SVR ENGINEERING COLLEGE

NANDYAL-518501, KURNOOL(DIST.) A.P

OFFERING DIPLOMA, B.TECH, M.TECH, MBA COURSES

APPROVED BY AICTE NEW DELHI- AFFILIATED TO JNTU, ANANTAPURAM.

DEPARTMENT OF

MECHANICAL ENGINEERING

FLUID MECHANICS & HYDRAULICS MACHINERY LAB MANUAL

SUBJECT CODE-15A01511

NAME	: ______________________
ROLL NO	: ______________________
CLASS/SEM	: ______________________
ACADEMIC YEAR	: 2020-21

INDEX

S.NO	DATE	NAME OF EXPERIMENT	PAGE.NO	MARKS	REMARKS
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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

B. Tech III-I Sem. (ME) **L T P C**
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15A01511 FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY

OBJECTIVE: *The object of the course to make the students understand the fluid flow concepts and get familiarity with flow measuring devices.*

SYLLABUS:

1. Calibration of Venturimeter
2. Calibration of Orifice meter
3. Determination of Coefficient of discharge for a small orifice by a constant head method.
4. Determination of Coefficient of discharge for an external mouth piece by variable head method.
5. Calibration of contracted Rectangular Notch and /or Triangular Notch.
6. Determination of Coefficient of loss of head in a sudden contraction and frictionfactor.
7. Varification of Bernoulli's equation.
8. Impact of jet on vanes.
9. Study of Hydraulic jump.
10. Performance test on Pelton wheel turbine.
11. Performance test on Francis turbine.
12. Efficiency test on centrifugal pump.

LIST OF EQUIPMENT:

1. Venturimeter Setup.
2. Orifice meter setup.
3. Small orifice setup.
4. External mouthpiece setup.
5. Rectangular and Triangular notch setups.
6. Friction factor test setup.
7. Bernoulli's theorem setup.
8. Impact of jets.
9. Hydraulic jump test setup.
10. Pelton wheel and Francis turbines.
11. Centrifugal pumps.

‘Instructions to the Students’

DO’s

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

DONT’s

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

Experiment No. 1 **Date:**

CALIBRATION OF VENTURIMETER

Aim:

To demonstrate the use of venturi meter as flow meter and to determine the co- efficientof discharge in closed conduit or pipe flows. Also to plot the graph of theoretical discharge vs actual discharge (Q_{th} vs. Q_a) and co-efficient of discharge vs. actual discharge (C_d Vs Q_a).

Apparatus Required:

1. A constant steady supply of water with a means of varying the flow rate using monoblock pump.
2. A pipe line fitted with a venturimeter.
3. Measuring tank to measure the flowrate.
4. Tappings with ball valves are provided at inlet & throat of venturimeter and these are connected to differentialmanometer.
5. Electronic digital timer with float switch for measurement of flow rate by collecting fixed quantity ofwater.

Specifications:

1. Supply pipe of ø 21 mm (3/4") connected to inletmanifold.
2. Venturimeter size inlet ø 21.5 mm and throat ø 15mm.
3. Orifice meter size inlet ø 20 mm and throat ø 14mm.
4. Differential mercury manometer tapings provided at inlet and throat of venturi meter and orifice meter. Manometer size 50 cmheight.
5. Measuring tank size - 300 mm x 300 mm x 300 mmheight.

Theory:

A **Venturimeter** is a device which is used for measuring the rate of flow of fluid through pipe line. The basic principle on which a venturimeter works is that by reducing the cross-sectional area of the flow passage, a pressure difference is created between the inlet and throat, and the measurement of the pressure difference enables the determination of the discharge through thepipe.

A venturimeter consists of,

1. An inlet section followed by a convergentcone,
2. A cylindrical throatand
3. A gradually divergentcone.

The inlet section of the venturimeter is of the same diameter as that of the pipe which is followed by a convergent cone. The convergent cone is a short pipe which tapers from the original size of the pipe to that of the throat of the venturimeter. The throat of the venturimeter is a short parallel sided tube having its cross sectional area smaller than that of the pipe. The divergent cone of the venturimeter is a gradually diverging pipe with its cross-sectional area increasing from that of the throat to the original size of the pipe. At the inlet section and the throat of the venturimeter, pressure taps are provided through pressure rings.

Photograph of the setup:

CUT SECTIONAL VIEW OF VENTURIMETER

VENTURIMETER SETUP

Procedure:

All the necessary instrumentations along with its accessories are readily connected. It is just enough to follow the instructions below:

1. Fill in the sump tank with cleanwater.
2. Keep the delivery valveclosed.
3. Connect the power cable to 1 Ph, 220 V, 10 Amps with earthconnection.
4. Switch ON the pump and open the deliveryvalve.
5. Open the corresponding ball valve of the venturimeter pipe, keeping the valve of orificemeterclosed.
6. Adjust the flow through the control valve of thepump.
7. Open the corresponding ball valves fitted to venturimetertappings.
8. Expel if any air is there by opening the drain cocks provided with the manometer and note down the differential head reading in themanometer.
9. Close the Butterfly Valve of the collecting tank and note down the time taken for 20 c.m. rise of waterlevel
10. Keep the butterfly valve open when the readings are nottaken.
11. Change the flow rate and repeat the steps 6 to 9 for 10 different flowrates.

Observation Table:

S.No	Discharge of water collected		Manometer readings		
	Rise in water 'R' in cm	Time taken "t" in sec.	Head 'h_1' in cm of Hg	Head 'h_2' in cm of Hg	Differential head $h= h_1-h_2$ in cm ofHg
1.					
2.					
3.					
4.					
5.					

Calculation:

S.No	Loss of head H=12.6(m)	Actual Discharge Q_a,m^3 /sec	Theoretical discharge Q_{th} , m^3/sec	Co-efficient of discharge C_d	Average C_d
1.					
2.					
3.					
4.					
5.					

Data:

Area of measuring tank = "A" = 0.12m^2
Acceleration due to gravity = "g" = 9.81m\sec^2
Diameter of venturimeter (throat) "d"=12.5mm
Diameter of inlet pipe of Venturimeter "D"=25mm

Formulae:

1. Theoreticaldischarge:$Q_{th} = \frac{a_1 a_2\sqrt{2gH}}{\sqrt{(a^2{}_1 - a^2{}_2)}}$

Where,a_1= areaof inlet section of venturimeter =$\frac{\pi D^2}{4}$$m^2$

a_2= area of throat of venturimeter =$\frac{\pi d^2}{4}$$m^2$

2. Actual discharge $Q_n = \frac{A\times R}{t} m^2/sec$

Where A= area of measuring tank in $m^{2.}$

R= rise of water level in m.

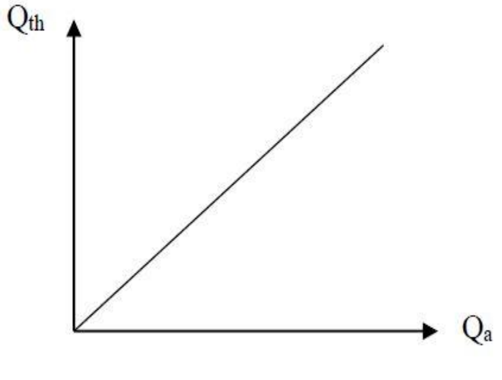
t = time taken for rise of water level in sec.

