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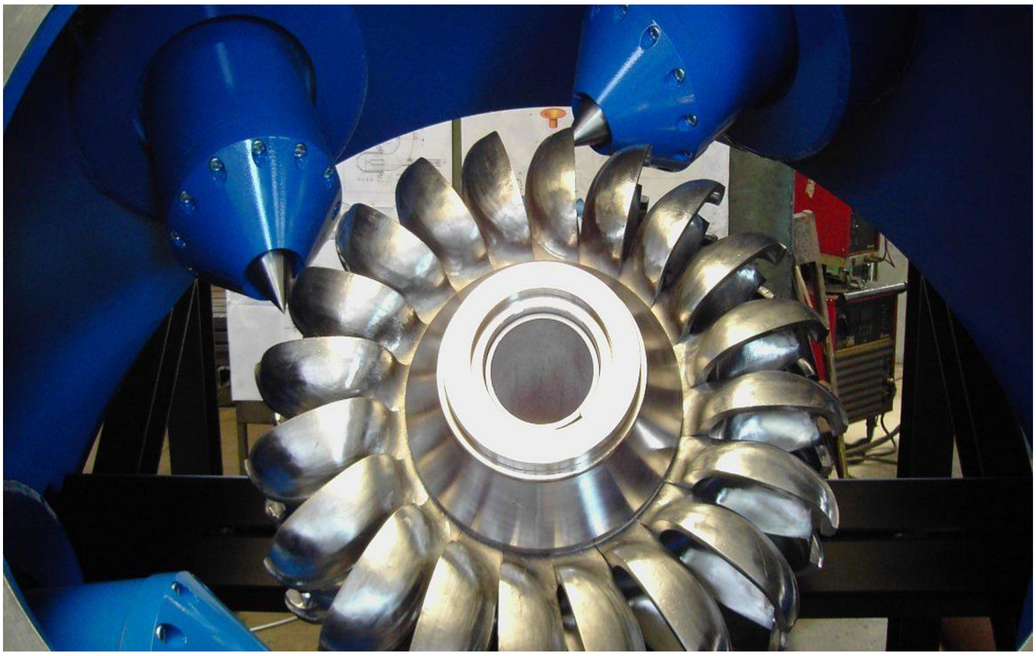


FLUID MECHANICS & MACHINERY LAB (BCV402)

DEPARTMENT OF CIVIL ENGINEERING

Prepared by: Dr. PURUSHOTHAMA C.T.

Syllabus

Subject Code: BCV402 CIE Marks: 20

COURSE OUTCOMES

At the end of the course, the students will be able to

Students will develop understanding of

1. The use of various instruments for fluid flow measurement
2. Working of Hydraulic machines under various conditions of working

Syllabus

1) Verification of Bernoulli's equation
2) Determination of Cd for Venturimeter or Orifice meter
3) Determination of Hydraulic coefficients of small vertical orifice
4) Calibration of Triangular notch
5) Determination of Major losses in pipes
6) Determination of cd for ogee or broad crested weir
7) Determination of force exerted by a jet on flat and curved vanes
8) Determination of efficiency of centrifugal pump
9) Determination of efficiency of Kaplan or Francis turbine
10) Determination of efficiency of Pelton wheel turbine

INDEX

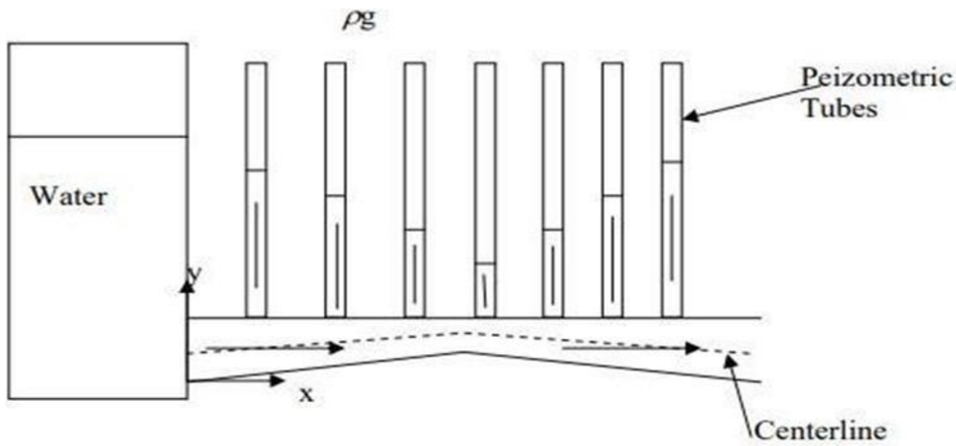
Experiment No. 1

VERIFICATION OF BERNOULLI'S EQUATION

OBJECTIVE: To understand the Bernoulli's theorem through an experiment

APPARATUS: Bernoulli's apparatus, controlling valve at inlet and outlet, Discharge Measuring Tank, Scale, Stopwatch etc.

EXPERIMENTAL SET UP:



PROCEDURE:

1. The apparatus should be accurately leveled by means of screws provided at the base.
2. Connect the water supply to the radial diffuser in the upstream tank.
3. Adjust the level of the discharge pipe by means of the stand and clamp provided to a convenient position.
4. Allow water to flow through the apparatus until all air has been expelled and steady flow conditions are achieved. This can be accomplished by varying the rate of inflow into the apparatus and adjusting the level of the discharge tube.
5. Readings may then be taken from the piezometer tubes and the flow through the

apparatus measured.

6. A series of readings can be taken for various through flows

OBSERVATION:

Area of pipe (a)(m^2)	**Time for 10cm rise of water (sec)**	**Actual discharge Qact =AH/t (m^3/sec)**	**Velocity = Qact/a (m/sec)**	**Velocity head $V^2/2g$ (m)**	**Pressure head P/γg (m)**	**Datum head (Z) (m)**	**Total head P/γg + $V^2/2g$ + z (m)**

1. Actual discharge:

   Qact =AH/t

2. Velocity:

   Qact/a =

3. Velocity head:

   $V^2/2g$ =

4. Total head:

   $P/\rho g + V^2/2g + z = \text{constant}$

RESULT:

The total energy of a streamline, while the particle moves from one point to another. Bernoulli's theorem for an incompressible fluid flow is verified.

Experiment No. 2

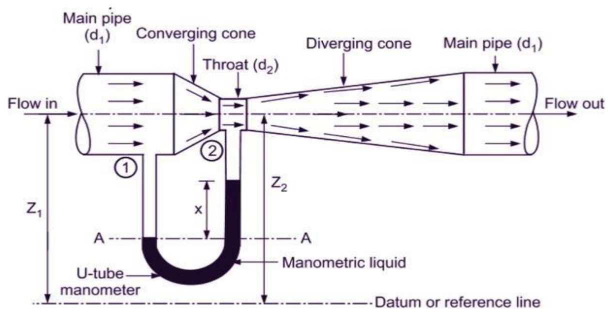
DETERMINATION OF C_d FOR VENTURIMETER

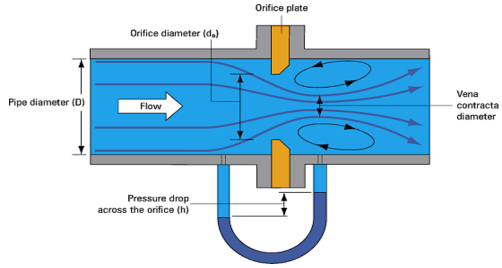
OBJECTIVE: To determine the co-efficient of discharge [C_d] for Venturimeter and Orificemeter.

APPARATUS: Venturimeter/Orifice meter fitted across a pipeline leading to a collecting tank, Stop Watch,U-Tube manometer connected across entry and throat sections etc.

EXPERIMENTAL SETUP:

Venturimeter and Orifice meter are working on the principle on Bernoulli's equation. Venturimeter and Orifice meter is a device used for measuring the rate of fluid flowing through a pipe. Venturimeter consists of three parts 1. Converging cone part, 2. Throat. 3. Diverging cone part. Orifice meter consist of orifice plate with concentric hole at center.





PROCEDURE:

1. Set the manometer pressure to the atmospheric pressure by opening the upper valve.
2. Now start the supply at water controlled by the stop valve.
3. One of the valves of any one of the pipe open and close all other of three.

4. Take the discharge reading for the particular flow.
5. Take the reading for the pressure head on from the u-tube manometer for corresponding reading ofdischarge.
6. Now take three readings for this pipe and calculate the Cd for that instrument using formula.
7. Now close the valve and open valve of other diameter pipe and take the three reading for this.
8. Similarly take the reading for all other diameter pipe and calculate Cd for each.

FORMULA:

Coefficient of discharge = Cd= Qact/Qthe Qact = A.H/t

Qthe = a1 a2 /$\sqrt{a1^2 - a2^2}$ * $\sqrt{2gh}$ ……. For Venturimeter

OBSERVATION:

S.No	**Manometer reading pressure difference Hm (m)**	**Head loss h(m)**	**Time required for 10cm Rise ofwater (t) (sec)**	**Actual discharge Qact (m^3/sec)**	**Theoretical discharge Qthe (m^3/sec)**	**Coefficient ofdischarge Cd = Q_{act}/Q_{the}**

RESULT:

Coefficient of discharge (Cd) for Venturimeter =

Experiment No. 3

DETERMINATION OF HYDRAULIC COEFFICIENTS OF SMALL VERTICAL ORIFICE

OBJECTIVE:

To determine the co-efficient of velocity [Cv] co-efficient of contraction [Cc] and co-efficient of discharge [Cd] for circular orifice by constant head method.

APPARATUS:

An Orifice fitted across a pipeline leading to a collecting tank, Stop Watch

EXPERIMENTAL SETUP:

The orifice meter consists of a throat tiling device (an orifice plate) inserted in the flow. This orifice plate creates a measurable pressure difference between its upstream and downstream sides. This pressure is then related to the flow rate. Like the Venturimeter, the pressure difference varies directly with the flow rate. The co-efficient of discharge is 0.62-0.67 for orifice meter.

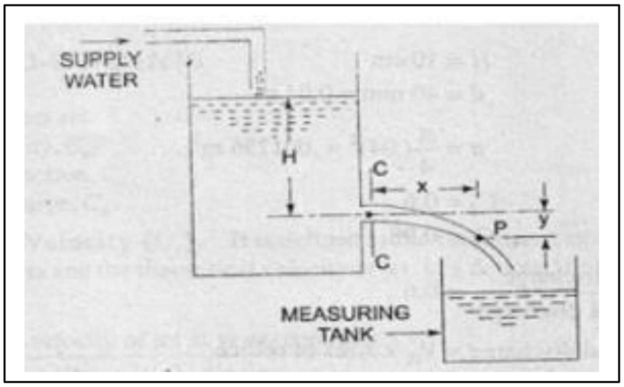


Fig.2 Experimental setup

PROCEDURE:

1. Measure the diameter of the orifice.
2. Supply water to the tank.
3. When the head at the tank (measured by a piezometer attached to the tank) is steady record the reading of the manometer.
4. Measure the x and y co-ordinate of the jet from the vena contracta.
5. Measure the flow rate.
6. Repeat the procedure for different combinations of discharge.

OBSERVATION:

Diameter of the orifice (d) = 						Area of orifice (a) =

S.No	ConstantHead (h)(m)	Time requiredfor 10cm Rise of water (t)(sec)	Actual dischargeQact (m^3/sec)	Theoretical discharge Qthe (m^3/sec)	Coefficientof discharge Cd = Qact/Qthe	Pointer reading (m)		Coeff. of velocity(Cv)	Coeff.of contraction(Cc)
						x	y		

Qact = AH/t =

1. **Theoretical discharge:**

   Qthe = ax√(2gh) =

2. **Coefficient of discharge:**

   Cd = Qact/Qthe =

3. **Coeff.of velocity:**

   Cv = $\sqrt{(x^2/4yH)}$ =

4. **Coeff.of contraction:**

   Cc=Cd/Cv =

RESULT:

The mean values of hydraulic coefficients are as follows:

a) Coefficient of discharge, Cd = ______

b) Coefficient of velocity, Cv = _______

c) Coefficient of contraction, Cc = _____

Experiment No. 4

CALIBRATION OF TRIANGULAR NOTCH

OBJECTIVE:

To determine the co-efficient of discharge [C_d] for Triangular notch.

APPARATUS:

Channel with triangular/rectangular notch, Point gauge, Collecting tank, Stop watch, Scale

EXPERIMENTAL SETUP:

The notch is a thin steel plate which placed across a channel to measure the rate of flow of water. Based on the shape of the crest notches are classified into rectangular notch, triangular notch and trapezoidal notch.

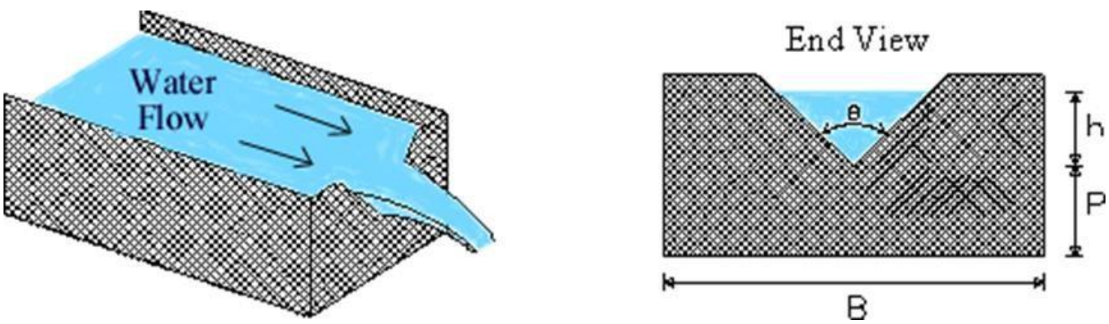


Fig 4.1 Triangular Notch

PROCEDURE:

1. Position the notch plate at the end of approach channel, in a vertical plane, with the sharp edge on the upstream side.

2. Admit water to channel until the water discharges over the notch plate.

3. Close the flow control valve and allow water to stop flowing over weir.

4. Set the point gauge to a datum reading (H1).

5. Position the gauge about half way between the notch plate and stilling baffle.

6. Admit water to the channel and adjust flow control valve to obtain heads (H2).

7. For each flow rate, stabilize conditions, measure and record H.

8. Take readings of volume and time using the volumetric tank to determine the flow rate.

OBSERVATION:

S.No	**Difference inwater depth (H) (m)**	**Time required for 10cm Rise of water (sec)**	**Actual discharge Q_{act} (m^3/sec)**	**Triangular notch Theoretical discharge Q_{the} (m^3/sec)**	**Triangular notch Coefficient of discharge Cd = Qact/Qthe**

Theoretical discharge (Triangular notch):

$$Q_t = \frac{8}{15}\sqrt{2g}\ \tan\frac{\theta}{2} H^{5/2}$$

Coefficient of discharge:

Cd (Triangular) = Qact/Qthe

RESULT:

Coefficient of discharge of Triangular notch =

Experiment No. 5

DETERMINATION OF MAJOR LOSSES IN PIPE FLOW

OBJECTIVE:

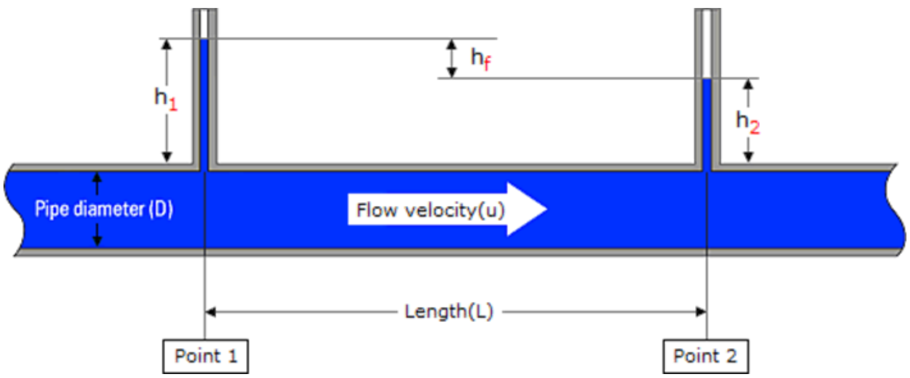
To investigate the coefficient of friction (f) for a pipe carrying water

APPARATUS:

U – Tube manometer connected across a pipe line, Stop Watch, Collecting tank.

EXPERIMENTAL SETUP:

The equipment used in the experiment was the fluid flow setup and the materials used were steel tape, stopwatch and thermometer. Water was used as the working fluid. The pump was primed and started in order for the fluid to initiate the flowing along the pipelines. Collecting tank collects the water for calculating volumetric flow rate.



PROCEDURE:

1. Measure the diameter of the pipe and distance between the two tapings.
2. Prime the mercury manometer.
3. Connect the test section pipe to the main water supply pipe.
4. Open flow control valve, priming test section and pipe work.
5. Open clips on water manometer, allowing water to circulate through the system until all the air is expelled.
6. Close pipe clips.
7. Bleed mercury manometer via bleed screws in conjunction with the control valves.

8. Close flow control valve.

9. Observe datum level on manometer.

10. To achieve maximum flow fully open flow control valve. Note levels in manometer and measure flow rate. Repeat for different control valve position.

FORMULA:

Loss of head due to friction (hf) = 4flv2/2gd Where,

f = coefficient of friction

l = length of the pipe v = velocity in the pipe

d = diameter of the pipe

OBSERVATION:

Diameter of the pipe (d) = Area of the pipe =

Length of the pipe (l) =

S.No	**Difference in manometric reading (m) (Hm)**	**Frictional head loss(h_f) (m)**	**Time required for 10cm rise of water (t) (sec)**	**Actual discharge (Qact) (m^3/sec)**	**Velocity in the pipe (m/sec)**	**Coefficient of friction (f)**
1						
2						
3						

1. Frictional head loss (hf) = (Sm/Sw -1)Hm

2. Actual discharge: Qact = AH/t

3. Velocity (V) = 4Q/πd2

4. Coefficient of friction (f) = 2 h_f g d = $4lv^2$

RESULT:

The coefficient of friction “f” for the pipe is found to be

Experiment No. 6

DETERMINATION OF FORCE EXERTED BY A JET ON CURVED VANE

OBJECTIVE:

To determine the coefficient of impact when jet strikes a) Flat Vane b) Curved Vane with 1350 angle of deflection.

APPARATUS:

Jet and Vane Setup, Flat and Curved Vanes, Digital Weighing Balance, Stop watch

EXPERIMENTAL SETUP:

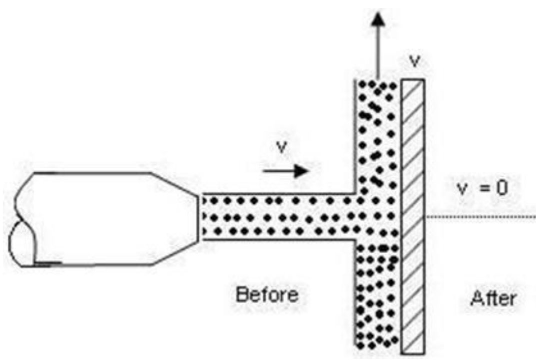


Fig 6.1 Jet striking flat stationary plate

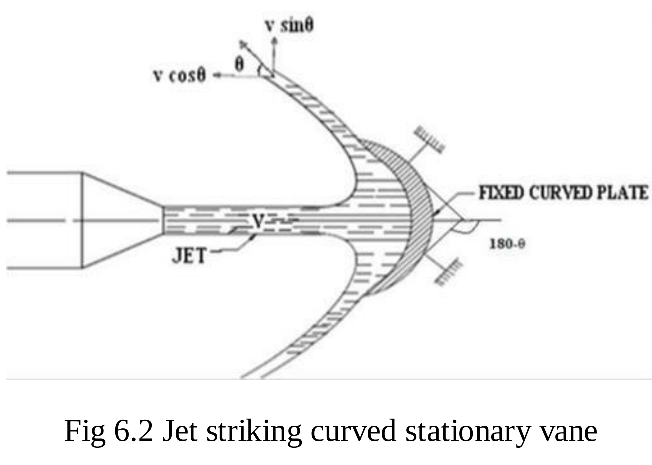


Fig 6.2 Jet striking curved stationary vane

PROCEDURE:

1. Fix up the required vane to the setup and balance the lever.

2. Start the water supply and adjust the water flow to allow the jet create an impact on the fixed vane such that lever will be lifted up.

3. Note the lifting or impact weight on the vane using digital weighing balance as a positive value.

4. Measure the time required (T) for 10cm rise of water level in the collecting tank by closing its valve.

5. The experiment is repeated for a minimum of 3 times for different input discharges.

6. Tabulate the observations as shown in Tabular Column and calculate the average Ci value by substituting the values of Fa and Ft obtained.

OBSERVATIONS:

1. Diameter of the nozzle (d) =

2. Area of orifice (a) = π/4 * d2 =

Sl. No.	**Actual Force (Fa) kg**	**Time taken for 10 cm rise (H) of water in thecollecting tank (t) sec**

Sl. No.	**Discharge (Q) (m^3/sec)**	**Velocity V (m/sec)**	**Theoretical Force Ft (kg)**	**Actual ForceFa (kg)**	**Coefficient of Impact Ci**	**Average Coefficient ofImpact**

1. Actual discharge, Q= AH/t

2. Velocity of Water, $V = Q/a$

3. Actual force, $F_a =$

4. Theoretical Force, $F_t = \rho a V$

5. Coefficient of Impact, $C_i = F_a/F_t$

RESULT:

1. Average Coefficient of Impact on flat Vane from the experiment, $C_i =$

2. Coefficient of Impact on Flat Vane from the graph, $C_i =$

Experiment No. 7

DETERMINATION OF EFFICIENCY OF CENTRIFUGAL PUMP

OBJECTIVE:

To find the efficiency and draw the performance characteristics of Centrifugal pump.

EXPERIMENTAL SETUP:

The primary difference between single-stage and multistage centrifugal pumps lies in the number of stages (also referred to as impellers) they have. As the name implies, single-stage pumps have only one impeller, whereas multistage pumps have at least two.

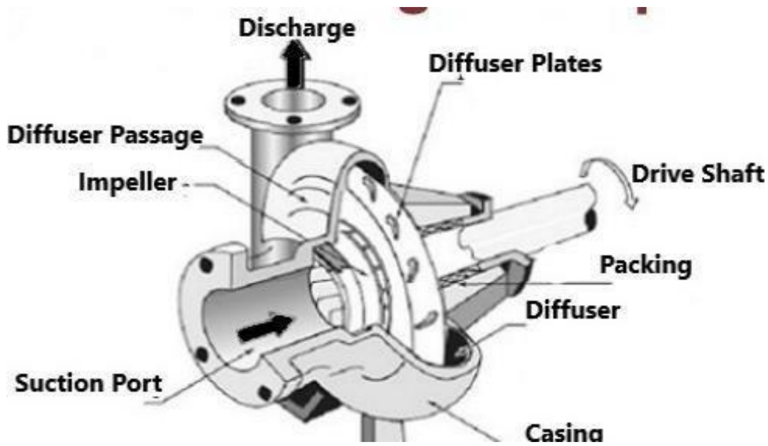


Fig.7.1 Centrifugal Pump

PROCEDURE:

1. Prime the pump, close the delivery valve and switch on the unit.

2. Set the speed of the pump to a certain desired rated RPM, open the delivery valve and maintain the required delivery head.

Note: a) The pressure gauge reading G

b) The Vacuum gauge reading V

c) Time taken for 5 pulses in the energy meter by means of stopwatch.

3. Close the drain valve and note down the time taken for 10 cm rise of the water level in the collecting tank.

4. Take at least 4 to 5 sets of readings varying the head from maximum at shutoff to minimum where valve is fully open.

OBSERVATION:

a) Single stage centrifugal pump:

S.No.	**Pressure gaugereading (G) kg/cm^2**	**Vacuum gauge reading (V) mm of Hg**	**Time required for 5 pulses of energy meter (t) sec**	**Time required for10 cm rise of water level (t) sec**
1				
2				
3				

S.No.	**Actual Discharge (Qact) m^3/sec**	**Total head (H)meters of water**	**Output power of pump (O.P) kW**	**Input power of pump (I.P) kW**	**Efficiency of the pump (η) %**

1) Actual Discharge (Qact) = AH/t Where, A= Area of tank

h= Rise of water level considered

t= Time required for rise

2) Pressure Head, G = Pressure Gauge reading x 10 Vacuum Head, V= (mm of Hg x13.6)/1000 Datum Head, X = 0m

Total Head (H) = G+V+X

3) Output power of pump (B.P) =W*Qact*H

Where, W= Equivalent weight of water (9.81 kN/m3) Qact = Actual Discharge

H = Total head

4) Input power = X x 3600 x 0.6 / C x T kW

Where, X = No.of revolutions of energy meter disc (say 5 Rev) T = Time for energy meter revolutions disc in sec

C = Energy meter constant

5) Efficiency = OP/IP x 100

RESULT:

The efficiency of the single- stage centrifugal pump is =

Experiment No. 8

DETERMINATION OF EFFICIENCY OF KAPLAN TURBINE

OBJECTIVE:

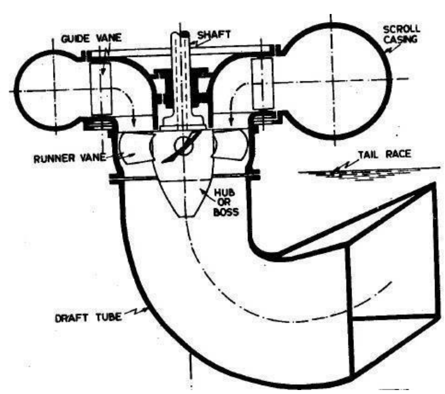
To conduct performance test on Kaplan turbine.

APPARATUS:

Kaplan turbine test rig, tachometer.

EXPERIMENTAL SETUP:

Kaplan Turbine works on the principle of axial flow reaction. In axial flow turbines, the water flows through the runner along the direction parallel to the axis of rotation of the runner. The water at the inlet of the turbine possesses both kinetic energy as well as pressure energy for effective rotation the blades in a hydro-power station.



8.1 Longitudinal Section View of Kaplan Turbine

PROCEDURE:

1. Close the inlet valve and prime the pump.

2. Start the pump, gradually open the gate valve while monitoring the inlet pressure to the turbine, and set it to the desired value.

3. Increase the primary load on the break drum say 1 kg, thus secondary load gets increased.

4. Measure the turbine rpm using tachometer.

5. Note the pressure gauge reading at the turbine inlet.

6. Note down the Orifice meter pressure gauge readings P1 and P2.

7. Repeat the experiment by increasing weights on the hanger.

FORMULA:

Input Power IP = ρxQxH kW

Turbine Output, OP = (2ΠNT)/ 60000 kW

Efficiency, η = (OP/IP) x100

Sl. No.	**Inlet PressureP (kg/cm^2)**	**P1 (kg/cm^2)**	**P2 (kg/cm^2)**	**Speed of theturbine N (rpm)**	**Primary LoadW1 (kg)**	**Secondary Load W2 (kg)**
2						
3						

Sl. No.	**Orifice meter head h (m)**	**Net Load W (N)**	**Discharge Q(m^3/s)**	**Input Power I/P**	**Output PowerO/P**	**Efficiency η (%)**
1						
2						
3						

1. Input Total Head, H = Pressure Gauge Reading (P) in kg/cm2x10 m

2 Orifice meter head, h = (P1 – P2)x10m

3 Theoretical discharge $Q = a1ao\sqrt{(2gh)}/\sqrt{(a12-ao2)}$ m3/sec

4 Input Power $IP = \rho x Q x H$ kW

5 Torque = (W1+Weight of rope and hanger – W2)x D/2 x 9.81 N

6 Turbine Output, $OP = 2\Pi NT/60000$ kW

7 Efficiency, $\eta = OP/IP \times 100$

RESULT:

The efficiency of Kaplan Turbine, η =

Experiment No. 9

DETERMINATION OF EFFICIENCY OF PELTON WHEEL TURBINE

OBJECTIVE:

To conduct performance test on Pelton Wheel turbine and to draw characteristic curves.

APPARATUS:

Pelton Wheel turbine test rig, weights, tachometer

EXPERIMENTAL SETUP:

The turbine capable of working under the high potential head of water is the Pelton Wheel Turbine which works on the head greater than 300 m. The runner consists of a circular disc with a suitable number of double semi-ellipsoidal cups known as buckets which are evenly spaced around its Periphery. One or more nozzles are mounted so that, each directs a jet along the tangent to the circle through the centres of the buckets called the Pitch Circle. A casing is provided only to prevent the splashing of water and for discharging the water to the tailrace.

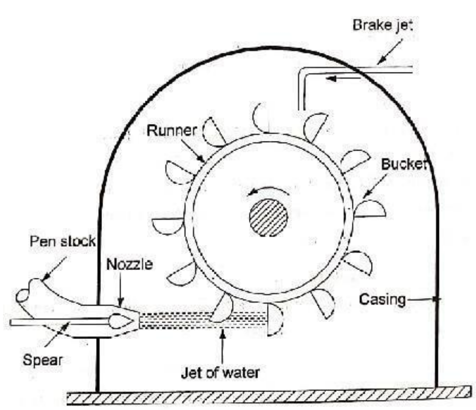


Fig.9.1 Pelton wheel turbine experimental setup

PROCEDURE:

1. Close the inlet valve and prime the pump.

2. Keep the nozzle at full opening.

3. Start the pump, gradually open the gate valve while monitoring the inlet pressure to the turbine, and set it to the desired value.

4. Add minimum load to the weight hanger of the break drum say 1 kg.

5. Measure the turbine speed in rpm with tachometer.

6. Note the pressure gauge reading at the turbine inlet.

7. Note down the Venturimeter pressure gauge readings P1 and P2.

8. Repeat the experiment by increasing weights on the hanger.

FORMULA:

Input Power, IP = $\rho x Q x H$ kW

Turbine Output, OP = $2\Pi NT/60000$ kW

Efficiency, η = Output/Input x100 %

OBSERVATION:

Effective Break Drum diameter = Constant 'K' Value = 3.183×10^{-3}

Weight of rope and hanger = Specific Weight of Water, $\rho = 9.81$ kN/m^3

Sl. No.	**Inlet PressureP (kg/cm^2)**	**P1 (kg/cm^2)**	**P2 (kg/cm^2)**	**Speed of theturbine N (rpm)**	**Weight onhanger W1 (kg)**	**Spring Balance Reading W2 (kg)**
2						

3						

S.No.	**Venturimeter head h (m)**	**Net Load N (kg)**	**Discharge Q(m^3/s)**	**Input Power I/P**	**Output Power O/P**	**Efficiency η (%)**
1						
2						
3						

1. Input Total Head, H = Pressure Gauge Reading (P) in kg/cm2 x10 m

2. Venturimeter Head, h = (P1 – P2)x10 m

3. Theoretical discharge Q = K√h

4. Input Power IP = ρxQxH kW

5. Torque (T) = ((W1 + Weight of rope and hanger) – W2)x D/2 x 9.81 N

2ΠNT

6. Turbine Output, OP = kW

60000

7. Efficiency, η = OP/IP x100

RESULT:

The efficiency of Pelton Wheel Turbine, Ƞ =