ATRIA INSTITUTE OF TECHNOLOGY

Affiliated to VTU

LABORATORY MANUAL

18CVL48-Fluid Mechanics and Hydraulic Machines Laboratory

2020-2021

DEPARTMENT OF CIVIL ENGINEERING

AKSB Campus, 1st Main Road, Anand Nagar,

Hebbal, Bengaluru 560024

SYLLABUS

B. E. CIVIL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY

Course Code	18CVL48	CIE Marks	40
Teaching ours/Week(L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives: This course will enable students to;
1. calibrate flow measuring devices
2. determine the force exerted by jet of water on vanes
3. measure discharge and head losses in pipes
4. understand the fluid flow pattern

Experiments:

1. Verification of Bernoulli's equation.
2. Determination of Cd for Venturimeter and Orifice meter.
3. Determination of hydraulic coefficients of small vertical orifice.
4. Determination of Cd for Rectangular and Triangular notch
5. Determination of Cd for Ogee and Broad crested weir
6. Determination of Cd for Venturiflume
7. Determination of force exerted by a jet on flat and curved vanes.
8. Determination of efficiency of Pelton wheel turbine
9. Determination of efficiency of Francis turbine
10. Determination of efficiency of Kaplan turbine
11. Determination of efficiency of centrifugal pump
12. Determination of Major Loss in Pipes
13. Determination of Minor losses in pipe due to sudden enlargement, sudden contraction and bend.

Course outcomes: During the course of study students will develop understanding of:
1. Properties of fluids and the use of various instruments for fluid flow measurement.
2. Working of hydraulic machines under various conditions of working and their characteristics.

- All experiments are to be included in the examination except demonstration exercises.
- Candidate to perform experiment assigned to him.
- Marks are to be allotted as per the split up of marks shown on the cover page of answer script.

Reference Books:

1. Sarbjit Singh , Experiments in Fluid Mechanics - PHI Pvt. Ltd.- New Delhi
2. Mohd. Kaleem Khan, "Fluid Mechanics and Machinery", Oxford University Press
3. Hydraulics and Fluid Mechanics' – Dr. P.N. Modi& D r S.M. Seth, Standard Book House New Delhi. 2009Edition

LIST OF EXPERIMENTS

S. No.	Experiment
1	Verification of Bernoulli's equation.
2	Determination of Cd for Venturimeter and Orifice meter.
3	Determination of hydraulic coefficients of small vertical orifice.
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7	Determination of force exerted by a jet on flat and curved vanes.
8	Determination of efficiency of Pelton wheel turbine
9	Determination of efficiency of Francis turbine
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11	Determination of efficiency of centrifugal pump
12	Determination of Major Loss in Pipes
13	Determination of Minor losses in pipe due to sudden enlargement, sudden contraction and bend.

EXPERIMENT NO 1
COEFFICIENT OF DISCHARGE OF NOTCHES

AIM: To Determine the coefficient of discharge of different notches .

APPARATUS:

Different notches, Collecting tank, Constant head tank, Stop watch, scale.

THEORY:

Notch is a structure which is used to measure the rate of flow in canal, streams and channels. The flow of water in the canals is obstructed by notch structure. This will cause rise of water on upstream side of notch and head builds above sill level of notch.

This causes the flow over notch. By principle, the kinematic head is converted into static head and again it converts into kinetic head.

EXPERIMENTAL SETUP:

The experimental setup consists of supply tank with perforated sheets placed near inlet valve to reduce the velocity of incoming water and to reduce the velocity of approach. Thus the perforated sheet can reduce eddies and steady flow can be obtained in the channel.

The notches are fitted in interchangeable groove at the front end of the channel. A collecting tank is provided to measure the actual discharge.

PROCEDURE:

1. Fix the notch plate in the groove and measure the sill length of the notch.
2. Open the inlet valve and allow the water into the channel to rise up to sill of the notch in the channel.
3. Measure the water surface level with the help of hook gauge (initial water level) H_1.
4. Allow the water to enter into channel and flows over the sill of the notch at steady state condition.
5. Measure the water surface level with the help of hook gauge (final water level) H_2.
6. The difference between initial water level and final water level gives the head causing flow over the notch.
7. Collect the known volume of water (V) in collecting tank in specified time (t).
8. Determine the actual discharge Q_{act}.
9. Determine the theoretical discharge Q_{th}.
10. Determine the coefficient of discharge C_d.
11. Repeat the step for various heads of water above the sill level of notch in the channel.

OBSERVATIONS AND CALCULATIONS:

Observations:

1. Angle of notch (for V notch) θ = 60
2. Length of notch (for rectangular notch and weirs) L =
3. Cross section area of collecting tank A = 0.3X0.3
4. Time taken for collection of water t =
5. Rise of water in the tank R =

Model calculations:

1. Volume of water collected $V = A \times R$
2. Initial water level $H_1 =$
3. Final water level $H_2 =$
4. Head of water above the sill level $H = H_1 - H_2$
5. Actual discharge $Q_{act} = \frac{V}{t}$
6. Theoretical discharge (for V notch) $Q_{th} = \frac{8}{15} \tan\theta \, H^{2.5} \sqrt{(2g)}$
7. Theoretical discharge (for rectangular notch) $Q_{th} = \frac{2}{3} L H^{1.5} \sqrt{(2g)}$
8. Theoretical discharge for weirs $Q_{th} = 1.705 \, C_d \, L \, H^{1.5}$
9. Coefficient of discharge $C_d = \frac{Q_{act}}{Q_{th}}$

TABULAR COLUMN:

V notch

SL No	Initial water level H_1	Final water level H_2	Head $H = H_1 - H_2$	Volume of water collected V	Time taken for collection t	Actual discharge Q_{act}	Theoretical discharge Q_{th}	Coefficient of discharge C_d

Rectangular Notch

SL No	Initial water level H_1	Final water level H_2	Head $H = H_1 - H_2$	Volume of water collected V	Time taken for collection t	Actual discharge Q_{act}	Theoretical discharge Q_{th}	Coefficient of discharge C_d

Graphically,

A log Q_a vs log H suggests a straight line relation as shown in fig. This equation is of the form

$Q_a = 8/15\ C_d \tan\theta \sqrt{2g} \times H^{5/2} = KH^n$

Taking log on both sides

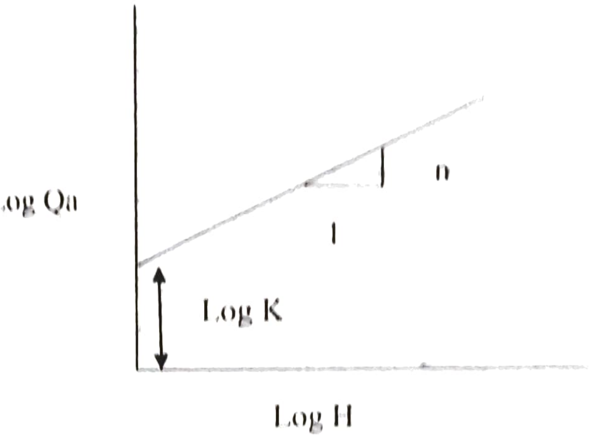
$\log Q_a = \log K + n \log H$

Where logK is the intercept on the log Q axis

n is the slope of the straight line.

Knowing the valve of logK, K can be determined and then the value of Ca is determined as follows.

$$Ca = (1/K) \times (1/Slope)$$



Result:

Coefficient of discharge of triangular notch(Analytical) =
Coefficient of discharge of triangular notch(Graphical) =
Coefficient of discharge of Rectangular notch(Analytical) =
Coefficient of discharge Rectangular notch(Graphical) =

EXPERIMENT NO 2

VENTURIMETER AND ORIFICEMETER

AIM: To demonstrate the use of Venturimeter as flow meter and to determine the Co-efficient of discharge.

APPARATUS:

1. Measuring Tank to measure the flow rate

2. A pipe line with a Venturimeter/orificemeter

3. Tappings with valve are provided at inlet & throat of Venturimeter or the venacontracta of orificemeter, which are connected to Manometer.

4. A constant steady supply of water with a means of varying the flow rate using monoblock pump.

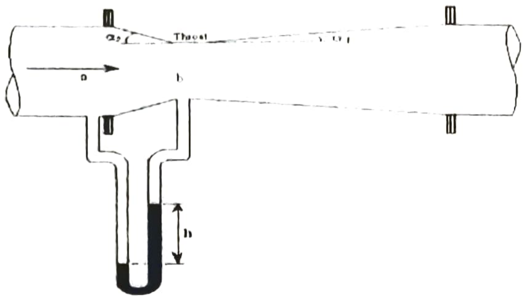
THEORY:

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 the pipe.

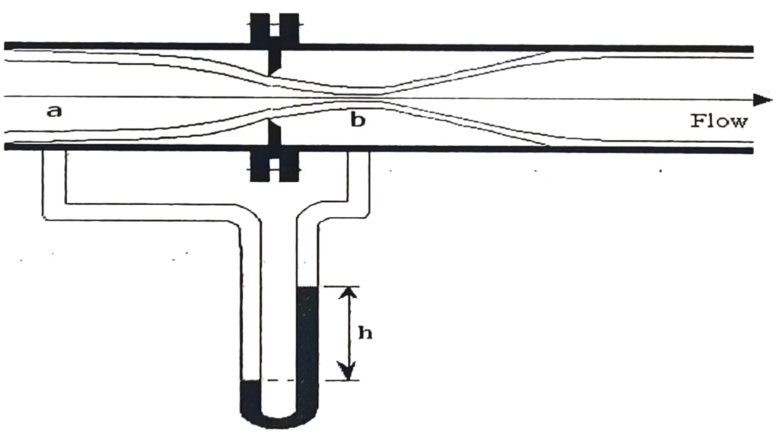
A Venturimeter consists of,

1. An inlet section followed by a convergent cone
2. A cylindrical throat &
3. A gradually divergent cone

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 side tube having its cross-sectional area smaller than that of the pipe. The divergent cone of the Venturimeter is 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 & the throat of the Venturimeter pressure difference is provided through manometer.



An Orificemeter is a device used to measure the rate of flow of a liquid in a pipeline. It works on the same principle as venturimter. A standard sharp-edged orifice meter is shown in Figure. It consists of an accurately machined and drilled plate mounted between two flanges with the hole concentric with the pipe in which it is mounted. Pressure taps, one before and one after the orifice plate, are connected to a manometer to measure the pressure drop. The position of the taps is arbitrary. As in the case of the venturi meter, the empirical coefficient, the coefficient of discharge is introduced. For accurate work, an orifice meter must be calibrated to get the coefficient of discharge, C_d. The value of C_d depends on the position of the pressure taps and is a function of the diameters of the orifice hole and the pipe. It is important that enough straight pipe be provided both before and after the orifice to ensure a flow that is undisturbed by fittings, valves or other equipment. C_d is typically about 0.63 for an orifice meter.



OPERATING INSTRUCTIONS & EXPERIMENTAL PROCEDURES

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 the clean water
2. Keep the delivery valve closed
3. Connect power connection to 1ph,220v,10amps
4. Switch ON the pump & open the delivery valve.
5. Open the valve of the Venturimeter/orificemeter
6. Adjust the flow through the control valve of the pump
7. Open the gate valve fitted to Venturi/orifice tappings

8. Note down the differential head reading in the Manometer (Expel if any air is there by opening the drain cocks provided with the Manometer)
9. Operate the PVC Ball Valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken
10. Change the flow rate & repeat the experiment

FORMULAE

DATA:

Area of measuring tank	"A" = 0.3*0.3 .... M^2
Acceleration due to gravity	"g" = 9.81................ M/s^2
Diameter of venturi meter(throat)	"d" = 0.0145............... M
Diameter of inlet pipe of venturi meter	"D" = 0.0254...............M

VENTURI METER:

1. Theoretical discharge

$$Q_{th} = \frac{a_1 a_2 \sqrt{2 g H}}{\sqrt{(a_1^2 - a_2^2)}} \text{......... } m^3/sec$$

where,
a1 =area of inlet section of venturi
a2 = area of outlet section of venturi
Loss of head H = 12.6 h M
Where h = differential head in mm of Hg

2. Actual discharge:

$$Q_a = \frac{A * R}{t}$$

where.
A =area of measuring tank
R =Raise of water level for in mtr
t =Time taken for raise of water in sec

3. Co-efficient of discharge

C_d = Qa/Qth

Tabular column:

Sl no	Manometer difference h.........M	Time taken for collecting 0.1 M of water t.........sec

The valve of C_d can be determined by plotting a graph of Q Vs $H^{1\ 2}$

$$C_d = \frac{1}{k} \times \left(\frac{1}{slope}\right)$$

ORIFICEMETER

1. Theoretical discharge

$$Q_{th} = \frac{a_1 a_2 \quad 2 g H}{(a_1^2 - a_2^2)} \text{.........} \ m^3/sec$$

where,
a1 =area of inlet section of venturi
a2 = area of outlet section of venturi
Loss of head H = 12.6 h M
Where h = differential head in mm of Hg

2. Actual discharge:

$$Q_a = \frac{A * R}{t}$$

where,
A =area of measuring tank
R =Raise of water level for in mtr
t =Time taken for raise of water in sec

3. Co-efficient of discharge

$C_d = Qa/Qth$

Tabular Coloumn

Sl no	Manometer difference h.........M	Time taken for collecting 0.1 M of water t.........sec

The valve of C_d can be determined by plotting a graph of Q Vs $H^{1/2}$

$$C_d = \frac{1}{k} \times \left(\frac{1}{slope}\right)$$

Result

Coefficient of discharge of venturimeter graphically =
Coefficient of discharge of venturimeter analytically =
Coefficient of discharge of Orificemeter graphically =
Coefficient of discharge of Orificemeter analytically =

PRECAUTIONS AND THINGS TO REMEMBER:

1. Do not start the pump if the voltage is less than 180V.

2. Do not forget to give electrical neutral & earth connections correctly.

3. Frequently (once in three months) Grease/oil the rotating parts.

4. Initially, put clean water free from foreign material, and change once in a month.

5. Every week operate the unit for atleast five minutes to prevent clogging of the moving parts.

EXPERIMENT NO 3

FRICTION IN PIPES
(MAJOR LOSSES)

AIM: To determine the coefficient of friction for pipes of different sizes

APPARATUS:

1. Pipe line of ¾,1/2, 1 inched GI pipe.
2. U- Tube manometer with a stabilizing valve to measure the pressure different across the tapping, one at either end of the pipe line fitted with a Ball Valve
3. A constant steady supply of water with a means of varying the flow rate using Centrifugal type monoblock pump
4. Measuring tank to measure the flow rate
5. Each pipe line is provided with separate control valve to conduct experiments separately

THEORY:
A closed circuit of any cross section used for flow of liquid is known as pipe. In hydraulics, generally pipes are assumed to be running full and of circular cross section. Liquids flowing through pipes are encountered with resistance resulting in loss of head or energy of liquids. This resistance is of two types depending upon the velocity of flow.

1. Viscous Resistance and
2. Frictional Resistance due to different diameters

OPERATING INSTRUCTIONS & EXPERIMENTAL PROCEDURES:

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 clean water
2. Keep the delivery valve closed
3. Connect the power cable to 1Ph. 220V 10A with earth connection
4. Switch –ON the pump & open the delivery valve
5. Open the corresponding gate valve of the pipe line
6. Adjust the flow through the control valve of the pump
7. Open the corresponding ball valves provided in control panel to measure differential head

8. Note down the differential head reading in the Manometer (Expel if any air is there by opening the drain cocks provided with the Manometer)
9. Operate the PVC Ball valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken
10. Change the flow rate & repeat the same procedure.

Tabular column:

Sl no	Manometer difference h.........M	Time taken for collecting 0.1 M of water t.........sec

INITIAL DATA:

Area of measuring tank (A) = 0.3X0.3
Length of pipe (l) = 1.85
Density of water (ρ) =1000 kg/m^3
Acceleration due to gravity (g) = 9.81m/sec^2
Diameter of pipes (d) = 1/2, 3/4, 1 inch pipe

Constants:

Diameter of the pipe (d) =
Length of tapping distance L =
Area of the collecting tank A =
Raise in collecting tank water level R =
Time taken for collection of water, t =
Differential head, in room temperature h =
Density of manometer liquid, Sm =13600 m^3/sec
Density of water. Sw =1000 m^3/sec
Kinematic viscosity of water v =

Calculations:

Actual discharge Qact = $\frac{A*R}{t}$ m^3/sec

Differential pressure head in terms of water head,

hf =h ((Sm/Sw -1) m

Area of the pipe $a = \frac{\Pi}{4} (d^2)$ m^2

Velocity of the pipe, $V = \frac{Qact}{a}$ m/sec

Coefficient of Friction, $f = \frac{h \times d \times 2g}{4 \times l \times V^2}$

PRECAUTIONS:

1. Do not start the pump if the voltage is less than 230V
2. Do not forget to give electrical neutral & earth connections correctly
3. Frequently (At least once in three months) Grease/oil the rotating parts
4. Initially, put clean water free from foreign material, and change once in three months.
5. At least every week operate the unit for five minutes to prevent clogging of the moving parts

Result : Coefficient of friction of Pipe =

EXPERIMENT NO 4

VERTICAL ORIFICE

AIM: To determine the coefficient of velocity (C_v), Coefficient of contraction (C_c), coefficient of discharge (C_d), for a sharp edged circular orifice.

APPARATUS:

1. Header tank with the sharp edged orifice in the vertical plane of the tank.
2. A steady water supply with means of varying the discharge.
3. A vertical sight glass tube to record the water level in the tank.
4. A travelling distance gauge to facilitate accurate measurement of x and y
5. Slide callipers.

PROCEDURE:

1. Fill soft clean water into the sump tank up to 25 to 30 mm below the full level.
2. Fix any desired orifice in position to the side of the headed tank and secure it.
3. Connect the power chord to the electrical power source, the mains indicator will glow.
4. Open fully the pump bypass valve and measuring tank, butterfly valve, keeping all other valves situated under the headed tank closed.
5. Push the starter (green) button and start the pump.
6. Close the pump bypass valve partially to allow water into headed tank.
7. Maintain any derived constant head of water over the orifice or mouthpiece by selecting any one of the three over flow valves.
8. A jet of water issues out of the fixed orifice or mouthpiece and fall into the collecting /measuring tank.
9. Regulate the bypass valve so that a small quantity of water flow through the selected constant head over flow pipe.
10. Note down the following readings and tabulate
    a) Head of water indicted on the headed tank piezometer
    b) Co-ordinates X and Y are measured approximately at vena contracta (in case of orifice only) and at a short distance along X axis through from vena contracta.
    c) Quantity of water collected in the measuring tank up to 10cm height against tank't' on the piezometer tube of the measuring tank.
11. Repeat the experiment by varying the head over the orifice or mouthpiece. Tabulate the readings and calculate C_v, C_c, C_d for the given orifice or mouthpiece.

Calculations:(Any one trial)

To find Coefficient of discharge C_d :

Actual discharge= Q_{act}= Ar/t

A = Area of measuring tank
r = Rise of water level in the measuring tank
t = time for r cm rise in measuring tank

Theoretical discharge $Q_{th} = a_o \sqrt{2gH}$
Where a_o= area of the orifice in m^2
H= Head over the orifice plate in m.

$$C_d = \frac{Q_{act}}{Q_{th}}$$

To find Coefficient of velocity C_V :

I-method:

Actual Velocity = $V_{act} = Q_{act} / a_o$

Theoretical Velocity = $V_{th} = \sqrt{2gH}$

$$C_v = \frac{V_{act}}{V_{th}}$$

II-method:

$C_v = X/\sqrt{4HY}$

Where

X= Horizontal distance of point of deviation from vena contracta
Y= vertical distance of point of deviation from vena contracta
H = Head over the orifice

To find coefficient of contraction in C_c

$$C_c = \frac{C_d}{C_v}$$

Tabular column:

Type of orifice-
Dimension of the orifice-
Initial X coordinate = Initial Y coordinate=

Sl no	Final X coordinate	Final Y coordinate	X	Y	Time for 5cm rise 't' in tank	Q_{act}	Q_{th}	C_d	C_v	C_c

Result:

Coefficient of discharge C_d =
Coefficient of Velocity C_v =
Coefficient of contraction C_c =

EXPERIMENT NO 5
IMPACT OF JET ON VANES

AIM: To determine the Co-efficient of impact jet – vanes combination by the force for stationary vanes of different shapes VIZ: Hemispherical, Flat plate, inclined plate.

THEORY:

When jet of water is directed to hit the vane of particular shape, the force is exerted on it by fluid in the opposite direction. The amount of force exerted depends on the diameter of jet, shape of vane, fluid density, and flow rate of water. More importantly, it also depends on whether the vane is moving or stationary. In our case, we are concern about the force exerted on stationary vanes. The following are the figures and formulae for different shapes of vane, based on flow rate.

HEMISPHERICAL	$F_t = 2\,\rho\,A\,V^2/g$
FLAT PLATE	$F_t = \rho\,A\,V^2/g$
INCLINED PLATE	$F_t = (\rho\,A\,V^2/g)\,\sin^2\theta$

Where,

$g = 9.81 m/sec^2$
A = Area of jet in m^2
ρ = Density of water = 1000 Kg/m^3
V = Velocity of jet in m/sec=Q/A

θ = Angle of deflected vanes makes with the axis of striking jet. 45 degree.
F_t = theoretical force acting parallel to the direction of jet
F_a = Actual force acting parallel to the direction of jet

DESCRIPTION:

It is a closed circuit water re-circulating system consisting of sump tank. mono block pump set. and jet / vane chamber. The water is drawn from sump to mono block pump and delivers it vertically to the nozzle. The flow control valve is also provided for controlling the water into the nozzle. The water issued out of nozzle as jet. The jet is made to strike the vane. the force of which is transferred directly to the vane. A collecting tank with piezo meter to measure discharge. The provision is made to change the size of nozzle jet and vane of different shapes.

SPECIFICATIONS:

Vane shapes : Flat. Hemispherical. Inclined (standard) & any other optional shapes at extra cost.

Jets diameter : 6mm.

Measurements: Pressure of jet by pressure gauges and discharge by collecting tank with the help of stop watch

Pump : 1 hp. single phase, 230volt with starter

Type : Recirculating with sump & jet chamber made of stainless steel.

Jet chamber : Fixed with toughened glass windows with leak proof rubber gaskets.

OPERATION:

1. Fix the required diameter jet and the vane of required shape in position.
2. Keep the delivery valve closed & switch ON the pump.
3. Close the front transparent cover tightly.
4. Open the delivery valve and adjust the flow rate of water by gate wall provided.
5. Note down the diameter of jet. shape of vane. flow rate & force and tabulate the results.
6. This way take readings for 1) different flow rates

   2) Different vanes

TABULAR COLUMN:

sl no	Type of vane used	Time taken for 10 cm raise of water in measuring tank in sec	Actual discharge m^3/sec Qa	Velocity of jet m/sec Va	Actual force Fa	Theoretical force Ft m/sec	Co-efficient of impact

CALCULATION:

1. Area of the vane A=......................m^2

2. Volume of water collected U =.............. m^3

3. Actual discharge Qa= U/t =…....................m^3/sec

4. Velocity of water jet = Va = Qa/A =.............m/s

5. Theoretical force = Ft ....m/sec

6. Actual force Fa = ……..

7. Co-efficient of impact = k = Fa/Ft =……….

Results: Coefficient of Impact for flat vane:
Coefficient of Impact for Inclined vane:
Coefficient of Impact for curved vane:

EXPERIMENT NO 6
VARIABLE SPEED CENTRIFUGAL PUMP TEST RIG

AIM: To determine the efficiency of the centrifugal pump

INTRODUCTION:

In general, a pump may be defined as a mechanical device which, when interposed in a pipe line, converts the mechanical energy supplied to it from some external source into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

The pumps are of major concern to most Engineers and Technicians. The types of pump vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial purposes are: Centrifugal, Piston, Axial Flow (Stage Pumps), Air jet, Diaphragm and Turbine pumps. Most of these pumps fall into the main class, namely: Rotodynamic, Reciprocating (Positive Displacement), Fluid (Air) operated pumps.

While the principle of operation of other pumps is discussed elsewhere, the Centrifugal pump which is of present concern falls into the category of Rotodynamic pumps. In this pump, the liquid is made to rotate in a closed chamber (Volute Casing), thus creating the centrifugal action, which gradually builds the pressure gradient towards outlet thus resulting in the continuous flow. These pumps compared to Reciprocating Pumps are simple in construction, more suitable for handling viscous, turbid (Muddy) liquids can be directly coupled to high-speed electric motors (without any speed reduction), easy to maintain. But, their hydraulic heads per stage at low flow rates is limited, and hence not suitable for very high heads compared to Reciprocating Pumps of same capacity. But, still in most cases, this is the only type of pump, which is being widely used for agricultural applications because of its practical suitability. The present test rig allows the students to understand and draw the operating characteristics at various heads and flow rates and speeds.

DESCRIPTION:

The present pump test rig is a self-contained unit operated on closed circuit (Re circulation) basis. The Centrifugal pump, DC Motor with suitable DC drive, sump tank, collecting tank, Control panel are mounted on rigid frame work with arranged with the following provisions:

1. To measure overall input power to the DC Motor using Energy Meter and stop watch.
2. For recording the Pressure & Vacuum
3. For changing the Pressure by operating the delivery valve.
4. For measuring the discharge by Collecting Tank

OPERATING INSTRUCTIONS:

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 clean water
2) Keep the delivery valve closed after initially priming the pump
3) Connect the power cable to single Phase, 230 V, 5A with earth connection
4) Prime the pump using priming valve and close it after priming.
5) Switch –ON the mains and slowly vary the voltage regulator provided in the DC drive and keep it at required speed.
6) Now, you will find the water starts flowing to the Measuring tank
7) Close the delivery valve slightly, so that the delivery pressure is readable
8) Operate the PVC Ball valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken
9) Note down the Pressure Gauges, Vacuum Gauges, and time for Energy Meter reading.
10) Note down the other readings as indicated in the Tabular Column
11) Repeat the experiment for different pressures.
12) Tabulate the readings as shown in tabular column and calculate the results using Formulae
13) Similarly repeat the experiment for different speeds
14) After the experiment is over, switch off the pump.

PRECAUTIONS AND THINGS TO REMEMBER:

6. Do not start the pump if the voltage is less than 200V
7. Do not forget to give electrical neutral & earth connections correctly
8. Add a little "Machine Coolant" to the water to prevent rusting of parts

9. Frequently (At least once in three months) Grease/oil the rotating parts
10. Initially, put clean water free from foreign material.
11. At least every week operate the unit for five minutes to prevent clogging of the moving parts.

SPECIFICATIONS:

* Electrical Supply : 230 Volts, 5 Amps, 1Ph 50 Hz with Neutral & Earth Connection
* Centrifugal Pump ; 1HP, Kirloskar make.
    - Motor : 1 HP DC motor
* Pressure Gauges : 4.2 Kg /CM²
* Vacuum Gauge : 0-760 mm of Hg
* Energy Meter constant : Rev./KWH
* Control Valves : For control flow rate of water
* Measuring Tank Size : 0.3X0.3=0.09m²

BASIC DATA:

1HP = 736 Watts
1kg/cm² = 760 mm of Hg(10 m of water)
Density of water ("W") = 1000 kg/m³
Emc = rev/kWh
Area of collecting tank = 0.4 x 0.4

CALCULATION

1. **Input power:**

$$HP = \frac{n \times 3600}{Emc \times t} \ldots \ldots kW$$

Where,
n = no.of revolution

t = time taken for n rev or imp.

2. Rate of discharge

$$Q = \frac{A \times h}{1000 \times T}$$

Where,
A = area of collecting tank
h = height of water collected in mm
T = time taken in sec.for collecting tank.

3. Total head

H = 10(delivery pressure + Vacuum head)
= 10(Pd +Ps/760) .... m of water

5. Power output (delivered by the pump)

$$P = \frac{WQH}{0.8} \text{......Kw}$$

Where, W = specific weight = 9.81 kN/m³
Q = discharge
H = Total Head
0.8 = motor efficiency = 80%

6. Overall efficiency

$$\eta_{overall} = \frac{\text{output power}}{\text{input power}} \times 100$$

$\eta_{overall}$ = Overall Efficiency in %

Tabular coloumn

Sl	V in volts	N	Energy meter reading 10 imp n	Collecting tank reading t=sec	Pd pressure

Calculation

$$HP = \frac{n \times 3600}{Emc \times t} \text{... .... kW}$$

$$= \frac{10X3600}{30.43X1600}$$

Where,
n = no.of revolution
t = time taken for n rev or imp.

Graphs:

Main characteristic curves

i. η_o v/s N

ii. O/P v/s N

iii. Q v/s N

Operating characteristic curves

i. η_o v/s H

ii. O/P v/s H

iii. Q v/s H

Results:

Overall Efficieny analytically =
Overall Efficiency graphically =

EXPERIMENT NO 7
PELTON TURBINE TEST RIG

AIM: To determine the efficiency of the pelton wheel turbine

INTRODUCTION

The Pelton Turbine test rig is supplied as a complete set to conduct experiments on model Pelton turbine in Engineering colleges and Technical institutions. It has been specially designed to conduct experiments in metric units. The test rig mainly consists of (1) Pelton turbine (2)Flow measuring unit consisting of a venturimeter and pressure gauges and (3) Piping system (4)A suitable capacity sump tank (5) suitable capacity Pump.

GENERAL DESCRIPTION

The unit essentially consists of casing with a large circular transparent window kept at the front for the visual inspection of the impact of the jet on buckets a bearing pedestals rotor assembly of shaft, runner and brake drum, all mounted on a suitable sturdy iron base plate. A rope brake arrangement is provided to load the turbine. The input to the turbine can be controlled by adjusting the spear position by means of a hand wheel fitted with indicator arrangement. The water inlet pressure, by a pressure gauge and for the measurement of speed, uses a rpm indicator.

CONSTRUCTIONAL SPECIFICATION

1. CASING : Of closed Mild steel having a large circular transparent window.

2. RUNNER: Of cast gun metal is fitted with accurately finished gun metal buckets and Powder coated.

3. NOZZLE: Of stainless steel designed for smooth flow.

4. SPEAR : Of stainless steel designed for efficient operation.

5. BRAKE ARRANGEMENT: Consisting of a machined and polished Brake drum cooling water pipes, internal water scoop discharge pipes, Standard cast iron dead weight spring balance, rope brake etc. arranged for loading the turbine.

TECHNICAL SPECIFICATION

PELTON TURBINE(IMPULSE TURBINE)

1. Rated Supply Head :

2. Discharge:

3. Normal Speed : 1000 rpm

4. Power Output : 1 kW

5. Jet diameter : 16mm (Maximum)

6. No. of buckets : 16 Nos.

7. Brake drum diameter : 210mm

8. Rope Diameter : 16 mm

SUPPLY PUMPSET

01. Rated Head : 32 meters
02. Discharge : 1200 LPM
03. Normal Speed : 2880 RPM
04. Power Required : 5 HP
05. Size of Pump : 65 mm x 50 mm
6. Type : Centrifugal medium speed, single suction

FLOW MEASURING UNIT:

1. Size of Venturimeter : 50mm

2. Diameter Ratio : 0.5916

3. Area Ratio : 0.35

4. Throat Diameter : 25.454mm

5. Inlet cone angle of Venturimeter : 20°

6. Diverging cone angle of Venturimeter : 10o

7. Pressure gauge : 0-4 Kg/cm^2 range – 1 no.
8. Acrylic manometer : 1 no.
8. 'K' Value : 3.183×10^{-3}
[$Q = k\sqrt{h}$ m3/sec]

INSTALLATION

The turbine is placed on the sump tank level. The supply pumpset draws water from the main underground. The gate valve is provided just above the inlet bend of the turbine to regulate the discharge and net supply head on the turbine in relation to the spear settings. A spear and nozzle arrangement is provided on one side of the runner to control the load the spear being operates through a hand wheel with suitable indicating gear.

STARTING UP(COMMISSIONING)

Make sure before starting that the pipe lines are free foreign matter. Also note whether all the joints are water tight and a leak proof. Start pump with closed gate valve. The spear in the turbine inlet and should also be in the closed position while starting the pump. See that all the ball bearings and such bearings in the units are properly lubricated. Then slowly open the gate valve situated above the turbine and read the pressure gauge and sees that the pump develops the rated head. The pump develops the required head, slowly open the turbine spear by rotating the hand wheel until the turbine attains the normal speed run the turbine at the normal speed for about 15 min and carefully notes the following.

1. Operation of the bearings, temperature rise, etc.
2. Steady constant speed & speed fluctuations if any.
3. Vibration of the unit.

In addition to this, on the pump side note the operation of the stuffing box. (The stuffing box should have a drip of water. If the gland is over tightened, the leakage stops but the packing will heat up burn and damage the shaft).

If the operation of the above parts is normal, load the turbine slowly and take readings. To load the turbine standard dead weight are provided with figures stamped on them to indicator their weights. Open the water inlet valve and allow some cooling water through the brake drum when the turbine runs under load, so that the heat generated by the brake drum is carried away by the cooling water.

Do not suddenly load the turbine, load the turbine gradually and the same time open the spear to run the turbine at normal speed.

TO SHUT DOWN

Before switching off the supply pump set, first remove all the dead weights on the hanger. Close the cooling inlet water gate valve slowly close the spear to its full closed position. Then close the gate valve just above turbine. Then switch off the supply pump set. Never switch off the supply pump set when the turbine is working under load. If the electric lines trips of when the turbine is working first unload the turbine, close all the valves. Start the electric motor again, when the line gets the power and then operate the turbine by operating the valve in the order said above.

TESTING

Water turbines are tested in the hydraulic laboratory to demonstrate how tests on small water turbine are carried out, to study their construction, and to given the students a clear knowledge about the different type of turbines and their characteristics.

Turbine shall be first tested at constant net supply head (at the rated value of 35-40m) by varying the load, speed and setting. However the net supply head on the turbine may be reduced and the turbine tested in which case the power developed by the turbine and the best efficiency speed will also be reduced.

Though the turbine can also be tested at higher net supply heads, the supply pumpset cannot develop the higher head at the same time maintaining higher of flow.

The output power from the turbine is calculated from the readings taken on the brake and the speed of the shaft. The input power supplied to the turbine is calculated from the net supply head on the turbine and discharge through the turbine. Efficiency of the turbine being the ratio between the output and input can be determined from these two readings.

The discharge is measured by the 50mm venturimeter and with the pressure gauges. Supply head is measured with help of the pressure gauge.

It is suggested that the turbine shall be tested at normal speed, three speeds below normal speed. 3 speeds above normal speed covering a range of 50% of the normal speed. The runaway speed(the speed of the turbine at no load and at rated condition of supply head) and pull out torque(the maximum torque at stalled speed) may also be observed.

After starting and running the turbine at normal speed for some time, load the turbine and take readings. Note the following:

1. Net supply head
2. Discharge (Pressure gauge readings)
3. Turbine shaft speed
4. Brake weight (Dead Weights plus hanger and rope weight) (1kg)
5. Spring balance reading.

For any particular setting of the spear first run the turbine at light load and then gradually load it, by adding dead weights on the hanger. The net supply head on the turbine shall be maintained constant at the rated value. and this can be done by adjusting the gate valve fitted just above the turbine.

PELTON TURBINE TEST RIG (CLOSED CIRCUIT)

Brake drum dia D=0.21 m

Input total head H in m of water=Pressure gauge reading in kg/cm^2x 10

Rope Dia t = 0.016m

Venturimeter Head h in m of water h= 12.6x h meter

Effective Radius of = (D/2 + t)

Discharge Q = K√h (h in m of water)

Weight of rope & hanger –W_2 kg = 1 kg

Brake Drum net load W= (W_1 + Weight of rope hanger)

Spear opening = 0.5

Turbine output OP =(2π NW R_e x 9.81)/ 60000 kW

'K' Value = *3.183 x 10^{-3}*

Efficiency η = *(output / Input) x 100%*

Sl N	Speed N	Venturi - meter h	Pressure gauge reading H	Weight on hanger W_1	Spring balance reading W_2	Net Load W	Discharge Q	Output OP	Input IP	Efficiency η
	rpm	meters	kg/cm^2	kg	kg	kg	m^3/sec	kW	kW	%
1.										
2.										
3.										
4.										
5.										

IMPORTANT FORMULA:

Input Power = γQH kW

Where γ = Specific weight of water = 9.81 KN/m^3

Q = Discharge in m^3/sec.

H = Supply head in meters.

$$\text{Brake Power} = \frac{2\pi\, N\, ReW \times 9.81}{60000}\ \text{kW}$$

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \times 100\%$$

Where N = Turbine speed in RPM.

T = Torque in Kg m, (effective radius of the brake drum in meters (R_e) x The net brake load in kg(W).

9. MAINTENANCE

As these units are built very sturdily, they do not require any routine or regular maintenance. However, we recommend the following to be done about once in a year to increase the life of the elements.

Lubricate all the working parts where provision for lubricating is made. Grease cups are provided for lubrication ball bearings. Remove the grease drain plugs where fitted, and inject fresh grease through grease cups until waste grease along with a portion of fresh grease us ejected out through the grease drain hole. Then run the machine for a few minutes to eject the excess grease in the bearing housing. Then fit the grease drain plug. Over greasing results in excessive heat due to a pumping action of the bearing, and it is a harmful as under greasing.
Clean the stuffing box, repack and lubricating it. If any packing ring it's worn out, replace it with good quality as bets graphically packing. While repacking the successive ring joints should be staggered by 90 or 180 degrees. Tighten the gland nuts evenly and allow the stuffing box to drip water occasionally to lubricate the packing rings.

Never run the pump without water in it as this would cause damage to stuffing box, bush bearings etc.

Graph : Plot the graph of Output Versus Input

Results :

Efficiency of Pelton wheel Turbine graphically=
Efficiency Analytically =

EXPERIMENT NO 8
KAPLAN TURBINE TEST RIG

AIM : To conduct Performance test and to determine the efficiency of a Kaplan Turbine

APPARATUS: Kaplan Turbine, Digital speed indicator. Pressure gauge. Vacuum gauge. weights. brake dynamometer, Venturimeter and centrifugal pump.

THEORY: The Kaplan Turbine operates under low heads and large quantities of flow. The water from the pump enters through the spiral casing into the guide vanes and then to the runner. While passing through the spiral casing and guide vanes a portion of the pressure head is converted into kinetic energy. The water enters the runner at a higher velocity than in the pipe line.
Experimentally, the efficiency is determined in the same way as for Pelton or Francis Turbines.

EXPERIMENTAL SETUP:-
A Kaplan Turbine is an axial flow reaction turbine. It consists essentially of a runner . a ring of adjustable guide vanes and volute casing. The guide vanes are of aerofoil section and can be rotated about their axis by means of a hand wheel The runner has four blades of aerofoil section which is fixed.. The turbine is loaded by putting weights on the hanger of the brake dynamometer.
Water under pressure is supplied to the turbine by a centrifugal pump. The discharge from the pump is controlled by means of a butterfly valve fitted in the pipe line. The discharge in the pipe line and hence through the turbine can be measured with the help of a venturimeter. The head of water is measured with the help of a pressure gauge and vacuum gauge.

CONSTRUCTION SPECIFICATION:

A. **Spiral Casing :** is of close grained cast iron.

B. **Runner:** is of gunmetal and nickel plated. designed for efficient operation accurately machined and smoothly finished.

C. **Guide Vane** Mechanism: Consists of gun metal guide vanes. operated by a hand wheel through a link mechanism.

D. **Shaft:** is of EN8 steel accurately machined and provided with a brass and gunmetal Sleeve at the stuffing box.

E. **Ball Bearings:** is of double row deep groove rigid type in the casing And double row self aligning type in the bearing pedestal both of Liberal size.

F. **Draught Bend:** is provided at the exit of the runner. To the bend is connected. a straight conical draught tube of steel fabrication.

G. **Brake Arrangement:** Consisting of a machined and polished cast iron brake drum, cooling water pipes,
Standard cast iron dead weights, spring balance, rope brake etc. arranged for loading the turbine.

H. **Sump Tank:** approximately about 1200 ltr stainless steel tank is provided for closed circuit operation.

TECHNICAL SPECIFICATION:

01. Rated Supply Head	: 10-15 meters approximately
02. Rated Speed	: 1000 rpm
03. Power Output	: 1kW
04. Runaway Speed	: 1750 RPM
05. Runner Diameter	: 160 mm
06. No. of guide vanes	10
07. P.C.D. guide vanes	: 230mm
08. Brake Drum Diameter	: 360 mm
09. Rope Diameter	: 16 mm

SUPPLY PUMP SET

01. Rated Head	: 10- 15 meters
02. Discharge	: LPM approximately
03. Normal Speed	: 2880 RPM
04. Power Required	:7.5 HP
05. Size of Pump	: 100 mm x 100 mm
06. Type	: Centrifugal medium speed, single suction volute

FLOW MEASURING UNIT :

01. Inlet diameter of venturimeter	: 100 mm
02. venturimeter throat Diameter	: 48 mm
03. Pressure Gauges	: 0-4 Kg/cm2

PROCEDURE:-

1. Connect the power supply to the pump
2. Close the turbine inlet gate valve fully before starting the pump
3. Start the centrifugal pump.

4. Allow the water to flow into the turbine by opening the gate valve.

5. Keep the guide vane at desired value where we get max rpm or head

6. Then close the gate valve so as to attain 1000 or 1200 rpm

7. Allow it to sabilibe at that speed

8. Load the turbine gradually say ¼, ½, 3/ 4 & full load by maintaining the turbine speed 1000RPM by operating the gate valve.

9. Note down the all the parameters as per the tabulation column given below

10. Repeat the experiment for different loads.

11. After the experiment remove the load on the weight hanger and close the gate valve

10. Stop the pump motor.

12. Calculate the power input, power output and efficiency.

CALCULATIONS:-

In the experimental setup the discharge is measured by means of a venture meter. If a_1 and a_2 are the areas of cross section at locations 1 and 2 respectively and C is the co-efficient of venture meter, then it can be shown that

Where,

h = (P2 - P3)10 = ……m of water
D1 = Diameter of venturimeter= 100 mm
D2 = Throat diameter of venturimeter = 48mm
C = 0.962
a_1 & a_2 = area of section of inlet & throat of venturimeter

Power input

Input Power = γQH kW

Where γ = Specific weight of water = 9.81 KN/m^3
Q = Discharge in m^3/sec.
H = Supply head in meters.

$= (P1 + (Pv \times 13.6 \times 10^{-3})\ 10$

$$\text{Brake Power} = \frac{2\pi\ N\ T \times 9.81}{60000} \ldots\ldots \text{kW}$$

Where N = Turbine speed in RPM.
T = Torque in = ((W-S)+1) R.......Kg- m
W = dead weights applied
S = spring balance reading
and 1 kg is the hanger weight
R = arm length = 0.196 m

$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}}\ 100$$

TABULAR COLUMN:

SL NO.	W	S	Pv	P1	P2	P3	N	h	H	P input (kW)	P output (kW)	η in%

Where,
W = dead weight load in kg
S = Spring balance reading in kg
Pv = Vaccum gauge reading in mm of Hg
P1 = Total head pressure gauge reading in kg/ cm2
P2 = Pressure at venture inlet in kg/ cm2
P3 = Pressure at venture throat in kg/ cm2
N = speed of the turbine
h = venturi head in meter of water
H = total head in meter of water

Graph : Plot the graph of Output Versus Input

Results :

Efficiency of Kaplan Turbine graphically=
Efficiency Kaplan Turbine Analytically =

EXPERIMENT NO 9
VENTURIFLUME

AIM: To determine the coefficient of discharge of venturiflume

APPARATUS:

1. Venturiflume with point gauges at the entrance and the throat installed in an open channel
2. A constant steady supply of water with a means of varying discharge.
3. Measuring tank and stop watch to measure the actual discharge.

THEORY:

A venturiflume is a device used to measure the rate of flow of a liquid in an open channel. It consists of a convergent fluming section, throat section (constant width) and divergent fluming section. The principle (Bernoulli's theorem) used is to measure the difference of head between two sections and computing the average flow velocity from which the discharge is computed using discharge continuity equation. Coefficient of discharge is the ratio of actual discharge to the corresponding theoretical discharge.

PROCEDURE:

1. Select a venturiflume set up.
2. Note down the widths of the channel and flumed(throat) section
3. Allow the water to flow in the channel by opening the gate valve.
4. Note down the gauge readings at the entrance and throat section
5. Note down the Rota meter reading to know the actual discharge and conduct the experiment for various discharges.

Table and calculations:

Width at the entrance b_1=……m
Width of the throat b_2=…….m

Sl No	Rotameter reading LPM	Water level at entrance h1 meter	Water Level at the throat h2 meter	$H = h_1 - h_2$	$a_1 = b_1 h_1$	$a_2 = b_2 h_2$	$Q_{th} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{(a_1^2 - a_2^2)}}$	$C_d = \frac{Q_{act}}{Q_{th}}$

Calculations:

$Q_{th} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{(a_1^2 - a_2^2)}}$

Q_{act} = Rotameter reading (LPM) =________________ m^3/sec

$C_d = \frac{Q_{act}}{Q_{th}}$

Result: Coefficient of discharge (graphical) =_______________
Coefficient of discharge (analytical)=_______________

EXPERIMENT NO 10
BERNOULLI'S APPARATUS

AIM: To verify Bernoulli`s theorem

Bernoulli's Theorem:

In an ideal , incompressible , steady and continuous flow , the sum of pressure energy , potential energy , kinetic energy per unit weight of fluid is constant.

The energy per unit weight of fluid (N.m/N) has got a dimension of length (L) and can be expressed in metres of fluid column , commonly called as head .Thus according to the BERNOULLI`S theorem , the sum of pressure head (P/γ) ,datum head (Z) and the velocity head ($V^2/2g$)is constant .

i.e. $P/\gamma + Z + V^2/2g = \text{constant}$.

In cases of real fluids , because some energy is always lost in overcoming frictional resistance , the BERNOULLI`S theorem for real fluids is

$P_1/\gamma + V_1^2/2g + Z_1 = P_2/\gamma + V_2^2/2g + Z_2 + H_{L2}$

Where H L is loss of head from section 1 to 2

Experimental Set-up

The set-up consists of a horizontal converging-diverging duct having a varying width and varying depth. The duct is made of transparent Perspex sheets. A number of piezometer are fitted on the duct to indicate the piezometric levels at various sections.

The duct is connected to a constant-head tank at one end. The supply tank is fitted with a piezometer to indicate the water depth. The overflow pipe discharges the excess water and thus keeps the water level constant.

The water is collected in the measuring tank for determination of the discharge.

A small tank with a valve is provided at the downstream end of the duct.

A graph paper can be fixed on a wooden board placed behind the piezometric tubes for making the water levels.

PROCEDURE:

1. Allow water to flow from the supply tank by slowly opening the inlet valve .
2. Adjust the flow in such a manner that a constant head of water is available in the supply tank (i.e inflow = outflow)
3. Note down the quantity of water collected (Q) in the measuring tank for a given interval of time using a stopwatch.
4. Compute the areas of cross section (A_1 and A_2) under the piezometer tubes.

5. Use the continuity equation to get v1 and v2 as follows: $Q = A_1v_1 = a_2v_2$

Therefore $v_1 = Q/A_1$ and $v_2 = Q/A_2$

6. Read the pressure head p/w directly from the piezometer tubes at the concerned sections.

7. Note down the datum head z at different sections. (For a horizontal pipe line z will be a constant)

8. Continue the procedure for different discharges.

Observations and Calculations:

Width of the duct	b = 43mm , 35mm , 28mm , 21mm
Length of the collecting tank	L = 300mm
Width of collecting tank	B = 300mm
Area of cross-section	A = L x B =

DISCHARGE OF WATER

Q=V/t

V =LXBXH (H=100mm)

Where V =volume of water collected
t =time taken for 100mm rise of water

VELOCITY

$V_1^2/ 2g = \{Q/A_1\}^2 \times 1/2g$

$V_2^2/ 2g = \{Q/A_2\}^2 \times 1/2g$

Where A1 ,A2 are the cross sectional area of of duct
The loss of head at various sections

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + H_{l2} = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + Z_3 + H_{l3}$$

OBSERVATION:

Area of the collecting tank, A
Rise in water level, R
Time required for collection of volume of water, t
Pressure head at piezometric connection point in the conduit, p/ γ
Constant head in water supply tank, h_1
Volume of water collected in collecting tank, A x R
Actual discharge Q_{act} = AR/t

CALCULATION:

Area of the conduit section, a =

Velocity of flow at any section of conduit, $v=Q_{act}/a$

Velocity head $V^2/2g$

Datum head, Z=0(since longitudinal axis of pipe is datum line)

total head, $H= p/\gamma + V^2/2g + Z$

TABULAR COLUMN

Sl no	Pressure head		Time t sec for 5cm rise in measuring tank	Q= $\frac{A X 5}{100t}$	$V_1 = Q/A_1$	$V_2 = Q/A_2$	Velocity head		Total head	
	P_1/w	P_2/w					$v_1^2/2g$	$v_2^2/2g$	$P_1/w + v_1^2/2g$	$P_2/w + V_2^2/2g$
1.										
2.										
3.										

Result : $P_1/w + v_1^2/2g + z_1 = P_2/w + v_2^2/2g + z_1$

Hence Bernoulli's theorem is verified

EXPERIMENT NO 11
MINOR LOSSES

AIM: To determine the minor losses due to sudden enlargement, sudden contraction and bend

APPARATUS:

A flow circuit of G. I. pipes of different pipe fittings viz. Large bend, Small bend, Elbow, Sudden enlargement, Sudden contraction, U-tube differential manometer, collecting tank.

THEORY:

When a fluid flows through a pipe, certain resistance is offered to the flowing fluid, which results in causing a loss of energy. The various energy losses in pipes may be classified as:

(i) Major losses.
(ii) Minor losses.

The major loss of energy as a fluid flows through a pipe, is caused by friction. It may be computed mainly by Darcy-Weisbach equation. The loss of energy due to friction is classified as a major loss because in case of long pipelines. It is usually much more than the loss of energy incurred by other causes.

The minor losses of energy are those, which are caused on account of the change in the velocity of flowing fluid (either in magnitude or direction). In case of long pipes these losses are usually quite small as compared with the loss of energy due to friction and hence these are termed 'minor losses' which my even be neglected without serious error. However, in short pipes these losses may sometimes outweigh the friction loss. Some of the losses of energy that may be caused due to the change of velocity are indicated below

Sudden Enlargement:- Two pipe of cross-sectional area A1 and A2 flanged together with a constant velocity fluid flowing from smaller diameter pipe. This flow breaks away from edges of narrow edges section, eddies from and resulting turbulence cause dissipation of energy. The initiations and onset of disturbances in turbulence is due to fluid momentum and its area.

It is given by:- $K = h_f/((V1-V2)^2/2g))$

Eddy loss:- Because the expansion loss is expended exclusively on eddy formation and continues substance of rotational motion of fluid masses.

Sudden Contraction:- It represents a pipe line in which abrupt contraction occurs. Inspection of the flow pattern reveals that it exists in two phases.

$K = h_f/((0.5\ V2)^2/2g))$ V2 = velocity at the contracted pipe

Losses at bends, elbows and other fittings:-
The flow pattern regarding separation and eddying in region of separations in bends, valves. The resulting head loss due to energy dissipation can be prescribed by the relation $K = h_f/(V^2/2g)$

Where V is the average flow velocity and the resistance coefficient K depends on parameter defining the geometry of the section and flow. Resistances of large sizes elbows can be reduced appreciably by splitting the flow into a number of streams by a jet of guide vanes called cascades.

PROCEDURE:

1. Fill in the sump tank with clean water
2. Keep the delivery valve closed
3. Connect the power cable to 1Ph , 220 V , 10A with earth
4. Switch on the pump and open the delivery valve
5. Open the corresponding ball valve of the pipeline
6. Adjust the flow through the control valve of the pump
7. Note down the head reading in the manometer (Expel if any air is there by opening the drain cocks provided with the manometer)
8. Operate the PVC ball valve to note down the collectiung tank reading against the known rise and keep it open when the readings are not taken
9. Change the flow rate and repeat the experiment

OBSERVATION TABLE:

Sl No	Type of Pipe Fitting	Manometer Reading(H in mm of Mercury)	Time taken for 10cm rise in collecting tank(sec)

Formulas

Actual discharge $Q_{act} = \frac{A*R}{t}$ m^3/sec

Differential pressure head in terms of water head,

$$h_f = h\left(\left(S_m/S_w - 1\right)\right) \quad m$$

Area of the pipe $a = \frac{\Pi}{4}(d^2)$ m^2

Velocity of the pipe, $V = \frac{Q_{act}}{a}$ m/sec

Sudden Enlargement

$K = h_f/((V1-V2)^2/2g))$

Sudden Contraction

$K = h_f/((0.5\ V2)^2/2g))$

Losses at bends, elbows and other fittings:-

$K = h_f/(V^2/2g)$

Result :

EXPERIMENT NO.12
OGEE WEIR

AIM: To calibrate the ogee weir and hence to determine the value of C_d

APPARATUS:

1. A constant steady water supply with a means of varying the flow
2. An approach channel (flume)
3. ogee weir (to be calibrated)
4. A flow rate measuring facility ((calibrated rectangular notch)
5. Hook gauge

THEORY:

Generally ogee shaped weirs are provided for the spillway of a storage dam. The crest of the ogee weir is slightly rises and falls into parabolic form. Flow over ogee weir is also similar to flow over rectangular weir. The crest of the weir rises upto a maximum of 0.115H, where H is the head over the weir.

Formula governing the flow over a ogee weir is $Q = = (2/3)LC_d \sqrt{2g}H^{3/2}$ ------------ 1

Where L= length of weir (measured perpendicular to the direction of flow or the width of the

channel in the laboratory)

PROCEDURE:

1. Start the pump with the help of electrical 3phase DOL starter (Direct on line) and observe water flowing in the flume. Wait till the water level rises to the crest level of the weir fixed at the downstream end

2. Adjust the vernier scale any whole number of main scale division and lock it.
3. Bring the hook gauge point exactly to the water level, note it as initial level h_1
4. measure the discharge flowing over the ogee weir note it as h_2
5. Procedure was repeated for different discharges.

OBSERVATION AND CALCULATIONS

		Head over weir			Length of the weir L=0.298mt		
Sl No	Rotameter reading LPM	Crest level h_1 m	Water level h_2 m	Head over weir H= $(h_1 - h_2)$	Q_{act} m^3/sec	Q_{th} m^3/sec	Coefficient of discharge C_d
			Average				

Calculations:(any one trial)

Q_{the} $=(2/3)\sqrt{2g}\,LH^{3/2}$

Qact = Rotameter reading in m^3 / sec

C_d= Qact / Qthe

Graphically,

A log Q_a vs log H suggests a straight line relation as shown in fig. This equation is of the form

$$Q_a=(2/3)\sqrt{2g}C_d L \times H^{3/2}=KH^n$$

Taking log on both sides

$$\log Q_a = \log K + n \log H$$

Where logK is the intercept on the log Q axis
n is the slope of the straight line.

Knowing the valve of logK, K can be determined

and then the value of C_d is determined as follows.

$$C_d = (1/K) \times (1/\text{Slope})$$

Result: Coefficient of discharge (graphical) =-----------------------
Coefficient of discharge (analytical)=............................

EXPERIMENT NO 13
FRANCIS TURBINE

AIM : To conduct Performance test and to determine the efficiency of a Francis Turbine

APPARATUS: Francis Turbine, Digital speed indicator, Pressure gauge, Vacuum gauge, weights, brake dynamometer, Venturimeter and centrifugal pump.

THEORY: The Francis Turbine operates under medium heads and large quantities of flow. The water from the pump enters through the spiral casing into the guide vanes and then to the runner. While passing through the spiral casing and guide vanes a portion of the pressure head is converted into kinetic energy. The water enters the runner at a higher velocity than in the pipe line.
Experimentally, the efficiency is determined in the same way as for Pelton or Kaplan Turbines.

THEORY:

The Francis turbine is a reaction turbine, which means that the working fluid changes pressure as it moves through the turbine, giving up its energy. A casement is needed to contain the water flow. The turbine is located between the high pressure water source and the low pressure water exit, usually at the base of a dam.
The inlet is spiral shaped. Guide vanes direct the water tangentially to the runner. This radial flow acts on the runner vanes, causing the runner to spin. The guide vanes (or wicket gate) may be adjustable to allow efficient turbine operation for a range of water flow conditions.
As the water moves through the runner its spinning radius decreases, further acting on the runner. Imagine swinging a ball on a string around in a circle. If the string is pulled short, the ball spins faster. This property, in addition to the water's pressure, helps inward flow turbines harness water energy.At the exit, water acts on cup shaped runner features, leaving with no swirl and very little kinetic or potential energy. The turbine's exit tube is shaped to help decelerate the water flow and recover the pressure.

CONSTRUCTION SPECIFICATION:

A. **Spiral Casing :** is of close grained cast iron.

B. **Runner:** is of gunmetal and nickel plated, designed for efficient operation accurately machined and smoothly finished.

C. **Guide Vane** Mechanism: Consists of gun metal guide vanes. operated by a hand wheel through a link mechanism.

D. **Shaft:** is of EN8 steel accurately machined and provided with a brass and gunmetal Sleeve at the stuffing box.

E. **Ball Bearings:** is of double row deep groove rigid type in the casing And double row self aligning type in the bearing pedestal both of Liberal size.

F. **Draught Bend:** is provided at the exit of the runner. To the bend is connected, a straight conical draught tube of steel fabrication.

G. G . **Brake Arrangement**: Consisting of a machined and polished cast iron brake
   i. Standard cast iron dead weights, spring balance. rope brake etc. arranged for loading the turbine.

H. **Sump Tank:** approximately about 1000 ltr stainless steel tank is provided for closed circuit operation.

TECHNICAL SPECIFICATION:

a. Rated Supply Head	: 20 meters approximately
b. Rated Speed	: 1000 rpm
c. Power Output	: 1kW
d. Runaway Speed	: 1750 RPM
e. Runner Diameter	: 160 mm
f. No. of guide vanes	10
g. P.C.D. guide vanes	: 230mm
h. Brake Drum Diameter	: 360 mm
i. Rope Diameter	: 16 mm

SUPPLY PUMP SET

01. Rated Head	: 26 meters
02. Discharge	: 14 LPS approximately
03. Normal Speed	: 2880 RPM
04. Power Required	:7.5 HP
05. Size of Pump	: 80 mm x 65 mm
06. Type	: Centrifugal medium speed. single suction volute

FLOW MEASURING UNIT :

01. Inlet diameter of venturimeter : 65mm
02. venturimeter throat Diameter : 35 mm
03. Pressure Gauges : 0-4 Kg/cm2

PROCEDURE:-

1. Connect the power supply to the pump
2. Close the turbine inlet gate valve fully before starting the pump
3. Start the centrifugal pump.
4. Allow the water to flow into the turbine by opening the gate valve.
5. Keep the guide vane at desired value where we get max rpm or head
6. Then close the gate valve so as to attain 1000 or 1200 rpm
7. Allow it to stabilize at that speed
8. Load the turbine gradually say ¼, ½, 3/ 4 & full load by maintaining the turbine speed 1000RPM by operating the gate valve.
9. Note down the all the parameters as per the tabulation column given below
10. Repeat the experiment for different loads.
11. After the experiment remove the load on the weight hanger and close the gate valve
12. Stop the pump motor.
13. Calculate the power input, power output and efficiency.

CALCULATIONS:-

In the experimental setup the discharge is measured by means of a venture meter. If a_1 and a_2 are the areas of cross section at locations 1 and 2 respectively and C is the co-efficient of venture meter, then it can be shown that

$$Q_a = C \times Q_{th}$$

Where,

$h = (P1 - P2)/10 = \ldots\ldots$ m of water
D1 = Diameter of venturimeter= 65 mm
D2 = Throat diameter of venturimeter = 35 mm
C = 0.962
a_1 & a_2 = area of section of inlet & throat of venturimeter

Power input

Input Power = γQH kW

Where γ = Specific weight of water = 9.81 KN/m^3
Q = Discharge in m^3/sec.
H = Supply head in meters.
= P3 X 10

$$\text{Brake Power} = \frac{2\pi N T \times 9.81}{60000} \ldots\ldots \text{ kW}$$

Where N = Turbine speed in RPM.
T = Torque in = ((W-S)+1) Re...... Kg- m
W = dead weights applied
S = spring balance reading
and 1 kg is the hanger weight
Re = arm length = 0.12 m

$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}} \; 100$$

TABULAR COLUMN:

SL NO.	W	S	Pv	P1	P2	P3	N	h	H	P input (kW)	P output (kW)	Ŋ in%

Where.
W = dead weight load in kg
S = Spring balance reading in kg
Pv = Vaccum gauge reading in mm of Hg
P1 = Total head pressure gauge reading in kg/ cm2

P2 = Pressure at venture inlet in kg/ cm2
P3 = Pressure at venture throat in kg/ cm2
N = speed of the turbine
h = venturi head in meter of water
H = total head in meter of water

Graph : Plot the graph of Output Versus Input

Results :

Efficiency of Kaplan Turbine graphically=
Efficiency Kaplan Turbine Analytically =