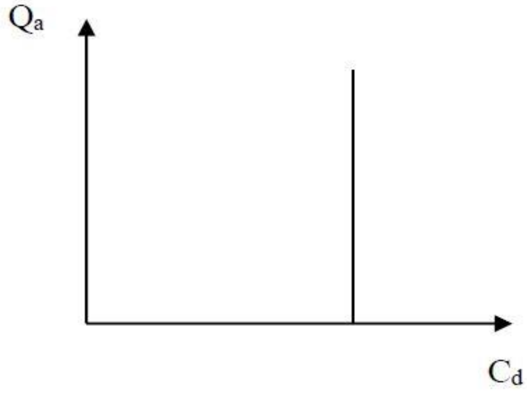
3. co-efficient of discharge:

$$C_d = \frac{Actual\ discharge}{theoritical\ discharge}, \frac{Q_a}{Q_{th}}$$

Graph:

Plot the graph of theoretical discharge vs actual discharge$Q_{th} = Q_a$ and co-efficient of discharge vs actual discharge C_d vsQ_a





Precautions:

1. Avoid manual error while noting the readings
2. Do not start the pump if the voltage is less than 180v.
3. Frequently (at least once in three months) grease / oil the rotatingparts.
4. Initially, put clean water free from foreign material, and change once in threemonths.
5. Operate the unit for five minutes to prevent clogging of the moving parts.

Trouble shooting:

S.No.	Problem	Remedy
1.	Unsteady manometer reading	Remove the air bubbles by opening the drain cock.
2.	Pump not working	Prime the pump

Result /Conclusion:

The average co-efficient of discharge was calculated and found outtobe______________.

Experiment No. 2 **Date:**

CALIBRATION OF ORIFICEMETER

Aim:

To demonstrate the use of Orificemeter as flow meter and to determine the co-efficient of discharge in closed conduit or pipe flows. Also to plot the graph of theoretical discharge vs. actual discharge (Q_{th} vs. Q_a) and co-efficient of discharge vs. actual discharge (C_d vs. Q_a).

Apparatus Required:

1. A constant steady supply of water with a means of varying the flow rate using monoblock pump.
2. A pipe line fitted with an orificemeter.
3. Measuring tank to measure the flowrate.
4. Tappings with ball valves are provided at inlet and outlet of orificemeter and these are connected to differentialmanometer.
5. Electronic digital timer with float switch for measurement of flow rate by collecting fixed quantity ofwater.

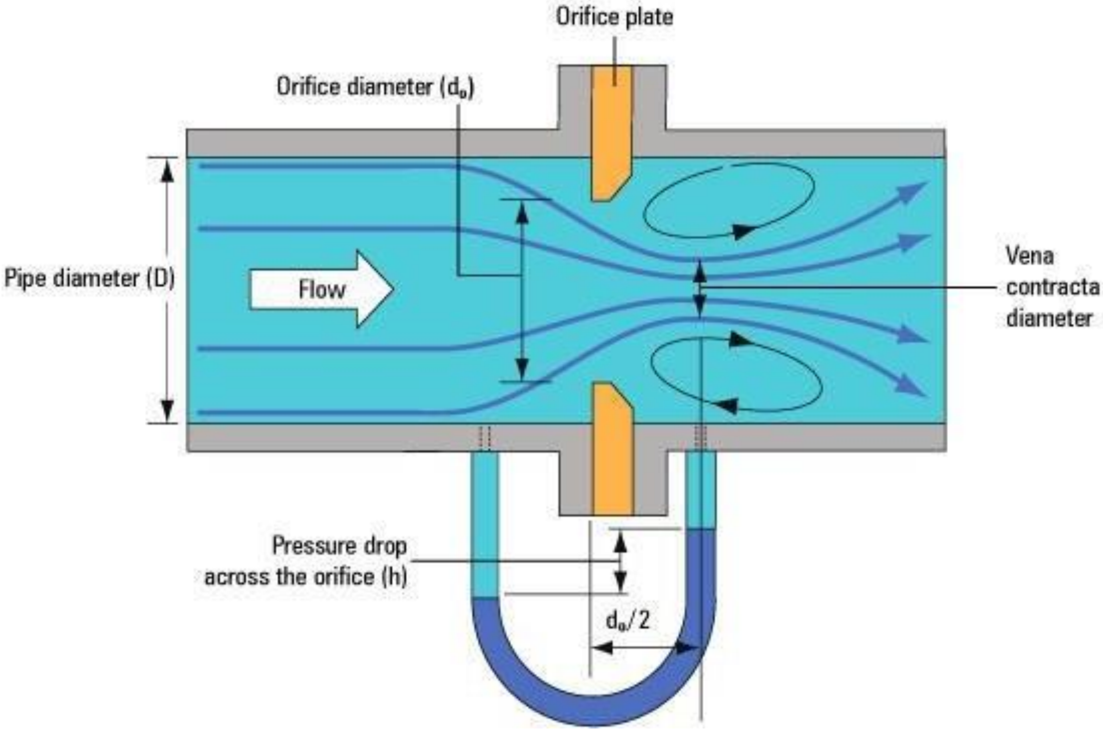
Specifications:

1. Supply pipe of ø 21 mm (3/4") connected to inletmanifold.
2. Orifice meter size inlet ø 20 mm and throat ø 14mm
3. Differential mercury manometer tapings provided at inlet and throat of orificemeter and orifice meter. Manometer size 50 cmheight.
4. Measuring tank size - 300 mm x 300 mm x 300 mmheight.

Theory:

An ORIFICE METER is another simple device used for measuring the discharge through pipes. Orifice meter also works on the same principle as that of venturimeter i.e., by reducing the cross-sectional area of the flow passage, a pressure difference between the two sections before and after orifice is developed and the measurement of the pressure difference enables the determination of the discharge through the pipe. However, an orifice meter is a cheaper arrangement for discharge measurement through pipes and its installation requires a smaller length as compared with venturimeter. As such where the space is limited, the orificemeter may be used for the measurement of discharge through pipes.

Photograph of the setup:



CUT SECTIONAL VIEW OF ORIFICEMETER

ORIFICEMETER SETUP

Procedure:

All the necessary instrumentations along with its accessories are readily connected. It is just enough to follow the instructions below:

1. Fill in the sump tank with cleanwater.
2. Keep the delivery valveclosed.
3. Connect the power cable to 1 Ph, 220 V, 10 Amps with earthconnection.
4. Switch ON the pump and open the deliveryvalve.
5. Open the corresponding ball valve of the orificemeter pipe, keeping the valve of venturimeter closed.
6. Adjust the flow through the control valve of the pump.
7. Open the corresponding ball valves fitted to orificemeter tappings.
8. Expel if any air is there by opening the drain cocks provided with the manometer and note down the differential head reading in themanometer.
9. Close the Butterfly Valve of the collecting tank and note down the time taken for 20 cm. rise of waterlevel
10. Keep the butterfly valve open when the readings are nottaken.
11. Change the flow rate and repeat the steps 6 to 9 for 10 different flowrates.

Observation Table:

S.No.	Discharge of water collected		Manometer readings		
	Rise in water 'R' in cm	Time taken "t" in sec.	Head 'h_1' in cm of Hg	Head 'h_2' in cm of Hg	Differential head $h = h_1 - h_2$ in cm ofHg
1.					
2.					
3.					
4.					
5.					

Calculation:

S.No	Loss of head H=12.6(m)	Actual Discharge Q_a, m^3/sec	Theoretical discharge Q_{th}, m^3/sec	Co-efficient of discharge C_d	Average C_d
1.					
2.					
3.					
4.					
5.					

Data:

Area ofmeasuringtank	"A"	=	$0.12m^2$
Acceleration duetogravity,	"g"	=	$9.81\ m/sec^2$
Diameter oftheorifice	"d"	=	12.5 mm
Diameter of the Inlet pipe of Orificemeter,	"D"	=	25 mm

Formulae:

1. Theoritical discharge: $Q_{th} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{(a^2{}_1 - a^2{}_2)}}$

   Where, a1= area of inlet section of venturimeter $= \frac{\pi D^2}{4} m^2$

   a_2= area of throat of venturimeter $= \frac{\pi d^2}{4} m^2$

2. Actual discharge $Q_n = \frac{A \times R}{t} m^2/sec$

   Where A= area of measuring tank in $m^{2.}$

   R= rise of water level in m.

