SNS COLLEGE OF TECHNOLOGY

(An autonomous Institution)

Approved by AICTE and Affiliated to Anna University, recognized by UGC

Accredited by NBA-AICTE, NAAC-UGC with 'A++' Grade

Sathy Main Road, SNS Kalvi Nagar, Saravanampatti Post, Coimbatore 641 035, Tamil Nadu, India.

DEPARTMENT OF MECHANICAL ENGINEERING

19MEB 201 - FLUID MECHANICS AND MACHINERY

Name : ……………………………………

Register Number : ……………………………………

Year & Semester : ……………………………………

Branch / Class : ……………………………………

Academic Year : ……………………………………

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NAME:…………………………………………………

COURSE:………………………………………………..

REGISTER NO:……………………………………….

Certified that this is the Bonafide record of work done by the above student of the **19MEB201- FLUID MECHANICS AND MACHINERY LABORATORY** during the year ……………… to ………………

Signature of Lab-in-charge Head of the Department

Submitted for the practical examination held on ………………………..

Index

Ex.No.	Date	Experiment	Page No.	Performance (40)	Viva (10)	Total marks (50)	Staff Initial
1.		Verification of Bernoulli's equation.					
2.		Determination of the Coefficient of the Orifice meter.					
3.		Determination of the Coefficient of the Venturimeter.					
4.		Determination of friction factor for a given set of pipes.					
5.		Determination of major and minor losses in pipes					
6.		Performance test on centrifugal pump					
7.		Performance test on reciprocating pump					
8.		Performance studies on Francis turbine					
9.		Performance studies on Pelton wheel					
10.		Performance studies on Kaplan turbine					
					Average:		

19MEB201	FLUID MECHANICS AND MACHINERY	L	T	P	C
		3	0	2	4

UNIT-I	FLUID PROPERTIES AND FLOW CHARACTERISTICS	9 +6

Units and dimensions - Properties of fluids - mass density, specific weight, specific volume, specific gravity, viscosity, compressibility, vapour pressure, surface tension and capillarity. Flow characteristics -concept of control volume - application of continuity equation, energy equation and momentum equation.

Lab Experiments:

- Verification of Bernoulli's equation
- Determination of the coefficient of discharge of given Orifice meter/Venturimeter.

UNIT-II	FLOW THROUGH CIRCULAR CONDUITS	9 +6

Hydraulic and energy gradient - Laminar flow through circular conduits - Boundary layer concepts -types of boundary layer thickness -Darcy Weisbach equation –friction factor - Moody diagram - commercial pipes - minor losses -Flow through pipes in series and parallel.

Lab Experiments:

- Determination of friction factor for a given set of pipes
- Determination of major and minor losses in pipes

UNIT-III	DIMENSIONAL ANALYSIS AND SIMILITUDE	9

Need for dimensional analysis –dimensional analysis by using Buckingham's π theorem method - Similitude –types of similitude - Dimensionless parameters - application of dimensionless Parameters-Model analysis.

UNIT-IV	PUMPS	9 +6

Impact of jets -Euler's equation - Theory of roto - dynamic machines- various efficiencies-velocity components at entry and exit of the rotor - velocity triangles -Centrifugal pumps-working principle - work done by the impeller - Reciprocating pump - working principle.

Lab Experiments:

- Performance studies on centrifugal pump
- Performance studies on reciprocating pump

UNIT-V	TURBINES	9 +12

Classification of turbines -heads and efficiencies -velocity triangles. Axial, radial and mixed flow turbines. Pelton wheel, Francis turbine and Kaplan turbines - working principles - work done by water on the runner -draft tube. Specific speed - unit quantities.

Lab Experiments:

- Performance studies on Pelton wheel
- Performance studies on Francis turbine
- Performance studies on of Kaplan turbine

L:45	P:30	T: 75 PERIODS

TEXT BOOKS

1. Yunus A. Çengel, John M. Cimbala., Fluid Mechanics: Fundamentals and Applications, McGraw - Hill Higher Education, 2010, 3rd edition (Unit I, II, III, IV, V)
2. Bansal, R.K., Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi. 2011. 10th Edition (Unit I, II, III, IV, V)

REFERENCES

1. Modi P.N. and Seth, S.M. "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, New Delhi 2013. 19thEditon (Unit I, II, III, IV, V)
2. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, "Fluid Mechanics and Machinery", 2011. (UNIT - I, II, III, IV, V)
3. Kumar. K.L., Engineering Fluid Mechanics, Eurasia Publishing House (P) Ltd., New Delhi, 2010. 8th Edison (Unit I, II, III)
4. Streeter. V. L., and Wylie, E.B., Fluid Mechanics, McGraw Hill, 2010. 9th Edition (Unit I, II, III)
5. Rajput. R. K, "A text book of Fluid Mechanics and Hydraulic Machines", S. Chand & Company Ltd., New Delhi, sixth edition, 2010 (Unit I, II, III, IV, V).

WEB RESOURCES

https://nptel.ac.in/courses/105101082/
https://www.youtube.com/watch?v=fa0zHI6nLUo&list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm
https://nptel.ac.in/courses/112105183/

COURSE OUTCOMES

At the end of the course students should be able to

- Explain the fundamental concepts of fluid mechanics with different properties of fluids.
- Analyse and calculate major and minor losses associated with pipe flow in piping networks.
- Predict the nature of physical quantities and to predict the behavior of the prototype/model by applying model laws.
- Analyse the performance of pumps.
- Analyse the performance of hydraulic turbines.

Mapping Course outcomes with Program Outcomes (POs) and Program Specific Outcomes(PSOs)

COURSE OUTCOMES	PROGRAMME OUTCOMES												PSO1	PSO2
	a	b	c	d	e	f	g	h	i	j	k	l		
I	S	S											S	
II	S	S				M							S	
III	S	S	S			M							S	M
IV	S	S			S								S	S
V	S	S			S								M	S

SNS COLLEGE OF TECHNOLOGY- COIMBATORE 35

(An Autonomous Institution)

COIMBATORE -35

DEPARTMENT OF MECHANICAL ENGINEERING

Vision

The Department of Mechanical Engineering Endeavors to be a recognized Knowledge Centre for Quality Education and Research by Producing Competent and Creative Engineers to meet the Global Challenges.

Mission

- To Impart Knowledge by Providing Effective Means of Learning and Facilitate Personal Commitment for Productive Careers Globally.
- To Provide Students and Faculty Members with Opportunitiesfor Creative Thinking, Interpretation, Application andKnowledge Dissemination.
- To Inculcate Life-Long Learning, Human Values andEntrepreneurship Culture in the fields of Engineering Design,Thermal, Manufacturing, Automation etc.
- To Link with Industries and Institutions for Mutual Benefit.

Program Educational Objectives (PEOs) : B.E-Mechanical Engineering

PEO 1: Graduate will be Capable of Applying the Skills of Basic Science, Mathematics, and Engineering for their Successful Professional Career.

PEO 2: Graduate will Design and Conduct Experiments, Interpret, Analyze and Communicate Effectively for the Real Life Problems.

PEO 3: Graduate will apply the State of the Art Tools, Technologies and Interdisciplinary Knowledge to Bring Enhancements in the Society.

PEO 4: Graduate will possess the Qualities of Self-Learning, Team Work, Ethical Conduct and Entrepreneurial Spirit.

SNS COLLEGE OF TECHNOLOGY- COIMBATORE 35

(An Autonomous Institution)

COIMBATORE -35

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAMME OUTCOMES (PO)

PO-1	**Engineering Knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO-2	**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.
PO-3	**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.
PO-4	**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.
PO-5	**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
PO-6	**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.
PO-11	**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.
PO-12	**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.

At the end of the program, graduate will be able to

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO-1 Apply engineering knowledge and design & analysis tools to solve problems in the domains of structural, thermal and fluid mechanics.

PSO-2 Engage professionally in industries or as an entrepreneur by applying manufacturing and management practices

INTRODUCTION

Fluid mechanics and Machinery:

Fluid mechanics is a fascinating study of fluids at its rest position or in its motion. A fluid is defined as a substance that continually deforms (flows) under an applied shear stress regardless of the magnitude of the applied stress. Fluid mechanics have played an important role in human life. Therefore, it also attracted many curious people. Imagine a substance that can change its form according to the container that holds it and has unharnessed potential to cut through metals, lift heavy loads and yet is feeble. On the other hand, fluid machines are devices that work with fluids or work on fluids to produce desired effect or work. These machines are used to transfer fluids from one level to the other, extract energy from the fluid and even to measure the properties of fluid.

Fluid mechanics and Machinery Lab:

Fluid mechanics lab is a place of experimentation and excitement where the fluid, mainly water is used for study. The entire lab is split into three major sections based on the property of the fluid to store energy, release energy and the hydraulic devices used for it. They are:

- Energy consuming devices – pumps
- Energy producing devices – Turbines
- Energy measuring devices – Meters

The first section deals with the energy consuming devices such aspumps which converts electrical energy into flow energy to energize the fluid to lift it from a lower datum to a higher datum. The second section consist of devices that extracts the flow energy [resent in the fluid and converts into electrical energy. The third section deals with the devices which are basically used to measure the amount of fluid flow rate and different meters are used for different working condition of water based on topography, volume and the energy level of water.

COURSE OBJECTIVE:

- To demonstrate the Bernoulli's equation in Bernoulli's apparatus.
- To measure the fluid flow through Orifice meter, venturimeter.
- To evaluate the friction factor for a given set of pipes.
- To predict the performance parameter of various rotary and reciprocating pumps.
- To estimate the performance parameter of various rotary turbines.

COURSE CONTENT:

PART A – ENERGY MEASURING DEVICES	
S.NO.	**EXPERIMENTS**
1	Verification of Bernoulli's equation.
2	Determination of the Coefficient of the Orifice meter
3	Determination of the Coefficient of the Venturimeter meter
4	Determination of friction factor for a given set of pipes.
5	Determination major and minor loss in pipes.
PART B – ENERGY CONSUMING DEVICES	
6	Performance test on centrifugal pump
7	Performance test on reciprocating pump
PART C – ENERGY PRODUCING DEVICES	
8	Performance test on Francis turbine
9	Performance test on Pelton wheel turbine
10	Performance test on Kaplan turbine

SAFETY INSTRUCTIONS:

- Read and fully comprehend the lab procedure as set forth in the lab manual before you begin any experiment. If you do not understand the procedure, contact the staff incharge.
- All lab experiments require a closed toe shows. No open toed shoes; no loose fitting clothing; Jewelry should be removed; long hair should be tied back
- Always maintain awareness of the surrounding activities and walk in aisles to the extent possible.
- Maintain clean and orderly laboratories and work area. Discard immediately unwanted items. Leave coats, books and note books in the lecture room. Make sure all spilled liquids are wiped up immediately.
- Students are responsible for maintaining work area in a safe and reasonable condition.
- Be aware of the various experiment controls (start button, stop button, speed control) for each lab.
- Be aware of the experiment harness when conducting experiments.
- Wear safety eyewear when needed. Additional safety equipment must be utilized based on specific experiment requirements.
- Do not leave experiments running unattended.
- Immediately report any spills, equipment malfunctions, injuries or other perceived safety hazards to your staff member.
- Work deliberately and carefully.
- Make note of fire escape routes and emergency locations.

EQUIPMENTS:

- Bernoulli's apparatus
- Orifice meter setup
- Venturi meter setup
- Major and minor losses measuring setup
- Friction factor apparatus setup pipes
- Centrifugal pump
- Reciprocating pump setup
- Pelton wheel setup
- Francis turbine setup
- Kaplan turbine setup

EX.NO:1 **VERIFICATION OF BERNOULIS EQUATION**
DATE :

PRIOR LEARNING:

1. Continuity equation
2. Euler's equation
3. Bernoulli's equation

OBJECTIVE:

To verify the Bernoulli's theorem.

THEORY:

Bernoulli's theorem states that when there is a continues connection between the particle of flowing mass liquid, the total energy of any sector of flow will remain same provided there is no reduction or addition at any point. i.e. sum of pressure head and velocity head is constant.

Bernoulli's apparatus

Write the physical description of the following:

1. Hydraulic bench
2. Piezometer
3. Venturimeter
4. Series of tubes in the se3t up

APPARATUS REQUIRED:

1. Bernoulli's apparatus with equipment
2. Hydraulic bench
3. Piezometer
4. Venturimeter

WORK SPACE:

FORMULAE:

1. Actual Discharge (Q_a) :

= [(Cross sectional area of the tank) X (Rise of water level in the tank)] / (Time taken to rise the water)

Q_a = AH / t in m^3/s

Where,

A = Area of the tank in m^2

H = Height of water rise for the given time 't second' in m, in piezometer

t = Time taken for 'H' m rise of water in s

2. Suction Velocity (V_x) :

$\mathbf{V_x} = \mathbf{V} \times Q / a_x$

Q = Actual discharge in m^3/s

a_x = Cross section area of pipe in m^2

3. Velocity head (V_h) :

$V_h = 100 \times \mathbf{V_x^2 / 2g}$

WORKING PROCEDURE

Sl.no.	Cross Section area	Piezometer reading p × cm of water			Suction velocity (V)	Velocity head 100× (v^2× 2 g)	Pressure head + Velocity head
Unit / Run values	m^2	T1 50	T1 40	T3 30	m/sec.	cm of water	cm of water

CALCULATION

S. No.	Expression	Formula/value	Unit
1	**Piezometer Reading**		
2	**Time for 5 cm rise**		
3	**Discharge Q in**		
4	**Pressure Head**		
5	**Velocity Head**		
6	**Datum head**		
7	**Total Head**		

NOTE:

1 mm of Hg = 13.6/1000 m of H_2O
1 kg/ cm^2 = 10.33 m of H_2O

WORKING PROCEDURE:

VIVA:

1. Write Bernoulli's equation.
2. What are assumptions of Bernoulli's equation?
3. Write Euler's equation.
4. Explain about a coefficient of discharge of nozzle.
5. What is pitot static tube, and piezometer?

SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at te beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

RESULT:

Verification of Bernoulli's theorem was made.

EX.NO:2
DATE :

DETERMINATION OF THE COEFFICIENT OF THE ORIFICEMETER

PRIOR LEARNING:

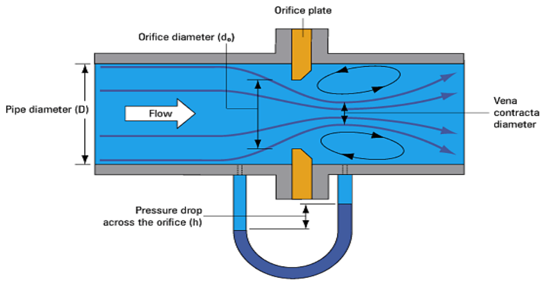
1. Bernoulli’s principle
2. Continuity equation
3. Vena-contracta

OBJECTIVE:

To determine the co-efficient of discharge through the orifice meter.

THEORY:

An orifice meter is a conduit and a restriction to create a pressure drop. An hour glass is a form of orifice. A nozzle, venturi or thin sharp edged orifice can be used as the flow restriction. The principle of the orifice meter is identical with that of the venturi meter. The reduction of the cross section of the flowing stream in passing through the orifice increases the velocity head at the expense of the pressure head, and the reduction in pressure between the taps is measured by a manometer. Bernoulli's equation provides a basis for correlating the increase in velocity head with the decrease in pressure head.



Orifice meter Setup

Write the physical description of the following:

1. **Flange:**

2. **Vena-contracta:**

3. **Pipe:**

APPARATUS REQUIRED:

1. Orifice meter set-up.
2. Stop watch.
3. Meter scale.
4. Collecting tank fitted with piezometer.
5. Differential U-tube mercury manometer.

WORK SPACE:

FORMULAE:

X_1 = Level of Mercury in left limb

X_2 = Level of Mercury in right limb

$X = X_1 - X_2$ m of Mercury (Hg)

$h = X (S_{Hg} / S_{water} - 1)$m of water

$= X (13.6/1-1)$

$= X(12.6-1)$

S_{Hg} Sp. gravity of Hg

S_{water} Sp. gravity of water

$\mathbf{Q_T = a_1 a_2 \sqrt{(2gh)} / \sqrt{(a_1^2 - a_2^2)}}$ in m^3 / s

where,

Q_t **=** Theoretical discharge**,** m^3 / s

a_1 = Area of the main pipe in m^2

a_2 = Area of the orifice meter in m^2

h = Pressure head difference in m of water

Actual discharge (Q_a),

= [(Cross sectional area of the tank) **X** (Rise of water level in the tank)] **/** (Time taken to rise the water)

$Q_a = AH/ t$ m^3/s

Q_{act} =_____________________

Coefficient of Discharge, $C_d = Q_a /Q_t$

TABULATION

Diameter of the inlet (d_1) =

Diameter of the orifice (d_2) =

Dimension of the Collecting tank

Length =

Breadth =

S.No	Manometer reading		Manometer head $h=(x_1 \sim x_2) \times 12.6 \times 10^{-2}$ m	Time taken for H=10 cm rise of water t Sec	Actual discharge Qact = AH / t (m^3/s)	Theoretical discharge Qth m^3 / s	Co-efficient of discharge C_d (no unit)
	x_1 cm of Hg	x_2 cm of Hg					
						Mean Cd =	

CALCULATION

S. No.	Expression	Formula/value	Unit
1	Diameter of inlet, d_1		
2	Diameter of orifice meter, d_2		
3	Specific gravity of the mercury, S_m		
4	Specific gravity of the liquid, S_l		
5	Difference in manometer level, x		
6	Differential head, h		
7	Area of inlet, a_1		
8	Area of orifice meter, a_2		
9	Theoretical discharge, Q_{th}		
10	Actual discharge, Q_{act}		
11	Actual discharge, Q_{act} (measured)		

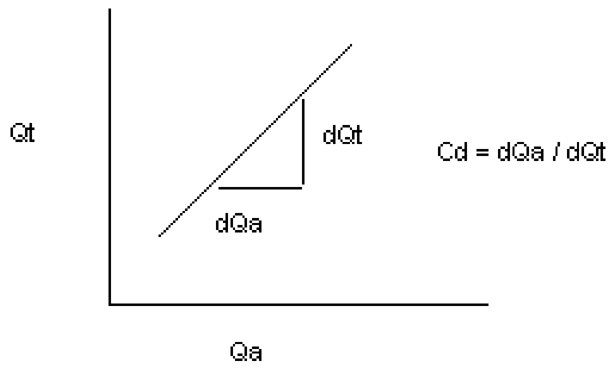
NOTE:

1 mm of Hg = 13.6/1000 m of H_2O

EXPERIMENTAL PROCEDURE:

MODEL GRAPH:

Actual Discharge (Q_a)VS Theoretical Discharge (Q_t)



SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at te beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

RESULT:

The mean value of Co-efficient of discharge of orifice meter, C_d =

EX.NO:3
DATE :

DETERMINATION OF THE COEFFICIENT OF THE VENTURIMETER

PRIOR LEARNING:

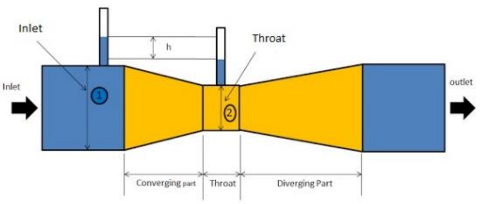
1. Bernoulli's principle
2. Veturi effect
3. Continuity equation

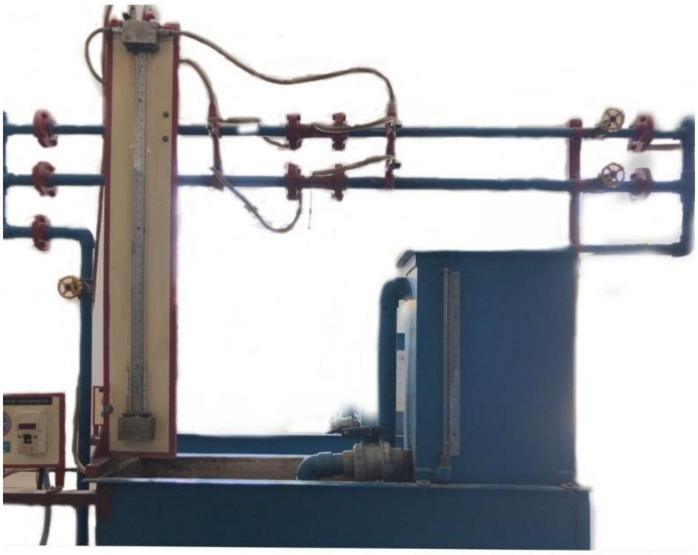
OBJECTIVE:

To determine the co-efficient of discharge of the given venturimeter.

THEORY:

Venturimeter is a device used to measure the flow rate or discharge of fluid through a pipe. Venturimeter is an application of Bernoulli's equation. Total energy of the flowing fluid at any point in its flow is same. The principle of venture meter is firstly developed by G.B. Venturi in 1797. The principle is that when cross sectional area of the flow is reduced then a pressure difference is created between the different areas of flow which helps in measuring the difference in pressure. With the help of this pressure difference we can easily measure the discharge in flow by using Bernoulli's equation.





Venturimeter Setup

Write the physical description of the following:

1. **Short converging part:**

2. **Throat:**

3. **Diverging part:**

APPARATUS REQUIRED:

1. Venturimeter set-up.
2. Stop watch.
3. Meter scale.
4. Collecting tank fitted with piezometer.
5. Differential U-tube mercury manometer.

WORK SPACE:

FORMULAE:

X_1 = Level of Mercury in left limb
X_2 = Level of Mercury in right limb

$X = X_1 - X_2$ m of Mercury (Hg)

$h = X (S_{Hg} / S_{water} - 1)$m of water
$= X (13.6/1-1)$
$= X(12.6-1)$
S_{Hg} Sp. gravity of Hg
S_{water} Sp. gravity of water

$\mathbf{Q_T = a_1 a_2 \sqrt{(2gh)} / \sqrt{(a_1^2 - a_2^2)}}$ in m^3 / s
where,

$\mathbf{Q_t}$ = Theoretical discharge, $\mathbf{m^3 / s}$
a_1 = Area of the venturimeter inlet in m^2
a_2 = Area of the venturimeter throat in m^2
h = Pressure head difference in m of water

Actual discharge (Q_a),

= [(Cross sectional area of the tank) X (Rise of water level in the tank)] / (Time taken to rise the water)

$Q_a = AH/ t \ m^3/s$

Q_{act} =____________________

Coefficient of Discharge, $C_d = Q_a /Q_t$

WORKING PROCEDURE:

CALCULATION:

TABULATION

Diameter of the inlet (d_1) =

Diameter of the orifice (d_2) =

Dimension of the Collecting tank

Length =

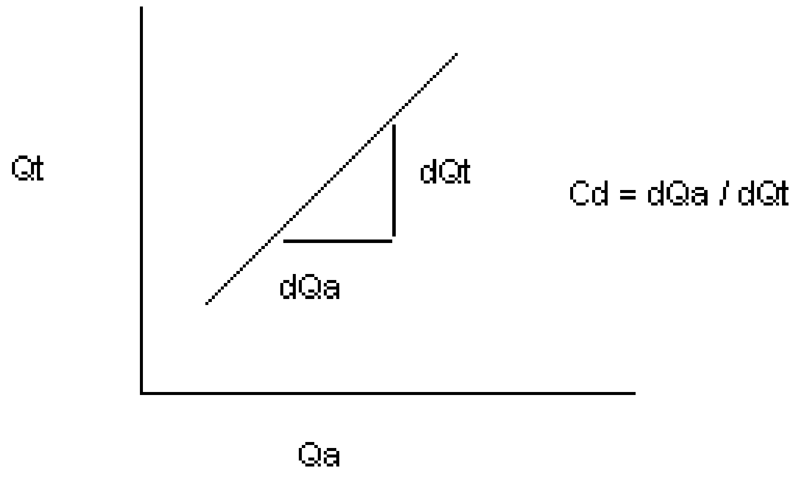
Breadth =

S.No	Manometer reading		Manometer head $h=(x_1 \sim x_2)$ x 12.6 x 10^{-2} m	Time taken for H=10 cm rise of water t Sec	Actual discharge Qact = AH / t (m^3/s)	Theoretical discharge Qth m^3 / s	Co-efficient of discharge Cd (no unit)
	x_1 cm of Hg	x_2 cm of Hg					

S. No.	Expression	Formula/value	Unit
1	Diameter of inlet, d_1		
2	Diameter of throat, d_2		
3	Specific gravity of the mercury, S_{Hg}		
4	Specific gravity of the liquid, S_{water}		
5	Difference in manometer level, X		
6	Differential head, h		
7	Area of inlet, a_1		
8	Area of throat, a_2		
9	Theoretical discharge, Q_t		
10	Actual discharge, Q_{act}		
11	Coefficient of discharge		

GRAPH:

Actual Discharge (Q_a) Vs Theoretical Discharge (Q_t)



SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at the beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn’t overflow.
- Leaning and looking into the collecting tank should be avoided.

RESULT:

The mean value of Co-efficient of discharge of the given venturimeter, Cd =

EX.NO :4 **DETERMINATION OF THE FRICTION FACTOR FOR A GIVEN SET OF PIPES**

DATE :

PRIOR LEARNING:

Various losses in fluid flow

Darcy-Weisbach equation

OBJECTIVE:

To determine the friction factor 'f' for the given pipe.

THEORY:

Energy input to the gas or liquid is needed to make it flow through the pipe or conduit. This energy input is needed because there is frictional energy loss (also called frictional head loss or frictional pressure drop) due to the friction between the fluid and the pipe wall and internal friction within the fluid.

Pipe setup for Friction Factor

Write the physical description of the following:

1. What do you meant by friction and list out its effects?
2. What do you meant by major loss in pipe?
3. Write down the Darcy-Weisbach equation?
4. What are the types of losses in pipe flow?

APPARATUS REQUIRED:

1. A pipe provided with inlet, outlet and pressure tapping.
2. Differential U-tube manometer.
3. Collecting tank with piezoelectric and control valves.
4. Stop Watch.
5. Meter Scale

FORMULAE:

1. **Difference in manometer level (x):**

$x = h_1 \sim h_2$ in m.

Where,

h_1 = Manometer head in one limb of manometer in m

h_2 = Manometer head in another limb of manometer in m

2. **Differential Head (h):**

$h = x[(S_m/S_l) – 1]$ in m of water

Where,

S_m = Specific gravity of the mercury = 13.6

S_l = Specific gravity of the liquid (water) = 1

3. **Actual Discharge (Q_a) :**

$Q_a = AH / t$ in m^3 / s

Where,

A = Area of the collecting tank in m^2

H = Rise of the water in the collecting tank in m

t = Time taken for H cm rise of water in the tank in s

4. **Cross sectional area of the pipe (a)**

$a = (\pi/4)xd^2$ in m^2

Where,

d = Diameter of the pipe in m

5. **Velocity (v :**

$v = Q_a /a$ in m/s

Where,

a = Area of the pipe in m^2

6. **Friction factor (f) :**

$f = (2gdh_f)/Lv^2$

Where,

h_f = Head loss in m

L = Length of pipe in m

WORK SPACE:

Calculations

S. No.	Expression	Formula/value	Unit
1	h_1 = Manometer head in one limb of manometer		
2	h_2 = Manometer head in another limb of manometer		
3	Sm = Specific gravity of the mercury =		
4	S_l = Specific gravity of the liquid (water) =		
5	Actual Discharge (Qa) :		
6	Velocity (V) :		
7	Friction factor (f) :		

NOTE:

1 mm of Hg = 13.6/1000 m of H_2O

TABULATION

Diameter of the pipe(d) =

Length of the pipe (L)=

Dimension of the Collecting tank

Length =

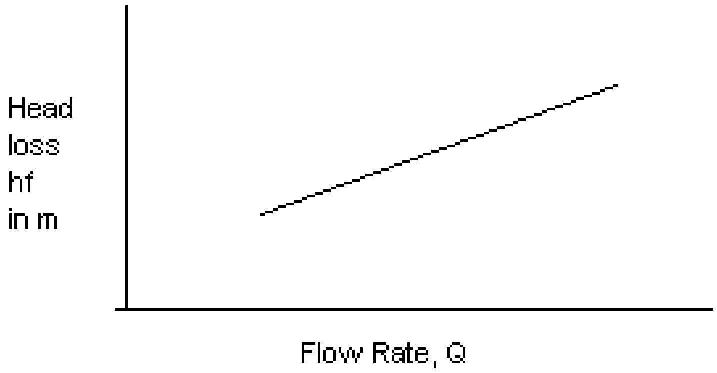
Breadth =

S.no	Type of pipe	Manometer readings			Time for H=10cm rise of water t sec	Actual discharge Qact = AH /t x 10^{-3} m^3 / s	Velocity V m/s	V^2 (m/s)	Friction factor $F = \frac{2gd\,h_f}{Lv^2}$
		h1 x 10^{-2} m	h2 x 10^{-2} m	h_f = (h1-h2) x 10^{-2} m					
Mean f =									

WORKING PROCEDURE

GRAPH:

Flow rate Vs Head loss



SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at the beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

VIVA:

1. What is the relationship between friction head loss and pipe diameter?
2. What is the relationship between friction head loss and flow velocity?
3. What is the relationship between friction head loss and pipe length?
4. How is the flow rate and head loss related?
5. If flow velocity doubles, what happen to the frictional head loss?

RESULT:

The mean value of friction factor of given set of pipes is obtained as, f =

EX.NO :5

DATE :

DETERMINATION OF MINOR LOSSES IN PIPES

PRIOR LEARNING:

Various losses in fluid flow

Bernoulli's Equation

OBJECTIVE:

To determine the minor losses for the given pipe.

THEORY:

Minor losses in pipe flow are a major part in calculating the flow, pressure, or energy reduction in piping systems. Liquid moving through pipes carries momentum and energy due to the forces acting upon it such as pressure and gravity. Just as certain aspects of the system can increase the fluids energy, there are components of the system that act against the fluid and reduce its energy, velocity, or momentum. Friction and minor losses in pipes are major contributing factors.

Minor Loss Setup

Write the physical description of the following:

5. Sudden enlargement
6. 'L' Bend
7. Sudden contraction

APPARATUS REQUIRED:

6. A pipe provided with inlet, outlet and pressure tapping.
7. Differential U-tube manometer.
8. Collecting tank with piezoelectric and control valves.
9. Stop Watch.
10. Meter Scale

FORMULAE:

7. **Difference in manometer level (x):**

$x = h_1 \sim h_2$ in m.

Where,

h_1 = Manometer head in one limb of manometer in m

h_2 = Manometer head in another limb of manometer in m

8. **Differential Head (h):**

$h = x[(S_m/S_l) – 1]$ in m of water

Where,

S_m = Specific gravity of the mercury = 13.6

S_l = Specific gravity of the liquid (water) = 1

9. **Actual Discharge (Q_a) :**

$Q_a = AH / t$ in m^3 / s

Where,

A = Area of the collecting tank in m^2

H = Rise of the water in the collecting tank in m

t = Time taken for H cm rise of water in the tank in s

10. **Cross sectional area of the pipe (a)**

$a = (\pi/4)xd^2$ in m^2

Where,

d = Diameter of the pipe in m

11. **Velocity (V) :**

$V_1 = Q_a /a_1$ in m/s

$V_2 = Q_a /a_2$ in m/s

WORK SPACE:

For Bend and Elbow

$h = V^2/2g$

12. Sudden Contraction

$h = V_2^2/2g$

13. **Sudden Enlargement**:

$h = (V_1 - V_2)^2/2g$

V_1 and V_2 are velocity water at before and after the sudden changes in pipe cross section

Calculations

S. No.	Expression	Formula/value	Unit
1	h_1 = Manometer head in one limb of manometer		
2	h_2 = Manometer head in another limb of manometer		
3	Sm = Specific gravity of the mercury =		
4	S_l = Specific gravity of the liquid (water) =		
5	Actual Discharge (Qa) :		
6	Velocity (V) :		
7	Minor losses(f) :		

NOTE:

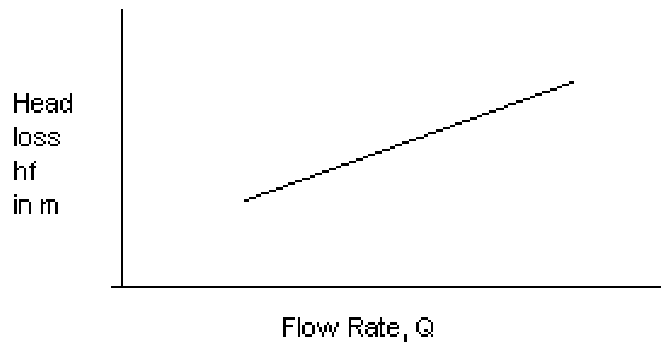
1 mm of Hg = 13.6/1000 m of H_2O

Bend / Elbow / Sudden expansion/ Sudden expansion	Manometer readings			Head loss	Tie taken for 10cm rise of water	Actual discharge (Q_{actual})	Velocity		$V^2 / 2g$	Loss of head (m)	K
	h1	h2	x= $(h_1-h_2) \times 10^{-2}$				V1	V2			
	cm	cm	m	m of water	Sec.	m^3 / s	m / s	m / s	m	m	

WORKING PROCEDURE

GRAPH:

Flow rate Vs Head loss



SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at the beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

VIVA:

6. What is the relationship between friction head loss and pipe diameter?
7. What is the relationship between friction head loss and flow velocity?
8. What is the relationship between friction head loss and pipe length?
9. If flow velocity doubles, what happen to the frictional head loss?

RESULT:

The mean value of minor losses of given set of pipes is obtained as, f =

TASK:

1. State Bernoulli's principle and Bernoulli's equation.
2. Make a model, indicating the flow of air through a venturi meter.
3. Justify the model by validating the model making.
4. Enumerate in the model about the narrow section during the flow through pipes.
5. Enumerate on the application of Bernoulli effect in IC engines , make a prototype / model and explain at least one application in IC engines.

EX.NO:6 **PERFORMANCE TEST ON CENTRIFUGAL PUMP**
DATE :

PRIOR LEARNING:

1. Pump
2. Centrifugal force
3. Discharge

OBJECTIVE:

To study the performance characteristics of a centrifugal pump and to determine the characteristic with maximum efficiency.

THEORY:

A centrifugal pump converts rotational energy, often from a motor, to energy in a moving fluid. A portion of the energy goes into kinetic energy of the fluid. Fluid enters axially through eye of the casing, is caught up in the impeller blades, and is whirled tangentially and radially outward until it leaves through all circumferential parts of the impeller into the diffuser part of the casing. The fluid gains both velocity and pressure while passing through the impeller. The doughnut-shaped diffuser, or scroll, section of the casing decelerates the flow and further increases the pressure. It is important to note that the water is not pushed radially outward by centrifugal force (non-existent force), but rather by inertia, the natural tendency of an object to continue in a straight line (tangent to the radius) when traveling around circle. This can be compared to the way a spin-cycle works in a washing machine.

Centrifugal Pump

Write the physical description of the following:

1. Diffuser

2. Casing

3. Impeller blades

APPARATUS REQUIRED:

1. Centrifugal Pump Set-up.
2. Stop Watch.
3. Meter Scale.
4. Collecting tank.

FORMULAE:

1. Actual Discharge (Q_a) :

Q_a = AH / t in m^3 / s
Where,
A = Area of the tank in m^2
H = H = Height of water rise for the given time't second' in m,
t = Time taken for 'H' m rise of water in s

2. Input Power (P_i):

P_i **= (3600 x N_r) / (N_c x T)** in kW
Where,
N_r = Number of revolution of Energy meter
N_c = Energy meter constant in rev/Kw hr
T = Time taken for N_r revolution of energy meter in s

3. Output power (P_o) :

P_o **= w Q_a h/1000** in kW
Where,
w = Specific weight of water in N/m^3
Q_a = Actual discharge in m^3/s
h = Total head in m

4. Total Head (h):

h = h_d + h_S in m
Where,
h_d = Delivery head in m
h_S = Suction head in m

5. Efficiency (η) :
η = (P_o / P_i) x 100 in %

WORK SPACE:

TABULATION

Dimension of the Collecting tank

Length = Breadth =

Number of revolutions (Nr) =

Energy meter constant (N_e) = rev/kW hr

S.No	Suction head		Delivery Head		Total Head (h= hs + hd) in m of water	Time taken for 'H=10 cm' rise of water (t) sec	Time taken for Nr revolution t Sec	Actual Discharge (Qact) m^3\sec	Input Power (Pi) kW	Output Power (Po) kW	% η
	mm of Hg	h_s m of water	h_d in kg/cm^2	h_d m of water							

CALCULATION

S. No.	Expression	Formula/value	Unit
1	Suction head, h_s		
2	Delivery head, h_d		
3	Specific weight of water, w		
4	Actual Discharge, Q_a		
5	Output power, P_o		
6	Energy meter constant, N_c		
7	Number of revolution of Energy meter, N_r		
8	Input Power, P_i		
NOTE: 1 mm of Hg = 13.6/1000 m of H_2O			

WORKING PROCEDURE:

GRAPH:

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

Viva

1.What is a pump?
2.What is a centrifugal pump?
3.what are forces involved in impeller?
4.What is priming?

SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at the beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.

RESULT:

Thus the performance characteristics of centrifugal pump was studied and the maximum efficiency was found to be _____________%

EX.NO:7 **PERFORMANCE TEST ON RECIPROCATING PUMP**

DATE :

PRIOR LEARNING:

1. Energy meter
2. Pumps
3. Air vessels

OBJECTIVE:

To conduct the performance test on reciprocating pump and to draw the characteristic curves.

THEORY:

Reciprocating pumps are positive displacement pump as a definite volume of liquid is trapped in a chamber which is alternatively filled from the inlet and empited at a higher pressure through the discharge. The fluid enters a pumping chamber through an inlet and is pushed out through outlet valve by the action of piston. They are either single acting independent suction and delivery strokes or double acting suction and delivery both the directions. Reciprocating pumps are self priming pumps and are suitable for very high head at low flows. They deliver reliable discharge and it is often used for metering duties because of constancy of flow rate.

Reciprocating Pump

Write the physical description of the following:

1. **Suction Pipe:**

2. **Delivery Pipe:**

WORK SPACE:

3. Piston Cylinder Arrangement:

APPARATUS REQUIRED:

1. Reciprocating Pump Set-up.
2. Stop Watch.
3. Meter Scale.
4. Collecting tank.
5. Collecting tank fitted with piezometer.
6. Differential U-tube mercury manometer.

FORMULAE:

1. Actual Discharge (Q_a) :

$$Q_a = AH / t \text{ in } m^3 / s$$

Where,
A = Area of the tank in m^2
H = Height of water rise for the given time 't second' in m,
t = Time taken for 'H' m rise of water in s

2. Input Power (P_i):

$P_i = (3600 \times N_r) / (N_c \times T)$ in kW
Where,
N_r = Number of revolution of Energy meter.
N_c = Energy meter constant rev/Kw hr.
T = Time taken for N_r revolution of energy meter in s.

3. Output power (P_o) :

$P_o = w\, Q_a\, h/1000$ in kW
Where
w = Specific weight of water in
Q_a = Actual discharge in m^3/s
h = Total head in m

4. Total Head (h):

$h = h_d + h_S$ in m
Where,
h_d = Delivery head in m
h_S = Suction head in m

5. **Efficiency (η) :**
$\eta = (P_o / P_i) \times 100$ in %

TABULATION

Dimension of the Collecting tank

Length = Breadth =

Number of revolutions (Nr) =

Energy meter constant (N_e) = rev/KW hr

1 kg/cm^2 = 10m of water 1mm of Hg = 0.0136 m of water

S. No	Suction head		Delivery head		Total head h= hs + hd	Time taken for H=10 cm of rise of water	Actual discharge Q_{act} m^3/s	Time taken for N rev of energy meter disc t sec	Input power P_i kW	Output power P_o kW	% in η
	hs in mm of Hg	hs in m of H_2O	hd in kg/cm^2	hd in m of H_2O							

CALCULATION:

S. No.	Expression	Formula/value	Unit
1	Suction head, h_s		
2	Delivery head, h_d		
3	Specific weight of water, w		
4	Actual Discharge, Q_a		
5	Output power, P_o		
6	Energy meter constant, N_c		
7	Number of revolution of Energy meter, N_r		
8	Input Power, P_i		

NOTE:

1 mm of Hg = 13.6/1000 m of H_2O

WORKING PROCEDURE:

GRAPH:

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

SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at te beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

VIVA:

1. What is the reason for internal cavitation in reciprocating pumps?
2. What is cavitation?
3. In what way the fluid displacement is engaged in a double acting reciprocating pump?
4. How cavitation can be eliminated in pumps?
5. What is suction head and acceleration head in pumps?

RESULT:

The performance characteristic of the reciprocating pump is studied and the maximum efficiency is calculated …………… %

EX.NO:8 **PERFORMANCE TEST ON FRANCIS TURBINE**

DATE :

PRIOR LEARNING:

1. Reaction turbine
2. Force Exerted by the jet on moving curved plate

OBJECTIVE:

To conduct the performance test on Francis turbine at rated speed and at constant valve opening and to draw the characteristic curves.

THEORY:

The Francis turbine is a reaction turbine, which means that the working fluid changes pressure as it moves through the turbine, giving up its energy. A casement is needed to contain the water flow. The turbine is located between the high pressure water source and the low pressure water exit, usually at the base of a dam. The inlet is spiral shaped. Guide vanes direct the water tangentially to the runner. This radial flow acts on the runner vanes, causing the runner to spin. The guide vanes (or wicket gate) may be adjustable to allow efficient turbine operation for a range of water flow conditions. At the exit, water acts on cup shaped runner features, leaving with no swirl and very little kinetic or potential energy. The turbine's exit tube is specially shaped to help decelerate the water flow and recover kinetic energy.

Francis Turbine

Write the physical description of the following:

1. Spiral Casing:

2. Guide Vanes:

3. Draft Tube:

APPARATUS REQUIRED:

1. Francis turbine Set-up.
2. Tachometer
3. Dead weights
4. Stop watch

FORMULAE:

1. **Actual Discharge (Q_a) :**

$$Q_a = C_d . a_1 a_2 \sqrt{(2gh)} / \sqrt{(a_1^2 - a_2^2)} \text{ in } m^3/s$$

where,

a_1 = Area of the venturimeter inlet in m^2
a_2 = Area of the venturimeter throat in m^2
h = Total head in m

2. **Input Power (P_i):**

$$P_i = w\, Q_a\, h \text{ in watts}$$

where,

w = Specific weight of water
Q_a = Actual discharge in m^3 / s
h = Total head in m

3. **Output power (P_o) :**

$$P_o = (2x\pi\, NT) / 60 \text{ in watts}$$

where,

N = speed in r.p.m
T = Torque in N-m

4. **Torque (T) :**

$$T = [(W-S)(D+d).9.81] / 2 \text{ in N-m}$$

where,

W = Dead weight in hanger in kg
S = Spring balance reading in kg
D = Diameter of brake drum in m
d = Diameter of rope in m

5. **Efficiency (η) :**

$$\eta = (P_o / P_i) \times 100 \ \%$$

WORK SPACE:

S. No	Mano-meter reading		Pressure gauge reading (P)		Vacuum gauge reading(g)		H=P+g+X (X=0.15 m)	Load		Speed of the turbine N rpm	Torque (T) (Nm)	Discharge (Q) x 10^{-3} m^3\sec	Input power kW	Output power kW	η %
	h_1 cm	h_2 cm	Kg/cm^2	m of H_2o	mm at Hg	m of H_2o		M_1	M_2						
														Mean =	

CALCULATION:

S. No.	Expression	Formula/value	Unit
1	Diameter of inlet, d_1		
2	Area of inlet, a_1		
3	Diameter of throat, d_2		
4	Area of throat, a_2		
5	Coefficient of discharge, C_d		
6	Difference in manometer level, x		
7	Differential head, h		
8	Actual Discharge, $\mathbf{Q_a}$		
9	Input Power, P_i		
10	Torque (T)		
11	Output power (P_o)		
12	Efficiency (η)		

NOTE:
1 mm of Hg = 13.6/1000 m of H_2O
1 kg/cm^2 = 10.33 m of H_2O

WORKING PROCEDURE:

GRAPH:

1. Discharge Vs Total Head
2. Discharge Vs Output Power
3. Discharge Vs Efficiency

VIVA:

I. What is radial flow turbine?
II. What is the difference between impulse and reaction turbine?
III. What is Hydraulic Efficiency?
IV. What is Mechanical Efficiency?
V. What is Volumetric Efficiency?
VI. What is Overall Efficiency?

SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at te beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

RESULT:

Thus the performance characteristics of the Francis wheel turbine are done and the maximum efficiency of the turbine is ____________%

EX.NO:9 **PERFORMANCE TEST ON PELTON WHEEL**
DATE :

PRIOR LEARNING:
1. Turbine
2. Force Exerted by the jet on moving curved plate

OBJECTIVE:

To conduct the performance test on Pelton wheel turbine at rated speed and at constant spear opening and to draw the characteristic curves.

THEORY:

Pelton Turbine is a Tangential flow impulse turbine in which the pressure energy of water is converted into kinetic energy to form high speed water jet and this jet strikes the wheel tangentially to make it rotate. It is also called as Pelton Wheel.

Pelton Wheel

Write the physical description of the following:

1. **Nozzle:**

2. **Casing:**

3. **Breaking jet:**

APPARATUS REQUIRED:

1. Pelton wheel Set-up.
2. Tachometer
3. Dead weights
4. Stop watch.

FORMULAE:

1. Actual Discharge (Q_{act}) :

Q_{act} = $Cd.a_1 a_2 \sqrt{(2gh)} / \sqrt{(a_1^2 - a_2^2)}$ in m^3 / s

where,

a_1 = Area of the venturimeter inlet in m^2
a_2 = Area of the venturimeter throat in m^2
h = Total head in m

2. Input Power (Pi):

$P_i = w Q_{act} H / 1000$ in kW

where,

w = Specific weight of water
Q_{act} = Actual discharge in m^3 / s
H = Total head in m of water

3. Output power (Po) :

$P_o = (2\pi NT) / 60000$ in kW

Where,

N = speed in rpm
T = Torque in N-m

4. Torque (T) :

$T = [(M-S)(D+d)x9.81] / 2$ in N-m

where,

M = Mass of hanger in kg
S = Spring balance reading in kg
D = Diameter of brake drum in m
d = Diameter of rope in m

5. Efficiency (η) :

$\eta = (P_o / P_i) \times 100$ %

S. No	Pressure gauge reading Kg/cm^2	Manometer reading		Spring Balance reading		$h = \frac{h_1 - h_2}{\rho g} \times 10^4$ m	Actual discharge $Q_{act} \times 10^{-3}$ (m^3/s)	Speed N (rpm)	Torque T(Nm)	Input power kW	Output power kW	η %
		h_1 (cm)	h_2 (cm)	M_1	M_2							
											Mean =	

CALCULATION

S. No.	Expression	Formula/value	Unit
1	Diameter of inlet, d_1		
2	Area of inlet, a_1		
3	Diameter of throat, d_2		
4	Area of throat, a_2		
5	Coefficient of discharge, C_d		
6	Differential head, h		
7	Actual Discharge, $\mathbf{Q_a}$		
8	Input Power, P_i		
9	Torque (T)		
10	Output power (P_o)		
11	Efficiency (η)		

NOTE:

1 mm of Hg = 13.6/1000 m of H_2O

1 kg/ cm^2 = 10.33 m of H_2O

WORKING PROCEDURE:

GRAPH:

1. Load Vs Total Head
2. Load Vs Output Power
3. Load Vs Efficiency

VIVA:

1. What are the Advantages of Pelton wheel?
2. What are the Disadvantages of Pelton wheel?
3. What are the application of Pelton wheel Application?
4. Where do you prefer Pelton Wheel?
5. What are the main components of Pelton wheel?

SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at te beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

RESULT:

Thus the performance characteristics of the Pelton Wheel Turbine are done and the maximum efficiency of the turbine is ___________%

EX.NO:10 **PERFORMANCE TEST ON KAPLAN TURBINE**

DATE :

PRIOR LEARNING:

1. Axial flow reaction turbine
2. Force Exerted by the jet on moving curved plate

OBJECTIVE:

To conduct the performance test on Kaplan turbine at rated speed and at constant spear opening and to draw the characteristic curves.

THEORY:

Kaplan turbine is a propeller type, axial flow water turbine. It has adjustable blades. Adjustable blades help in obtaining good efficiency at wide range of head and discharge available to the turbine. It is suitable for low head and high flow applications. It is an evolution of Francis turbine. It is designed to operate where head is low. It has automatically adjusted propeller blades with automatically adjusted wicket gates to achieve efficiency over a wide range of flow and water level. The Kaplan turbine was an evolution of the Francis turbine. Its invention allowed efficient power production in low-head applications which was not possible with Francis turbines. The head ranges from 10–70 metres and the output ranges from 5 to 200 MW. Runner diameters are between 2 and 11 metres. Turbines rotate at a constant rate, which varies from facility to facility. That rate ranges from as low as 54.5 rpm to 450 rpm.

Kaplan Turbine

Write the physical description of the following:

1. **Scroll casing:**

2. **Hub with vanes or runner of the turbine:**

3. **Draft tube:**

APPARATUS REQUIRED:

1. Kaplan turbine Set-up.
2. Tachometer
3. Dead weights
4. Stop watch

WORKING PROCEDURE:

FORMULAE:

1. **Actual Discharge (Q_a) :**

$Q_a = C_d.a_1\, a_2 \sqrt{(2gh)} / \sqrt{(a_1^2 - a_2^2)}$ in m^3 / s
where,
a_1 = Area of the venturimeter inlet in m^2
a_2 = Area of the venturimeter throat in m^2
h = Total head in m

2. **Input Power (P_i):**

Pi = w Qa h in watts
where,
w = Specific weight of water
Q_a = Actual discharge in m^3 / s
h = Total head in m

3. **Output power (P_o) :**

$P_o = (2x\pi\, NT) / 60$ in watts
where,
N = speed in r.p.m
T = Torque in N-m

4. **Torque (T) :**

T = [(W-S)(D+d).9.81] / 2 in N-m
where,
W = Mass of hanger in kg
S = Spring balance reading in kg
D = Diameter of brake drum in m
d = Diameter of rope in m

5. **Efficiency (η) :**

$\eta = (P_o / P_i) \times 100$ in %

WORK SPACE:

CALCULATION

S. No.	Expression	Formula/value	Unit
1	Diameter of inlet, d_1		
2	Area of inlet, a_1		
3	Diameter of throat, d_2		
4	Area of throat, a_2		
5	Coefficient of discharge, C_d		
6	Difference in manometer level, x		
7	Differential head, h		
8	Actual Discharge, $\mathbf{Q_a}$		
9	Input Power, P_i		
10	Output power (P_o)		
11	Torque (T)		
12	Efficiency (η)		

NOTE:

1 mm of Hg = 13.6/1000 m of H_2O
1 kg/cm^2 = 10.33 m of H_2O

GRAPH:

1. Discharge Vs Total Head
2. Discharge Vs Output Power
3. Discharge Vs Efficiency

VIVA:

1. What is function of draft tube?
2. Why draft tube is used in Kaplan turbine?
3. How are hydraulic turbine classified?
4. What is Mechanical Efficiency?
5. What is Volumetric Efficiency?
6. What is Overall Efficiency?

SAFETY INSTRUCTIONS:

- Make sure that all the valves are closed at te beginning of the experiment.
- The discharge valve and collecting tank valve should be closed when starting the experiment.
- Care must be taken to ensure that the collecting tank valve is opened at appropriate time to ensure that water doesn't overflow.
- Leaning and looking into the collecting tank should be avoided.

RESULT:

Thus the performance characteristics of the Kaplan turbine are done and the maximum efficiency of the turbine is ___________ %

TASK:

1. Enumerate the operation theory of impulse and reaction turbine
2. Make a model on Pelton turbine
3. Make a model on wind turbine
4. Discuss on Helicopter shaft rotation (coaxial contra rotation) and compare with the turbine wheel rotation
5. Make a comparison table on at least three rotary machines application, principle and power produced.