bubbles are not developed.
2. Check for the possible leakages at delivery and suction pipes.
3. Sufficient time should be given for the flow to become steady- uniform.

4. Voltage and current input to the pump-motor should be maintained near constant during the recording of readings.
5. Both delivery and suction gauge readings should be maintained constant, and if varying during the readings, average values are to be considered.

POSSIBLE ERRORS:

1. Sensitivity of the pressure gauge may effect the computation of the efficiency and analysis of performance of the pump.
2. Ignoring the vertical difference between the delivery and suction gauges.
3. The head for the flow through the pipe for the jet before and after taking readings of volumetric measurements (actual discharge) should be the same. If not, take the average of the two readings for volumetric readings.
4. Reading errors at volumetric piezometer scale may occur by not recording the readings at the eye level.
5. Synchronize the stopwatch operations for volumetric measurements.

SPECIMEN CALCULATION:

Actual discharge, $Q_a = \frac{A \times r}{t}$

A = Area of measuring tank = ………………. × …………... = ……………..m^2

r = Rise of water level in the measuring tank = …………………

t = Time for r cm rise in measuring tank = ……………………..

Total head, H = G + V + z + $\frac{V_d^2 - V_s^2}{2g}$ = ……………………

G = ……………….. kg/cm^2 = …………….. × 10 m of water

V = ……………….. kg/cm^2 = …………….. × 10 m of water

Out from the pump = γQH = ……………….. kW

γ = Specific weight of water 9.81 kN/m^3

Q = Discharge from the pump

H = Total head

Input to pump = $\eta_{motor} \times \frac{3600 \times 10}{NT}$ = …………… kW

Efficiency of the pump = $\eta = \frac{\text{Output}}{\text{input}} \times 100\%$

GRAPHS:

Draw the graph of output vs input. The slope of the straight line fit gives the efficiency

Calculations:

Results:

Normal graph

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRELAB QUESTIONS

1.What is a pump?

2.What is a centrifugal pump?

3.what are forces involved in impeller?

4.What is priming

PRELAB QUESTIONS

1.How do you classify the pumps

2.What is the difference between centrifugal pump and reciprocating pump

3.Which one is deliveres maximum discharge

4.What is the use of priming

EXPERIMENT:12

PERFORMANCE TEST ON RECIPROCATING PUMP

AIM: To conduct the performance test on single stage Reciprocating pump.

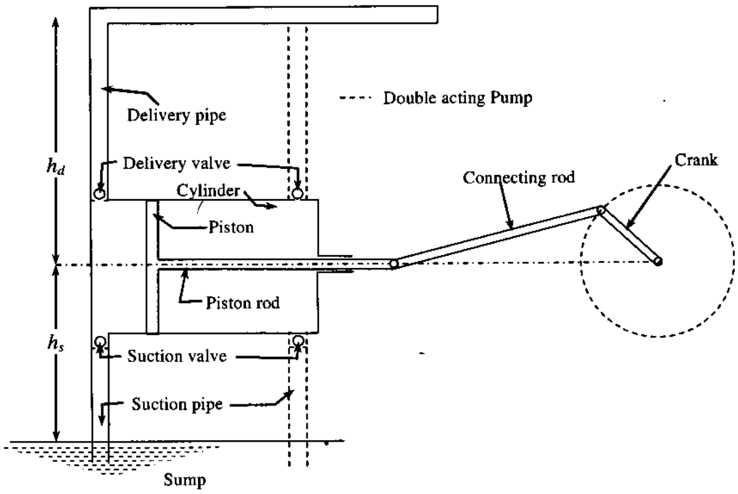
APPARATUS:

1. Double acting Reciprocating pump with an electric motor device (constant speed)
2. Pipe network system with necessary control valves
3. Vacuum and pressure gauges
4. An energy meter to measure the input power to the motor
5. Measuring tank and stop watch to measure the actual discharge
6.

THEORY

A Reciprocating pump is a **Hydraulic machine** which converts mechanical energy into hydraulic energy, used to lift water from lower level to higher level. A Reciprocating pump consists of essentially a plunger or piston and a cylinder. The rotation of the crank connected to the plunger causes the plunger moves to the right during suction stroke. This causes the atmospheric pressure on the water surface to force the water up the suction pipe or water is sucked through the suction pipe and the suction valve is opened which pushes the water into the cylinder. On the return stroke of the plunger (plunger moving to the left) called delivery stroke, the water pressure closes the suction valve and opens the delivery valve forcing the water up the delivery pipe. Again, in the suction stroke, the water is sucked from the sump and the cycle repeats.

An energy meter is provided to measure the input to the motor and a collecting tank is provided to calculate the discharge from the pump. Pressure and vacuum gauges are provided in the delivery and suction sides of the pump to measure the heads, respectively.



Experimental setup

PROCEDURE

1. Prime the pump with water.
2. Open the gate valve 1 or 2 rotations
3. Start the motor and set the vacuum gauge to the required head.
4. Note down the following readings :
   (a) Pressure gauge reading, G
   (b) Vacuum Gauge reading, V
   (c) Time taken for 10 revolutions in the energy meter, T
   (d) Time taken to fill up of 20 cm rise in the collecting tank, t
   (e) The difference in the levels of the pressure and vacuum gauges, x
5. Then set the vacuum gauge reading to the other heads.
6. Note down the above readings G, V, T and t.
7. Take at least 5 sets of readings by varying the head through delivery valve, and note down the readings

FORMULAE:

$Q_a = \frac{A \times r}{t}$ m^3/s

H = G + V + Z + $\frac{(V_d^2 - V_s^2)}{2g}$ m

G = Pressure head

V = Vacuum head

Z = Vertical difference in level between pressure and vacuum gauges

V_d = Velocity of water in delivery pipe

V_s = Velocity of water in suction pipe

g = Specific gravity = 9.81 m/ sec^2

Output from the pump = γQH kW

Where, γ is the specific weight of water = 9.81 kN/m^3 Q is the discharge through the pump in m^3/s and H is the total head in m

Input to the pump = I.P. = $\eta_{pump} \times \frac{3600 \times 10}{NT}$ kW

η_{pump} = Efficiency of the pump = 85% (assumed)

N = Energy meter constant- ………………revolutions/ kWh

T = Time for 10 revolutions of the disk in energy meter

Efficiency = h = $\frac{Output}{Input}$

Percentage slip = $\frac{Q_t - Q_a}{Q_t} \times 100, where\ Q_t = \frac{L \times N\,(2A-a)}{60}$

L is stroke length of the plunger, N is the Speed of motor, A is the area of piston (or cylinder) and a is area of piston rod.

TABULAR COLUMAN

S. No.	Pressure gauge reading (G)	Vacuum gauge reading (V)	Total head (H)	Time for ____ mm rise in tank(t)	Actual discharge (Q)	Time for 10 revolutions in energy meter(T)	Input	Output	Efficiency
	kg/cm^2	kg/cm^2	m	s	m^3/s	S	kW	kW	%
1									
2									
3									
4									
5									

PRECAUTIONS:

1. Check for the possible leakages at delivery and suction pipes.
2. Sufficient time should be given for the flow to become steady –uniform.
3. Voltage and current input to the pump-motor should be maintained near constant during the recording of readings.
4. Both delivery and suction gauge readings should be maintained constant, and if vary during the readings, average values are to be considered.

POSSIBLE ERRORS:

1. Sensitivity of the pressure gauge may affect the computation of the efficiency and analysis of performance of the pump.
2. Ignoring the vertical difference between the delivery and suction gauges.
3. The head for the flow through the pipe for the jet before and after taking readings of volumetric measurements (actual discharge) should be the same. If they are not same, take the average of the two readings for volumetric readings.
4. Reading errors at volumetric piezometer scale by not reading the readings at the eye level.
5. Synchronize the stopwatch operations for volumetric measurements.

SPECIMEN CALCULATION

Actual discharge, $Q_a = \frac{Ar}{t}$

A = Area of measuring tank = ……………….. × …………..m^2

r = Rise of water level in the measuring tank = ……………

t = Time for r cm rise in measuring = …………….

Total head, H + G + Z + $\frac{v_d^2 - V_s^2}{2g}$ = ……………

$G = \ldots\ldots\ldots\ldots \text{ kg / cm}^2 = \ldots\ldots\ldots\ldots\ldots\ldots \times 10$ m of water

$V = \ldots\ldots\ldots\ldots \text{kg / cm}^2 = \ldots\ldots\ldots\ldots\ldots\ldots \times 10$ m of water

Output from the pump = $\gamma QH = \ldots\ldots\ldots\ldots$kW

γ = Specific weight of water 9.81 kN / m^3

Q = Discharge from the pump

H = Total head

Input to pump = $\eta_{motor} \times \frac{3600 \times 10}{NT}\ Output = \ldots\ldots\ldots\ldots\ldots\ldots$kW

Efficiency of the pump = $\eta = \frac{Output}{Input} \times 100\%$

Theoretical discharge = $Q_t = \frac{L \times N(2A - a)}{60}$

Percentage slip = $\frac{Q_t - Q_a}{Q_t} \times 100 = \ldots\ldots\ldots\ldots$

Calculations

Results :

Normal graph

Evaluation Sheet

S.No	Skills of Assessment	Marks	Score
1	Knowledge of equipment	1	
2	Observation and recordings	2	
3	Calculations	2	
4	Graphs and interpretation	2	
5	Viva voice	3	
	Total	**10**	

PRELAB QUESTIONS

1.What is a pump?

2.What is a reciprocating pump?

3.what are forces in volved

4.What is priming

5.Explain the slip

PRELAB QUESTIONS

1.How do you classify the pumps

2.What is the difference between centrifugal pump and reciprocating pump

3.Which one is deliveres maximum discharge

4.What is the use of priming

5.How do you calculate negative slip and positive slip