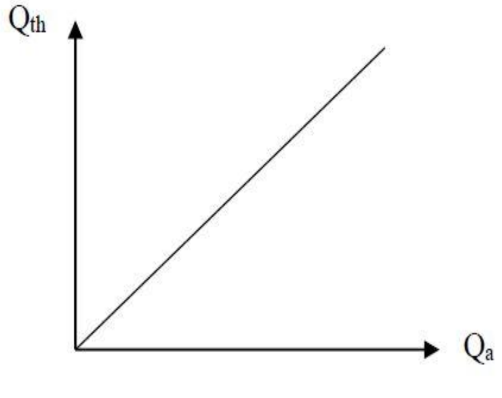
   t = time taken for rise of water level in sec.

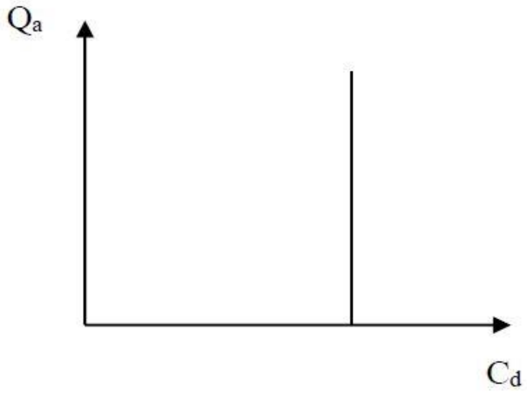
3. Co-Efficient of discharge:

   $C_d = \frac{Actual\ discharge}{theoritical\ discharge}, \frac{Q_a}{Q_{th}}$

Graph:

Plot the graph of theoretical discharge vs actual discharge$Q_{th} = Q_a$ and co-efficient of discharge vs actual discharge $C_d$vs Q_a





Precautions:

1. Avoid manual error while noting the readings
2. Do not start the pump if the voltage is less than 180v.
3. Frequently (at least once in three months) grease / oil the rotatingparts.
4. Initially, put clean water free from foreign material, and change once in threemonths.
5. Operate the unit for five minutes to prevent clogging of the moving parts.

Trouble shooting:

S.No.	Problem	Remedy
1.	Unsteady manometer reading	Remove the air bubbles by opening the drain cock.
2.	Pump not working	Prime the pump

Result /Conclusion:

The average co-efficient of discharge was calculated and found outtobe______________.

Experiment No. 3 **Date:**

OPERATING INSTRUCTIONS FOR PIPE FRICTION

AIM:

To find the friction factor in different diameter of G.I. pipes.

THEORY:

When a fluid is flowing through the pipe, it is subjected to flow resistance by a shear forces between the fluid particles. This resistance is called FRICTIONAL RESISTANCE and it depends on the velocity of flow and area of surface is in contact. This frictional resistance causes pressure loss in the direction of flow.

APPARATUS:

SS Sump Tank, SS Measuring. Tank, Manometer, G.I. Pipes of Dia 12.7 mm, 19mm and 25.4 mm, Flow Control valve, Clamps, Pressure Tappings

SPECIFICATIONS:

1. 0.5 HP Centrifugal Pump 25 X 25 mm size, mounted on Sump Tank.
2. Mercury Manometer to measure the pressure difference.
3. Stainless Steel Measuring Tank 300 mm (L) x 400 mm (W) x 500 mm (H)Capacity 60 1itres.
4. Stainless Steel Sump Tank 1000 mm (L) x 400 mm (W) x 300 mm (H) Capacity 120 liters.

TEST PROCEDURE:

1. The Sump Tank is filled with water
2. All valves are kept open and pump started to check free flow in pipelines.
3. Reduce flow rate with Outlet valve adjustment, so that mercury heads in Manometer can be varied
4. The heads and flow rates are noted.
5. Please note that all Gate valves & taps off and other lines are closed, while operating the third line.

OBSERVATIONS & TABULATION FOR PIPE FRICTION

S.No.	Pipe line (Dia)	Manometer reading, h (m)			Time taken for 20 ltrs of water collection, t (sec)	Discharge $Q = \frac{0.02}{t}$ (m^3/sec)	Velocity $V = \frac{Q}{A}$ (m/sec)	Loss of head $h_f = 12.6 x h$	Friction factor $F = \frac{2xgxdxh_f}{4xLxV^2}$
		h_1	h_2	$h_1 - h_2$					
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.									
12.									

PRECAUTIONS:

1. Do not close the gate valve completely.
2. The instrument should be operated within the range mentioned (Pressure gauge, manometer reading)
3. Water filled in the Sump tank should be free from any oil and dirt and shouldbe changed every 15 days.

GRAPH:

Draw the graph between loss of head & velocity

RESULT/CONCLUSION:

Friction Factor for 12.7 mm dia G.I Pipe:______________________________

Friction Factor for 19.0 mm dia G.I Pipe:______________________________

Friction Factor for 25.4 mm dia G.I Pipe:______________________________

Experiment No. 4 **Date:**

LOSS OF HEAD DUE TO SUDDEN CONTRACTION

Aim: To determine the loss of head due to sudden contraction in pipe

Apparatus:

The setup consists of mm basic piping in which the above fitting which is connected to a common difference manometer a gate valve at outlet and a bypass valve at pump discharge to control the flow of water.

Theory:

While installing a pipe line for conveying a fluid, it is generally not possible t0 install a long Pipe line of same size all over and straight for various reasons like space restrictions, Aesthetics location of outlet etc. Hence the pipe size varies and it changes its direction. A Variation of fluid head. The apparatus is designed to demonstrate the loss of head due to sudden contraction of the flow.

At sudden contraction, velocity of water increase which causes pressure head to drop (According to Bernoulli's Theorem) in addition to this is loss of head due to sudden contraction.

Manometer Reading= head drop due to increment of velocity + Head due to sudden contraction

Assuming no loss to do there due to contraction and applying Bernoulli's theorem at inlet and Outlet of the section.

$$\frac{p_1}{W} + \frac{{v_1}^2}{2g} = \frac{p_o}{w} + \frac{{p_o}^2}{2g}$$

Specifications:

1. Basic pumping of size 254 mm
2. Sudden contraction from 254 mm to 12mm.
3. 0.5 HP centrifugal pump to circulate the water through the piping
4. Differential Manometer
5. The sump tank of suitable capacity 1000 X 400 X 300 (120 Liters)
6. Measuring tánk-500 X 400 X 300 mm (60 Liters)

Procedure:

1. Fill up sufficient clean water in the sump tank
2. Fill up mercury in the manometer.
3. Connect the electric supply see that the flow control valve bypass valve are fully open and all the manometer corks opened.
4. Start the pump and adjust the flow rate

OBSERVATIONS & TABULATION FOR SUDDEN CONTRACTION

S.No.	Manometer reading, H (m)			Time taken for 20 ltrs of water collection, t (sec)	Discharge $Q = \frac{0.02}{t}$ (m^3/sec)	Velocity at inlet $V_i = \frac{Q}{A_i}$ m/sec	Velocity at outlet $V_o = \frac{Q}{A_o}$ m/sec	Loss of head due to velocity increment $h_v = \frac{1}{2g}(V^2{}_o - V^2{}_i)$ (m)	Manometric head h = Hx12.6 (m)	Loss of head due to sudden contraction $h_c = h - h_v$
	h_1	h_2	$h_1 - h_2$							
1.										
2.										
3.										
4.										
5.										

