JAGANNATH GUPTA INSTITUTE OF ENGINEERING AND TECHNOLOGY, JAIPUR

FLUID MECHANICS AND HYDRAULIC MACHINES LAB MANUAL

Experiment No :1 Calibration of Venturimeter

Aim:- To determine the coefficient of discharge of the given flow meter.

Apparatus:-Venturimeter experimental setup, stop watch.

Theory: A flow meter is used to measure the flow rate of a fluid in a pipe. A venturimeter consist of short length of a pipe narrowing to a throat in the middle and then diverging gradually to the original diameter of the pipe. As the water flow through these meters, velocity is increased due to the reduced area and hence there is a pressure drop.

Theory/Description:-

A venturi meter is a device which is used for measuring the rate of flow of fluid through the pipe.

Principle:-The basic principle on which a venturimeter works is that by reducing the cross sectional area of the flow passage, a pressure difference created and the measurement of the pressure difference enables the determination of the discharge through the pipe.

Venturi meters consist of 1. An inlet section which is in the form of convergent cone 2. Throat 3.outlet section which is in the form of divergent cone. The inlet section of the venturi meter is of the same diameter as that of the pipe diameter. The convergent cone is a short pipe which tapers from the original size of the pipe so that the throat of the venturimeter. The throat is a short pipe having its cross sectional area smaller than that of the pipe .The divergent cone of the venturimeter is a gradually diverging pipe with its cross section area increasing from that of throat i.e 1 and 2 of the venturimeter

Pressure taps are provided through the pressure ring as shown in the figure.

The length of convergent cone is equal to the (D-d).where ‘D’ is the diameter of the inlet section and ‘d’ diameter of throat .The length of the pipe is equal to the diameter of the pipe. The diameter of the throat may vary from 1/3 to ¾ of the pipe diameter.

The divergent cone has more length as that of the convergent cone due to avoid the possibility of flow separation (eddies) and energy loss.

The cross section area of the throat is smaller than the cross section area of the inlet section .According to the the flow at the throat result in the decrease in the pressure .so the pressure difference will be developed between the inlet and the throat .This pressure difference can be determined by using suitable manometer.

Experimental Procedure:

1. Select the required flow meter.

2. Open its pressure valves and close the other pressure valves, so that only pressure for the flow meter in use is communicated to the manometer.

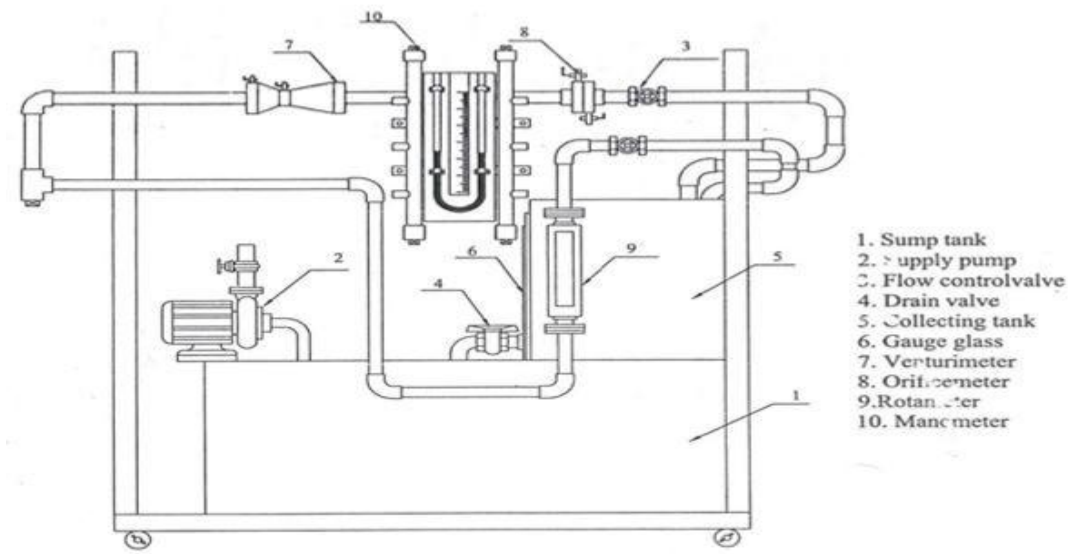
3. Open the flow control valve and allow a certain flow rate.

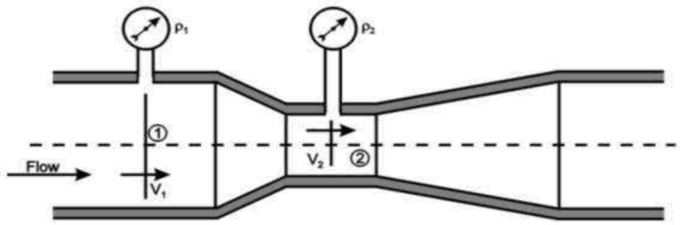
4. Observe the reading of the manometer. And change the flow rate.

5. Note down the readings of the manometer.

6. Collect the water in the collecting tank .Close the drain valve and find the time taken for 5cm rise in the tank.

Schematic diagram of venturimeter:





venturimeter

Calculations:

$h_{1=}$ manometric head in the left limb.

$h_{2=}$ manometric head in the right limb.

t=time taken for h_{cm} rise of water in tank.

$h_{w=}$ venturi head in terms of flowing liquid.

$m=(h_2 - h_1) \times \left(\frac{\text{specific gravity of ccl4}}{\text{specific gravity of water}} - 1\right)$

Specific gravity of ccl_4=1.6.

Specific gravity of water=1.

Theoretical discharge $Q_t = k \times (\sqrt{h})\ Cm^2/s$.

$$K=\frac{a1 x a2\sqrt{2g}}{\sqrt{a1^2-a2^2}}$$

Where a_1=area of cross section of pipe.

a_2=area of cross section of the throat.

Q_a =volume of the water collected in the tank i.e. [area of the tank x rise of water level in the tank] cm^3/s.

Coefficient of discharge $(C_d)= \frac{Q_a}{Q_t}$

Tabular Column for venturimeter:

S.No	**Manometeric reading**		**Time taken for h cm** rise of water in tank (s)	**Theoretical** discharge Q_{t} cm^3/sec	**Actual** discharge Q_a cm^3/sec	**Coefficient** of discharge (C_d)
	h_1(cm)	h_2(cm)				
1						
2						
3						
4						
5						

Graphs:

1. Coefficient of Discharge (C_d) versus Actual discharge (Q_a).
2. Coefficient of Discharge (C_d) versus Theortical discharge (Q_{t}).

Result: The coefficient of discharge of venturimeter is $C_{d=}$___________.

Experimental No:2 Calibration of an orificemeter

Aim: To determine the coefficient of discharge of the given flow meter.

Apparatus: orifice meter experimental setup, stopwatch.

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

An orifice meter consists of a flat circular plate with circular perforated hole called orifice which is concentric with the pipe axis. The thickness of the plate is less than an equal to 0.05 times the diameter of the pipe. The diameter of the orifice may vary from 0.2 to 0.85 times the pipe diameter but generally the diameter is kept as 0.5 times pipe diameter.

Two pressure taps are provided at section -1 on the upstream side of the orifice plate and other at section -2 on the downstream side of the orifice plate since in the case of an orifice change in the cross section as area of the flow passage is provided and there being a gradual change in the cross sectional area of the flow passage as in the case of venturimeter there is a gradual loss of energy in a orifice meter than in a venturimeter.

The experimental setup consist of 20mm pipe lines fixed to an MS stand .The pipe is connected with an orifice meter with the action valves for pressure tapping's. The meter is connected to a common middle chamber, which is in turn connected to a mercury chamber. The pipe line is provided with a flow control valve.

Experimental Procedure:

1. Select the required flow meter.

2. Open its pressure valves and close the other pressure valves so that only pressure for the meter in use is communicated to the manometer.

3. Open the flow control valve and allow certain a 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 5cm rise in the tank.

Calculations of Orificemeter:

Theoretical discharge(Q_t)

$h_{1=}$ manometric head in the left limb.cm

$h_{2=}$ manometric head in the right limb.cm

Difference in the manometer level =h_x=h_1-h_2 cm

t=time taken for h_{cm} rise of water in tank.

Theoretical discharge Q_t=K $\sqrt{h}$

K= $a_1 * a_2 * \sqrt{2g}$

$a_{1=}$ area of cross section of the pipe.

$a_{2=}$area of the throat.

Actual discharge (Q_a)

The area of the collecting tank =50cm*50 cm

Rise of water level in the tank =5cm

Time taken for collecting ‘ h ‘in the collecting tank

Qa=AR/t

Coefficient of discharge C_d=Q_a/Q_t

Tabular column of orifice-meter:

S.no	Manometer Reading			$H = x(\frac{SO}{Sw} - 1)$	Time taken (t sec) for 5cm rise water	$Q_t = K\sqrt{h}$ (cm^3/sec)	$Q_a = AR/t$ Cm^3/sec	Coefficient discharge of orifice-meter (C_d)
	$h_{1(Cm)}$	h_2(cm)	$H_x = h_2 - h_{1(cm)}$					
1								
2								
3								
4								

Graphs:

1. Actual discharge versus Theoretical discharge.
2. Actual discharge versus Coefficient of discharge.

Result: The coefficient of discharge (C_d) for orificemeter is ________________

Precautions:

1. Wear tight overalls and Safety shoes.
2. Take reading properly.

Experiment no-3 Determination of Friction for a given pipe line

Aim: To determine Coefficient of Friction factor for a given pipe line.

Apparatus: Friction factor Experimental Test Rig, stop watch.

Theory:

Frictional factor Experimental setup consist of pipe system with two pipelines of size 20mm (Square) and 15mm (Round) with pressure tapping's are connected to a multiport manifold which in turn is connected to manometer.

Mostly the flow in the pipe is turbulent. The velocity in turbulent flow is relatively uniform and the velocity profile of turbulent flow is much flatter than

When water flows through a pipe, a certain amount of energy (or pressure energy)has to be spent to overcome the friction due to the roughness of the pipe surface. This roughness effect depends on the roughness effect or frictional effect depends on the material of the pipe and scale formation if any. If the surface is smooth the friction effect is less first. For an old pipe due to the scale formation or chemical deposits the roughness and hence the friction effect is higher.

Pipe line system in general includes several auxiliary components. In addition to types. These components include the following:

1. Transitions or sudden expansion And contraction for changing pipe size.

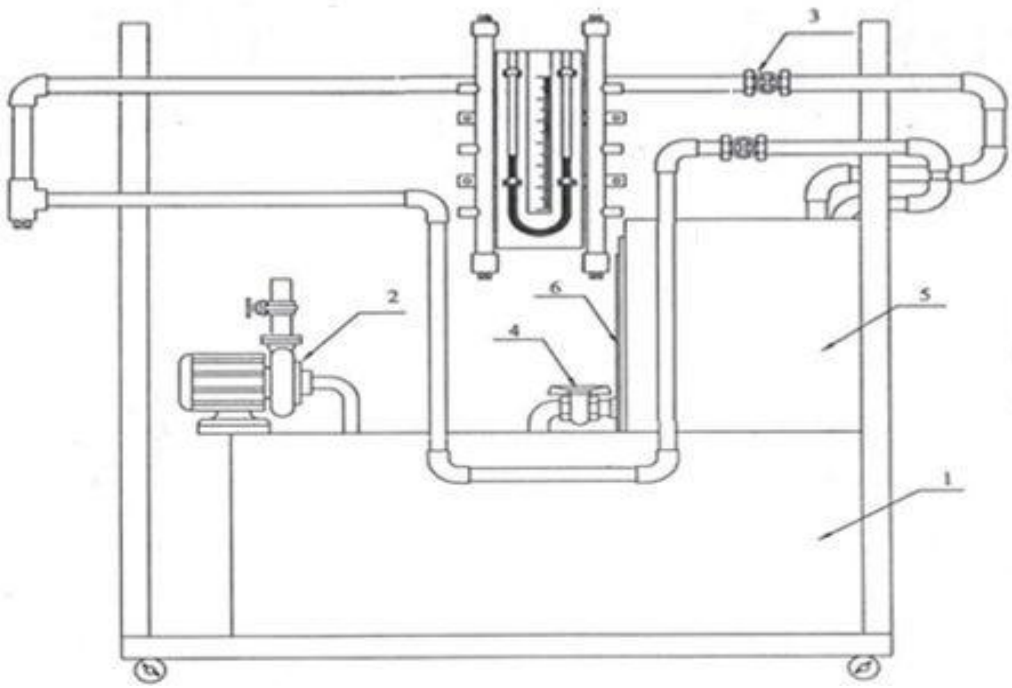
2. Elbows and bends for changing flow directions.

These components introduce disturbances in the flow that cause turbulence and as mechanical energy loss in addition to that which occur in basic type flow due to friction. The energy loss although occurs over a finite distance, then viewed from the perspective of an entire pipe system are localized near the component. Hence these losses are referred to as local losses or minor losses. It should be remembered that these losses sometimes are the dominant losses in piping system and hence the term minor losses is a misnomer often.

Experimental procedure:-

1. Select the required pipe line
2. Connect the pressure tapping's of the required pipe line to the manometer by opening the appropriate pressure valves and closing all the pressure valves.
3. Note down the pressure difference from the manometer mercury column.
4. Collect the water in the collecting tank for 5 cm rise of level and note down the time taken.
5. Repeat the experiment, at other flow rates.

Schematic diagram of friction losses through a pipe(Square and circular pipe):



1. Sump tank
2. Supply pump
3. Flow controlvalve
4. Drain valve
5. Collecting tank
6. Gauge glass

Tabular column:

(I) For square pipe:

S.NO	Manometric head			Time taken for h cm raise of water in tank t	Discharge (Q) Cm^3/sec	Velocity (v) m/s	Friction factor (f)
	$h_{1(Cm)}$	$h_{2(cm)}$	$h_{f(cm)}$				
1							
2							
3							
4							
5							

(II) For circular pipe:

S.NO	Manometric head			Time taken for h cm raise of water in tank t	Discharge (Q) Cm^3/sec	Velocity (v) m/s	Friction factor (f)
	$h_{1(Cm)}$	$h_{2(cm)}$	$h_{f(cm)}$				
1							
2							
3							
4							
5							

Calculations:

The distance between the pressure tapping's and pipe line L=200 cm.

Diameter of round pipe =1.5 cm.

Loss of head due to friction $h_f=(\frac{Sm}{S}-1)$

Area of the collecting tank A =50x50 cm^2.

Where S_m :specific gravity of mercury 13.6

S: specific gravity of water 1

Rise of water level for 5 cm in collecting tank R = 5cm

Time taken for collecting water = t sec's.

Discharge Q=(AXR/t) cm^3/sec

Manometer Readings

Reading in the left limb=$h_1$cm v^2

Reading in the right limb=h_2 cm

Darcy's constant-f:

Head loss H= $\frac{2gdhf}{4flv2}$

Result: The friction factor (f) for square pipe is_______________.

The friction factor (f) for circular pipe is_______________.

Experiment :4 Verification of Bernoulli's Theorem

AIM:

To verify the Bernoulli's theorem.

APPARATUS:

A supply tank of water, a tapered inclined pipe fitted with no. of piezometer tubes point, measuring tank, scale, and stop watch.

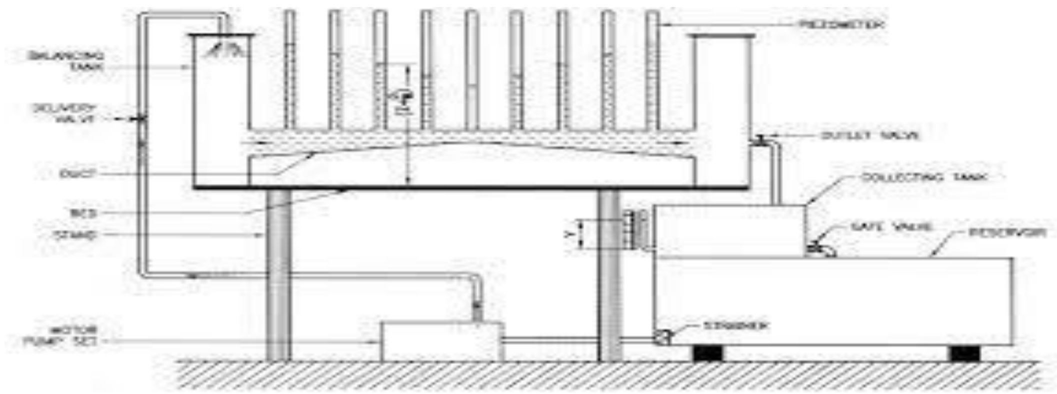
THEORY:

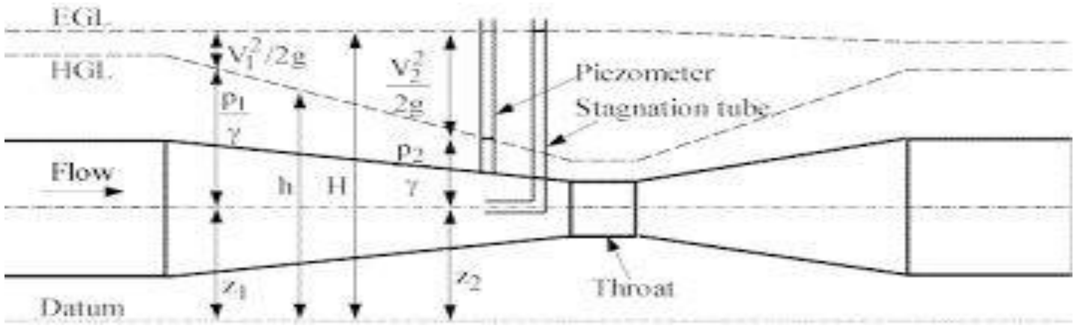
Bernoulli's theorem states that when there is a continues connection between the particle of flowing mass liquid, the total energy of any sector of flow will remain same provided there is no reduction or addition at any point. I.e. sum of pressure head and velocity head is constant.

PROCEDURE:

1. Open the inlet valve slowly and allow the water to flow from the supply tank.
2. Now adjust the flow to get a constant head in the supply tank to make flow in and outflow equal.
3. Under this condition the pressure head will become constant in the piezometer tubes. Note down piezometer readings.
4. Note down the quantity of water collected in the measuring tank for a given interval of time.
5. Compute the area of cross-section under the piezometer tube.
6. Compute the values of velocity head and pressure head.
7. Change the inlet and outlet supply and note the reading.
8. Take at least three readings as described in the above steps.

SCHEMATIC DIAGRAM:





Throat

TABULARCOLUMN:

Trail-1:

S.No	Duct point	Pizeometer Reading	time for 5cm rise	Discharge Q m^3/s	Pressure Head m	Velocity Head m	Datum head m	Total Head m
1								
2								
3								
4								
5								
6								
7								

Trail -II

S.NO	Duct Point	Pizeometer Reading	time for 5cm rise	Discharge Q m^3/s	Pressure Head m	Velocity Head m	Datum head m	Total Head m

1								
2								
3								
4								
5								
6								
7								

Trial-III

S.NO	Duct Point	Pizeometer Reading	time for 5cm rise	Discharge Q m^3/s	Pressure Head m	Velocity Head m	Datum head m	Total Head m
1								
2								
3								
4								
5								
6								
7								

CALCULATIONS:

Pressure head = $\frac{P}{\rho g}$

Velocity head = $\frac{v2}{2g}$

Datum head = Z = 0 (for this experiment)

Velocity of water flow = v

Q (Discharge) = [Volume of water collected in tank/time taken to collect water]

= [Area of tank × height of water collected in tank]/ t

Also

Q= velocity of water in pipe × area of cross section = v × A_x

Area of cross section (A_x) = A_t + [$\frac{(Ai-At)\times Ln}{L}$]

A_t = Area of Throat

A_i = Area of Inlet

Diameter of throt = 25mm

Diameter of inlet = 50mm
L_n= distance between throat and corresponding pizeometer
L=length of the diverging duct or converging duct = 300mm
Distance between each piezometer = 75mm

Total Head = $\frac{P}{\rho g} + \frac{v2}{2g}$ + Z

RESULT: By conducting experiment on Bernoulli's apparatus and taking Trail-I,Trail-II,Trail-III ,we have got constant total head.
Hence Bernoulli's theorem is proved.

PRECAUTIONS:
1. Note the piezometer readings carefully.

Experiment no -6 Impact of jet on vanes

Aim : To find the coefficient of impact of jet on vanes.

Apparatus: Impact of jet on vanes experimental test rig, Flat vane, curved vane, Dead weights, stop watch.

Theory: A jet of fluid emerging from a nozzle has some velocity and hence it possesses a certain amount of kinetic energy. If the jet strikes an obstruction placed in its path, it will exert force on obstruction. This impressed force is known as impact of jet and it is designated as hydrodynamic force, in order to distinguish it from the force due to hydrostatic pressure. since a dynamic force is exerted by virtue of fluid motion, it always involves a change of momentum, unlike a force due to hydrostatic pressure that implies no motion.

Principle: The impulse momentum principle may be utilized to evaluate the hydrodynamic force exerted on a body by a fluid jet.

(1) When jet strikes a stationary Flat vane

In this case the flat vane is stationary and jet strikes on it at the middle and then splits in two parts leaves the corners tangentially so

$$P=m/v$$

$$M=pa.s$$

Now dividing the equation with time t.

$$M/t=pa.s/t$$

$$M=\rho av$$

Since we know that the impact of jet on vane is

$$F=Ma$$

$$F=M\,\frac{\Delta v}{t}$$

$$F=(M/t).\Delta v$$

$$F=M(v_{inlet-}v_{outlet})$$

$$F=M(v+v\cos\theta)$$

$$F=\rho av^2(1+\cos\theta)$$

The force of Impact will be maximum if the angle of declination is $\theta=90°$

Experimental procedure:

1. Fix the vane to be tested inside the testing chamber by opening then transparent door provided. Close the door and tighten the lock.

2. Note the initial reading on the scale.

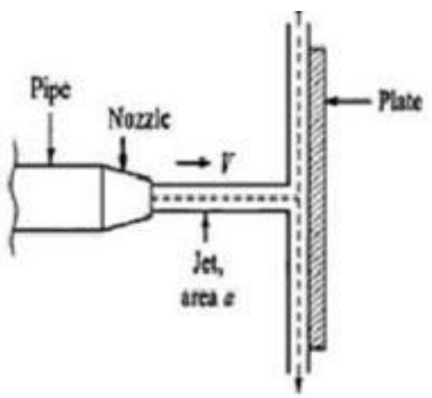
3. Open the inlet water. The water jet from the nozzle strikes on vane gets deflected and drains back to collecting tank.

4 .Close the collecting tank drain valve and note down the time taken for 2cm rise in water level in the collecting tank. Open the drain valve.

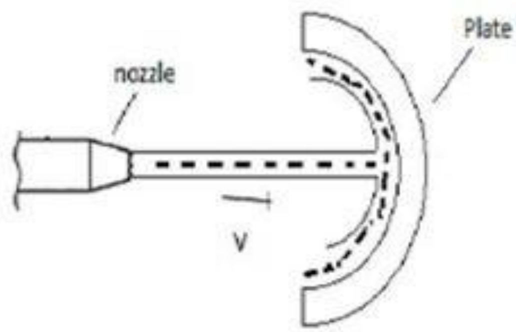
5. Add dead weight to bring the pointer back to the initial reading on the scale. Note down the dead weights.

6. Repeat the experiment for different flow rates by adjusting the position of the inlet valves and for different vanes.

Schematic diagram:



Flat plate



Hemispherical plate

Tabular column:

(I) Flat vane:

S.NO	**F_a(Actual Force) N**	**F_t (Theoretical force) N**	**t (Time taken for h cm raise of water in tank) S**	**Q= $\frac{A\times h}{t}$ m^3/s**	**K = F_a/F_t (coefficient of Impact)**
1					
2					
3					
4					
5					

(II) Curved vane:

S.NO	**F_a (Actual Force) N**	**F_t (Theoretical force) N**	**t (Time taken for h cm raise of water in tank) s**	**Q= $\frac{A\times h}{t}$** m^3/s	**K = F_a/F_t (coefficient of Impact)**
1					
2					
3					
4					
5					

Calculations:

Theoretical force (N): $F_t = \rho a v^2 (1+\cos\varphi)$
For Flat vane= $\frac{\rho a v2}{g}$

For curved vane= $\frac{\rho a v2}{g}(1 + cos\theta)$

Where diameter of nozzle = 1cm

Area of collecting tank= $\frac{AR}{t}$

Where A= Area of collecting tank

R=rise in water level.

Coefficient of impact on vanes= $\frac{Fth}{Fa}$

Result: The coefficient of impact of jet on vanes for Flat vane is_____________.

The coefficient of impact of jet on vanes for Curved vane is____________.

Precautions:

1. Wear tight overhauls and safety shoes.

2. Fix correct vane for the hanger.

3. Don’t start the motor by closing the supply valve.

Experiment No:7 Performance test on Pelton wheel

Aim:- To conduct the performance test and to plot the operating characteristics of Pelton wheel turbine.

Apparatus: Pelton wheel test rig, Tachometer.

Theory:-

Pelton turbine is a impulse turbine. Which uses water available at high heads (pressure) for generation of electricity. All the available potential energy of the water is converted into 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 bucket with the least resistance and shock and glides along the path of the cup, deflecting through an angle of 160° to 170°.This deflection of the water causes a change in momentum of the water jet and hence an impulse force is supplied to the buckets. As a result, the runner attached to the bucket moves, rotating the shaft. The specific speed of Pelton wheel varies from 10 to 100

In the test rig the Pelton wheel is supplied with water under the high pressure by a centrifugal pump .The water flows through the venturimeter to the Pelton wheel. A gate valve is used to control the flow rate to the turbine. The venturimeter with pressure gauges is connected to determine the flow rate in the pipe. The nozzle opening can be decreased or increased by opening the spear wheel at entrance side of the turbine.

The turbine is loaded by applying the dead weights on the brake drum. Placing the weights on the weight hanger. The inlet head is read from the pressure gauge. The speed of the turbine is measured with the help of tachometer.

Experimental procedure:

1. Prime the pump with water and start the pump.

2. Gradually open the delivery valve of the pump.

3. Adjust the nozzle at the half of the opening by operating the needle valve by using the spear wheel .

4. The head should be made constant by operating the delivery valve and the head shows be maintained at constant value.

5. Measure the turbine rpm with the tachometer.

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

7. Observe the readings of h_1 and h_2 corresponding the fluid level in the two manometer links which are connected to venturimeter.

8. Adjust the load on the break drum and note down the speed of the turbine, using the tachometer and spring balance reading.

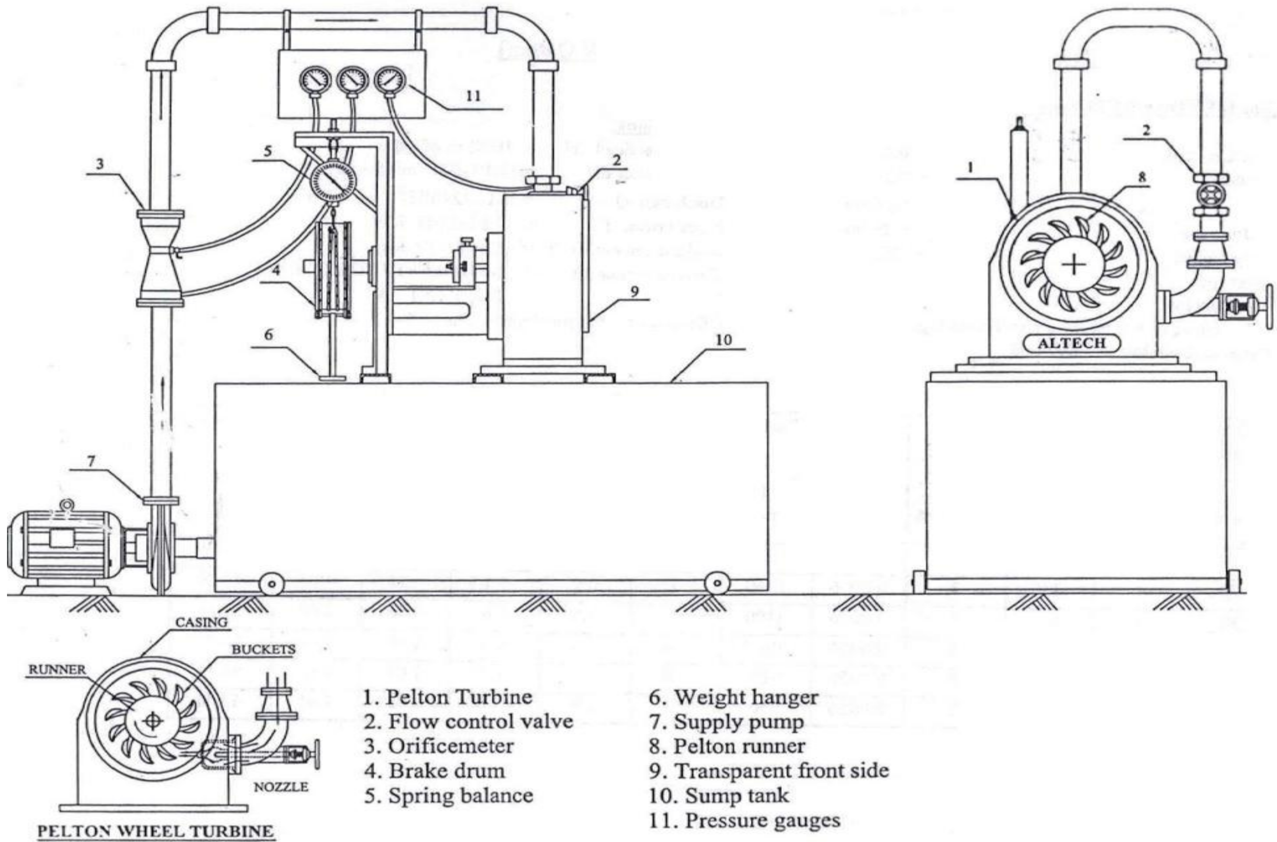
9. Add additional weights and repeat the experiment for other loads.

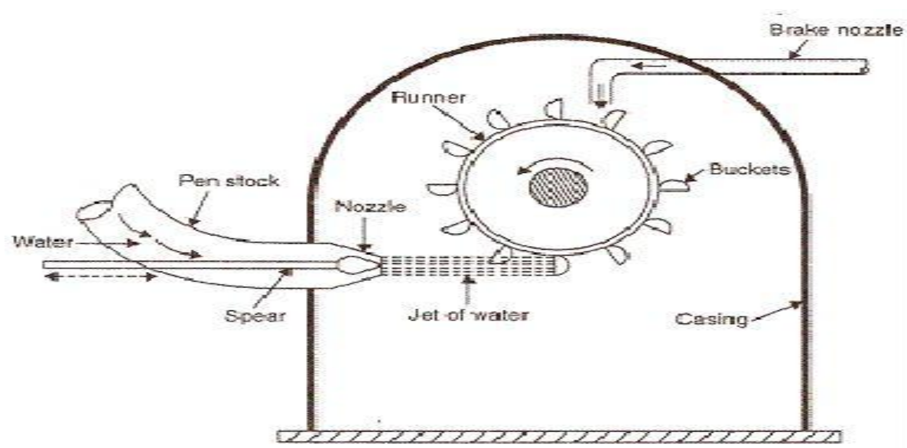
10. For constant speed tests, the main valve has to be adjusted to reduce or increase the inlet head to the turbine for varying loads spring balance reading.

9. Add additional weights and repeat the experiment for other loads.

10. For constant speed tests, the main valve has to be adjusted to reduce or increase the inlet head to the turbine for varying loads.

<u>Schematic diagram of pelton wheel turbine</u>





Cut- Sectional view of pelton wheel turbine

TABULARCOLUMN:

S.No	Gate opening	Pressure gauge (kg/cm^2)	Vacuum pressure mm of Hg	Manometer reading		Speed of rotation	Spring balance		P_i KW	P_o KW	η%
				h_1 cm	h_2 cm		T_1 kg	T_2 kg			
1											
2											
3											
4											
5											

Electrical output

Load (kw)	Voltage V	Current (I) A	Speed(N) rpm

CALCULATIONS:

Input power (P_i) = ($\rho \times g \times Q \times h$) W ___

Flow rate of water Q = $C_d \frac{a1 \times a2 \times \sqrt{2gH}}{\sqrt{a1^2 - a2^2}}$

d_1 = diameter Of venture inlet = 65mm

d_2 = diameter. Of venture throat= 39mm

C_d = coefficient of discharge of venturimeter = 0.9

Where a_1 = area of inlet of the venturimeter.

a_2 = area of the venturimeter throat.

H= h_1-h_2 [$\frac{s1}{s2}$ -1]

h = Total head of water (m)

h = suction head (h_s) + delivery Head (h_d) + Datum Head

Where h_d = delivery head = P_d/ρ

h_s = suction head= $\frac{Ps \times 13600}{\rho}$

Output power (P_o) = $\frac{2\pi \times N \times T}{60}$ watts

T = (T_1-T_2) ×g × dia. Of break drum

dia. Of break drum = 0.15m

N = speed in tacho meter

Efficiency of the turbine η_m%= P_o/P_i

Electrical efficiency = η_e% = p_o / P_i

p_o= electrical output = V × I

GRAPHS:

1. speed vs. efficiency
2. speed vs. power input
3. speed vs. power output.

RESULT: The efficiency of pelton wheel is__________%.

PRECAUTIONS:

Experiment no-7 Performance test on Francis turbine

Aim: To conduct performance test and to plot the operating characteristics of Francis turbine.

Apparatus: Francis turbine rig, tachometer.

Theory:

Francis turbine is a reaction type hydraulic turbine, used in dams and reservoir of medium height to convert hydraulic energy into mechanical and electrical energy. Francis turbine is radial inward flow reaction turbine. This has the advantage of centrifugal forces acting against the flow, thus reducing the tendency of the turbine to over speed. Francis turbines are best suited for medium heads. The specific speed ranges from 25 to 3oo.

The turbine test rig consist of a 1.0 KW (1.34 HP) turbine supplied with water from a suitable 5HP centrifugal pump through suitable pipelines, a gate valve, and a flow measuring venturimeter. The turbine consists of a cast iron body with a volute casing and gun metal runner consisting of two shrouds with an aerofoil shaped curved vanes in between. The runner is surrounded by a set of brass guide vanes. At the outlet, a draft tube is provided to increase the net head across the turbine. The runner is attached to the output of the shaft with a brake drum to absorb the energy.

Water under the pressure from the pump enters the guide vanes into the runner while passing through the spiral casing and guide vanes; a portion of pressure energy is converted into velocity energy. Water thus enters the runner at high velocity and as it passes through the runner vanes, the remaining pressure energy converted into kinetic energy. Due to the curvature of the vanes, the kinetic energy is transformed into mechanical energy. 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 pipeline into the turbine is measured with the venturimeter fitted in the pipeline. The venturimeter is provided with the 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 is torque is determined with a rope brake drum dynamometer. A tachometer is used to measure

SPECIFICATION:

1. **Spiral casing**: made of cast iron with smooth inner surface.
2. **Runner:** made of gunmetal casting designed for efficient operation.

Accurately machined and smoothly finished.

3. **Guide vane** :consists of guide vanes rotating in gunmetal bushes Mechanism operated by hand wheel through a link mechanism.
4. **Shaft** : stainless steel accurately machined
5. **Bearing:** one number ball bearing and one number taper roller bearing.
6. **Draft tube bend**: provided at the exit of the runner with a transparent cylindrical window for observation of flow past the runner to the bend is connected a draft tube of mild steel fabrication.

7. **Brake arrangement**: consists of a machined and polished cast iron brake drum, cooling water pipes, internal water scoop discharge pipe, spring balances, screw rod, and belt brake arrangement.

PROCEDURE:

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

2. Close the main gate valve and start the pump.

3. Open the gate valve while monitoring the inlet pressure to the turbine .set it for the design value of 1.0 kg/sq.cm

4. Open the cooling water valve for cooling the brake drum.

5. Measure the turbine rpm with the tachometer.

6. Note the pressure gauge and vacuum gauge reading at the turbine inlet and outlet.

7. Note the venturimeter pressure gauge reading, P1 and p2.

8. Add additional weights and repeat the experiment for other loads

9. For constant speed test, the main valve has to be adjusted to reduce or increase the inlet head to turbine for varying loads.

SUPPLY PUMP:

1. Rated head : 20 m
2. Discharge : 2000Lpm
3. normal speed : 1440 Rpm
4. Power required : 15hp (11.2 Kw)
5. Size of pump : 100×100 mm
6. Type : centrifugal high speed single suction volute.

FRANCIS TURBINE:

1. rated supply head : 15.0 m
2. discharge : 2000Lpm
3. rated speed : 1250 Rpm
4. unit speed : 51.5 Rpm
5. specific speed : 95.5 Rpm
6. runner diameter : 150 mm
7. no. of guide vanes 8
8. brake drum diameter : 300 mm

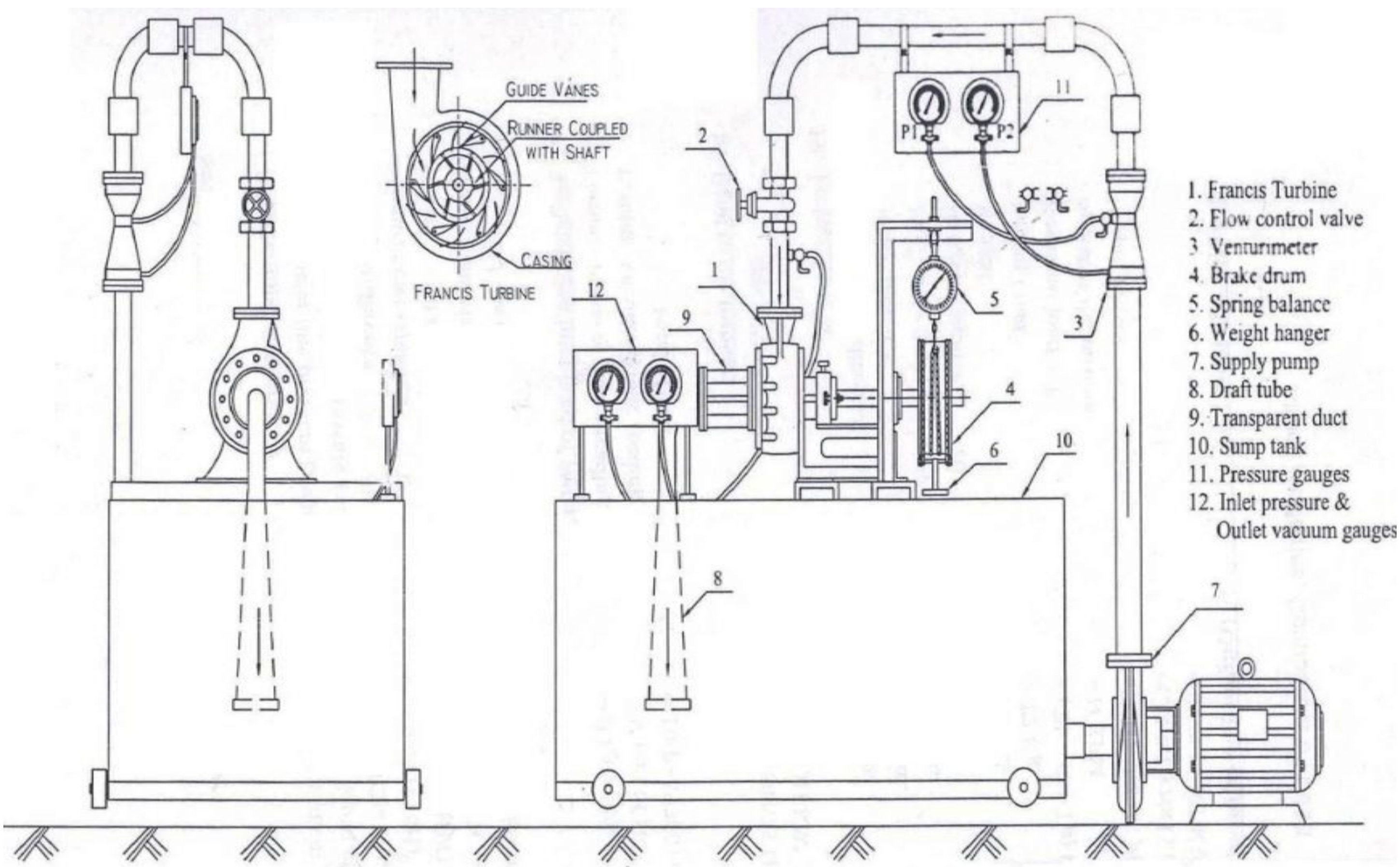
FLOW MEASURING UNIT:

Size of venturi meter 100 mm
Throat diameter for venturi meter 60 mm
Manometer Double column differential type.

Tabular column:

S.no	**Gate opening**	**Pressure gauge (kg/cm^2)**	**Vacuum pressure (kg/cm^2)**	**Manometer reading**		**Speed of rotation (Rpm)**	**Spring balance**		**P_i (KW)**	**P_o (KW)**	**η %**
				$h_{1(cm)}$	**$h_{2(cm)}$**		**T_1**	**T_2**			
1											
2											
3											
4											
5											

Schematic diagram of francis turbine:



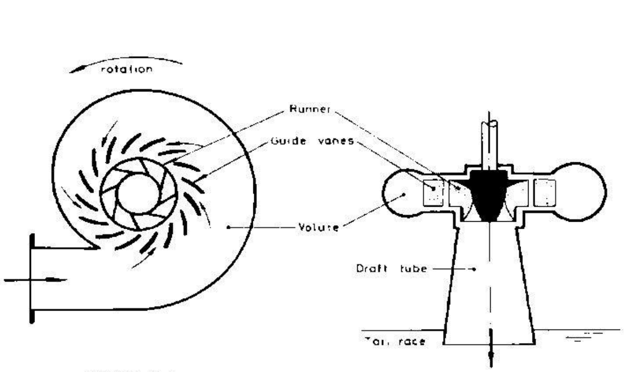
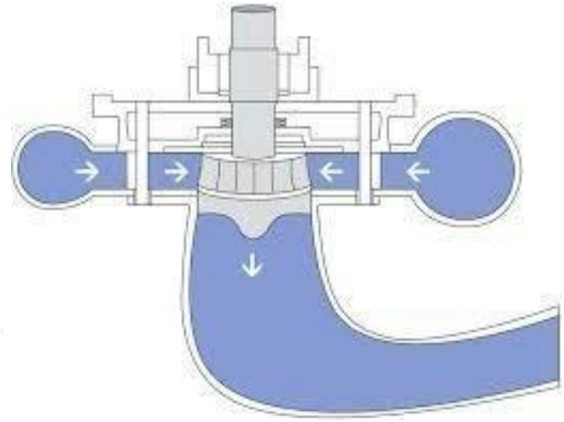


FIGURE B. 6 :
Sectional Views of a Francis Turbine



Francis turbine

CALCULATIONS:

Input power (P_i) = ($\rho \times g \times Q \times h$) watts

Flow rate of water Q = $\frac{Cd \times a1 \times a2 \times \sqrt{2gH}}{\sqrt{a1^2 - a2^2}}$

d_1 = dia. Of venture inlet = 100mm

d_2 = dia. Of venture throught = 60mm

C_d = coefficient of discharge of venturimeter = 0.9

Where a_1 = area of inlet of the venturimeter.

a_2 = area of the venturimeter throat.

H = h_1-h_2 [$\frac{s1}{s2}$-1]

h = Total head of water (m)

h = suction head (h_s) + delivery Head (h_d) + Datum Head

Where h_d = delivery head = P_d/ρ

h_s = suction head= $\frac{Ps \times 13600}{\rho}$

Output power (P_o) = $\frac{2\pi \times N \times T}{60}$ watts

T = (T_1-T_2) ×g × dia. Of break drum

dia. Of break drum = 0.15m

N = speed in tacho meter

Efficiency of the turbine $\eta_m\% = P_o/P_i$

Electrical efficiency = $\eta_e\% = p_o / P_i$

p_o= electrical output = V × I

GRAPHS:

1. speed vs. output power
2. speed vs. efficiency

RESULT: The efficiency of Francis turbine is______________%.The characteristics curves are drawn.

PRECAUTIONS:

Experiment No:8 Performance test on Kaplan turbine

Aim: To conduct the performance test and to plot the operating characteristics of Kaplan turbine

Apparatus: Kaplan turbine test rig, Tachometer.

Theory:

A Kaplan turbine is a type of reaction turbine. It is an axial flow turbine which is suitable for relatively low heads, and requires a large quantity of water to develop large amount of power. It is a reaction type turbine and hence it operates entirely in a closed conduit from head race to tail race.

The test rig consist of a 1 kW Kaplan turbine supplied with water from a suitable 5HP pump through pipe lines, a valve and a flow measuring venturimeter. The turbine consists of a cast iron body with a volute casing, an axial flow gunmetal runner, a ring of adjustable guide vanes and a draft tube. The runner consists of three aerofoil section. The guide is vanes can be rotated about their axis by means of hand wheel. A rope brake drum is mounted on the turbine to absorb the power developed. Suitable dead weight and a hanger arrangement, a spring balance and cooling water arrangement is provided for the brake drum.

Water under pressure from the pump enters through the volute casing and the guide vanes into the runner .while passing through the spiral casing and guide vanes, a portion of the pressure energy (potential energy) is converted into velocity energy (kinetic energy) .Water thus enters the runner at high velocity and it passes through the runner vanes, the remaining potential energy is converted into kinetic energy . Due to the curvature of the vanes, the kinetic energy is transformed into the mechanical i.e. the water head is converted into mechanical energy hence the runner rotates. The water from the runner is then discharged into the draft tube.

The flow through the pipe lines into the turbine is measured with the venturimeter fitted in the pipe line. Two pressure gauges are provided to measure the pressure difference across venturimeter. The net pressure difference across the turbine inlet and exit is measured with a pressure gauge and vacuum gauge. The turbine output is determined with the rope brake drum. A tachometer is used to measure the speed.

Experimental Procedure:

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

2. Close the main gate valve and start the pump.

3. open the gate valve while monitoring the inlet pressure to the turbine .set it for the design value of 1.0 kg/sq.cm

4.Open the cooling water valve for cooling the brake drum.

5. Measure the turbine rpm with the tachometer.

6.Note the pressure gauge and vacuum gauge reading at the turbine inlet and outlet.

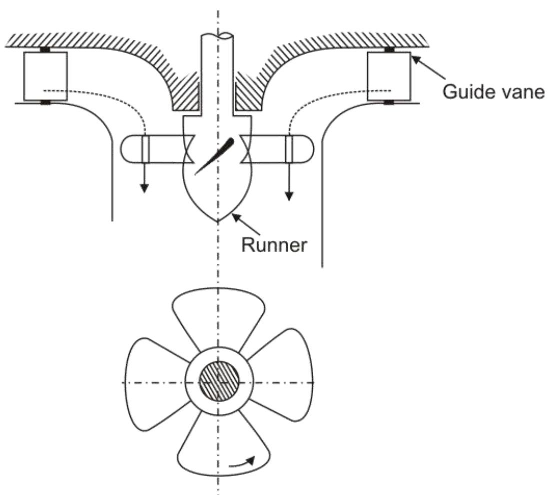
7. Note the venturimeter pressure gauge reading, P1 and p2.

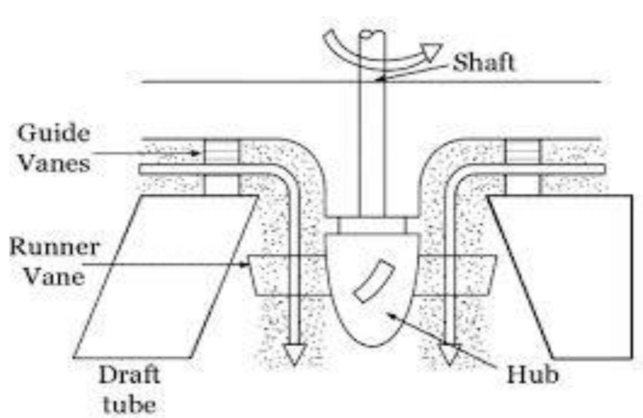
8. Add additional weights and repeat the experiment for other loads

9. For constant speed test, the main valve has to be adjusted to reduce or increase the inlet head to turbine for varying loads.

Schematic diagram of Kaplan turbine:

Schematic diagram of Kaplan turbine





Tabular column Kaplan turbine:

S.No	Gate opening	Pressure gauge (kg/cm²)	Vacuum pressure (kg/cm²)	Manometer reading		Speed of rotation (N)Rpm	Spring balance		P_i (KW)	P_o (KW)	η %
				h_1	h_2		$T_{1(kg)}$	$T_{2(kg)}$			
1											
2											
3											
4											
5											

Electrical output:

Load (kw)	Voltage V	Current (I) A	Speed(N) rpm

CALCULATIONS:

Input power (P_i) = ($\rho \times g \times Q \times h$) kW

Flow rate of water $Q = C_d \frac{a1 \times a2 \times \sqrt{2gH}}{\sqrt{a1^2 - a2^2}}$

d_1 = dia. Of venture inlet = 0.13m

d_2 = dia. Of venture throat = 0.078m

C_d = coefficient of discharge of venturimeter = 0.9

Where a_1 = area of inlet of the venturimeter.
a_2 = area of the venturimeter throat.
$H = h_1 - h_2 [\frac{s1}{s2} - 1]$

h = Total head of water (m)
h = suction head (h_s) + delivery Head (h_d) + Datum Head
Where h_d = delivery head = P_d/ρ
h_s = suction head= $\frac{Ps \times 13600}{\rho}$
Output power (P_o) = $\frac{2\pi \times N \times T}{60}$ watts
T = (T_1-T_2) ×g × dia. Of break drum
dia. Of break drum = 0.15m
N = speed in tachometer
Efficiency of the turbine η%= P_o/P_i

Electrical efficiency = η_e% = p_o / P_i
p_o= electrical output = V × I

GRAPHS:

1. speed vs. efficiency
2. speed vs. power input
3. speed vs. power out put

RESULT: The efficiency of the Kaplan turbine____________.The characteristics curves are drawn.

PRECAUTIONS:

Experiment No:9 Performance test on Centrifugal Pump

Aim: To find the efficiency and performance of centrifugal pump.

APPARATUS: Centrifugal pump test Rig, Stopwatch.

Theory: The pump which raises water from a lower level by the action of centrifugal force is known as centrifugal pump. The pump lifts water because of atmospheric pressure acting on the surface of water.

Principle: A centrifugal pump is Rotodynamic pump that uses a rotating impeller to the pressure of a fluid. It works by the conversion of rotational kinetic energy, typically from an electric motor to an increased static fluid pressure. They are commonly used to move the liquids in pipe system.

Fluid enters axially through the hollow middle section of the pump called eye, after which encounters the rotating blades. It acquires tangential and radial velocity by momentum transfer with impeller blades and acquires radial velocity by centrifugal forces.

The performance of a pump is characterized by its net head h. which defined as the change in Bernoulli's between the suction and delivery of the pump . h is expressed in equivalent column height of water.

$$Hw = (\rho 2/2g+v2 +Z)delivery-(\rho 2/2g+v2 +Z)suction$$

P=Absolute water pressure(N/m2)

V=velocity of water inside the pipe,(m/s)

P=Density of water,(kg/m3)

g=Acceleration due to gravity(m/s2)\

Z=Elevation, (m)

The velocity of water can be calculated using discharge and diameter of pipes. The discharge produced by the pump can be determined using the collecting tank and stop watch.

Discharge,

Q=A*R/t

Where A=Area of the collecting tank, m2

R=Rise of water column in the Piezometer (cm)

t=time taken for 10 cm rise (sec).

The net head is proportional to useful power actually delivered to fluid in the pump. Traditionally it is called the water horse power even if the power is not measured in whp

$$P=\rho Qxghw(W)$$

The input electrical energy to the motor can be determined by using watt hour energy meter the expansion for power is

$$Ein= \frac{3600XN}{KXT}$$

Where n =number of revolutions of energy meter disk.

K=energy meter constant rev/kwhr.

T=time for 3 revolutions (sec).

In the pump terminology the external energy supplied to the pump is called brake horse power of pump

Pbhp=n motor x Ein

The pump efficiency is defined as $\eta pump= \frac{Pump\ output}{Pump\ input} * 100$

Procedure:

1) Prime the motor, close the delivery valve and switch on the unit

2) open the delivery valve and maintain the required delivery head. Note the reading.

3) Note the corresponding suction head.

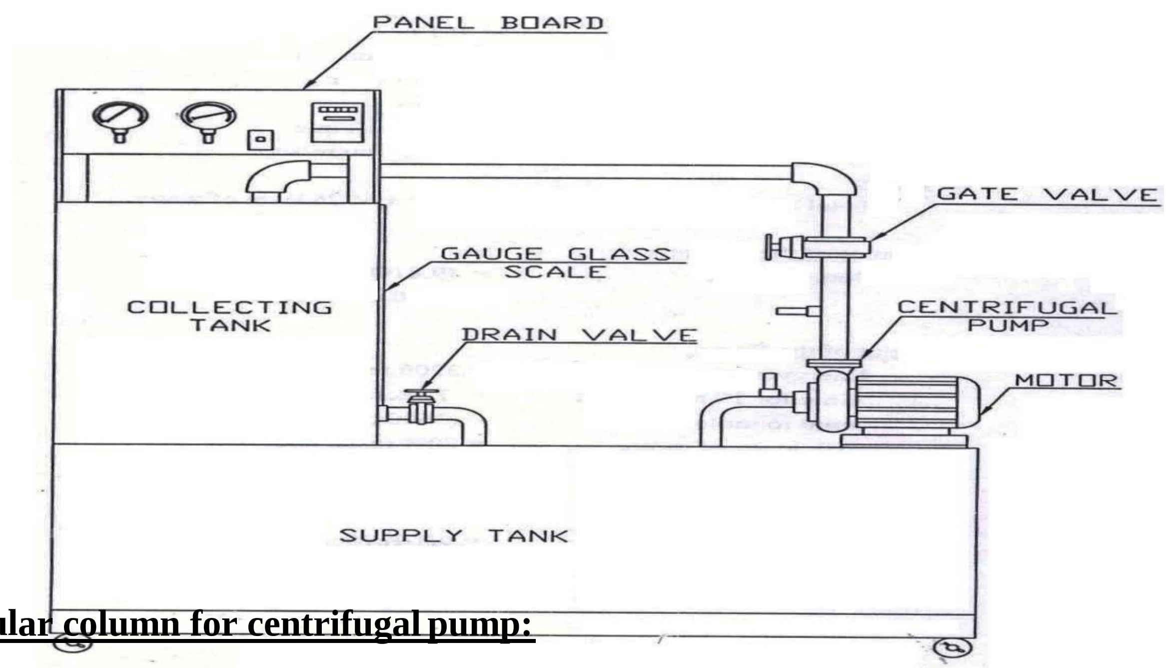
4) Measure the area of the collecting tank.

5) Close the drain valve and note down the time for 10 cm rise of water level in the collecting tank

6) For the different delivery heads repeat the experiment.

7) For every set of reading note the time taken for 10 revolution of energy meter.

Schematic diagram of centrifugal pump:



Tabular column for centrifugal pump:

S.NO	Pressure gauge reading P_d (Kg/cm^2)	Vacuum gauge reading mm of Hg(P_s)	Time for 3 rev of Energy meter seconds (t_e)	Time for 10 cm rise in collecting tank (t) seconds	Discharge (Q) m^3/sec	Input Power P_i (KW)	Output Power P_o (KW)	η%

1								
2								
3								
4								
5								

Calculations:

The total effective h and H in meters of Working of centrifugal pump

W.C=Hd+Hs+x

Since the delivery pressure is in kg/cm2 and suction gauge pressure are in mm of Hg the total head developed by the pump to be converted in to meters of water column.

Where Hd=Delivery head

Hs =Suction head

X=Datum level difference

Note: The velocity and the loss of head in the suction pipe are neglected

We know the discharge Q= *AR* /t m3/sec.

The work done by the pump is given by po(p+g+Q+H)/1000 KW
The input power Pi=3600/Ex10/te KW

The efficiency of the pump=Po/Pix100

n=Po/Pix100%.

Graphs:

1) Plot Pi and Po versus Speed N

2) Speed versus Efficiency.

Results: The efficiency of centrifugal pump is_____________.The characteristics curves are drawn.

Precautions:

1.Wear tight overauls and safety shoes.

2.Take readings correctly

Experiment -10 Performance Test on Two stage centrifugal pump

Aim: To conduct the performance test and to plot the operating characteristics of two stage centrifugal pump.

Apparatus: Two stage centrifugal pump test-rig, stopwatch, and tachometer.

Theory:

Two stage centrifugal pumps are used in application where high delivery pressure are required. Water coming from out of the first stage is fed into the inlet of second stage and this result in higher delivery pressure at the second stage outlet.

The test pump is a self priming type mono block two stage centrifugal pump of size 1”x1” operating on on 220v, 50Hz.The two impellers are connected to a single shaft driven by an electric motor. Each impeller is encased separately and suitable passage connects the first stage outlet to second stage inlet. An energy meter and a stopwatch 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 pipelines to measure the pressure.

Experimental procedure:

1. Prime the pump with water if required.

2. Open the delivery gate valve completely.

3. Start the gate valve and adjust the gate valve to required pressure and delivery.

4. Note the following readings

(a) The pressure gauge reading P kg/sq.cm

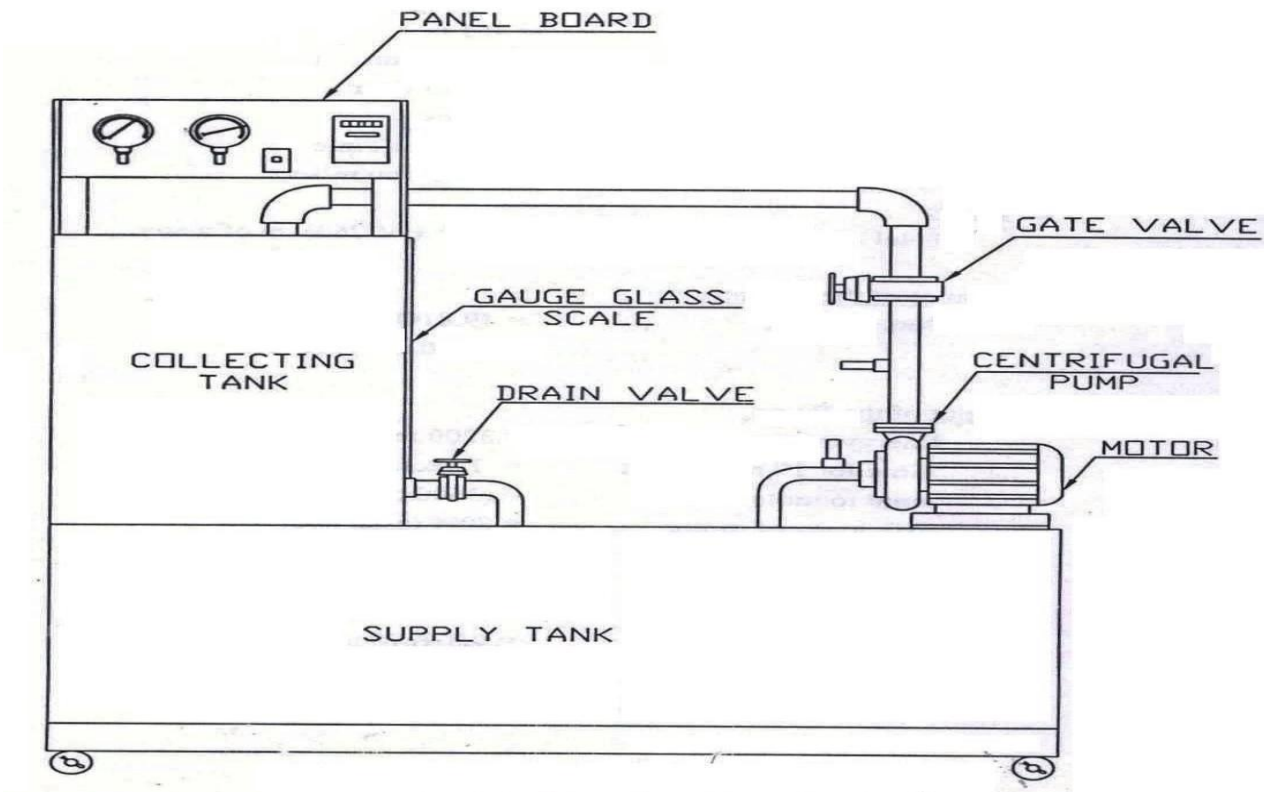
(b) The vacuum gauge reading V kg/sq.cm

(c) Time taken for every set of reading note the time taken for 3 rev. Energy meter.

(d) Close the drain valve and note down the time taken for 10cm rise of water in collecting tank.

5. Take 3 or 4 sets of reading by a varying the head for minimum to a maximum of about 3 kg/sq.cm.

Schematic diagram of Two stage centrifugal pump :



Tabular column:

S.NO	Pressure readings		Pressure gauge reading P_d (Kg/cm^2)	Vacuum gauge reading mm of Hg(P_s)	Time for 3 rev of Energy meter seconds (t_e)	Discharge (Q) m^3/sec	Input Power P_i KW	Output Power P_o KW	η%
	h_1 (cm)	h_2 (cm)							
1									
2									
3									

4									

Calculations:

Flow rate of water Q = $C_d \frac{a1 \times a2 \times \sqrt{2gH}}{\sqrt{a1^2 - a2^2}}$

d_1 = dia. Of venture inlet = 65mm

d_2 = dia. Of venture throat = 39mm

C_d = coefficient of discharge of venturimeter = 0.9

Where a_1 = area of inlet of the venturimeter.

a_2 = area of the venturimeter throat.

H= h_1-h_2 [$\frac{s1}{s2}$ -1]

h = Total head of water (m)

h = suction head (h_s) + delivery Head (h_d) + Datum Head

Where h_d = delivery head = P_d/ρ

h_s = suction head= $\frac{Ps \times 13600}{\rho}$

1. The work done by the pump is given by $P_o = \frac{\rho \times g \times Q \times H}{1000}$ Kw

   Where,

   ρ = Density of water (kg / m³)

   g = Acceleration due to gravity (m / s^2)

   H = Total head of water (m)

2. The input power $P_i = \frac{3600 \times N}{E \times te}$ Kw

   Where

   N = Number of revolutions of energy meter disc

   E = Energy meter constant = 150 (rev / Kw hr)

   T = time taken for 'N_r' revolutions (seconds)

3. The efficiency of the pump = (P_o/ P_i) ×100 %

GRAPH:

1. Actual discharge Vs Total head

2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

RESULT: The efficiency of two stage centrifugal pump is_____________%. The performance characteristics are drawn.

PRECAUTIONS:

Experiment no: 10 Performance Test on Reciprocating Pump

AIM:

To study the characteristics of Reciprocating pump.

APPARATUS:

1) Reciprocating pump test setup
2) Stop watch

DESCRIPTION:

Reciprocating pumps also classified as positive displacement pumps as a definite volume of liquid is trapped in a chamber which is alternatively filled from the inlet and emptied at a higher pressure through the discharge. Most piston pumps are acting with liquid admitted alternatively on each side of the piston so that one part of the cylinder is being filled while the other is being emptied to minimize fluctuations in the discharge.

It consists of a double action Reciprocating pump of size 25×20 mm with air vessel coupled to a 1 HP, 1440 rpm single phase motor, piping system consisting of pipes, gate valve, foot valve, pressure and vacuum gauges. Collecting tank with gauge glass scale fittings and drain valve. Panel with switch, starter and energy meter.

PROCEDURE:

1. Keep the delivery valve open and switch on the pump. Slowly close the delivery valve and maintain a constant head.
2. Note the delivery and suction gauge reading.
3. Note the time for 10 rev of Energy meter.
4. Note the time for 10 cm rise in water level in the collecting tank.
5. Note the speed of the pump (N) rpm.
6. Repeat the procedure for various openings of the delivery valves.

Schematic diagram of reciprocating pump:

SCHEMATIC DIAGRAM:

Reciprocating pump

TABULARCOLUMN:

S.NO	Pressure gauge reading P_d (Kg/cm^2)	Vacuum gauge reading mm of Hg(P_s)	Time for 3 rev of Energy meter (t_e)sec	Time for 10 cm rise in collecting tank (t)sec	Speed N_P rpm	Discharge (Q) m^3/sec	Input Power P_i KW	Output Power P_o KW	η%
1									
2									
3									
4									
5									

CALCULATIONS:

Stroke length of the pump (L) = 0.045m
Bore (d) = 0.04m
Piston area (a) = ($\boldsymbol{\pi}$/4) × $(0.04)^2$
Area of the collecting tank (A) = 50 X 50 cm^2
N_P = speed of mortar in rpm
To find the percentage of slip = $\frac{Qt - Qa}{Qt} \times 100$
Q_t = theoretical discharge = $\frac{2\ L \times a \times Np}{60}$ m/sec
Q_a = Actual discharge = Q= $\frac{A \times h}{t}$ m/sec
A = Area of the collecting tank
t = time for (h) rise in water level.

To find the overall efficiency of the pump = P_o/P_i

The input power $P_i = \frac{3600 \times N}{E \times te}$ Kw
Where
N = Number of revolutions of energy meter disc
E = Energy meter constant = 1600 (rev / Kw hr)
T = time taken for 'Nr' revolutions (seconds)

Output power $P_o = \frac{\rho \times g \times Q \times H}{1000}$ Kw
Where,
ρ = Density of water = 1000 (kg / m^3)
g = Acceleration due to gravity = 9.81(m / s^2)
H = Total head of water (m)
H = suction head (H_s) + delivery Head (H_d) + Datum Head
Where H_d = delivery head = P_d/ρ
H_s = suction head= $\frac{Ps \times 13600}{\rho}$
Z= datum level difference = 2.8 m

GRAPH:

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

RESULT: The efficiency of the reciprocating pump is__________%. To study and draw the characteristics curves.

PRECAUTIONS: