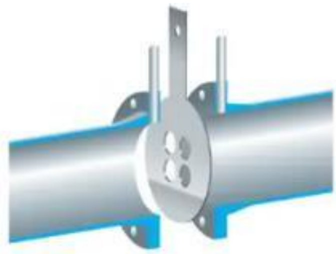
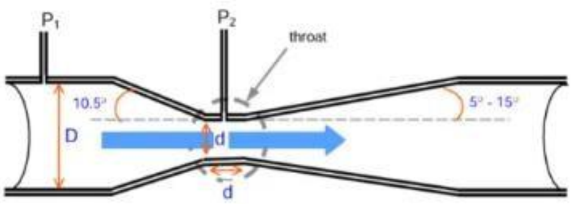
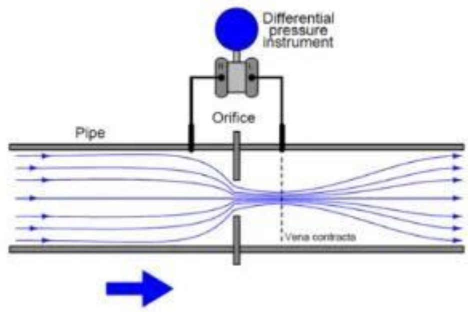
FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY

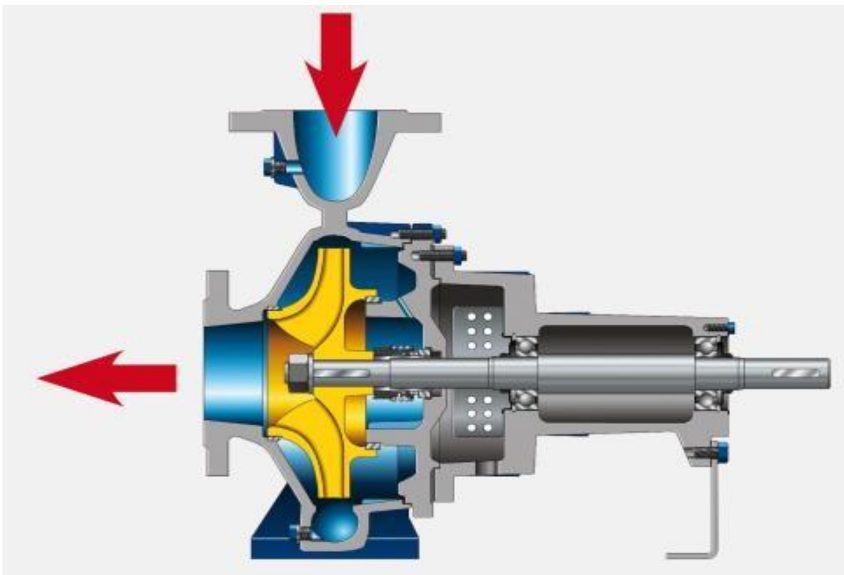
II B.Tech-IV Semester **Regulation: R23**

Academic Year: 2025-26









NAME OF THE STUDENT :

ROLL NUMBER :

SUBJECT CODE : **23MEC244L**

INSTITUTE VISION AND MISSION

VISION

- To emerge as a center of excellence for learning and researching the domains of engineering, computing and management.

MISSION

- Provide congential academic ambience with state-art of resources for learning and research.
- Ignite the students to acquire self-reliance in the latest technologies.
- Unleas hand encourage the innate potential and creativity of students.
- Inculcate confidence to face and experience new challenges.
- Foster enterprising spirit among students.
- Work collaboratively with technical institutes / universities / industries of national and international repute.

DEPARTMENT VISION AND MISSION

VISION

- To become a center of excellence in mechanical engineering studies and research.

MISSION

M1: Provide congential academic ambience with necessary infrastructure and learning resources.
M2: Inculcate confidence to face and experience new challenges from industry and society.
M3: Ignite the students to acquire self-reliance in the latest technologies.
M4: Foster enterprising spirit among students.

PROGRAMME EDUCATIONAL OBJECTIVES(PEO's)

Graduates of Mechanical Engineering shall

PEO1: Have professional competency through the application of knowledge gained from subjects like mathematics, physics, chemistry, inter-disciplinary and core subjects like manufacturing engineering, thermal sciences, CAD/CAM and design and development. **(Professional Competency)**.

PEO2: Excel in one's career by critical thinking towards successful services and growth of the organization or as an entrepreneur or through higher studies. **(Successful Career Goals).**

PEO3: Enhance knowledge by updating advanced technological concepts for facing the rapidly changing world and contribute to society through innovation and creativity.**(Continuing Education and Contribution to Society).**

PROGRAMM SPECIFIC OUTCOMES (PSO's)

PSO1: Apply the knowledge obtained in core areas for the design, analysis and manufacturing of mechanical systems and processes.

PSO2:Exhibit novel concepts on product development with the help of modern CAD/CAM integration, while ensuring best manufacturing practices.

PROGRAMOUTCOMES(PO's)

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO2.Problemanalysis: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.

PO7.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.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.

PO10. 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 the setoone'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.

23MEC24L	FLUIDMECHANICS&HYDRAULICMACHINERYLAB	L	T	P/D	C
	(Common to MECH and EEE Branches)	-	-	2	1

Course Educational Objectives:

CEO1: To understand the properties of fluid, types of fluid and types of flow.
CEO2: To understand about flow measuring devices based on Bernoulli's principle and notches.
CEO3: To help the students acquire knowledge about various loss in fluids flow through pipes.
CEO4: To acquire knowledge on basics of turbo machinery.
CEO5: To perform characteristic study of turbines and pumps.

List of Experiments

1. Calibration of venturimeter and orificemeter.
2. Determination of coefficient of discharge for small orifice by a constanthead method.
3. Determination of coefficient of discharge for an external mouth piece by variable head method.
4. Calibration of contracted rectangular notch and triangular notch.
5. Determination of coefficient of loss of head in a sudden contraction and friction factor.
6. Verification of Bernoulli's theorem.
7. Impact of jet on vanes.
8. Turbine flow meter.
9. Study of hydraulic jump.
10. Performance test on Turbine: a)Pelton wheel turbine, b)Francis turbine c)Kaplan turbine
11. Performance test on centrifugal pump: a)Single stage centrifugal pump, b)Multistage centrifugal pump.
12. Performance test on reciprocating ump.

Course Outcomes:

On successful completion of the course, students will be able to		Pos related to COs
CO1	Demonstrate the knowledge on properties of fluids and fluid flow characteristics of various hydraulic machines.	**PO1**
CO2	Measure and analyze the flow parameters using orifice ,mouthpiece and notches also analyze the performance of centrifugal, reciprocating pumps and also ability to engage in independent.	**PO2**
CO3	Determine and design the pipe flow by considering various loss of energy.	**PO3**
CO4	Understand working ,performance of hydraulic turbine by conduct investigation.	**PO4**
CO5	Follow the ethical principles while doing the experiments.	**PO8**
CO6	Do the experiments effectively as an individual and as a team member in a group.	**PO9**
CO7	Communicate verbally and in written form pertaining to results of the experiments.	**PO10**
CO8	Continue updating their skills related to fluid mechanics and hydraulic machines in future.	**PO12**

Text Books: Lab manual provided by the department.

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-
CO3	-	-	3	-	-	-	-	-	-	-	-	-
CO4	-	-	-	3	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	3	-	-	-	-
CO6	-	-	-	-	-	-	-	-	3	-	-	-
CO7	-	-	-	-	-	-	-	-	-	3	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	3
CO	3	3	3	3	-	-	-	3	3	3	-	3

SITAMS	FLUID MECHANICS AND HYDRAULIC MACHINES LAB	CODE: 23MEC244L

INDEXSHEET

Ex . No.	Date	Name of the Experiment	Page No.	Signature
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Signature of the faculty

SITAMS	FLUID MECHANICS AND HYDRAULIC MACHINES LAB	CODE: 23MEC244L

Internal marks- INDEX SHEET

S.No	Experiment Name	Knowledge Gained	Analysis, Design	Ability of do experiment and following of ethical principles	Result & Conclusion	VIVA VOCE	TOTAL	Signature of the Faculty
		3	3	3	3	3	15M	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
	Average							

Signature of the Faculty

SITAMS	FLUID MECHANICS AND HYDRAULIC MACHINES LAB	CODE: 23MEC244L

Attainment level -INDEX SHEET

S.No	Experiment Name	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8
		Knowledge	Analysis	Design	Complex Analysis &	Ethics	Individual/ Teamwork	Communicationa bility	Life Long Learning
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
	Total Attainment								

****Excellent (3) Good (2) Fair (1)**

Signature of the Faculty

Exp No: **Date:**

CALIBRATION OF VENTURIMETER AND ORIFICE METER

Aim:

To determine the Co-efficient of discharge (C_d) through venturimeter and orifice meter.

Apparatus Required:

Venturimeter and orifice meter test rig and stopwatch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently.
4. Open the corresponding ball valve of the venturimeter or orifice meter pipe line.
5. Adjust the amount of water flow through the pipeline by delivery valve of the pump.
6. Open the corresponding ball valves fitted to venturimeter or orifice meter tappings at two sections.
7. Note down the differential head readings in the U tube manometer.
8. Operate the butterfly valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken.
9. Change the flow rate and repeat the experiment in both venturimeter and orifice meter.
10. Reset the delivery valve and switch-OFF the pump gently.

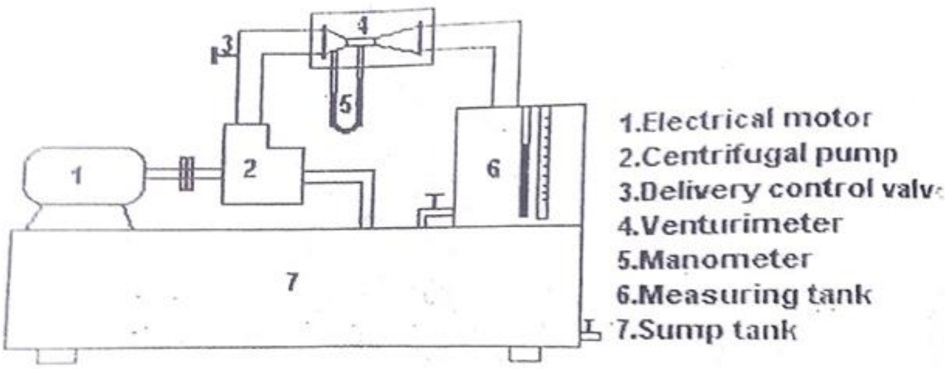


Fig: VENTURIMETER Test Rig.

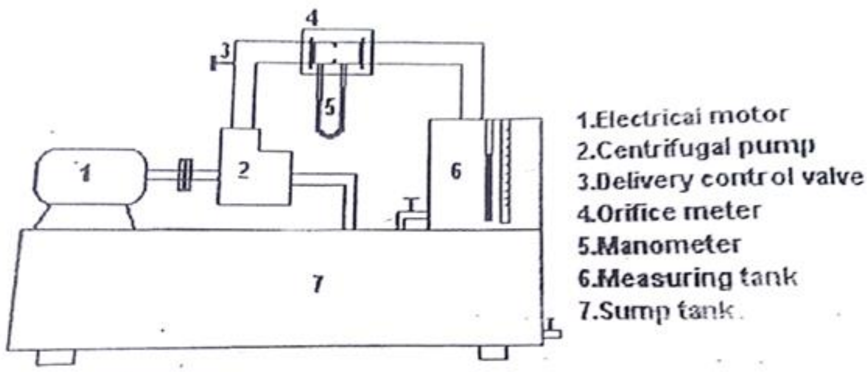


Fig: ORIFICEMETER Test Rig.

Tabular Column:

S.NO	Manometer Reading, h (cm of Hg)	Time taken for 10cm rise of water, T (sec)	Theoretical Discharge, Q_{th} (m^3/sec)	Actual Discharge, Q_{act} (m^3/sec)	Co-efficient of discharge, C_d
Flow through VENTURIMETER					
1					
2					
3					
4					
5					
Average Value of Cd					
Flow through ORIFICE METER					
1					
2					
3					
4					
5					
Average Value of Cd					

Specification:

- ✓ Area of Collecting (Measuring) tank, 'A' = 0.0750 m^2
- ✓ Acceleration due to gravity, 'g' = 9.81 m/s^2
- ✓ Diameter of the Venturimeter (throat), 'd' = 12.5 mm
- ✓ Diameter of the Venturimeter (Inlet) 'D' = 25 mm

Formulae:

1. **Theoretical Discharge,** $Q_{the} = \frac{a1 \cdot a2 \cdot \sqrt{2gH}}{\sqrt{a1^2 - a2^2}}$ **m^3/s**

   Where, a_1 = Area of inlet section of venturimeter = $\pi D^2/4$ m^2
   a_2 = Area of throat section of venturimeter = $\pi d^2/4$ m^2
   H = Pressure head = 12.6 x h m
   h = Manometer differential head in cm of Hg.

2. **Actual Discharge, Q_{act}** $= \frac{A.R}{T}$ **m^3/s**

   Where, A = Area of collecting tank m^2
   R = Water level rise in collecting tank = 10cm
   T = Time taken for 10cm water level rise in collecting tank

3. **Co-efficient of discharge, C_d = Q_{act} / Q_{the}**

Result: Coefficient of Discharge through Venturimeter =
Orificemeter =

Exp No: **Date:**

TURBINE FLOW METER

Aim:

To calculate the percentage error of turbine flow meter.

Apparatus Required:

Turbine flow meter test rig and stop watch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently.
4. Note down the time for 50 lit of water flow through turbine flow meter and time for 10cm water level rise in collecting tank.
5. Change the flow rate and repeat the experiment in turbine flow meter.
6. Reset the delivery valve and switch-OFF the pump gently.

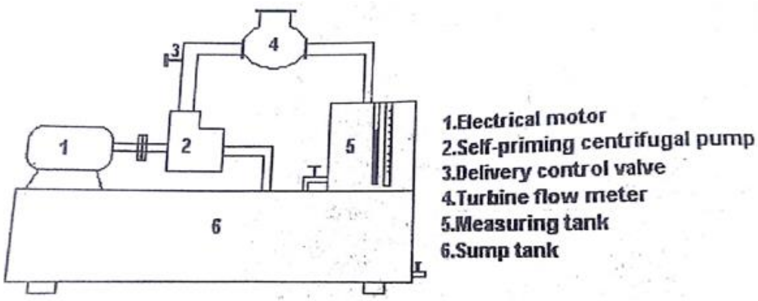


Fig: TURBINE FLOW METER Test Rig.

Tabular Column:

S.No	Time taken for: 50 lit water flow through meter, t_1 (sec)	Time taken for: 10 cm water level raise in measuring tank, t_2 sec	Discharge through the turbine flow meter, Q_w (lps)	Volume of water Collected, Q_{act} (lps)	Percentage Error (%)
1					
2					
3					
4					
5					
Average value of percentage error					

Formulae:

1. Discharge through the turbine flow meter (Q_w) = $50/t_1$ lps

   Where, t_1 = time for 50 lit of water flow through the meter.

2. Volume of water collected (Q_{act}) = AR *1000/t_2 lps

   Where, A = Area of collecting tank = L * B = 0.4 *0.4 m^2

   R = Rise of water level in collecting tank = 10cm

   t_2 = Time taken for 10 cm water level rise in collecting tank

Result: The percentage error of turbine flow meter is :

Exp No: **Date:**

EXPERIMENT ON MOUTHPIECE

Aim:

To determine the co-efficient of discharge of given mouth piece.

Apparatus Required:

Mouthpiece test rig, mouthpieces and stop watch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently.
4. Adjust the flow rate at required head in overhead tank by using piezometer.
5. Note down the time for 10cm water level rise in collecting tank.
6. Change the flow rate, head level in overhead tank and repeat the experiment by using different mouthpieces (cylindrical/convergent/divergent).
7. Reset the delivery valve and switch-OFF the pump gently.

Specifications:

- ✓ Cylindrical mouthpiece: Diameter (d) = 8 mm, Area (A) = 5.03×10^{-5} m^2
- ✓ Convergent mouthpiece: Diameter (d) = 7 mm, Area (A) = 2.83×10^{-5} m^2
- ✓ Divergent mouthpiece: Diameter (d) = 8 mm, Area (A) = 5.03×10^{-5} m^2
- ✓ Area of collecting tank = 0.075 m^2

Tabular Column:

Type of mouthpiece	S.No.	Head over the mouthpiece, H (m)	Time taken for 10cm water level rise in collecting tank, T (sec)	Theoritical discharge, (Qth) (m^3/sec)	Actual discharge, (Qact) (m^3/sec)	Co-efficient of discharge, Cd
Cylindrical (8 mm)	1					
	2					
	3					
					Average Value of Cd	
Convergent (7 mm)	1					
	2					
	3					
					Average Value of Cd	
Divergent (8 mm)	1					
	2					
	3					
					Average Value of Cd	

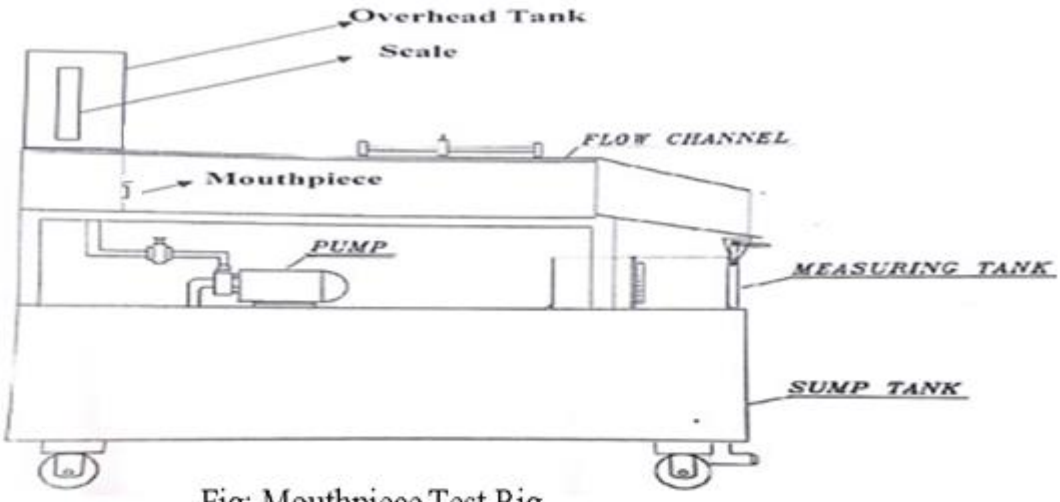


Fig: Mouthpiece Test Rig.

Formulae:

1. **Theoretical Discharge,** $Q_{the} = a\sqrt{2gH}$ m^3/s

   Where, a = Area of mouthpiece used in m^2
   H= Head of water at overhead tank in m
   g = Acceleration due to gravity = $9.81 m/s^2$

2. **Actual Discharge,** $Q_{act} = \frac{A.R}{T}$ m^3/s

   Where, A = Area of collecting tank = $0.075 m^2$
   R = Water level rise in collecting tank = 10cm
   T = Time taken for 10cm water level rise in collecting tank

3. **Co-efficient of discharge,** $C_d = Q_{act} / Q_{the}$

Result: Coefficient of Discharge (C_d) through given Mouthpiece:

Cylindrical mouthpiece =
Convergent mouthpiece =
Divergent mouthpiece =

Exp No: **Date:**

EXPERIMENT ON ORIFICE

Aim:

To determine the coefficient of velocity (C_V), coefficient of contraction (C_C) and coefficient of discharge (C_d) for a sharp-edged circular orifice.

Apparatus Required:

Orifice test rig, orifice plates and stop watch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently.
4. Adjust the flow rate at required head at constant in overhead tank by using piezometer and measure the head of water *H* above the centre line of the orifices.
5. Note down the values at near and farthest the jet of water leaves through orifice plate by measuring with the help of X-Y coordinates scale.
6. Note down the time for 10cm water level rise in collecting tank.
7. Repeat the experiment by change the flow rate, head level in overhead tank and change the different size of orifice plates.
8. Reset the delivery valve and switch-OFF the pump gently.

Tabular Column:

Dia. of Orifice, d (mm)	Head, H (mm)	Point Gauge reading						Time for 5 cm Rise of water level (sec)	Qact (m^3/sec)	Qth (m^3/sec)	C_d	V_{act}	V_{th}	C_V	C_C
		Horizontal X (mm)			Vertical Y (mm)										
		X_i	X_o	$X = X_o - X_i$	Y_i	Y_o	$Y = Y_i - Y_o$								
6															
	Average Values														
8															
	Average Values														
10															
	Average Values														

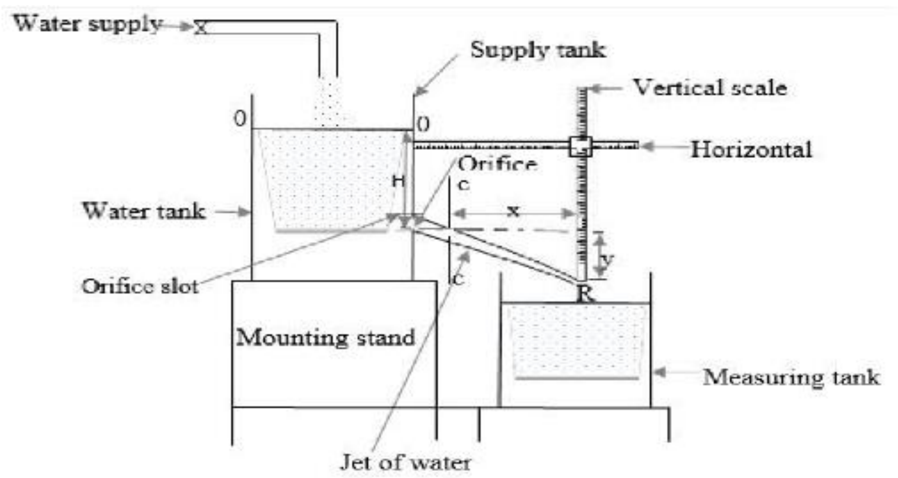


Fig: Orifice Test Rig.

Formulae:

1. **Theoretical Discharge,** $Q_{the} = a\sqrt{2gH}$ **m³/s**

   Where, a = Area of mouthpiece used
   H= Head of water at overhead tank in m
   g = Acceleration due to gravity = $9.81 m/s^2$

2. **Actual Discharge,** $Q_{act} = \frac{A.R}{T}$ **m³/s**

   Where, A = Area of collecting tank = $0.075 m^2$
   R = Water level rise in collecting tank = 10cm
   T = Time taken for 10cm water level rise in collecting tank

3. **Co-efficient of Discharge,** $C_d = Q_{act} / Q_{the}$

4. **Actual Velocity,** $V_{act} = \sqrt{(gx^2/2y)}$ **m/s**

5. **Theoretical Discharge,** $V_{the} = \sqrt{2gH}$ **m/s**

   Where, H = Head of the water in overhead tank in m.
   $X = X_o - X_i$ = Horizontal distance point gauge reading in m
   $Y = Y_i - Y_o$ = Vertical distance point gauge reading in m.
   g = Acceleration due to gravity= $9.81 m/s^2$

6. **Co-efficient of Velocity:** $C_v = V_{act} / V_{th}$

7. **Co-efficient of contraction** $C_c = C_d / C_V$

Result: The average values for a sharp-edged circular orifice are:

Coefficient of Discharge (Cd) =
Coefficient of velocity (C_V) =
Coefficient of contraction (C_C) =

Exp No: **Date:**

EXPERIMENT ON NOTCHES

Aim:

To calibrate the given V-notch and Rectangular notch by establishing the relationship between the flow rate and the head over notches.

Apparatus Required:

Notch test rig with hook gauge, notch plates and stop watch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Fix the required notch under test at the end of the flow channel.
4. Switch-ON the pump and open the delivery valve gently.
5. Adjust the flow rate and measured the head of water flow in channel by using hook gauge while the gauge needle just touches the free surface of water.
6. Note down the time for 10cm water level rise in collecting tank.
7. Change the flow rate and repeat the experiment at different discharge quantity and also change the various shape and size of given notches.
8. Reset the delivery valve and switch-OFF the pump gently.

Tabular Column:

Type of Notch	S.No	Hook gauge reading (mm)	Time taken for 10 cm water level rise in collecting tank (sec)	Q_{act} (m^3/sec)	Q_{th} (m^3/sec)	C_d
Rectangular Notch b=0.06m	1					
	2					
	3					
	Average Value of C_d					
V-Notch (60^0 or 90^0)	1					
	2					
	3					
	Average Value of C_d					

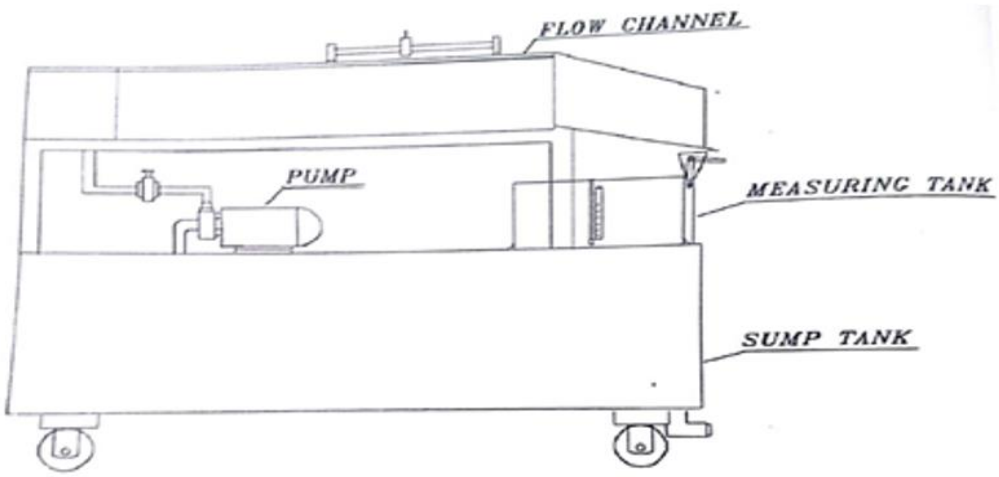


Fig: Notches Test Rig.

Formulae:

1. **Actual Discharge, $Q_{act} = \frac{A.R}{T}$ m^3/s**

   Where, A = Area of collecting tank = $0.075m^2$
   R = Water level rise in collecting tank = 10cm
   T = Time taken for 10cm water level rise in collecting tank

2. **Theoretical Discharge through rectangular notch, $Q_{th} = (2/3)\ b\ \sqrt{2gH}$ m^3/s**

   Where, Width of the Notch, b = 60 mm
   Acceleration due to gravity, g = $9.81m/s^2$
   H = Height of water surface above the sill level in meter.

   [Or]

   Theoretical Discharge through V-notch, $Q_{th} = (8/15)\sqrt{[(2g)\ \tan(\theta/2)\ H^{5/2}]}$ m^3/s

   Where, θ = Angle of V-notch (60^0 or 90^0)

3. **Co-efficient of Discharge, $C_d = Q_{act} / Q_{th}$**

Result:

Coefficient of discharge through rectangular notch =

Coefficient of discharge through 60^0 / 90^0 V-notch =

Exp No: **Date:**

VERIFICATION OF BERNOULLI'S THEOREM

Aim:

To verify the Bernoulli's theorem (Law of conservation of energy) by using the venturimeter.

Apparatus Required:

Bernoulli's experiment test rig and stop watch.

Theory: A fluid body can possess the following types of energy, namely;

Pressure energy, Kinetic energy and Potential energy.

Pressure Energy: is the energy possessed by the fluid body by virtue of the pressure at which it is maintained.

Kinetic Energy: is the energy possessed by the fluid body by virtue of its motion.

Potential Energy: is the energy possessed by the fluid body by virtue of its position or location in space.

Bernoulli's theorem is states that "In an incompressible fluid the flow is steady and continuous the sum of pressure head, kinetic head and potential head is same at all sections.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently.
4. Control the flow of water through balancing tank (supply tank and delivery tank) connected to venturimeter with connections to piezometer tubes at 10 different sections and measured the values of head of water in it.
5. Note down the time for 10cm water level rise in collecting tank.
6. Change the flow rate and repeat the experiment at different head of water in balancing tank.
7. Reset the delivery valve and switch-OFF the pump gently.

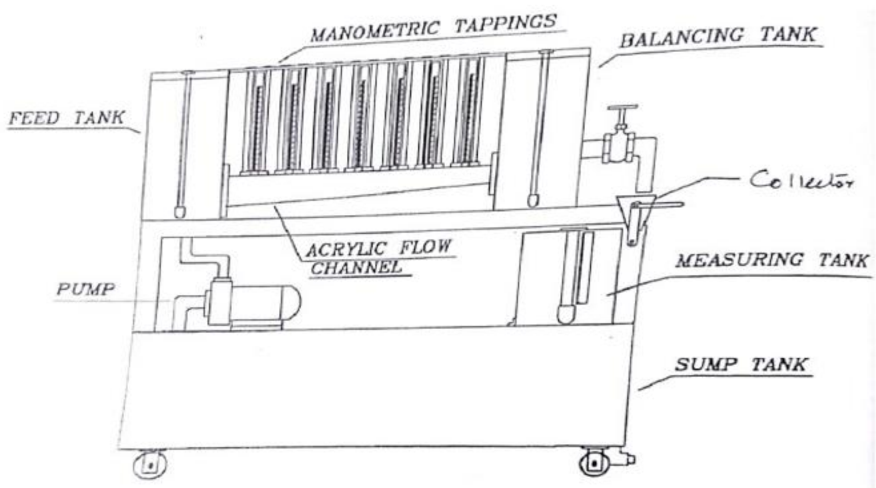


Fig: Bernoulli's Theorem Test Rig.

Tabular Column:

Tapping	Area of venturi (m^2)	Head at sections (m) (a)	Delivery head (m) (b)	Time for 10cm rise of water level (sec)	Discharge (m^3/sec)	Velocity (m/s)	Velocity head (m) (c)	Total head (m) (a+b+c)
P1	0.000491							
P2	0.000357							
P3	0.000245							
P4	0.000153							
P5	0.000123							
P6	0.000153							
P7	0.002020							
P8	0.000279							
P9	0.000369							
P10	0.000471							

Formulae:

1. **Discharge, Q_{act} = $\frac{A.R}{T}$ m^3/s**

   Where, A = Area of collecting tank = 0.044m^2

   R = Water level rise in collecting tank = 10cm

   T = Time taken for 10cm water level rise in collecting tank

2. **Velocity = Q/A (m/s)**

   Where, Q = Discharge in m^3/s

   A = Area of venturi section in m^2

3. **Total Head, H = Pressure head +Kinetic head +Potential head**

   H = (Head at point in m) + ((Velocity in m/s)^2/2 g)+ (Delivery head in m)

Result:

Bernoulli's theorem is states that "In an incompressible fluid, the flow is steady and continuous, the sum of pressure head, kinetic head and potential head is same at all sections.

(i.e) Total Head, H =

Hence the Bernoulli's theorem is verified.

Exp No: **Date:**

IMPACT OF JET ON VANES

Aim:

To determine the co-efficient (Ci) of impact of jet on vanes (Flat vane / Inclined vane / Hemi-spherical vane).

Apparatus Required:

Impact of jet on vanes test rig with various shape of vanes and various size of nozzles and stop watch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Fix the required vane and nozzle and set the force indicator to show zero.
4. Close the front transparent cover tightly.
5. Switch-ON the pump and open the delivery valve gently.
6. Adjust the water flow rate, measured the rotameter reading and also observe the force as indicated on force indicator.
7. Note down the diameter of jet, shape of vane, flow rate, force and tabulate the results.
8. Repeat the experiment at different flow rates with same jet and vane.
9. Change the vanes/nozzles and carryout the experiment with different flow rates.
10. Reset the delivery valve and switch-OFF the pump gently.

Tabular Column:

Type of Vane	Jet Dia.	Discharge, Q_d		Actual Force, F_A (kg)	Area, A (m^2)	Velocity, V (m/s)	Theoretical force, F_T (N)	Coefficient of impact, Ci
		Rota meter reading, Q (lpm)	(m^3/s)					
Flat Vane	4 mm or 5 mm or 7 mm	**5**						
		10						
		15						
							Average C_i	
Inclined Vane		5						
		10						
		15						
							Average C_i	
Curved Vane		5						
		10						
		15						
							Average C_i	

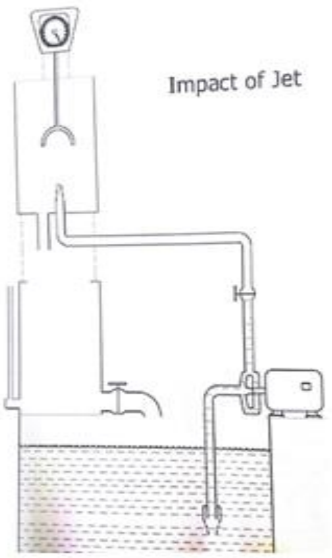


Fig: Impact of Jet on Vanes Test Rig.

Formulae:

1. **Discharge, $Q_d = \frac{Q}{60 \times 1000}$ m^3 / s**

   Where: Q = Rota meter reading in lpm

2. **Velocity, $V = (Q_d / A)$ m/s**

   Where, A = Area of jet in $m^2 = (\pi d^2 /4)\ m^2$

   d = Diameter of nozzle in m

3. **Theoretical force, F_T:**

   i. For Flat Vane: **$F_T = \rho A V^2/g$ kg**

   ii. For Hemispherical or Curved Vane: **$F_T = 2\rho A V^2/g$ kg**

   iii. For Inclined Vane: **$F_T = \rho A V^2 \sin\theta/g$ kg** (Where, $\theta = 60^0$)

4. **Co-efficient of Impact, $C_i = F_A/F_T$**

   Where, F_A = Actual force obtained directly from force indicator.

Result: Coefficient of impact on: Flat vane, **C_i =**

Hemi-spherical vane, **C_i =**

Inclined vane, **C_i =**

Exp No: **Date:**

PERFORMANCE TEST ON MULTI STAGE CENTRIFUGAL PUMP

Aim:

To conduct a performance test on multi stage centrifugal pump and to obtain the overall efficiency.

Apparatus Required:

Multistage centrifugal pump test rig with energy meter setup and stop watch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump and if necessary prime the pump.
3. Switch-ON the pump and open the delivery valve gently and maintained the delivery pressure as per our requirements.
4. Note down the suction pressure, time taken for 10 cm water level rise in collecting tank and measure the time for 10 revolution of energy meter disc for the corresponding delivery pressure.
5. Follow the similar procedure and repeat the test on various delivery pressures of the fluid.
6. Reset the delivery valve and switch-OFF the pump gently.

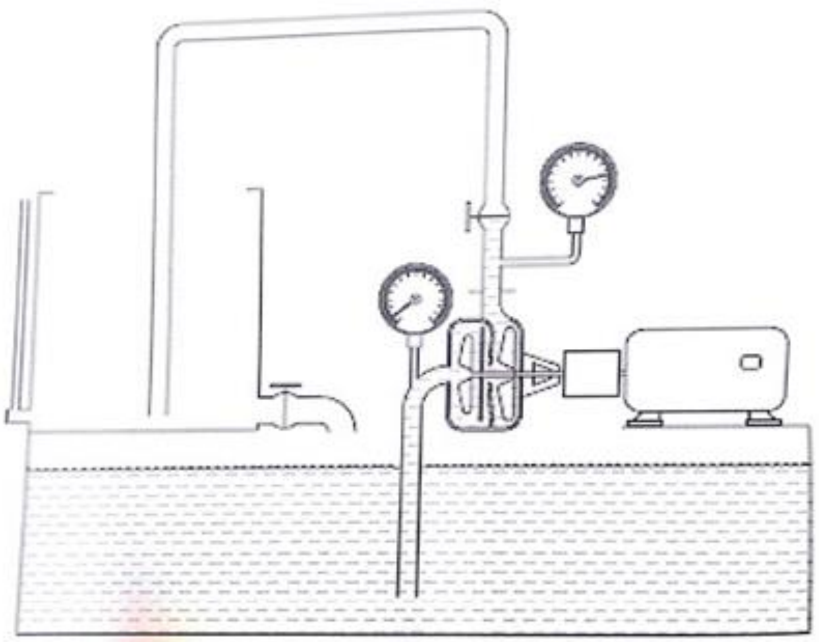


Fig: Multistage Centrifugal Pump Test Rig.

Tabular column:

S.No	Delivery Pressure Head		Suction Pressure Head		Total head, $H=H_s+H_d+X$	Time Taken		Discharge, Q_{act}	Input power, P_i	Output power, P_o	Overall Efficiency, $\eta_{overall}$
	P_d (kg/cm^2)	H_d (m of water)	P_s (mm of Hg)	H_s (m of water)	(m of water)	10cm water level rise in collecting tank, T_w (sec)	10 rev.of energy meter disc, t_e (sec)	(m^3/s)	(kW)	(kW)	(%)
1											
2											
3											
4											
5											
Average Value of Overall Efficiency, $\eta_{overall}$											

Formulae:

1. **Discharge, Q = AR/T_w m^3/s**

   Where, A= Area of collecting tank = 0.7 x 0.7 m^2
   R= Rise of water in the collecting tank = 0.1m.
   T_w= Time taken for 10cm water level rise in collecting tank in seconds.

2. **Total head, H = H_s + H_d + X m of water.**

   Where, H_s = Suction head = [(P_s x 13.6 x 1) / 1000] in meter
   P_s = Suction pressure gauge reading in mm of Hg
   H_d = Delivery head in m of water = [P_d X 10] in meter
   P_d = Delivery pressure gauge reading in kg/cm^2
   X= Difference in height between the water level in the pump and the center of pressure gauge = 1m.

3. **Electrical power input to the pump (Input Power) = (n/t_e) x (3600 /K)×1000×0.8 W**

   Where, n = Number of revolutions of energy meter disc = 10 rev.
   t_e = Time taken for 10 revolutions of energy meter disc in seconds
   K = Energy meter constant = 1200 rev/kW-hr
   Motor efficiency = 80% = 0.8

4. **Water power output (Output Power) = ωQH Watt**

   Where, ω = Specific weight of water = 9810 N/m^3
   Q = Discharge in m^3/s
   H = Total head in m of water

5. **Overall efficiency of the pump, $\eta_{overall}$ = (Output power / Input power) x 100 %**

Graph: H Vs Q, Pi and $\eta_{overall}$

Result: The overall efficiency of multistage centrifugal pump ($\eta_{overall}$) is = %

Exp No: **Date:**

PERFORMANCE TEST ON RECIPROCATING PUMP

Aim:

To conduct a performance test on reciprocating pump and to obtain the overall efficiency and to determine the percentage of slip.

Apparatus Required:

Reciprocating pump test rig with energy meter setup and stop watch.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently and maintained the delivery pressure as per our requirements.
4. Note down the suction pressure, time taken for 10 cm water level rise in collecting tank and measure the time for 1revolution of energy meter disc for the corresponding delivery pressure.
5. Follow the similar procedure and repeat the test on various delivery pressures of the fluid.
6. Reset the delivery valve and switch-OFF the pump gently.

Tabular column:

S.No	Delivery Pressure Head		Suction Pressure Head		Total head,	Time Taken		Discharge		% of Slip	Input power, P_i	Output power, P_o	Overall Efficiency, $\eta_{overall}$
	P_d (kg/cm^2)	H_d (m of water)	P_s (mm of Hg)	H_s (m of water)	$H=H_s+H_d$ (m of water)	10cm water level rise in collecting tank, T_w (sec)	1 rev.of energy meter disc, t_e (sec)	Q_{act} (m^3/s)	Q_{the} (m^3/s)	(%)	(kW)	(kW)	(%)
1													
2													
3													
4													
5													
Average Values of % of slip												$\eta_{overall}$	

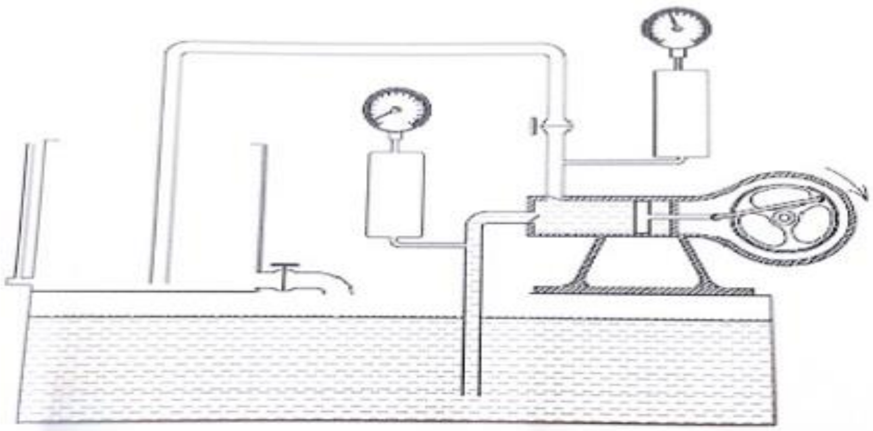


Fig: Reciprocating Pump Test Rig.

Formulae:

1. **Actual Discharge, $Q = AR/T_w$ m^3/s**

   Where, A= Area of collecting tank = 0.25 m^2

   R= Rise of water in the collecting tank = 0.1m.

   T_w= Time taken for 10cm water level rise in collecting tank in seconds.

2. **Theoretical discharge (Q_{th}) = 2LAN/60 m^3/s**

   Where, L = stroke length of the piston = 0.045m

   A = Piston area = 0.001257m^2

   N = Speed of pump = 326 rpm

3. **Percentage of slip = $[(Q_{th}-Q_{act})/Q_{th}] \times 100$ %**

4. **Total head, $H = H_s + H_d$ m of water.**

   Where, H_s = Suction head = $[(P_s \times 13.6 \times 1) / 1000]$ in meter

   P_s = Suction pressure gauge reading in mm of Hg

   H_d = Delivery head in m of water = $[P_d \times 10]$ in meter

   P_d = Delivery pressure gauge reading in kg/cm^2

5. **Electrical power input to the pump (Input Power) = $(n/t_e) \times (3600 / K) \times 1000 \times 0.8$ W**

   Where, n = Number of revolutions of energy meter disc = 1rev.

   t_e = Time taken for 10 revolutions of energy meter disc in seconds

   K = Energy meter constant = 240 rev/kW-hr

   Motor efficiency = 80% = 0.8

6. **Water power output (Output Power) = ωQH Watt**

   Where, ω = Specific weight of water = 9810 N/m^3

   Q = Discharge in m^3/s

   H = Total head in m of water

7. **Overall efficiency of the pump, $\eta_{overall}$ = (Output power / Input power) x 100 %**

Graph: H Vs Q, Pi and $\eta_{overall}$

Result: The overall efficiency of reciprocating pump ($\eta_{overall}$) is = %

Percentage of slip = %

Exp No: **Date:**

PERFORMANCE TEST ON PELTON WHEEL TURBINE

Aim:

To conduct a performance test on Pelton wheel turbine and to obtain the overall efficiency.

Apparatus Required:

Pelton wheel turbine test rig, tachometer and differential U-tube manometer.

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently.
4. Note down the pressure gauge reading and pressure difference in venturimeter for measuring the actual discharge from pump by use of differential U-tube manometer.
5. Note down the speed of the turbine by adding spring loaded weight on turbine break drum.
6. Rotate the spear wheel manually and maintained rated speed of the turbine.
7. Repeat the procedure for various discharge and speed.
8. Reset the delivery valve and switch-OFF the pump gently.

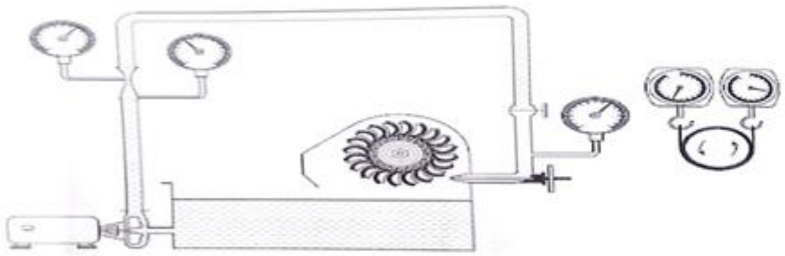


Fig: Pelton Wheel Turbine Test Rig.

Tabular column:

S.No	Pressure gauge reading, Pg (Kg/Cm^2)	Spring balance difference, W (Kg)	Monometer difference, h (m)	Discharge, Q (m^3/s)	Head over the turbine, H_T (m)	Input power, P_i (kW)	Output power, P_o (kW)	Overall efficiency, $\eta_{overall}$ (%)
1								
2								
3								
4								
5								
							Average values of overall efficiency, $\eta_{overall}$	

Formulae:

1. **Actual Discharge, $Q_{act} = C_d \times \frac{a1 . a2 . \sqrt{2gH}}{\sqrt{a1^2 - a2^2}}$ m^3/s**

   Where, a_1 = Area of inlet section of venturimeter = 1.963×10^{-3} m^2

   a_2 = Area of throat section of venturimeter = 1.13×10^{-3} m^2

   C_d = coefficient of discharge of Venturimeter = 0.98

   H = Pressure head = 12.6 x h m

   h = Manometer differential head in mm of Hg.

2. **Input power, Pi = $\omega Q H_T$ Watt**

   Where, ω = Specific weight of water = 9810 N/m^3

   Q = Discharge, in m^3/s

   H_T = Head over the turbine = P_g x 10 m

   P_g = Pressure gauge reading in kg/cm^2

3. **Output power (P_o) in Watts = $2\pi NT/60$ Watt**

   Where, N = Speed of turbine, in rpm

   T = WR = (Spring balance difference x 9.81) (0.12925+0.006) N-m

4. **Overall efficiency of the turbine, $\eta_{overall}$ = (Output power / Input power) x 100 %**

Graph: Q Vs Po, Pi, $\eta_{overall}$

Result: The overall efficiency of the Pelton turbine is = %

Exp No: **Date:**

PERFORMANCE TEST ON KAPLAN TURBINE

Aim:

To conduct a performance test on Kaplan turbine and to obtain the overall efficiency under constant head and constant speed.

Apparatus Required:

Kaplan turbine test rig, tachometer and differential U-tube manometer.

Specifications:

Rated supply head :5 to 8 m	Power input :1 HP	Runner outside diameter :125mm	Brake drum diameter:300 mm
Discharge :1000 lpm	Hub diameter:78 mm	Rope brake diameter:15mm	No. of runner blades:4
Rated speed:1000 rpm	Runway speed:1750 rpm	Pitch circle diameter of guide vanes: 180 mm	

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve at correct position in pump.
3. Switch-ON the pump and open the delivery valve gently.
4. Slowly open the gate, so that the turbine rotor picks up the speed and attains maximum at full opening of the gate.
5. Note down the voltage and current, speed, vacuum pressure on the control panel, head over the notch and tabulate the results.
6. Follow the same procedure described below for taking down the reading for evaluating the performance characteristics of the Kaplan turbine.
7. Reset the delivery valve and switch-OFF the pump gently.

Tabular column:

S. No	Pressure gauge reading, H (kg/cm^2)	Orifice meter head pressure gauge reading, P (kg/cm^2)			Discharge (m^3/s)	Weight on hanger (kg)	Spring balance reading (kg)	Total weight W= W1-W2 (kg)	Speed (rpm)	Input Power (kW)	Output Power (kW)	Overall Efficiency (%)
	P	P1	P2	P = P1 - P2	Q	W1	W2	W	N	IP	OP	$\eta_{overall}$
1												
2												
3												
4												
5												
											Average values of overall efficiency, $\eta_{overall}$	

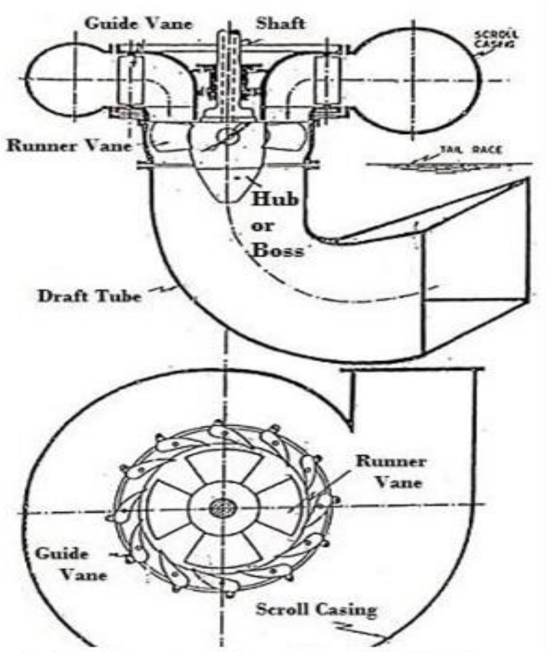


Fig: Kaplan Turbine Test Rig.

Formula:

Input power = wQH/1000 kW

Where, w = Specific weight of water = 9810 N/m^3

Q = discharge in m^3/sec

H = supply head in m

Brake (Output) power = [(2πNTx9.81) / (60 x 1000)] kW

Where, N = Turbine speed in rpm

T = Torque in N-m,

T = [Net brake load in kg (W) x Effective radius of the brake drum in meters (R)]

Overall Efficiency of the turbine, $\eta_{overall}$ = (Output power / Input power) x 100 %

- Brake Drum Dia, D_{BD} =0.3m,
- Input total head in meters of water = pressure gauge reading in kg/cm^2 x 10 m
- Rope Dia, D_R = 0.015 m,
- Orifice meter Head, P = (P_1 - P_2) x 10 m
- Effective radius = ($D_{BD}/2 + D_R$) = 0.165 m,
- Weight of rope and hanger = 1 kg,
- Discharge, Q = K√P (h in m of water),
- Input power, IP = ωQH kW (H in m of water),
- Run away speed, N = 1750 rpm,
- Brake drum net load, W = [(W_1+Weight of rope and hanger) – W_2] kg,
- Value of K = 2.3652 X 10^{-2},
- Turbine output, OP= (2πNWRe x 9.81) / (60 x 1000) kW
- R_e = 0.165 m.
- Efficiency η = (OP/IP) x 100 %.

Graph:

Q Vs Po, Pi, $\eta_{overall}$

Result:

The overall efficiency of the Kaplan turbine is = %

RUBRICS FOR FLUID MECHANICS AND MACHINERY LAB

	Excellent(3)	**Good(2)**	**Fair(1)**
Conduct Experiments (CO1)	Student successfully completes the experiment, records the data, analyzes the experiment's main topics and explains the experiment concisely and well.	Student successfully completes the experiment, records the data and analyzes the experiment's main topics.	Student successfully completes the experiment, records the data and unable to analyzes.
Analysis (CO2)	Thorough analysis of equipments’ performance.	Reasonable analysis of equipments’ performance.	Improper analysis of equipments’ performance.
Design (CO3)	Student understands what needs to be tested and designs an appropriate experiment and explains the experiment concisely and well.	Student understands what needs to be tested and designs an appropriate experiment.	Student understands what needs to be tested and does not design an appropriate experiment.
Complex Analysis & Conclusion (CO4)	Thorough comprehension through analysis/synthesis.	Reasonable comprehension through analysis/synthesis.	Improper comprehension through analysis/synthesis.
Report Writing (CO5)	Status report with clear and logical sequence of parameter using excellent language.	Status report with logical sequence of parameter using understandable language.	Status report not properly organized.
Lab Safety (CO6)	Student will demonstrate good understanding and follow lab safety.	Student will demonstrate good understanding of lab safety.	Students demonstrate a little knowledge of lab safety.
Ability to Work in Teams (CO7)	Performance on teams is excellent with clear evidence of equal distribution of tasks and effort.	Performance on teams is good with equal distribution of tasks and effort.	Performance on teams is acceptable with one or more members carrying a larger amount of the effort.
Continuous Learning (CO8)	Highly enthusiastic towards continuous learning.	Interested in continuous learning.	Inadequate interest in continuous learning.

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