Losses in pipes due to contraction

Calculations:

1. Actual discharge, Q=$\frac{0.02}{t}$ m^3/sec

   Where 0.02=volume of water collected in the measuring tank

t = time taken to collect 20 ltrs of water in measuring tank, sec

2. velocity at inlet, $v_{i=}\frac{Q}{A_i}$m/sec

   Where Q= actual dischargem^3/sec

   $A_{i=}$Cross sectional area of pipe at inlet_________m^2

3. velocity at outlet, $v_o = \frac{Q}{A}$ m/sec

   Where Q= actual discharge m^3/sec

   A_O =Cross sectional area of pipe at outlet __________m^2

4. Loss of head due to velocity increment,$h_v = \frac{{v_o}^2}{2g} - \frac{{v_i}^2}{2g}$

   $= \frac{1}{2g}[{v_o}^2 - {v_i}^2]m$

   Where g= Acceleration due to gravity

   v_o= velocity at outlet m/sec

5. Manometric head, H= Manometric reading ×(13.6-1)

   Where13.6=specific gravity of mercury

   1= specific gravity of water

6. Loss of head due to sudden contraction,$h_o = h - h_v$ m

   Where h=manometric head,

   h_v =Loss of head due to velocity increment, m

Precautions:

1. Open both the manometer crocks slowly and simultaneously otherwise the mercury will run away from the manometer.
2. Operate the valves gently; do not force to rotate them.
3. Always use clean water for the experiment

Result:

Loss of head due to sudden contraction in pipe is calculated as__________

Conclusion:

1. For any type of fitting loss of head is there, but its magnitude depends upon theFitting.
2. Loss of head occurs due to change in magnitude or direction of the fluid velocity.

Experiment No. 5 **Date:**

VERIFICATION OF BERNOULLI'S THEOREM

Aim:

To verify Bernoulli's Theorem (Law of Conservation of Energy) and also to plot the graph of piezometric head, kinetic head and total head vs. points along the pipe line.

Apparatus Required:

Bernoulli's apparatus, stop watch.

Specifications:

The present apparatus is a self-contained unit operated on a closed circuit basis consisting of Sump tank, balancing tank (Supply tank), collecting tank (Delivery tank) and mono block pump set with outlet delivery valve.

Theory:

Bernoulli's Theorem is stated as "In steady continuous flow of a frictionless incompressible fluid, the sum of the Potential head, the Pressure head and the Kinetic head is the same at all points".

It is represented in the following equation form

$$\frac{p_1}{W} + \frac{{v_1}^2}{2g} + z_1 = \frac{p_o}{W} + \frac{{p_o}^2}{2g} + z_2$$

Photograph of the setup:

Observation Table:

S.No	Rise of water, R(m)	Time taken, t sec	Discharge $Q=\frac{AxR}{T}$	Points in pipe	1	2	3	4	5	6	7	8	9	10
1.				Presuure head, $p/\rho g$										
				Dia. Of pipe,d										
				Area of pipe,a										
				Distance from inlet,L										
				Velocity of flow, V=Q/A										
				Velocity head, $V^2/2g$										
				Datum head,z										
				Total head, H $p/\rho g + V^2/2g + Z$										

Procedure:

1. Fill in the Sump tank with clean water and add some quantity of colored ink toit.
2. Keep the delivery valve open.
3. Connect the power cable to 1 phase, 220V 10 amps with neutral and earth connections.
4. Switch on the pump. Now, you will find water flowing to the Collecting tank through venturimeter.
5. Now you find the different piezometric heads for corresponding points of venturimeter for constant supply head and delivery head.
6. Note down all the piezometric readings and velocity head at a particular is also noted separately by bringing the inserted to that point.
7. Note down the height of water at supply tank and delivery tank.
8. Change the delivery head by pushing down the overflow pipe and repeat the experiment.
9. Also, change flow rate and repeat the experiment.

Graph:

Plot the graph of piezometric head, kinetic head and total head vs. points along the pipe line.

Inference:

Precautions:

1. Do not start the pump if the voltage is less than 180V.
2. Do not forget to give electrical neutral & earth connectionscorrectly.
3. Frequently (at least once in three months) grease / oil the rotatingparts.
4. Initially, put clean water free from foreign material, and change once in threemonths.
5. At least every week, operate the unit for five minutes to prevent clogging of the moving parts.

Result /Conclusion:

The Bernoulli's equation was verified by plotting the graph

Experiment No. 6 **Date:**

OPERATION INSTRUCTIONS FOR IMPACT OF JET APPARATUS

Aim:

To find the force exerted by impact jet on hemispherical vane and calculate the coefficient of impact.

Description:

The apparatus consists of Perspex chamber. A vane holder is provided in the chamber to which the vane is fixed counter weight is provided to balance the vane. Another moving weight is provided to balance the beam while the jet is striking the vane. A nozzle is fixed below the vane through which a vertical water jet issue. The control valve (wheel valve) is provided to control the pressure of the jet and hence the flow rate and velocity of the jet.

Flat and hemispherical vanes are provided. The vane can be fixed to the vane holder. By adjusting the moving weight the beam is balanced when the jet is striking the vane. By taking the moment about the fulcrum, impact force can be calculated. A nozzle of 8mm diameter is provided.

Experimental Procedure:

1. Fix the required vane to the vane holder. The scale reads zero.
2. Fill up sufficient water in the sump tank. (15mm below top level)
3. Open the control valve fully and start the pump. The jet strike the vane
4. Note down the force indicated in the scale
5. Note down the time (in seconds) for collecting 20liters water level rise in measuring tank.
6. Repeat the procedure by changing the control valve position.
7. Repeat the procedure for another vane.

Observations:

S.NO	Time for 20Ltr. Of Water collection in the measuring tank, t (sec) (16.7cm raise in water level tube)	Distance of moving wt from fulcrum (mtrs)
1.		
2.		
3.		
4.		
5.		

Tabular column:

Vane type: Hemispherical vane

S.No	Time for 20ltr. Water collection in the measuring tank t(sec.)	Discharge $Q = \frac{0.02}{t}$ (m^3/sec)	Velocity V=Q/A (m/sec)	Theoretical force, $F_{th} = \frac{2\rho AV^2}{g}$ (Kgf)	Actual force $F_a = \frac{m \times L}{X}$ (Kgf)	Co-efficient of impact $\frac{F_a}{F_t}$
1.						
2.						
3.						
4.						
5.						

Calculations:

1. Diameter of jet = 8×10^{-3} mts

   Cross sectional area of jet, a = 5.02×10^{-5} m^2

2. Let time required for 20 ltr level in measuring tank be t sec

$$Q = 0.02/t \quad m^3/sec$$

Where Q = water discharge in the test pipe

T = time taken in seconds to collect 20ltr. Water in the measuring tank

3. Velocity of jet

$$V = Q/A \quad m/sec$$

Where V is the velocity of water in the test pipe

4. Force extended on vane (theoretical formula)

$$F_t = \frac{2\rho A V^2}{g}$$

Where ρ = specific weight of water =1000Kg/m^3

G = gravitational acceleration 9.81 m/sec^2

5. Force extended on vane (By experimental)

$$F_a = \frac{m \times L}{X}$$

Where m = mass of sliding weight in Kg =0.3Kg (fixed value)

X = Distance of vane from the fulcrum=15cm

L = Distance of sliding weight from fulcrum

6. Coefficient of impact = $\frac{F_a}{F_t}$

Precautions:

1. Do not close the gate value completely.
2. Water filled in the sump tank should be free from any oil and dirt and should be changed every 15 days.

Result:

The coefficient of impact is calculated as ____________________

Conclusion:

Experiment No. 7 **Date:**

PELTON WHEEL TURBINE

Aim:

To determine the performance characteristics of Pelton wheel turbine under constant head and constant speed.

Apparatus Required:

Pelton wheel turbine test rig.

Specifications:

The actual experimental set-up consists of a multi-stage centrifugal pump set turbine unit, sump tank, notch tank arranged in such a way that the whole unit works as re-circulating water system. The centrifugal pump set supplies water from the sump tank to the turbine through control valve which has the marking to meter the known quantity of water. The water after passing through the turbine unit enters the collecting tank. The water then flows back to the sump tank through the notch tank which is fixed with θ0˚ V-Notch for the measurement of flow rate.

The loading of the turbine is achieved by rope brake drum connected to spring balance. The provisions for measurement of turbine speed (digital rpm indicator), head on the turbine (pressure gauge), are built-in on the control panel

Supply Pump /MotorCapacity	:	7.5 hp, 3 ph, 440V, 50 Hz AC.
Turbine	:	
MeanDia.	:	250 mm
No.ofbuckets	:	20
Dia.Ofjet	:	18 mm
RunawaySpeed	:	2000 rpm
FlowRate	:	165 lpm ($2.72 \times 10^{-3} m^3/sec$)
Head	:	Max. – 100 m.
Loading	:	BrakeDrum
	:	Brake Drum radius:0.15m
MaximumShaft Output fromTurbine	:	1.5 hp(Approx.)
Provision	:	Flow rate measurement by 60º - V notch, C_d =0.6

Theory:

Hydro -power is one of major cheap source of power available on earth, and hence it is widely used for generation of electric power worldwide. Water stored in the dam contains potential energy. The water flows through the turbine, so that power is generated by impact of water or reaction of water flow. The turbine drives a generator which delivers electrical power. Thus, turbines are of great importance.

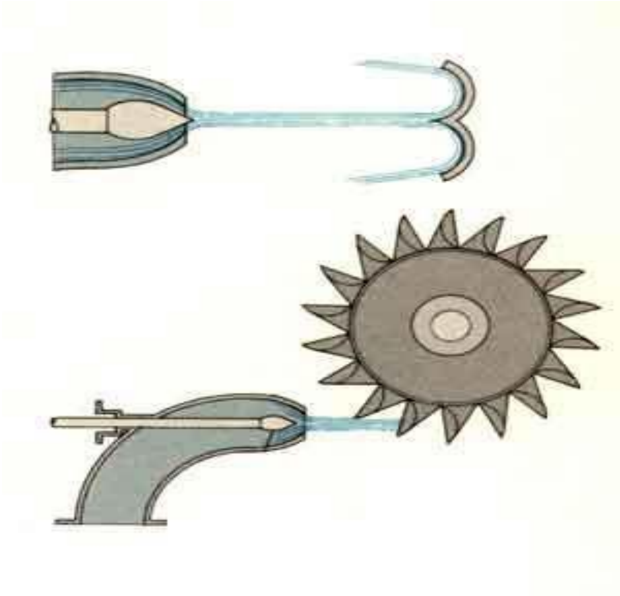
Turbines are basically of two types, viz. impulse turbines and reaction turbines. In impulse turbines, water coming from high head acquires high velocity. The high velocity water jet strikes the buckets of the turbine runner and causes it to rotate by impact. In reaction turbine, total head of water is partly converted into velocity head as it approaches turbine runner and it fills the runner and pressure of water gradually changes as it flows through runner. In impulse turbine, the only turbine used now-a-days is Pelton Wheel Turbine. In reaction turbines, Francis Turbine and Kaplan Turbine are the examples.

The Pelton wheel turbine consists of runner mounted over the main shaft. Runner consists of buckets fitted to the disc. The buckets have a shape of double ellipsoidal cups. The runner is encased in a casing provided with a Perspex window for visualization. A nozzle fitted in the side of casing directs the water jet over the 'Splitter' or center ridge of the buckets. A spear operates inside the nozzle to control the water flow. On the other side of the shaft, a rope brake is mounted for loading theturbine.

Impulse turbines change the velocity of a water jet. The jet impinges on the turbine's curved blades which reverse the flow. The resulting change in momentum (impulse) causes a force on the turbine blades. Since the turbine is spinning, the force acts through a distance (work) and the diverted water flow is left with diminished energy.

Prior to hitting the turbine blades, the water's pressure (potential energy) is converted to kinetic energy by a nozzle and focused on the turbine. No pressure change occurs at the turbine blades, and the turbine doesn't require housing for operation. Newton’s describes the transfer of energy for impulse turbines. Impulse turbines are most often used in very high head applications.

Photograph of the setup:



Procedure:

1. Connect the supply water pump – motor unit to 3 ph, 440V, 30A, electrical supply, with neutral and earth connections and ensure the correct direction of pump-motorunit.
2. Keep the Butterfly valve and spear valveclosed.
3. Keep the Brake Drum loading atminimum.
4. Press the green button of the supply pump starter. Now the pump picks-up the full speed and becomesoperational.
5. Slowly, open the spear valve so that the turbine rotor picks up the speed and attains maximum at full opening of thevalve.

a) To obtain constant speed characteristics:

1. Keep the Butterfly valve opening atmaximum
2. For different Brake Drum loads on the turbine, change the spear rod setting,between maximum and minimum so that the speed is heldconstant.
3. Tabulate the results as per Table - I.
4. The above readings are utilized for drawing constant speed characteristicsViz.,
   a. Percentage of full load V/s efficiency.
   b. Efficiency and BHP V/s discharge characteristics.

b) To obtain constant head characteristics:

1. Keep the spear rod setting and Butterfly Valve setting at maximum.
2. For different Brake load, note down the speed, Head over notch and tabulate the results as given in Table – II.

Observation Table:

Table I

Constant Speed Characteristics

Method : By keeping Butterfly Valve position fully open and by changing the spear valve position.

'**N**' in rpm	Spear valve position	Pressure '**P**' in kg/cm^2	Head over the notch '**h**' in meters	'**F$_1$**' kgf	'**F$_2$**' kgf	Remarks

Table II

Constant Head Characteristics

Method: 1) Spear rod at fixedposition

2) Butterfly Valve fully open&

3) Change Brake Drumload

Turbine speed '**N**' in rpm	Pressure **"P"** in kg/ cm^2	Head over notch (flow rate), **"h"** in m	'**F$_1$**' kgf	'**F$_2$**' kgf	Remarks

Calculations:

Table I

Constant Speed Characteristics

Turbine Speed 'N' rpm	Net head on Turbine 'H'm.	Discharge (flow rate) 'Q' m^3/sec	HP_{hyd}	BHP	% y_{tur}	Remarks

Table - II
Constant Head Characteristics

Turbine Speed ‘N’ in rpm	Net head on Turbine ‘H’ m.	Discharge (flow rate) ‘Q’ in m^3/Sec	HP_{hyd}	BHP	% y_{tur}	Remarks

Data:
Formulae:

1. Head on theTurbine
   'H’ in metersofwater = 10 P
   Where P is the pressure gauge reading in kg / cm^2.

2. Discharge (Flow rate)of water through the Turbine = Flow Rate over the 60º-Vnotch
   Q= 8/15 C_d √2g tan 0/2$h^{5/2}$
   Assuming C_d = 0.6, g= 9.81
   0= θ0˚, h= Head over notch in m.

3. Hydraulic Input to the Turbine,
   $$H_{avd} = \frac{WQH}{75}$$
   Where W=1000kgf/m^3
   Q= Flow rate of water per m^3/sec from formulae-2
   H= head on turbine from formulae-1

4. Brake horse power of the turbine,
   $$BHP = \frac{2\pi N(F_1 - F_2)}{4500}.$$
   Where F_1&F_2 are spring balance readings in kg/f
   R=0.15 m radius of brake drum.

5. Turbine Efficiency,
   $$\%\ y_{tur} = \frac{BHP}{HP \times 100}$$

Graph:

Constant head characteristics

1. Unit discharge (Qu) vs. Unit speed(Nu).
2. Unit power (Pu) vs. Unit speed (Nu).
3. Percentage efficiency (%y) vs. Unit speed(Nu).

Constant speed characteristics

1. Percentage efficiency (%y) vs. percentage full load.

Precautions:

1. Do not start pump set if the supply voltage is less than 300 V (phase to phasevoltage).
2. Do not forget to give electrical earth and neutral connections correctly. Otherwise, the RPM indicator gets burnt if connections arewrong.
3. Frequently, at least once in three months, grease all visual movingparts.
4. Initially, fill-in the tank with clean water free from foreign material. Change the water every sixmonths.
5. At least every week, operate the unit for five minutes to prevent any clogging ofthe movingparts.
6. To start and stop the supply pump, always keep gate valveclosed.
7. It is recommended to keep spear rod setting at close position before starting theturbine. This is to prevent racing of the propeller shaft withoutload.
8. In case of any major faults, please write to manufacturer, and do not attempt to repair.

Result /Conclusion:

The unit head and other quantities were calculated from the knowledge of constant head characteristics and the curves were drawn. Similarly the constant speed characteristics were calculated and the percentage efficiency vs. percentage full load was drawn.

Experiment No. 8 **Date:**

FRANCIS TURBINE

(USING VENTURIMETER)

Aim: To determine the performance characteristics of Pelton wheel turbine under constant head and constant speed.

INTRODUCTION:

Hydraulic (water) Turbines are the machines, which use the energy of water (Hydro –power) and convert it into Mechanical energy, which is further converted into electrical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce electricity (Hydroelectric power).

The Turbines are classified as impulse & reaction types. In impulse turbine, the head of water is completely converted into a jet, which exerts the force on the turbine; it is the pressure of the flowing water, which rotates the Impeller of the turbine. Of many types of turbine, the Pelton wheel, most commonly used, falls into the category of impulse turbine, while the Francis & Kaplan falls into the category of reaction turbines.

Normally, Pelton wheel (impulse turbine) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory because of the limitation of required head & discharges. Nevertheless, an attempt has been made to study the performance characteristics within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

While the impulse turbine is discussed elsewhere in standard textbooks, Francis turbine (reaction type) which is of present concern consists of main components such as Impeller (runner), scroll casing and draft tube. Between the scroll casing and the Impeller there are guide vanes, which guides the water on to the impeller thus rotating the Impeller shaft. There are eight guide vanes, which can be turned about their own axis so that the angle of inclination may be adjusted while the turbine is in motion. When guide vane angles are varied, high efficiency can be obtained over wide range of operating conditions.

The actual experiment facility supplied consists of a sump tank, centrifugal pump set, turbine unit and Venturimeter arranged in such a way that the whole unit works on recirculating water system. The centrifugal pump set supplies the water from the sump tank to the turbine through control valve (Gate valve). The water from the pump passes through a Venturimeter (for measurement of discharge) to the turbine unit enters the sump tank through the draft tube.

The loading of the turbine is achieved by electrical dynamometer coupled to the turbine through a V-Belt drive (V grooved pulley). The control panel is equipped with a set of heaters (electrical resistance) in steps of 200Vats each, 10 No. (200 x 10 Total 2Kw) with individual switches are provided for loading the electrical dynamometer (in turn loading the turbine). The provisions for measurement of load (by digital Voltmeter & Ammeter), turbine speed (digital RPM indicator), differential pressure across Venturimeter (Double column Mercury Manometer) & total head on turbine (pressure & vacuum gauge).

Specification:

Supply pump capacity : 7.5 Kw (10 Hp) 3ph, 400V

Turbine capacity : 2.6 HP (2 Kw)

Run away speed : 2000 RPM

TABULAR COLUMN

Constant Speed:

S No	Pressure Gauge reading 'P' Kg/cm^2	Head over the turbine 'H' in m	Presser Gauge reading in Kg/cm^2 Across Venturimeter		□ h	Alternator		Flow rate 'Q' m^3/s	Input power Kw (Ip)	Out put power Kw (Op)	Turbine efficiency % η turb
			h1	h2		V volts	I amps				

Procedure:

1. Install the equipment near a 3 phase 440 volts, 50 Hz, 20 amps power source & water source.
2. Connect the panel to the electrical source & ascertain the direction of the pump is in order (clock wise direction from shaft end) by momentarily starting the pump.
3. Fill filtered clear water into the sump tank up to ¾th its full capacity.
4. Keep the gate valve situated above the pump in fully closed position, turbine guide vanes in full open position.
5. Start the pump, gradually open the gate valve slowly so that the turbine achieves sufficient speed to generate 200 volts on the panel voltmeter.
6. Wait till the speed of the turbine & generated voltage maintained constant.
7. Put on the first electrical load switch and adjust the speed of Turbine to 200V on the panel Voltmeter and record the corresponding Ammeter, Pressure gauge & Head over the notch readings.

8. Continue increasing the load on the Turbine step by step by switching ON the consecutive load switches one by one, by gradually opening the Gate valve so that the Voltmeter reading shows 200V on each step. Record the corresponding readings of Ammeter, Pressure Gauge & Head over the notch.
9. Change the Turbine guide vane to any desired position (between fully open to closed conditions) by operating the hand wheel situated at the rear end of the Turbine to repeat the experiment on varied condition by following steps 7 & 8.
10. After the experiment is over bring the turbine to no load condition by switching OFF the load switches one by one and simultaneously closing the Gate valve (care must be taken to avoid sudden increase in speed / Volts while switching 'off ' the load switches) & stop the pump.
11. Tabulate all the recorded readings and calculate the input power, output power & efficiency of the Turbine.

Note: Drain all the water from the sump tank, refill with fresh clean water once in a month. When the equipment is not in use for a longer duration, drain all water from the sump tank keep it clean & dry.

Graphs to be plotted:

Main Characteristics Curves (constant Head)

Q_u Vs N_u

P_u Vs N_u

□o Vs N_u

Operating Characteristics Curves (Constant Speed)

□o Vs % full load.

Constant Head:

S No	Pressure Gauge reading 'P' Kg/cm^2	Head over the turbine 'H' in m	Presser Gauge reading in Kg/cm^2 Across Venturimeter		□ h	Alternator		Flow rate 'Q' m^3/s	Input power Kw (Ip)	Out put power Kw (Op)	Turbine efficiency % η turb
			h1	h2		V volts	I amps				

CALCULATION:

Output power Op =

Input power Ip =

Turbine efficiency η_{Tur} =

Precautions:

1. Do not start pump set if the supply voltage is less than 300 V (phase to phase voltage).
2. Do not forget to give electrical earth and neutral connections correctly. Otherwise, the RPM indicator gets burnt if connections are wrong.
3. Frequently, at least once in three months, grease all visual moving parts.
4. Initially, fill-in the tank with clean water free from foreign material. Change the water every six months.
5. At least every week, operate the unit for five minutes to prevent any clogging of the moving parts.

RESULT:

The unit head and other quantities were calculated from the knowledge of constant head characteristics and the curves were drawn. Similarly the constant speed characteristics were calculated and the percentage efficiency vs. percentage full load was drawn.

Experiment No. 9 **Date:**

KAPLAN TURBINE

Aim:

To determine the performance characteristics of Kaplan turbine under constant head and Constant speed.

Apparatus Required:

Kaplan turbine test rig.

Specifications:

The actual experimental set-up consists of a centrifugal pump set turbine unit, sump tank, notch tank arranged in such a way that the whole unit works on re-circulating water system. The centrifugal pump set supplies the water from the sump tank to the turbine through gate valve which has the marking to meter the known quantity of water. The water after passing through the turbine unit enters the collecting tank through the draft tube. The water then flows back to the sump tank through the notch tank with rectangular notch for the measurement of flowrate.

The loading of the turbine is achieved by electrical AC generator connected to lamp bank. The provisions for; measurement of electrical energy AC voltmeter and ammeter turbine speed (digital RPM indicator), Head on the turbine (pressure gauge), are built-in on the control panel.

Supply Pump /motorCapacity	:	12 hp, 3 ph, 440V, 50 HzAC.
Turbine	:	150 mm dia. Propeller with fourblades.
	:	Propeller blade angles adjustable from maximum to minimum.
	:	Run-away speed – 2500 rpm(approx.).
	:	Max. Flow of water – 2500 lpm(approx.).
	:	Max. Head – 10 m.(approx.).
Loading	:	AC generator.
Provisions	:	a. Flow rate by notch, C_d = 0.6(assumed). b. Head on turbine by pressure gauge of range "0.2kg / cm^2 and vacuum gauge :1 – 760 mm ofHg c. Electrical load change by toggle switch (maximum connected load: 2000watts). d. Electrical load measurement by energymeter. e. Voltage & current of generator by analogmeters. f. Propeller speed by digital rpmindicator g. Supply water control by gate valve.
Electrical Supply	:	3ph, 440V, AC, 30A, with neutral &earth.

Note: Volume of water required for operationunit : 3000 lt. (approx.).

Theory:

Hydraulic (or Water) turbines are the machines which use the energy of water (Hydro – Power) and convert it into mechanical energy. Thus the turbine becomes the prime-mover to run the electrical generators to produce the electricity, Viz., Hydro-Electric Power.

The turbines are classified as Impulse & Reaction types. In impulse turbine, the head of water is completely converted into a jet, which impulses the forces on the turbine. In reaction turbine, it is the pressure of the flowing water, which rotates the runner of the turbine. Of many types of turbine, the Pelton wheel, most commonly used, falls into the category of turbines. While Francis & Kaplan falls in category of impulse reactionturbines.

The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The design combines radial and axialfeatures.

The inlet is a scroll-shaped tube that wraps around the turbine's wicket gate. Water is directed tangentially, through the wicket gate, and spirals on to a propeller shaped runner, causing it to spin. Between the scroll casing and the runner, the water turns through right angle into the axial direction and passes through the runner and thus rotating the runner shaft. The runner has four blades which can be turned about their own axis so that the angle of inclination may be adjusted while the turbine is in motion. When runner blade angles are varied, high efficiency can be maintained over wide range of operating conditions. In other words even at part loads, when a low discharge is flowing through the runner, a high efficiency can be attained in case of Kaplan turbine, whereas this provision does not exist in Francis & Propeller turbines where, the runner blade angles are fixed and integral withhub.

The outlet is a specially shaped draft tube that helps decelerate the water and recover kineticenergy. The turbine does not need to be at the lowest point of water flow, as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube. The resulting pressure drop may lead to cavitation.

Normally, Pelton wheel (impulse turbine) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding he1ds and discharge are difficult to create in laboratory size turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind offacility.

Photograph of the setup:

Procedure:

1. Connect the supply pump – motor unit to 3 ph, 440V, 30A, electrical supply, with neutral and earth connections and ensure the correct direction of pump-motorunit.
2. Keep the gate closed.
3. Keep the electrical load at maximum, by keeping the all switches at ONposition.
4. Press the green button of the supply pump starter & thenrelease.
5. Slowly, open the gate so that the turbine rotor picks up the speed and attains maximum at full opening of thegate.
6. Note down the voltage and current, speed, pressure vacuum on the control panel, head over the notch, and tabulate theresults.
7. Close the gate and then switch OFF the supply water pumpset.
8. Follow the procedure described below for taking down the reading for evaluating the performance characteristics of the Kaplanturbine.

To obtain constant speed characteristics: (operating characteristics)

1. Keep the gate opening atmaximum
2. For different electrical loads on the turbine / generator, change the gate position, so that the speed is held constant; say at 1500 rpm. See that the voltage does not exceed 250 V to avoid excess voltage onBulbs.
3. Reduce the gate opening setting to different position and repeat (2) for different speeds 1500 rpm, 1000 rpm and tabulate the results.
4. The above readings will be utilized for drawing constant speed characteristicsViz.,
   a. Percentage of full load V/sefficiency.
   b. Efficiency and BHP V/s dischargecharacteristics.

To obtain constant head characteristics: (main characteristics)

1. Select the propeller vane angleposition.
2. Keep the gate closed, and start the pump.
3. Slowly open the gate and set the pressure on thegauge.
4. For different electrical load, change the rotor pitch position and maintain the constanthead and tabulate the results as given in Table – II.

To obtain Run – Away speed characteristics:

1. Switch OFF the entire load on the turbine and thevoltmeter.
2. Keep propeller vane angle at optimum position (Head, h = 0.75 Kg /cm^2).
3. Slowly open the gate to maximum and note down the turbine speed. This is the runaway speed which ismaximum.

Note:

Run-away speed is also influenced by the tightening in gland packing of the turbine shaft. More is the tightness, less is the run-awayspeed.

Observation Table:

Table-I:

Constant Speed Characteristics
Method : By keeping the Rotor Pitch constant&
By changing the Gate position.

Gate position	Turbine Speed in rpm	Head on Turbine		Head over Notch (Flow Rate), 'h'in m	Load on Generator		Wattage of Bulb inaction	Energy Meter Reading Time for 5 Rev. in seconds
		Pressure "P" in kg/cm^2	Vacuum "P_v" in mm of Hg		"V" Volts	"I" Amps		

Table-II:
Constant Head Characteristics
Method : By keeping the Gate opening constant&
By changing the Rotor pitch.

Head on Turbine		Turbine speed in RPM	Head over Notch (Flow Rate), "h" in m	Load on Generator		Energy Meter Reading Time for 5 Rev in secs.	Wattage of Bulb in action
Pressure "P" in Kg / Cm^2	Vacuum "P_v" in mm of Hg			"V" Volts	"I" Amps		

Calculations:

Table-I:

Constant Speed Characteristics

Method: By Changing the Rotor pitch constant
&By Changing Gateposition.

Turbine Speed in RPM	Net head on Turbine 'H' in m	Discharge (Flow Rate) 'Q in m^3/sec	HP_{hyd}	BHP	% y_{tur}	% of Full Load

Table-II:

Constant Head Characteristics

Turbine Speed in RPM	Net headon Turbine'H' in m	Discharge (FlowRate) 'Q inm^3/Sec	HP_{hyd}	BHP	% y_{tur}

Precautions:

1. Do not start pump set if the supply voltage is less than 300 V (phase to phase voltage).
2. Do not forget to give electrical earth and neutral connections correctly. Otherwise, the RPM indicator gets burnt if connections are wrong.
3. Frequently, at least once in three months, grease all visual moving parts.
4. Initially, fill-in the tank with clean water free from foreign material. Change the water every six months.
5. At least every week, operate the unit for five minutes to prevent any clogging of the moving parts.

RESULT:

The unit head and other quantities were calculated from the knowledge of constant head characteristics and the curves were drawn. Similarly the constant speed characteristics were calculated and the percentage efficiency vs. percentage full load was drawn.

Experiment No. 10 **Date:**

EFFICIENCY TEST ON CENTRIFUGAL PUMP.

Aim:

To determine overall efficiency of single stage Centrifugal Pump

THEORY:

Centrifugal Pump is a roto dynamic Machine which develops dynamic pressure of liquid by virtue of rotation for pumping of Liquid to a higher height. In centrifugal pump, liquid in the Impeller of the pump is made to rotate by external force, so that it is thrown away from the Centre of rotation. As constant supply of liquid is made available at the centre, liquid can be pumped to higher level

EQUIPMENT:

The unit consists of a centrifugal pump driven by a 1 H.P.D.C. Motor Input to motor is measured on Energy meter. A measuring tank is provided to measure the discharge Suction Vacuum and discharge pressure measured in the Gauges. A wheel valve on discharge pipe varies the water flow (The Head)Thus performance of pump can be estimated et various (100, 90, 0 set) sped &5 head.

SPECIFICATIONS:

Centrifugal Pump single stage 25 x 25 mm size, mounted on sump tank 1 HPDC Motor directly coupled to pump and regulated by o DC speed Regulator and Energy meter.

- Measuring Tank 300 mm (L) x 400 mm (W) x 500 mm (H) fitted with water level Tue and Drain Valve. Capacity (60 Ltrs)
- Sump Tank 1000 mm ()x 400 mm (W) x 300 mm (H) (Capacity 120 Ltrs)
- Wheel valve to regulate the discharge.
- Pressure Gauge 0-4 Kg/ Cm and Vacuum Gauge 0-760 mm/ Hg.
- Energy Meter to measure input of the motor.

TEST PROCEDURE:

- Fill up Sump Tank full with water (25 mm less from top level).
- Keep open all the pipeline valves,
- Set 100 in OC Motor Control Knob, switch on the Mains
- Keep water circulation for 3 Minutes
- Lock the Bypass valve and allow the water to fall in the Measuring Tank
- Regulate Wheel Valve till we get discharge Pressure of (0.5, 1, 1.5, and 2) up to max. 2 kg/ cm

Note down the initial reading in the Measuring Tank Close the drain tap of measuring tank and rote down me taken for 20 Ltre water collection in measuring (16.7 cm rise in scale] tank

Note down the reading in Pressure Gauge / Vacuum Gauge and time taken for 10 revolutions of the disc in the Energy Meter.

OBSERVATIONS:

SL.NO	DISCHARGE PRESSURE P_D(mm/hg)	SUCTION VCCUMP_S (mm/hg)	Time taken for 20 ltrs of water collection in the measuring tank(16.7mm maxim scale) t ,sec	Time taken for 10 revolutions of the disc in energy meter t_o(sec)

FORMULAE:

1. Discharge pressure P_D=___________Kg/cm^2

For water 10 meter height corresponds to 1 Kg/ om Therefore

Discharge Head $h_d = p_d$ -P x 10 m of water

2. Suction Vacuum p_s=__________mm/ hg

Suction Head $h_s = \frac{p_s}{1000} \times \frac{13.6}{1}$

Here

Sp. Gravity of Hg- 13.6

Sp. Gravity of water-1

3.Total Head $h_t = h_d + h_s + h_r$

Where h_f= 2 mtr is the head loss due to friction (For centrifugal Pump)

4. ACTUAL DISCHARGE

$Q = \frac{0.02}{t} m^3$/sec

Where

Q=Water Discharge in the Test Pipe

t =Time taken in seconds to collect 20 Ltrs. Water in the measuring tank

5. Output power of pump

$$O_p = \frac{W \times Q \times h_r}{1000}$$

Where

W= specific weight of water -3810 N (Fixed value)

Q= Discharge (m^3/ Sec)

h_r = Total head (mtrs)

6. ELECTRICAL INPUT:

$$I_P = \frac{10}{t_e} \times \frac{3600}{1200}$$

Taking motor efficiency as 75% we have input shaft power

SP=Elect.IP×o.75

Where t_e=time required for 10 rev. of energy meter disc in sec

7. OVERALL EFFECIENCY OF CENTRIFIGUAL PUMP (single stage) =

$$n_o = \frac{WP}{SP} \times 100$$

PRECAUTONS:

- Pump should never be run empty
- Use clean water in sump. Operate at 100/90/80 setting in DC Motor Controlknob
- Discharge pressure Max up to 2 kg/ c (For Centrifugal Pump)

Result:

Experiment No. 11 **Date:**

EFFICIENCY TEST ON RECIPROCATING PUMP

AIM:

To determine overall efficiency of a Reciprocating Pump.

THEORY:

Reciprocating Pump is a positive displacement pump. It is often used where relatively small quantity of water is to be handled and delivery pressure is quite large. Reciprocating pumps are used in Automobile service stations, chemicals & Industries Dosing Pumps.

EQUIPMENT:

The apparatus consists of a single cylinder, double acting reciprocating Pump mounted on the sump tank. The pump 1S driven by D.C Motor with Electronic Speed Regulator. An energy meter measures electrical input to motor. Measuring Tank is provided to measured discharge of the pump. The pressure and vacuum Gauges are provided to measure the delivery and suction pressure.

SPECIFICATI ONS:

- Reciprocating Pump 40mm bore dia stroke length 45 mm double acting with air vessel on discharge side, Suction dia 25 mm & Discharge 19 mm.
- 1 HP DC Motor, Speed varied by electronic Regulator.
- Stainless steel Measuring Tank 300 mm (L)x 400 tr (W) x 500 mm (H)provided with water level tube.
- Stainless teel Sump tank I000 mm (L) x 400 mm (W)x 300 mm (H)
- Pressure gauge 0- 4 Kg/C tor Discharge pressure.
- Vacuun1 gauge 0-760 mm Hg for suction vacuum.
- Single phase energy meter for Motor Input Measurement.

TEST PROCEDURE:

- Fill up Sump tank full with water (15 mm less from top level)
- Keep open all the pipeline valves.
- Set 100 in DC Motor Control Knob, switch on the Mains.
- Keep water circulation for 3 Minutes.
- Lock the Bypass valve and allow the water to fall in the Measuring Tank
- Regulate Wheel Valve till we get discharge Pressure of (0.5, 1,1.5,2) up to max, 2 kg/ cm'
- Note down the initial reading in the Measuring tank, Close the drain tap of measuring tank and note down time taken for 20 Ltre water collection in measuring tank (16.7 cm rise in the water level tube)
- Note down the reading in Pressure Gauge Vacuum Gauge and time taken for 10 revolutions of the disc in the Energy Meter. Tabulate

OBSERVATIONS:

Sl.no	*Discharge pressure* p_d *(KG/CM²)*	*Suction vacuum* p_s *(mm/hg)*	*Time taken for 20 ltrs of water collection in the measuring tank(16.7 cm rise in water level tube)(sec)*	*Time taken for 10 revolutions of the disc in energy meter* t_e*(sec)*
1.				
2.				
3.				Type equation here.

CALCULATIONS:

Discharge Pressure p_d = _________$KG/$CM^2

For water, 10meter height corresponds to 1 Kg/ cm

Therefore

Discharge Headh_d=p_d X 10 m of water mm/ hg

Suction Vacuum Ps=_________mm/hg

Suction head$h_s = \frac{p_s}{1000} \times \frac{13.6}{1}$

Where Sp gravity of Hg=13.6

Sp. Gravity of Water

Total Head$h_t = h_d + h_s + h_f$

Whereh_f =3mtr is the head loss due to pipe fittings

Actual Discharge

$$Q = \frac{0.02}{t} m^3/sec$$

Where Q= Water Discharge in the Test Pipe

t=Time taken in seconds to collect 20 1Ltrs. Water in the measuringtank

Output power of pump

$$O_p = \frac{w \times Q \times h_t}{1000}$$

Where W=Specific weight of water = 9810 N/m^3 (Fixed value)

Q=Discharge (m^3/ Sec)

h_t=Total Head (mtrs)

Electrical input$I_p = \frac{10}{t_e} \times \frac{3600}{1200}$

Taking motor efficiency as 75% we have input shaft power

SP= Elect. IP x 0.75

Wheret_e =time required ror 10 rev, of energy meter disc in (Sec.)

Overall efficiency of Reciprocating Pump$n_o = \frac{WP}{SP} \times 100\%$

PRECAUTIONS:

- Pump should never be run empty.
- Use clean water in sump. Operate at 100/90/80 setting in Dc Motor Control knob.
- Discharge Pressure Max up to 2 kg / cm2 (For Reciprocating Pump.

Result: