Estd.: 2001

Balaji Institute of Technology & Science

Laknepally, NARSAMPET, Warangal – 506331

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BITS NARSAMPET www.bitswgl.ac.in, email:principal@bitswgl.ac.in :: Ph. 98660 50044, Fax 08718-230521

LABORATORY MANUAL

Fluid Mechanics & Hydraulic Machines

II B.Tech II Semester

DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTE VISION

To be a centre for excellence in preparing the graduates professionally committed, intellectually adept and ethically balanced with high standards by imparting quality education with international standards to excel in their career to meet the challenges of the modern world and adapt to the technologically changing environment.

OUR MISSION

M1: To strive hard to produce technically trained human resources to serve the present and future global needs by providing quality education.

M2: To provide value based training in technological advancements and employment opportunities to students by strengthening institute's interaction with industries.

M3: To disseminate knowledge of need based technical education, innovative learning and research & development.

DEPARTMENT VISION

To excel in preparing mechanical engineering graduates with core knowledge, advanced skills and professional ethics in order to meet the ever changing industrial demands and social needs.

OUR MISSION

M1: To provide the students with the best of knowledge by imparting quality education in the area of Mechanical Engineering and allied fields.

M2: To facilitate the students by providing the interaction with Mechanical Engineering related companies to be part of technological advancements which enhances employment opportunities.

M3: To inculcate self learning abilities, leadership qualities and professional ethics among the students to serve the society.

PROGRAM EDUCATIONAL OBJECTIVES

PEO1: To make the graduates who are equipped with technical knowledge and engineering skills through the program to achieve a successful career in the field of mechanical engineering.

PEO2: To participate in ongoing developments of mechanical engineering to be strong with the fundamentals and relate it with the present trends.

PEO3: To gain the practical knowledge through the program by identifying, formulating and solving mechanical engineering related problems.

PROGRAM OUTCOMES

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

2. **PO2: Problem analysis:** Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of Mathematics, natural sciences, and engineering sciences

3. **PO3: Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **PO4: Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

5. **PO5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **PO6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **PO7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

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

10. **PO10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **PO11: Project management and finance:** Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments.

12. **PO12: Life-long learning:** Recognize the need for, and have the preparation and ability to Engage in independent and life-long learning in the broadest context of technological Change.

PROGRAM SPECIFIC OUTCOMES

PSO1: Identify and analyze the real time engineering problems in Manufacturing, Design and Thermal domains.

PSO2: Execute the work professionally as an employee in industries by applying manufacturing and management practices.

PSO3: Gain the knowledge of latest advancements in Mechanical Engineering using Computer Aided Design and Manufacturing.

COURSE OUTCOMES

Fluid Mechanics and Hydraulic Machines Lab	
After completion of the course students will be able to	
CO1	Explain the effect of fluid properties on a flow system.
CO2	Identify type of fluid flow patterns and describe continuity equation.
CO3	Analyze a variety of practical fluid flow, measuring devices and utilize fluid mechanics principles in design.
CO4	Select and analyze an appropriate turbine with reference to given situation in power plants.
CO5	Estimate performance parameters of a given centrifugal and reciprocating pump. Able to demonstrate boundary layer concepts.

CONTENTS

STUDY OF IMPACT OF JET ON VANES

Aim:

To conduct an experiment on the jet on vane apparatus and determine the vane efficiency.

Theory:

The study of impact of a jet of water is essential to understand the principle of an impulse turbine such as pelton wheel turbine. When high pressure water from a source such as a dam flows through a nozzle in the form of jet, the entire pressure energy of the water is converted into kinetic energy at the nozzle. When this jet of water hits a vane positioned in front of it, the vane deflects the jet and due to the change in the momentum of the water jet, a force is imparted to the vane by water.

Experimental setup:

The equipment consists of a high efficiency gun metal nozzle fitted to a 25mm.dia. Pipe supply line with a gate valve. Vertically above the nozzle, a gun metal vane is fitted to a bracket of a differential lever which balances the upward force of the jet from the nozzle.

The lever is provided with an adjustable no load screw mechanism. The force due to the jet on the lever is counter balanced by metric weights placed on a hanger. Different types of vanes can be fitted to the bracket.

The complete assembly is enclosed in A framed structure housing with a transparent window for visual observation. The water deflected by the vane is collected in the following tank.

For experimental purposes, a brass nozzle with 6 mm nozzle diameter and two gunmetal vanes of the following shape are provided.

1. Semi-circular vane (180deg.angle of deflection)
2. Horizontal flat vane (90deg. Angle of deflection)

Procedure:

1. Fit the required vane on the lever.
2. Measure the differential lever arms and calculate the ratio of lever arms (2.0 in this case).
3. Balance the lever systems by means of counter weight for no load.
4. Place a weight on the hanger.
5. Open the gate valve and adjust the jet, so that the weight arm is balanced.
6. Collect water in the collecting tank.
7. Note: a) the pressure gauge reading-p
   b) The weight placed-W
   c) Time for 5cm. Rise in the collecting tank-t
8. Calculate the discharge by weight.

Calculate the vertical force.

Figure:

Observation table:

Vane type	Inlet pressure (P) kg/cm^2	Time for 10cm rise(t) seconds	Flow rate (Q) m^3/sec	Mass flow rate (M) kg/sec	Jet velocity (V) m/sec	Input force (F) kg	Counter load(W) kg	Vane efficiency $(F_{act}/F)\%$

Calculations:

1. Area of collecting tank (A) : 0.3×0.3 cm^2
   Rise in water level (R) : 0.05m
   Time taken : t sec
   Actual rate (Q) : AR/t m^3/sec
   Actual mass flow rate (M) : 1000Qkg/sec

2. Nozzle diameter : d m
   Nozzle area (a) : $3.14 \times d^2/4$ m^2
   Jet velocity (V) : Q/a m/sec

3. Angle of deflection of the vane to the jet = T1-T2 deg
   Mass flow rate of water = 1000 Q kg/sec
   The lifting force = change in momentum per sec. in vertical direction.
   F= M×V× (sinT1-sinT2)/g
   For horizontal flat vane, T1= 90 deg and T2 = 0 deg.
   F= (M×V)/g.
   For semi circular vane, T1=90 deg and T2 = -90 deg.
   F= (2× M×V)/g.
4. Actual lifting force measured = W× lever arm ratio kg
   F act= 2.0 W
5. The efficiency of the jet: Fact/F.

Precautions:

1. After taking one set of reading release the tension of the belt and run the turbine at no load condition for at least five minutes
2. By pass valve should always fully open at the time of starting the pump.
3. Before starting the pump check the manometer tapings.
4. Tachometer should not touch with any moving part at the time of r.p.m. measurement.
5. After experiment drain off the water from the tank.

Results:

1. Input power = K.W
2. Output power = K.W
3. Efficiency = %

PERFORMANCE TEST ON PELTON WHEEL

Aim:

To study the characteristics of a pelton wheel turbine.

Description:

Pelton turbine is an impulse turbine that uses water available at high heads (pressure) for generation of electricity. All the available potential energy of water is converted in to kinetic energy by a nozzle arrangement. The water leaves the nozzle as a jet and strikes the buckets of the pelton wheel runner. These buckets are in the shape of double cups, joined at the middle portion in a knife edge. The jet strikes the knife edge of the buckets with least resistance and shock and glides along the path of the cup, deflecting through an angle 160to 170deg. This deflection of water causes a change in momentum of the water jet and hence an impulsive force is supplied to the buckets. As a result, the runner attached to the buckets moves, rotating the shaft. The specific speed of the pelton wheel varies from 10 to 100.

In the test rig the pelton wheel is supplied with water under high pressure by a centrifugal pump. The water flows through a venturimeter to the pelton wheel. A gate valve is used to control the flow rate to the turbine. The venturimeter with pressure gauges connected to it is used to determine the flow rate of water in the pipe.

The turbine is loaded by applying dead weights in the brake drum. This is done by placing the weights on the weight hanger. The inlet head is read from the pressure gauge. The speed of the turbine is measured with a tachometer.

Experimental procedure:

1. Close the delivery gate valve completely and start the pump.
2. Add minimum load to the weight hanger of the brake drum-say 1 kg.
3. Open the gate valve while monitoring the inlet pressure to the turbine. Set it for the design value of 3.0 Kg/sq.cm.
4. Open the cooling water valve for cooling the brake drum.
5. Measure the turbine rpm with tachometer.
6. Note the pressure gauge reading at the turbine inlet.
7. Note the venturimeter pressure gauge readings, P1 and P2.
8. Add additional weights and repeat the experiments for other loads.
9. For constant speed tests, the main valve has to be adjusted to reduce or increase the inlet head to the turbine for varying loads.

Observation table:

Sl.No.	Inlet pressure (p) Kg/cm^2	Total head (H) m of water	Venturimeter pressure gauge readings (kg/cm^2)			Flow rate (Q) M^3/sec	Speed (N)rpm	Wt. On hanger (T1)Kg	Wt. On spring balance (T2)kg	Net wt. (T) kg	Turbine output (Q) KW	Input (I) KW	Efficiency %
			P1	P2	P3								

Calculations:

1. **To determine discharge:**

   Venturimeter line pressure gauge readings = P1 kg/sq.cm
   Venturimeter throat pressure gauge reading = P2 Kg/sq.cm
   Pressure difference (dH) = (P1-P2) x 10 m of water
   Venturimeter equation (Q) = $0.00324\ (dH)^{0.5}\ m^3/sec$

   Note: Discharge (Q) = $Cd \times A \times B^2 \times ((2 \times 9.81 \times dH)/ (1-B^4))^{0.5}$

   Where, Cd – venturimeter discharge coefficient – 0.96.

   A- Inlet area-$3.14 \times D^2/4$

   Inlet dia, D-50mm: throat dia ratio=0.6

2. **To determine Head :**

   Turbine pressure gauge reading = P Kg/sq.cm
   Total head (H) = PX10 m of water

3. **Input to the turbine :**

   Input = 9.81x Q x H KW

4. **Turbine output :**

   Brake drum diameter = 0.20m

   Rope diameter = 0.015m

   Equivalent drum diameter = 0.215m

   Hanger weight –To = 1 kg

   Weight = T1 g.

   Spring load = T2 kg.

   Resultant load-T = (T1-T2+T0) kg

   Speed of the turbine = N RPM

   Turbine output = (3.14 x DxNxT)/ (102 x 60) KW

   = 0.00011 NT KW

5. **Turbine efficiency** = Output /Input.

Figure:

Precautions:

1. Always operate the turbine with load. Since the runaway speed of the turbine is high, running the turbine without any load will lead to excess vibrations and noise.
2. Provide cooling water for the brake drum when it is loaded. Absence of cooling water will cause brake drum heating and even charring of the rope under extreme conditions.
3. Amount of cooling water must be controlled to avoid excessive spillage and splashing.
4. The motor is provided with DOL starter to trip under overloaded, low voltage, uneven phase supply conditions. If the motor trips, check for voltage conditions. Also , do not run the supply pump at fully open valve conditions, as this is an overloaded condition for the pump.

FRANCIS TURBINE TEST RIG

Aim: To study the characteristics of a Francis turbine

Description:

Francis turbine is a reaction type hydraulic turbine. Used in dams and reservoirs of medium height to convert hydraulic energy into mechanical and electrical energy. Francis turbine is a radial inward flow reaction turbine. This is the advantage of centrifugal forces against the flow. Thus reducing the tendency of the turbine to over speed. Francis turbines are best suited for medium heads, say 40mm to 300mm.the specific speed ranges from 25 to 300.

The turbine test rig consists of a 3.72 KW (5HP) turbine supplied with water from a suitable 15HP centrifugal pump through suitable pipe lines, a gate valve, and a flow measuring Venturimeter .The turbine consists of a cast iron body with a volute casing and a gunmetal runner consisting of two shrouds with aerofoil shaped curved vanes in between. The runner is surrounded by a set of adjustable gunmetal guide vanes. These vanes can be rotated above their axis by a hand wheel. Their position is indicated by a pair of dummy guide vanes fixed on the outside of the turbine casing. At the outlet, a draft tube is provided to increase the net head across the turbine. The runner is attached to the output shaft with a brake drum to absorb the energy produced.

Water under presser from pump enters through the guide vanes into the runner. While passing through the spiral casing and guide vanes, a portion of the pressure energy is converted into velocity energy. Water thus enters the runner at a high velocity and as it passes through the runner vanes, the remaining pressure energy is converted into kinetic energy. Due to the curvature of the vanes, the kinetic energy is transformed into the mechanical energy i.e, the water head is converted into mechanical energy and hence the runner rotates. The water from the runner is then discharged into the tail race. The discharge through the runner can be regulated also by operating the guide vanes.

The flow through the pipe lines into the turbine is measured with the Venturimeter fitted in the pipe line. The venturimeter is provided with a set of pressure gauges. The net pressure difference across the turbine inlet and outlet is measured with a pressure gauge and a vacuum gauge. The turbine output torque is determined with a rope brake drum dynamometer. A tachometer is used to measure the rpm.

Experimental procedure:

1. Keep the guide vanes at required opening (say $3/8^{th}$).
2. Prime the pump if necessary.
3. Close the main gate valve and start the pump.
4. Open the gate valve for required discharge after the pump motor switches from star to delta mode
5. Load the turbine by adding weight in the weight hanger. Open the brake drum cooling water gate valve for cooling the brake drum.
6. Measure the turbine rpm with tachometer.
7. Note the pressure gauge and vacuum gauge readings
8. Note the Venturimeter pressure gauge readings.
9. Repeat the experiment for other loads.

10. For constant speed tests, the main sluice valve has to adjusted to vary the inlet head and discharge for varying loads (at a given guide vane operating position).
11. The experiment can be repeated for other guide vane positions.

Figure:

Calculations:

1. **To determine discharge**:

   Venturimeter line pressure gauge reading = P1 kg/sq.cm

   Venturimeter throat pressure gauge reading = P2 kg/sq.cm

   Pressure difference (dH) = (P1-P2) x 10 m of water

   Venturimeter equation (Q) = $0.01310(dH)^{0.5}$ m^3/sec

   NOTE: venturimeter inlet dia (D) = 100mm

   Throat dia ratio (B) = 0.6

   Discharge (Q) = $Cd \times A \times B^2 \times ((2 \times 9.81 \times dH)/(1-B^4))^{0.5}$

   Where, Cd- venturimeter discharge coefficient-0.98

   A-inlet area -3014 x D^2 /4

2. **To determine inlet head of water**:

   Turbine pressure gauge reading =P kg/cm^2

   Turbine vacuum gauge reading =V mm of HG

   Total head (H) =10(P+V/760) m of water.

3. **Input to the turbine**:

   Input power =1000 QH/75 HP

   = 9.81 QH k

4. **Turbine output:**

   Brake drum diameter =0.30m

   Rope diameter =0.015m

   Equivalent drum diameter =0.315m

   Hanger weight -To =1 kg

   Weight =T1 kg

   Spring load =T2 kg

   Resultant load -T =(T1-T2+To) kg

   Speed of the turbine =N rpm

   Output power =(3.14xDxNxT)/(75x60) HP

   =(3.14xDxNxT)/(102x60) Kw

   =0.000162 NT kw

5. **Turbine efficiency** =Output/Input

Sl.No .	Inlet pressure (p) Kg/sq.cm	Outlet vacuum (V) Mm of Hg	Total head (H) m of water	Venturimeter pressure gauge readings (kg/cm^2)			Flow rate (Q) cu.m/sec	Speed (N)rpm	Wt. On hanger (T1)Kg	Wt. On spring balance (T2)kg	Net wt. (T) kg	output (Q) KW	Input (I) KW	Efficiency %
				P1	P2	P3								

Observation Table

Precautions:

1. The main valve should be closed before starting the machine.
2. Do not load the turbine suddenly.
3. Loading should be done gradually and at the same time supply of water should b be increased so that the run at normal speed.

Result:

KAPLAN TURBINE TEST RIG

Aim:

To determine operating characteristics of Kaplan turbine.

Introduction:

The hydraulic turbines are classified according to the type of energy available at the inlet of the turbine, direction of flow through the vanes. The Hydraulic turbines mainly of two types:

1. Impulse Turbine
2. Reaction Turbine

Kaplan turbine is axial flow reaction turbine. If the water flows parallel to the axis of the rotation of the shaft the turbine is known as axial flow turbine. And of the head at the inlet of the turbine is the sum of pressure energy and kinetic energy and during the flow of water through the runner at part of pressure energy is converted into kinetic energy, the turbine is known as reaction turbine. When the vanes are fixed to hub and they are not adjustable the turbine is known as propeller turbine. But if the vanes of the hub are adjustable the turbine is known as Kaplan turbine after the name of V. Kaplan an Austrian Engineer. This turbine is suitable where a large quantity of water at low heads is available.

The main parts of Kaplan turbine are:

1. Scroll casing
2. Guide vanes mechanism
3. Hub with vanes or runner of the turbine
4. Draft tube

Specifications:

Centrifugal pump	: 100 x100mm coupled with motor(Kirloskar make)
Net head	: 15 meter approx
Discharge	: 1500 LPM Approx
Normal speed	: 1000 RPM Approx
Motor & centrifugal pump	: 7.5 HP Monoblock pump
Pump size	: 100 x 100 mm
Head	: 15 meter
Pump speed	: 1440 RPM
Turbine normal speed	: 1000 RPM
Turbine impeller	: cast iron
Runner outside diameter	: 175 mm
Hub diameter	: 78 mm

No. Of runner blade	: 4
No. Of guide vanes	: 8 Gun metal
Brake drum diameter	: 200 mm
Rope diameter	: 20
Orifice meter of throat	: 65mm
Storage tank capacity	: 650 Ltr.
Gauge	: pressure gauge, vacuum gauge

M.s pipe of 100 mm dia is used as draft tube.

Standard data:

g	= acceleration due to gravity	= 9.81 m/sec^2
D	= Diameter of brake drum	= 200 mm
d1	= Inlet area of orifice meter at diameter	= 0.100m
d2	= Throat area of orifice meter at diameter	= 0.065 mm
a1	= Inlet area of orifice meter at area	= 0.00785 m^2
a2	= Throat area of orifice meter at area	= 0.00342 m^2
Cd	= 0.98	
P1-P2	= Differences of pressure across the limbs of orifice meter	

Procedure:

1. Unload the turbine if there is any load on it.
2. Fill the sump tank with sufficient amount of water.
3. Switch on the power supply to start the centrifugal pump.
4. Now open the delivery valve slowly and adjust the required head at the inlet of turbine, simultaneously manipulate by pass valve, so as to adjust the required head.
5. Now open the supply of the water to cool load drum.
6. Adjust the load on load drum and note the corresponding reading of spring balance. Also measure the rpm. Increase the load slowly and note the corresponding values of spring balance.
7. Repeat the above procedures for different inlet pressures.

Figure:

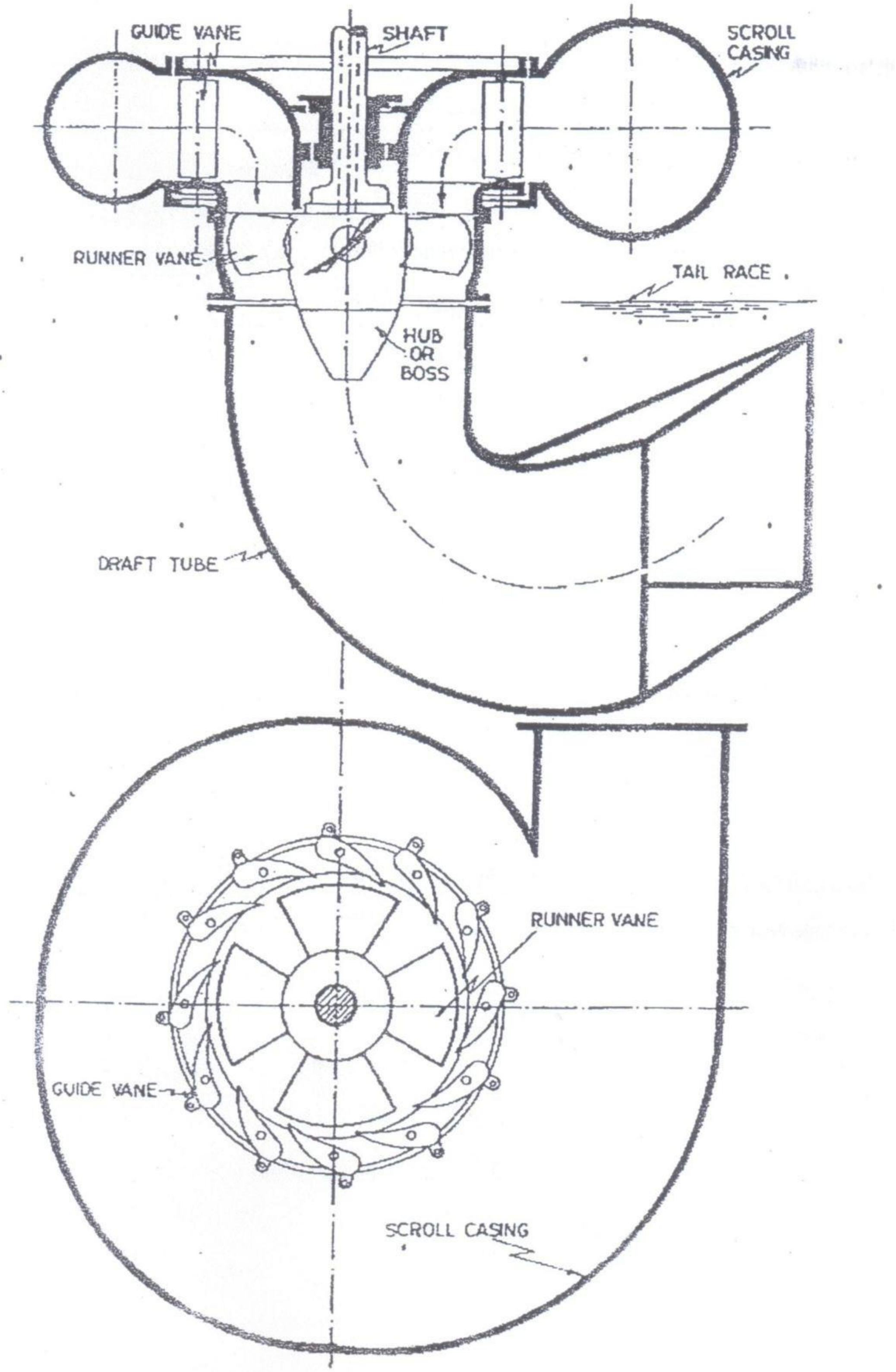

Fig: Sectional arrangement of Kaplan Turbine

m:

Observation Table:

Sl. No.	Runner speed 'N' in RPM	Head over the Turbine		Head over the notch `h' in	Load on generator		Wattage of bulbs in action	Time taken for 5rev of Energy meter reading's sec
		'P' in kgf/cm^2	P_v in mm of Hg		V in volts	I in Amps		

Calculation:

1. **Total Head**

H = 10 x Pressure gauge reading = meter

2. **Water head rate Discharge Q**

Where,

d1 = Inlet area of orifice meter at diameter = 0.100m

d2 = Throat area of orifice meter at diameter = 0.065 mm

a1 = Inlet area of orifice meter at area = 0.00785 m^2

a2 = Throat area of orifice meter at area = 0.00342 m^2

Cd = 0.98

P1-P2 = Differences of pressure across the limbs of orifice meter

$$\textbf{Q=}\ \text{Cd}\ \frac{(a1 \times a2)}{\sqrt{a_1{}^2 - a^2{}_2}} \times \sqrt{2g(P1 - P2)}\, m^3/\text{sec.}$$

$$\textbf{Q=}\ \text{Cd}\ \frac{(a1 \times a2)}{\sqrt{a_1{}^2 - a^2{}_2}} \times \sqrt{2 \times 9.81 \times (P1 - P2)}\, m^3/\text{sec.}$$

3. **Input = γ Q H KW**

γ = specific weight of = 9.91KN/m^2

4. **B.H.P (output)**

BHP = $\frac{2\pi NT}{45000} H.P$

T = (W1-W2) x D/2 x 9.81

BHP = $\frac{2\pi N (\text{W1- W2) x D/2 x 9.81}}{45000} H.P$

Rope Hanger weight = 0.6 kg

W1 = Weight + Hanger with rope reading

W2 = Spring balance

D= break drum + Rope diameter both side

= 200mm+ 10mm+10mm

= 0.220 meter

N = Number of R.P.M of break drum

5. **Efficiency of turbine:**

$\eta = \frac{BHP(output)}{HPhydraulic(input)} \times 100\%$

Precautions:

1. The water in the sump tank should be clean
2. To start and stop supply pump, keep gate valve closed.
3. It is recommended to close guide vanes before starting.

Result:

1. The constant head characteristic curves have been obtained______
2. The maximum efficiency of the Kaplan Turbine is_______

PERFORMANCE TEST ON SINGLE STAGE CENTRIFUGAL PUMP

Aim:

To conduct a test at various heads of given single stage centrifugal pump and to find its efficiency.

Apparatus:

1. Single Stage Centrifugal Pump,
2. Stop Watch,
3. Collecting Tank

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Introduction:-

Centrifugal pump consisting of one impeller the pump is called the single stage centrifugal pump. The impeller may be mounted on the same shaft. 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, the pressure gradually.

A centrifugal pump consists of an impeller rotating inside a casing. The impeller has a number of curved vanes. Due to the centrifugal force developed by the rotation of the impeller, water entering at the center flows outwards to the periphery. Here it is collected in a gradually increasing passage in the casing known as a volute chamber. This chamber converts a part of the velocity head of the water in to pressure head. For higher heads, multistage centrifugal pumps having two or more impellers in series will have to be used.

The test pump is a single stage centrifugal pump of size 1” x1” (25 x 25mm). It is coupled to a 1 HP capacity single phase AC motor by means of a cone pulley belt drive system.

An energy meter and a stop watch are provided to measure the input to the motor and a collecting tank to measure the actual discharge. A pressure gauge and a vacuum gauge are fitted in the delivery and suction pipe lines to measure the pressure.

Procedure:

1. Loosen the v-belt by rotating the hand wheel of the motor head and position head in the required groove of the pulley.
2. Prime the pump with water if required.
3. Close the delivery gate valve completely.
4. Start the motor and adjust the gate valve to required pressure and delivery.
5. Note the following readings:
    a) The pressure gauge reading P Kg/cm^2
    b) The vacuum gauge reading V mm of Hg.
    c) Time for 10 revolutions of energy meter disc-T secs.
    d) Time for 10cm rise in the collecting tank-t secs

e) Pump speed in RPM

Take 3 or 4 sets of readings by varying the head from a maximum at shut off to a minimum where gate valve is fully open. The experiment is repeated for other pump speeds.

Calculation:

1. Discharge:

   Area of tank (A) = 0.5 x0.5 m^2

   Rise of level (h) = 0.1 m

   Volume collected = A.h m^3=0.025 m^3

   Time taken = t secs.

   Discharge Q = volume/time=0.025/t m^3/sec.

2. Head:

   Total head H = 10(P+V/760) m of water.

3. Output of the pump :

   Output = 9.81x Q x H KW= (1000QH/75) HP.

4. Input of the pump:

   Energy meter constant N = 1200 revs per KWH

   Time for 10 revolution = T secs.

   Input to motor = (3600 x 10)/(N x T) kw

   Efficiency of motor = 80 %(assumed)

   Transmission efficiency = 90 % (assumed)

   Pump input = Motor input x 0.80 x 0.9 KW

   = 3600 x 10x0.8x0.9/ (1200 x T)

   = 21.6/T KW

Observation table:

Total Head(H) m	Discharge (Q) m^3/ sec	INPUT Power KW	OUT PUT Power KW	%η of pump

Precautions:-

1. Priming is must before starting the pump.
2. Pump should never be run empty.
3. Use clean water in the sump tank.

Results:-

1. Input power =________k.w
2. Output Power = ______k.w
3. %η of pump =

MULTI STAGE CENTRIFUGAL PUMP

Aim:

To conduct a test at various heads of given multistage centrifugal pump find its efficiency.

Apparatus:

1. Multi stage centrifugal pump
2. Stop watch
3. Collecting tank.

Introduction:

Closed circuit self sufficient portable packages system. Experimental multi stage centrifugal pump test rig is designed to study the performance of the multi stage centrifugal pump. In this equipment one can study the relationship between

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

This unit has several advantages like does not require any foundation, trench keeping in the laboratory.

General Description:

Constructional Specifications:

The test rig mainly consists of (1) Multi stage centrifugal pump set (2) Panel Board, (3) Pressure and vacuum gauges to measure the head (4) SS measuring tank to measure the discharge (5) Energy meter to measure the input to the motor and (6) SS pump.

A.C. Motor

The electric motor suitable for operation on 560 HZ A>C> supply is provided.

Gauges

Suitable range of pressure and vacuum gauges to measure the total; head on the pump with reasonable accuracy.

SS Measuring tank

It is provided to measure the discharge of the pump. The tank is complete with piezeometer and scale arrangement.

Piping System

Suitable piping system with pipes, bends and valves are provided. A simple strainer valve is provided on the suction side to prevent any foreign matter entering into the pump. The gate valve is provided in the delivery side to control the head on the pump. While starting the motor always keep the valve in close position.

Panel Board

The panel board houses all the necessary electrical items, like switch for the above pump set and an energy meter to read the power input and it is fitted with the unit on a strong iron base with sufficient height and with provisions for foundation.

Input power measurement

A kilowatt-hour meter is provided to measure the power input to the motor. The energy meter constant (the number of revolutions per minute of the energy meter Disc) is stamped on the meter from this the input power can be easily calculated.

SS Pump

It is provided to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Figure:

Procedure:

1. Start the motor keeping the delivery valve close.
2. Note down the pressure gauge and vacuum gauge reading by adjusting the delivery valve to require head say 0 meters. Now calculate the total head (H).

   Pressure head = Kg/cm^2 x 10 = 10 meters.

   Pressure head = mm of hg X 13.6/1000 meters

   Datum head = Distance between pressure and vacuum gauge in meters

   Total head (H) = Pressure Head_+ Vacuum Head + Datum Head
3. Note down the time required for the rise of 10 cm (i.e.0.1m) Water in the collecting tank by using stop watch. Calculate discharge using below formula.

Discharge: The time taken to collect some 'X' cm of water in the collecting tank in m^3/sec.

$$Q = \frac{A \times h}{t}$$

Where,

A = area of the collecting tank in m^2 (0.3m X 0.3m)

h= rise of water level taken in meters (say 0.1m or 10cm)

t= time taken of rise of water level to height 'h' in seconds.

4. Note down the time taken for 'X' revolutions of energy meter disk and calculate the input power

$$\text{Input power} = \frac{\text{X x3600x0.75}}{\text{CxT}} KW$$

Where,

0.75 = combined motor and friction losses

X = No. Of revolutions of energy meter disc (say 5 Rev.)

T = Time for energy meter revolutions disc, in seconds

C = Energy meter constant

5. Now calculate the output power

$$\text{Output power} = \frac{W \times Q \times H}{1000} Kw$$

Where,

W = sp. Wt. Of water (9810 N/m^3)

Q = Discharge

H = Total Head

6. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve.

Observation Table:

S.No.	Pressure gauge reading	Vacuum gauge reading	Time taken for 5 rev of energy meter disc	Time taken for collecting 10 cm rise Of water in collecting Tank.	Total head (p+v) meters	Discharge (Q)

Precautions:

1. Check weather all the joints are leak proof and watertight.
2. Check the piezo meter assembly of the measuring tank and see that it is fixed water tight and vertically.
3. Check whether all the electric connection is correct.
   See that the gauges are mounted on the correct position and their cocks closed.
4. Before starting the required electrical connection should be done correctly.

Result:

1. Input power **=** k.w

2. Output Power = k.w

3. %η of pump

RECIPROCATING PUMP TEST RIG

Aim:

To study the characteristic of a reciprocating pump at a variable speed.

Description:

The reciprocating pump is a positive displacement type pump and consists of a piston or a plunger working inside a cylinder. The cylinder has two valves, one allowing water into the cylinder from the suction pipe and the other discharging water from the cylinder into the delivery pipe.

Specification of the Pump:

Type: Double Acting Single Cylinder

(a)	Piston stroke	L	= 1 ¾” (44.5mm)
(b)	Piston Diameter	d	= 1 ½” (38mm)
(c)	Suction Pipe		= 1” (25mm)
(d)	Delivery Pipe		=3/4” (18mm)

The experimental setup consists of a reciprocating pump mounted on a sump tank the pump is driven by an electric motor through a cone pulley arrangement to obtain 4 different speeds by loosening the belt and shifting it to the required pulley groove. The outlet from the pump is collected in a collecting tank of cross sectional area of 0.4m x 0.4m this tank is fitted with a gauge glass scale fitting and a drain value. Suitable pressure and vacuum gauges and a pressure relief valve is fitted in the pump pipe lines. An energy meter is provided to determine input power to the motor.

Experimental Procedure:

1. Select the required speed
2. Open the gate valve in the delivery pipe fully
3. Start the motor
4. Throttle the gate valve to get the required head
5. Note the following readings
    a) The speed of the pump (n)
    b) Pressure gauge (p) & vacuum gauge reading (v)
    c) Time taken for 10 revolutions of energy meter disc
    d) Time taken for 10cm rise in collecting tank
    e) Take at least 3-4 sets of readings by varying the head
6. Repeat the experiment for other speeds.

Figure:

Calculations:

1. Discharge:

Area of tank	= 0.4 x 0.4 m^2
Rise of level (R)	= 0.1 m
Volume collected (AR)	= 0.016 cm^3
Time taken	= t secs
Discharge (Q)	= volume / time = 0.016/t m^3/sec

2. Head:

Total head H	= 10(P+V/760) m of water

3. Output of the pump :

Pump output	= (9.81 QH) KW=(1000QH/75) HP

4. Input of the pump :

Energy meter constant (N)	= 1200revs/KW Hr
Time for 10 revolution	= T secs.
Input to motor	= (3600 x 10)/(N/T) HP
Efficiency of motor	= 80 % (assumed)
Motor output	= 0.8 x 3600 x 10/ (1200xT) KW
	= 24.0/T KW
Transmission efficiency	= 90% (assumed)
Power input	= Motor output x 0.9
	=21.6/T KW

5. Efficiency of the pump :

Pump efficiency = pump output/pump input

Precautions:

1. Operate all the controls gently
2. Never allow to rise the discharge pressure above 40 kg/cm^2
3. Always use clean water for experiment
4. Before starting the pump ensure that discharge valve is opened fully

Results:-

Input power = k.w
Output Power = k.w
%η of pump =

Observation table:

S.no.	Pump speed (n) Rpm	Pressure gauge (p) Kg/cm^2	Vacuum gauge (v) Mm of hg	Total Head (h) M of water	Time for 10cm rise in collecting tank (t) Seconds	Discharge (q) M^3/sec	Time for 10 rev of energy meter disc (t) Seconds	Input (i) Kw	Output (o) Kw	Efficiency (%)

CALIBRATION OF VENTURIMETER

Aim:

To determine the Coefficient of Discharge of Venturi meter.

Apparatus Required:

1. Venturi Meter
2. Measuring Tank
3. Sump Tank
4. Differential Manometer
5. Piping System
6. Supply Pump Set
7. Stop Watch.

Description:

Flow meter is used to measure the flow rate of a fluid in a pipe. a venturimeter consists of a short length of pipe narrowing to a throat in the middle and then diverging gradually to the original diameter of the pipe . An orifice meter consists of an orifice plate housed between two flanges. As the water flows through these meters, velocity is increased due to the reduced area and hence there is a pressure drop. By measuring the pressure drop in these meters with a manometer, the flow rate is calculated from Bernoulli's equation.

The experimental setup consists of 20mm (3/4") and 25mm (1") pipe lines fixed to an MS stand each pipe has the respective venturimeter and orifice meter with quick action cocks for pressure tapings. The meters are fitted in the piping system with sufficiently long pipe lengths (greater than 10 dia) upstream of the meters .the pressure tapings are connected to a mercury manometer .the pipe line is provided with a flow control valve.

Experimental Procedure:

1. Select the required flow meter
2. Open its cock and close the other cocks so that only pressure for the meter in use is communicates to the manometer
3. Open the flow control valve and allow a certain flow rate
4. Vent the manometer if required
5. Observe the reading in the manometer
6. Collect the water in the collecting tank. Close the drain valve and find the time taken for 10 cm rise in the tank.

Figure:


VENTURI METER
AND
ORIFICE METER
VENTURIMETER AND ORIFICEMETER

Calculation:

Theoretical discharge for venturimeter and orifice meter:

Difference in manometer level = h (m of Hg)

The equivalent pressure drop = h (13.6-1)m of water

dH = 12.6hmm of water =0.126h

Flow meter equation Q = $K(dH)^{0.5}$ m^3/sec

Where,

K – flow meter constant ,

Note: Flow meter inlet dia D = 20mm/25mm

Throat dia ratio (B) = 0.6

Theoretical discharge ($Q_{t)}$ = $A \times B^2 \times [(2x9.81xdH)/(1-B^4)]^{0.5}$

Where,

A = inlet area = $3.14xD^2/4$

Q_a = flow rate = $C_d Q_t$

C_t = flow meter discharge coefficient

Q_t = $(0.000537\ dH^{0.5})$ for 20mm pipelines

= $(0.000839dH^{0.5})$ for 25mm pipelines

Actual Discharge:

The area of collecting tank A = 0.4x0.4 Sq.m.

Rise r = 0.1 m

Time Taken = t sec

The actual discharge Q_a = Ar/t

= 0.016/t

= $C_d.Q_t$

Where,

C_d is the discharge constant.

Hence,

$\mathbf{C_d}$ = Q_a/Q_t

Observation table:

S.No.	Manometer reading (cm of hg)			Manometer head (h) cm.	Time for (10 cm) rise of water level (t) in sec.
	H_1	H_2	H_m		

Fig:

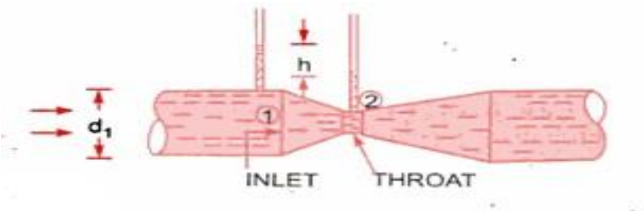

Fig. *Venturimeter.*

Precautions:

1. All the joints should be leak proof and water tight.
2. Manometer should be filled to about half the height with mercury.
3. All valves on the pressure feed pipes and manometer should be closed to prevent damage and over loading of the manometer before starting the motor.
4. Ensure that gauge glass and meter scale assembly of the measuring tank is fixed vertically and water tight.
5. Ensure that the pump is primed before starting the motor.

Results:

Actual discharge of Venturi meter ($(Q_{Act})_{act}$ =_____ m^3/sec

Theoretical discharge of Venturi meter $(Q_{The})_t$ =____ m^3/sec

Coefficient of discharge of Venturi meter (C_d) =______

CALIBRATION OF ORIFICE METER

Aim:

To determine the Coefficient of Discharge of orifice meter.

Apparatus Required:

1. Orifice meter.
2. Measuring Tank
3. Sump Tank
4. Differential Manometer
5. piping System
6. Supply Pump Set
7. Stop Watch.

Description:

Flow meter is used to measure the flow rate of a fluid in a pipe. a venturimeter consists of a short length of pipe narrowing to a throat in the middle and then diverging gradually to the original diameter of the pipe . An orifice meter consists of an orifice plate housed between two flanges. As the water flows through these meters, velocity is increased due to the reduced area and hence there is a pressure drop. By measuring the pressure drop in these meters with a manometer, the flow rate is calculated from Bernoulli's equation.

The experimental setup consists of 20mm (3/4") and 25mm (1") pipe lines fixed to an MS stand each pipe has the respective venturimeter and orifice meter with quick action cocks for pressure tapings. The meters are fitted in the piping system with sufficiently long pipe lengths (greater than 10 dia) upstream of the meters .the pressure tapings are connected to a mercury manometer .the pipe line is provided with a flow control valve.

Experimental Procedure:

1. Select the required flow meter
2. Open its cock and close the other cocks so that only pressure for the meter in use is communicates to the manometer
3. Open the flow control valve and allow a certain flow rate
4. Vent the manometer if required
5. Observe the reading in the manometer
6. Collect the water in the collecting tank. close the drain valve and find the time taken for 10 cm rise in the tank .

Figure1:


VENTURI METER
AND
ORIFICE METER
VENTURIMETER AND ORIFICEMETER

Calculation:

Theoretical discharge for venturimeter and orifice meter:

Difference in manometer level = h (m of Hg)

The equivalent pressure drop = h (13.6-1) m of water

dH = 12.6hmm of water =0.126h

Flow meter equation Q = $K (dH)^{0.5}$ m^3/sec

Where,

K – Flow meter constant,

Note: Flow meter inlet dia D = 20mm/25mm

Throat dia ratio (B) = 0.6

Theoretical discharge (Q_t) = $A \times B^2 \times [(2x9.81xdH)/(1-B^4)]^{0.5}$

Where,

A = inlet area = $3.14xD^2/4$

Q_a = flow rate = C_d Q_t

C_t = flow meter discharge coefficient

Q_t = ($0.000537\ dH^{0.5}$) for 20mm pipelines

= ($0.000839dH^{0.5}$) for 25mm pipelines

Actual Discharge:

The area of collecting tank A = 0.4x0.4 m^2.

Rise r = 0.1 m

Time Taken = t sec

The actual discharge Q_a = Ar/t

= 0.016/t

= $C_d.Q_t$

Where,

C_d is the discharge constant.

Hence,

$\mathbf{C_d}$ = Q_a/Q_t

Fig2:

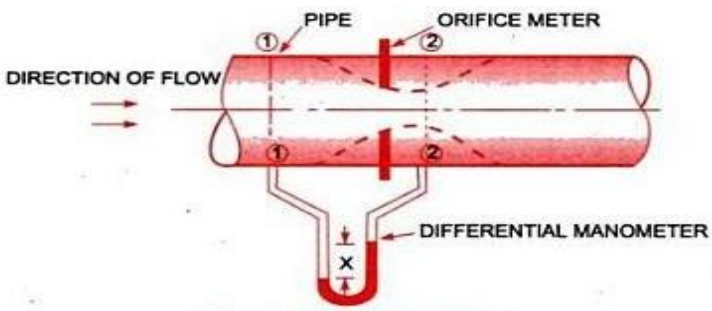

Fig. *Orifice meter.*

Table of Readings:

S.No.	Manometer reading (cm of hg)			Manometer head(h) cm.	Time for (10 cm) rise of water level (t) in Sec.
	h_1	h_2	h_m		

Precautions:

1. All the joints should be leak proof and water tight.
2. Manometer should be filled to about half the height with mercury.
3. All valves on the pressure feed pipes and manometer should be closed to prevent damage and over loading of the manometer before starting the motor.
4. Ensure that gauge glass and meter scale assembly of the measuring tank is fixed vertically and water tight.
5. Ensure that the pump is primed before starting the motor.

Results:

Actual discharge of Venturi meter ($Q_{Act})_{act}$ =_____ m^3/sec

Theoretical discharge of Venturi meter $(Q_{The})_t$ =____ m^3/sec

Coefficient of discharge of Venturi meter (C_d) =______

DETERMINATION OF FRICTION FACTOR FOR A GIVEN PIPE LINE

Aim:

To measure the frictional losses in pipes of different sizes

Apparatus Required:

1. Piping system
2. Sump Tank
3. Measuring Tank
4. Differential Manometer
5. Pump Set.
6. Stop Watch

Specifications:

1. Sump tank size : 0.95 m x 0.45 m x 0.3 m S.S. tan
2. Measuring Tank Size : 0.3 m x 0.3m x 0.5 m S.S. Tank
3. Differential Manometer : 1 m range with 1mm scale of graduation
4. No. of pipes : 1S.S, 2 Galvanized Iron(GI) pipes
5. Piping system sizes : 20 mm, 20mm, 12.7mm
6. Pressure taping distance : 0.1 m
7. Pump set : Pump is 25x25mm^2 size, centrifugal, moonset pump with single phase, 2pole, 220V, 1/2HP, 50 Hz, 2880 rpm, AC supply.

1. **Sump Tank**: It is S.S. tank to store sufficient fluid for experimentation and arranged within the floor space of main unit. The sump should be filled with fresh water having 25 mm space at the top.

2. **Measuring Tank**: It is also a S.S tank with gauge glass, a scale arrangement for quick and easy measurements. A ball valve which is outlet valve of measuring tank is provided to empty the tank.

3. **Differential Manometer**: It is used to measure the differential head produced by piping system.

4. **Pump Set**: It is used to pump water from sump tank to measuring tank through pipe.

Theory:

A pipe is a closed conduit which is used for carrying fluids under pressure. Pipes are commonly circular section. As the pipes carry fluids under pressure, the pipes always run full. The fluid flowing in a pipe is always subjected to resistance due to shear forces between fluid particles and the boundary walls of the pipe and between the fluid particles themselves resulting from the viscosity of the fluid. The resistance to the flow of fluid is, in general known as frictional resistance. Since certain amount of energy possessed by the flowing fluid will be consumed in overcoming this resistance to the flow, there will always be some loss of energy in the direction of flow, which however depends on the type of flow, W.froude conducted a series of experiments to investigate frictional resistance offered to the flowing water by different surfaces hf=$\frac{fL}{2gD}$ which is commonly used for computing the loss of head due to friction of pipes.Here is f fraction fractor.In order to determine the loss of head due to friction correctly, it is essential to estimate the value of the factor f correctly 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 pies may be classified as

i) major losses
ii) minor losses

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

Figure:

Procedure:

1. Before starting the experiment, do priming of the pump to remove air bubbles by pouring water into the priming device.
2. Open the inlet valve in the piping systems of the pump and outlet valve of one of the 3 pipes and remaining 2 valves will be in closed condition
3. Start the motor and open the upstream pressure feed pipe valves and downstream pressure feed pipe valves of the concerned pipe
4. Remove the air bubbles by opening the pressure feed pipe valves if any.
5. Note down the manometer reading
6. Close the outlet valve of measuring tank and measure the time taken for 10 cm raise in water level by measuring tank.
7. Repeat the procedure 2 to 3 times for various flow rates of water
8. Same procedure is adopted for 2 other pipes by opening the concerned valves and remaining valves in closed condition.
9. Note the values and do the calculation to find out the frictional loss.

Calculation:

The actual loss of head is determined from the manometer readings. The frictional loss of head pipes is given by the following formula

$$h = \frac{flv^2}{2gD}$$

f = Coefficient of friction for the pipe (frictional factor)

L= Distance between two sections from which loss of head is measured (3 m)

V= velocity of average flow = $\frac{Q}{a}$

a=Area of the pipe = π/4 x d^2

g = acceleration due to gravity

D = Pipe diameter in meters

n= $(\frac{sm-sf}{sf})X\frac{hw}{100})$

S_m = specific gravity of manometric liquid

S_f = specific gravity of flowing liquid

$$h_m = h_1 - h_2 \text{ cm of Hg}$$

Table of Readings:

Type of Pipe	Diameter of the Pipe 'd'		Area of Pipe A M^2	Manometer reading			Water collected in collecting tank 'R'		Time for (10 cm) rise of water level T in Sec.
				H_1	H_2	H_m			
	Mm	M		Cm of Hg			Cm	M	Sec

Precautions:

1. Ensure that the pump is primed before starting the motor
2. While doing the experiment on a particular pipe keep the other pipe line closed
3. Take the differential manometer readings without parallax error
4. Ensure that the electric switch does not come in contact with water
5. Remove air bubbles in differential manometer by opening air release valve

Results:

1. Coefficient of loss of head h_f=___________
2. Friction factor f =____________

DETERMINATION OF LOSS OF HEAD DUE TO SUDDEN CONTRACTION IN A PIPE LINE

Aim:

To determine the coefficient of loss of head due to sudden contraction

Apparatus Required:

1. Piping system
2. Sump Tank
3. Measuring Tank
4. Differential Manometer
5. Pump set.
6. Stop Watch

Specifications:

1. Sump tank size : 0.9 m x 0.45 m x 0.3 m S.S. tank
2. Measuring Tank Size : 0.6 m x 0.3m x 0.3 m S.S. Tank
3. Differential Manometer : 1 m range with 1mm scale of graduation
4. No. of pipes : 2 Galvanized Iron(GI)
5. Piping system sizes : 25 mm,12.5mm
6. Pressure taping distance : 0.5 m
7. Pump set : Pump is 25x25mm^2 size, centrifugal, moonset pump with single phase, 2pole, 220V, 1/2HP, 50 Hz, 2880 rpm, AC supply.

Description of Apparatus:

1. **Piping System**: piping system of size 25 mm diameter and 12.5 mm with a flow control valve.

2. **Sump Tank**: It is S.S. tank to store sufficient fluid for experimentation and arranged within the floor space of main unit. The sump should be filled with fresh water having 25 mm space at the top.

3. **Measuring Tank**: It is also a S.S tank with gauge glass, a scale arrangement for quick and easy measurements. A ball valve which is outlet valve of measuring tank is provided to empty the tank.

4. **Differential Manometer**: It is used to measure the differential head produced by piping system.

5. **Pump Set**: It is used to pump water from sump tank to measuring tank through pipe.

Figure:

Procedure:

1. Start the motor keeping the delivery valve close. Make sure that the ball valve is fully open which is at the collecting tank
2. Slowly open the cocks which are fitted at sudden contraction end and make sure that manometer is free from air bubbles
3. Make sure while taking the readings, that the manometer is properly primed. Priming is the operation of removing the air bubbles from the pipes. Note down the loss of head "h_c" from the manometer scale.
4. Note down the time required for the rise of 10 cm (i.e 0.1 m) water in the collecting tank by using stopwatch. Calculate the discharge using below formula.

Discharge: The time taken to collect some 'X' cm of water in the collecting tank in m^3/sec

$$Q = \frac{AR}{t}$$

Where,

A = Area of measuring (or) collecting tank = 0.3 x 0.3 m^2

R = Rise of water level taken in meters (say 0.1 m or 10 cm)

t = time taken for rise of water level to rise 'R' in 't' seconds

5. Calculate the velocity of the jet by following formula

V = Discharge / Area of pipe

= Q / A m/sec

Where,

A = Cross sectional area of the pipe = $\Pi / 4 * d^2$ d = diameter of the pipe.

6. Calculate the coefficient of contraction for the given pipe by

$$\mathbf{h_c = v^2 / 2g * K}$$

Where,

h_c = loss of head due to sudden contraction = $(h_1-h_2) * 12.6/100$ m K

Co-efficient for loss of head in contraction = $[1/C_c - 1]^2$

V = Average Velocity of flow in m/sec.

7. Repeat the steps 2 to 6 for different sets of readings by regulating the discharge valve.

Table of Readings:

Type of Pipe	Diameter of the Pipe ‘d’		Area of Pipe (A) m^2	Manometer reading			Water collected in collecting tank ‘R’		Time for (10 cm) rise of water level t in Sec.
				h_1	h_2	h_m			
	mm	m		cm of Hg			cm	m	Sec

Precautions:

1. Ensure that the pump is primed before starting the motor.
2. While doing the experiment on a particular pipe keep the other pipe line closed.
3. Take the differential manometer readings without parallax error
4. Ensure that the electric switch does not come in contact with water.
5. Remove air bubbles in differential manometer by opening air release valve.
6. Ensure that opening and closing of manometer valves should be done carefully to avoid leakage of mercury.
7. Check that gauge glass and meter scale assembly of the measuring tank is fixed vertically and water tight.

Results:

1. Loss of head due to sudden contraction hc =_____.
2. Coefficient of Contraction (C_c) =______.

BERNOULLIS THEOREM APPARATUS

Introduction:

The closed circuit self-sufficient portable package system Bernoulli's theorem apparatus does not require any foundation, trench work etc., so that you can conduct experiment with keeping the unit anywhere.

Bernoulli's theorem apparatus:

According to Bernoulli's theorem in a continuous fluid flow, the total head at any point along the same. That is datum head (Z)+pressure along the head (P/W)+Velocity head(v^2 /2g) is constant along the flow. Applying the equation between point 1 and 2 along the streamline AB.

$Z_1 + P_1 /W + V^2 /2g = Z_2 + P_2 /W + V^2 /2g$

(Our unit is designed for horizontal flow).

General Description:

The unit consists of supply chamber and experimental duct made of Perspex sheets

For the purpose of experiments with minimum of friction loss and the due to turbulence. Piezeometer glass tubes are provided at suitable intervals along with duct for the measurement of pressure head at various points through the apparatus. A collecting tank is provided for the measurement of rate of flow. Piezeometer glass tubes are provided at suitable intervals along with duct for the measurement of pressure head at various points A flow control valve is provided at the exit of the duct for adjusting and keeping different flow rates through the apparatus. A Collecting

Tank is provided at the exit of the duct for adjusting and keeping different flow rate through the apparatus. A Collecting tank is provided for the measurement of rate of flow.

The unit consists a sump of size 1250x300x300 mm height and a mono block is 0.5 HP, Single Phase 220 V, 2800 RPM and pump of size 25 mm to discharge about 15 LPM at 30m total head.

Experiment:

The Apparatus is fitted with piezeometer tubes and scales at 09 cross sectional points, along the experimental duct at suitable intervals for measurement of pressure head. The area of flow section (a) is written on each one of these 09 sections. The velocity of flow (V) can be calculated at each of these sections from the flow rate (Q) obtained from the measuring tank that is V=Q/a from the velocity head V^2 /2g.

Can be calculated for the each section

For the verification of bernouills theorem, the velocity head when superposed over the hydraulic gradient gives the energy gradient must be level line However, in the flow of need fluid, contain losses of energy is inevitable and this can be readily seen by plating energy gradient. Such sets of readings can be taken for different flow rated by adjusting the valve.

Figure:

Procedure:

1. Before starting the experiment, do priming of the pump to remove the air bubbles.
2. Open the inlet valve of the piping system of the pump.
3. Open the outlet valve of the piezeometer tube.
4. Start the motor and keep the water level constant in the supply tank by operating various valves.
5. Then note down the pressure head from the piezeometer scale directly
6. Close the outlet valve of the mercury tank and note down the time for 100 mm raise of water level note down the valves for pressure head, velocity head for different areas of piezeometer and calculate the total head.

Calculation:

Actual Discharge: Q = A R/T

A= Area of measuring tank = 0.3 x 0.3m^2

R = Difference in levels of water in measuring taking

T = time in seconds

Velocity = Q/A

a= cross sectional area of duct at various intervals.

Total Head:

$$\frac{p}{W} + \frac{v^2{}_1}{2g} + Z1 = C$$

P/W = Piezeometer Reading Pressure Head.

$V^2/2g$ = velocity head.

Z = Datum head

Observation table:

Cross sectional area (a)	Time for R= 10 cm rise	Actual discharge = Q_{act} =Ar/t	Velocity (v=Q/a)	Velocity head $(V^2/2g)$	piezeometer reading pressure head $\frac{p}{w}$	Datum Head (z)	Total head $\frac{v^2}{2g} + \frac{P_1}{W} + CZ$
m^2	Sec	m^3/s	m/s	m	m	m	m

Precautions:

1. Be careful to avoid leakage of the pizeometer tubes
2. The water filled in the sump tank should be 2 inches below the upper end
3. Ensure that the electric switch does not come in contact with water
4. Ensure that the water level is constant in the supply tank during the experiment
5. Check that the gauge glass and meter scale assembly of the measuring tank is fixed vertically and water tight.

Result:

The total head at any point along the flow is same.