DEPARTMENT OF CIVIL ENGINEERING

17CVCC84 HYDRAULICS ENGINEERING LAB MANUAL

LIST OF EXPERIMENTS

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CYCLE -I

1. Determination of co-efficient of discharge for orifice
2. Determination of co-efficient of discharge for notches
3. Determination of co-efficient of discharge for venturimeter
4. Determination of co-efficient of discharge for orifice meter
5. Study of impact of jet on flat plate (normal / inclined)
6. Study of friction losses in pipes

CYCLE -II

1. Study of minor losses in pipes
2. Study on performance characteristics of Pelton turbine.
3. Study on performance characteristics of Francis turbine
4. Study on performance characteristics of Kaplan turbine
5. Study on performance characteristics of Centrifugal pumps (Constant speed / variable speed)
6. Study on performance characteristics of reciprocating pump

TOTAL: 45 PERIODS

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2.	PERFORMANCE TEST ON A SUBMERGIBLEPUMP
3.	PERFORMANCE TEST ON ARECIPROCATING PUMP
4.	PERFORMANCE TEST ON CENTRIFUGALPUMP
5.	PERFORMANCE TEST ON A GEAR PUMP
6.	PERFORMANCE TEST ON A PENTONWHEEL TURBINE
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9.	FLOW THROUGH PIPE VENTURE METER
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Ex.No:1

DATE:

PIPE FRICTION APPARATUS

AIM:

To determine the friction factors for a given set of pipes.

APPARATUS REQUIRED:

- Collecting tank with Piezometer.
- Stop watch.
- Meter scale and measuring tape.

FORMULAE:

Friction loss of pipe

$$f = H_f 2gd / 4Lv^2$$

$V = Q / a$ m^3

$Q = A \times h / t$ m^3 / sec

$A = l \times b$ m^2

$a = \pi/4 \times d^2$ m^2

Where,

h_f = Loss of head the water in meter

h_f = H × 1.26 in mm

f = Friction factor of pipe

v = Average velocity of flow in m/sec

g = Acceleration due to gravity.

d = Pipe diameter in meter.

Q = Discharge

A = Area of measuring tank in meter

h = Rising the water level in meter

t = Time in seconds

PROCEDURE:

- Each individual pipe can be connected to the Manometer through the pressure head pipe having individual quick over action values.
- While taking reading close all the values in the pressure head.
- Pipe expect the upward stream value which directly connected to a mono meter to required pipe for which the loss in head to be determined.
- Adjust the control values kept at the exit end of the apparatus to be designed flow rate and maintain the flow steady.
- Note down the monometer reading and also note down the time for rise of water level (say 10 cm).
- Repeat the above procedure for different manometer reading by adjusting the gate value.
- Loss of (h_f) head Vs discharge (Q).
- Loss of (h_f) head Vs friction factor.

OBSERVATION:

Internal plan dimensions of the collecting tank

Length of collecting tank (L) =__________cm

Breadth of collecting tank (B) =__________cm

Length of pipe (L) =__________cm

Diameter of the Pipe (d) =__________cm

TABULATION:

SL.NO	Manometer reading		Head $H=h_1-h_2$	Time (t) *seconds*	Discharge (Q) m^3/s	Velocity (V) *m/s*	Loss of head (h_f) *m*	Friction factor (η)
	h_1	h_2						

RESULT:

Friction factor for a given pipe size is **η** = ______________

EX.NO:2
DATE:

PERFORMANCE TEST ON A CENTRIFUGAL PUMP

AIM:

Determine the overall efficiency of a centrifugal pump and to obtain its performance curve.

APPARATUS REQUIRED:

1. Centrifugal pump with driving unit
2. Pressure gauges
3. Stop watch
4. Collecting tank
5. Meter scale

DESCRIPTION:

PRIMING:

The operation of filling water in the suction pipe casing and a portion delivery pipe for the removal of air before starting is called priming.

After priming the impeller is rotated by a prime mover. The rotating vane gives a centrifugal head to the pump. When the pump attains a constant speed, the delivery valve is gradually opened. The water flows in a radially outward direction. Then, it leaves the vanes at the outer circumference with a high velocity and pressure. Now kinetic energy is gradually converted in to pressure energy. The high-pressure water is through the delivery pipe to the required height.

Centrifugal pumps are classified as roto dynamic type of pumps in which a dynamic pressure is developed which enables the lifting of liquids from lower to a higher level. The basic principle on which a centrifugal pump works is that when a certain mass of liquid is made to rotate by an external force, it is thrown away from the central axis of rotation and a centrifugal head is impressed which enables it to rise to a higher level.

FORMULA:

1. **ACTUAL DISCHARGE(Q_{act}):**

$$Q_{act} = \frac{AH}{t} \; m^3/s$$

Where, A = Area of the collecting tank m^2

H = 10 cm rise of water level in the collecting tank

t = Time taken for 10 *cm* rise of water level in collecting tank.

2. **TOTAL HEAD(H):**

$$H = H_d + H_s + Z$$

Total Head H = (Pr. gauge Reading ×10) + (Vacuum gauge Reading × $\frac{10.3}{760}$) + Datum Head(Z)

Where:

H_d = Discharge head, meter

H_s = Suction head, meter

Z = Datum head, meter

3. **OUTPUT POWER(P_o):**

$$P_o = \frac{\rho \times g \times Q_{act} \times H}{1000} \quad (Kw)$$

Where,

ρ = Density of water (kg / m³)

g = Acceleration due to gravity (m / s²)

H = Total head of water (m)

4. **INPUT POWER (P_i):**

$$\text{Input power}(p_i) = \frac{x}{T} \times \frac{3600}{\text{EMC}} \times 0.8\, Kw$$

x = number of flicking of light.(5 say)

T = time for (say 5) Flicking in seconds.

EMC = Energy meter Constant **3200 *Imp/Kw hr***.

0.8 = Efficiency of motor (80%)

5. **EFFICIENCY OF PUMP** **(η) :**

$$(\eta) = \frac{Output\ power}{Input\ power} \times 100 \quad \%$$

PROCEDURE:

1. The internal plan dimensions of the collecting tank and the difference in level between the suction and pressure gauges (x) are measured.
2. The speed of the pump and the energy meter N_e are noted.
3. With the delivery valve fully opened, driving unit is started.
4. Water is sucked in through the suction pipe and is lifted up by centrifugal action.
5. By varying the pressure gauge fitted to the delivery pipe the delivery head and in turn the discharges are varied.
6. For each pressure gauge reading the following observations are made
    i. Vacuum gauge reading
    ii. Pressure gauge reading
    iii. Time taken for number of flickering the energy meter disc.
    iv. Time (t) for a rise H in the collecting tank keeping the outlet valve completely closed.
7. The observations are tabulated and the efficiency of the pump is computed.

GRAPH:

The graph is drawn taking Q_a along x-axis and head (H_p), Output power (P_o) and efficiency (η) along y-axis.

Sl. No.	**X-axis**	**Y-axis**		
	Actual Discharge (Q_a)	**Head** *m*	**Output power** *KW*	**Efficiency** *%*
1				
2				
3				
4				
5				

OBSERVATION:

Energy meter constant=____________**rev./ kw/hr**

Internal plan dimensions of the collecting tank

Length (L) =_____________***m***

Breadth (B) =_____________***m***

SL. NO	Pressure Gauge Reading *Kg/cm²*	Datum Head in *M*	Vaccum Gauge Reading *'mm' Of Hg*	Total Head (H) *m*	Time For 10 cm raise of water (t) *sec.*	Time for 5 flicking of light (T) *sec*	Discharge (Q) in *m^3/sec.*	Input power (P_i) *Kw*	Output power (P_o) *Kw*	Efficiency (η) %
									Mean Efficiency =	

RESULT:

Thus the performance characteristics of centrifugal pump was studied and the maximum efficiency was found to be_________________

EX.NO:3

DATE:

PERFORMANCE TEST ON GEAR PUMP

AIM:

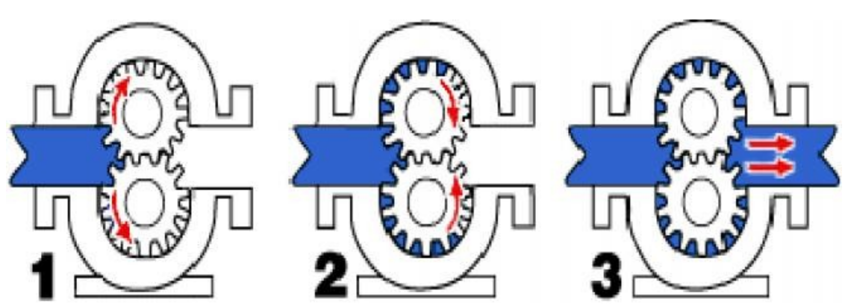
To determine the overall efficiency of a gear pump and to draw the performance curve.

APPARATUS REQUIRED:

1. Gear oil pump with driving unit
2. Pressure gauges
3. Stop watch
4. Collecting tank
5. Meter scale

THEORY AND DESCRIPTION OF SETUP:

A rotary gear pump consists essentially of two intermeshing spur gears which are identical and which are surrounded by a closely fitting casing. One of the pinions is driven directly by the prime mover while the other is allowed to rotate freely. The fluid enters the spaces between the teeth and the casing and moves with the teeth along the outer periphery until it reaches the outlet where it is expelled from the pump. Each tooth of the gear acts like a piston or plunger of on reciprocating pump and hence the pump can be termed a positive displacement pump. Gear pump is widely used for cooling water and pressure oil to be supplied for lubrication to motors, turbine, machine tools etc.



OBSERVATION: (PERFORMANCE TEST ON GEAR PUMP)

Energy meter constant=_____________**rev./ kw/hr**

Internal plan dimensions of the collecting tank

Length(L) =______________**m**

Breadth (B) =______________**m**

Difference in level between the centers of vacuum and pressure gauge (datum head Z) =________

SL. NO	**Pressure Gauge Reading** *Kg/cm^2*	**Vaccum Gauge Reading** *'mm' of Hg*	**Total Head (H)** *m*	**Time For 10 cm raise of water (t)** *sec.*	**Actual Discharge (Q_{act})** *$m^3/sec.$*	**Time for 5 flicking of light (T)** *sec.*	**Input power (P_i)** *(Kw)*	**Output power (P_o)** *(Kw)*	**Efficiency (η)** *%*
								Mean Efficiency (η) =	

FORMULAE:

1. **ACTUAL DISCHARGE(Q_{act})**

$$Q_{act} = \frac{AH}{t} \ m^3/s$$

Where,

A = Area of the collecting tank (m^2)

H = 10 cm rise of water level in the collecting tank

t = Time taken for 10 cm rise of water level in collecting tank.

2. **TOTAL HEAD(H)**

$$H = H_d + H_s + Z$$

Total Head H = (Pr. gauge Reading ×10) + (Vacuum gauge Reading × $\frac{10.3}{760}$) + Datum Head(Z)

Where:

H_d = Discharge head, meter

H_s = Suction head, meter

Z = Datum head, meter

3. **OUTPUT POWER(P_o)**

$$P_o = \frac{\rho \times g \times Q_{act} \times H}{1000} \quad (Kw)$$

Where,

ρ = Density of water (kg / m^3)

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

H = Total head of water (m)

4. **INPUT POWER (P_i)**

Input power (p_i) = (X/T)x(3600/EMC)x0.8 KW

x = number of number of flicking of light.(5 say)

T = time for (say 5) Flicking in seconds.

EMC = Energy meter Constant **3200 lmp/Kw hr**.

0.8 = Efficiency of motor (80%)

5. **Efficiency of pump (η)** = $\frac{Output\ power}{Input\ power}$ **X 100%**

PROCEDURE:

1. The gear oil pump is stated.
2. The delivery gauge reading is adjusted for the required value.
3. The corresponding suction gauge reading is noted.
4. The time taken for ‘N’ revolutions in the energy meter is noted with the help of a stopwatch.
5. The time taken for ‘h’ rise in oil level is also noted down after closing the gate valve.
6. With the help of the meter scale the distance between the suction and delivery gauge is noted.
7. For calculating the area of the collecting tank its dimensions are noted down.
8. The experiment is repeated for different delivery gauge readings.
9. Finally the readings are tabulated.

RESULT:

Thus the performance characteristics of gear oil pump were studied and maximum efficiency was found to be.___________%.

EX.NO:5

DATE:

PERFORMANCE TEST ON RECIPROCATING PUMP

AIM:

To conduct the performance test and to draw performance curves of a reciprocating pump.

APPARATUS REQUIRED:

1. Reciprocating pump with driving unit
2. Pressure gauges
3. Stop watch
4. Collecting tank
5. Meter scale

THEORY AND DESCRIPTION OF SETUP

Reciprocating is a positive displacement pump in which the liquid is sucked and then it is actually pushed or displaced due to the thrust exerted on it by a moving member, which results in lifting the liquid to the required height These pumps usually have one or more chambers which are alternatively filled with the liquid to be pumped and then emptied again As such the discharge of liquid pumped by these pumps almost wholly depends on the speed of the pump.

A reciprocating pump essentially consists of a piston or plunger, which moves, to and fro in a close fitting cylinder. The cylinder is connected to suction and delivery pipes, each of which is provided with a non-return or one-way valve called suction valve and delivery valve respectively. The function of one-way valve is to admit liquid in one direction only. Thus the suction valve allows the liquid only to enter the cylinder and the delivery valve permits only its discharge from the cylinder.

FORMULA:

1. **ACTUAL DISCHARGE(Q_{act})**

$$Q_{act} = \frac{AH}{t} \ m^3/s$$

Where,

A = Area of the collecting tank (m^2)

H = 10 cm rise of water level in the collecting tank

t = Time taken for 10 cm rise of water level in collecting tank.

2. **TOTAL HEAD(H)**

$$H = H_d + H_s + Z$$

Total Head H = (Pr. gauge Reading ×10) + (Vacuum gauge Reading × $\frac{10.3}{760}$) + Datum Head(Z)

Where:

H_d = Discharge head, meter

H_s = Suction head, meter

Z = Datum head, meter

3. **OUTPUT POWER(P_o)**

$$P_o = \frac{\rho \times g \times Q_{act} \times H}{1000} \quad (Kw)$$

Where,

ρ = Density of water *(kg / m³)*

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

H = Total head of water *(m)*

4. **INPUT POWER (P_i)**

Input power (p_i) = $\frac{x}{T} \times \frac{3600}{EMC} \times 0.8 \ Kw$

x = number of number of flicking of light.(5 say)

T = time for (say 5) Flicking in seconds.

EMC = Energy meter Constant **3200** ***lmp/Kw hr***.

0.8 = Efficiency of motor (80%)

5. Efficiency of pump (η) = $\frac{Output\ power}{Input\ power}$ **x100%**

PROCEDURE:

1. The internal plan dimensions of the collecting tank and the difference in level between the suction and pressure gauges (x) are measured.
2. The speed of the pump and the energy meter N_e are noted.
3. With the delivery valve fully closed, driving unit is started.
4. Water is sucked in through the suction pipe and is lifted up by centrifugal action.
5. By varying the pressure gauge fitted to the delivery pipe the delivery head and in turn the discharge are varied.
6. For each pressure gauge reading the following observations are made

   Vacuum gauge reading

   Pressure gauge reading

   Time taken for number flicking of the energy meter disc.

   Time (t) for a rise H in the collecting tank keeping the outlet valve completely closed.

7. The observations are tabulated and the efficiency of the pump is computed.

GRAPH:

The graph is drawn taking H along x-axis and Discharge (Q), Output power (P_o) and efficiency (η) along y-axis.

GRAPH TABLE:

Sl. No.	X-axis	Y-axis		
	Total Head (H) *m*	**Actual Discharge (Q_{act})** *m^3/s*	**Output power (P_o)** *Kw*	**Efficiency** *(%)*
1				
2				
3				
4				
5				

OBSERVATION:

Energy meter constant=______________*rev./ kwhr*

Internal plan dimensions of the collecting tank

Length(L) =_____________*m*

Breadth (B) =_____________*m*

Difference in level between the centers of vacuum and pressure gauge (datum head Z) =___

TABULATION:

SL. NO	Pressure Gauge Reading *Kg/cm^2*	Vaccum Gauge Reading *'mm' of Hg*	Total Head (H) *m*	Time For 10 cm raise of water (t) *sec.*	Actual Discharge (Q_{act}) *m^3/sec.*	Time for 5 flicking of light (T) *sec.*	Input power (P_i) *Kw*	Output power (P_o) *Kw*	Efficiency (η) *%*
Mean Efficiency (η) =									

RESULT:

The performance characteristic of the reciprocating pump is studied and the efficiency is calculated_______________%

Ex.No:6

DATE:

PERFORMANCE TEST ON SUBMERSIBLE PUMP

AIM:

To determine the best driving conditions of the submersible pump at constant speed and to draw the characteristic curves.

APPARATUS REQUIRED :

1. Submersible pump
2. Pressure gauges
3. Stop watch
4. Collecting tank
5. Meter scale

THEORY AND DESCRIPTION OF SETUP

A submersible pump is a centrifugal pump, which is attached to an electric motor and operates while submerged in water. The sealed electric motor spins a series of impellers. Each impeller in the series forces water through a diffuser into the eye of the one above it. In a typical 100 mm submersible pump, each impeller will add an approximately 6.32 m of water. For example, a typical 10-stage pump will develop a pressure of about 63.2 m of water at its outlet (i.e.10 impellers x 6.32 m of water).

The capacity of the pump is determined by the width of the impeller vanes and its pressure by the number of impellers. The electric motor and the pump bowl assembly are both submerged below the lowest pumping water level. The power cable goes down the well to supply power to the motor. The strainer is located between the motor and pump that is usually of the multistage centrifugal type. Submersible pumps are efficient, high in capacity, require very little maintenance and are generally very economical for wells that are 24 m or more in depth. The energy supplied to the pump is measured using energy meter.

FORMULAE :

1. ACTUAL DISCHARGE:

$$Q_{act} = \frac{Ah}{t} \qquad \textbf{(m³ / sec)}$$

Where,

A = Area of the collecting tank (m²)

H = 10 cm of height of the water level collected (cm)

t = Time taken for 'h' rise of water (seconds)

2. INPUT POWER:

$$P_i = \frac{V \times I}{1000} \qquad \textbf{(kw)}$$

Where,

V= Volumetric

I= Ammeter

3. OUTPUT POWER:

$$P_o = \frac{\rho g \times Q_{act} \times H}{1000} \qquad \textbf{(KW)}$$

Where,

ρ = Density of water (1000 kg/m³)

g = acceleration due to gravity (9.81 m/s²)

Q_{act} = actual discharge (m³ / s)

H = total head of water (m)

4. EFFICIENCY:

$$\% \eta = \frac{\text{Output power Po}}{\text{input power Pi}} \text{ x 100}$$

PROCEDURE:

1. The submersible pump is started
2. The delivery gauge reading is set to the required value by means of Adjusting the gate-Valve
3. The time taken for Nr revolutions in the energy meter disc is noted with the help of stop watch.
4. The time taken for 'h' rise in water level in the collecting tank is found carefully. If the water flow is heavy reduce the 'h' value
5. The experiment is repeated for different delivery gauge readings
6. Finally the readings are tabulated and calculated.

GRAPH

The graph is drawn taking Q_{act} along x-axis and head (H_p), Output power (P_o) and efficiency (η) along y-axis.

GRAPH TABLE

Sl. No.	X-axis	Y-axis		
	Actual Discharge (Q_a) ***m^3/s***	**Head** ***m***	**Output power** ***(Kw)***	**Efficiency** ***(%)***
1				
2				
3				
4				
5				

OBSERVATION:

Internal plan dimensions of the collecting tank

Length (L) =____________*m*

Breadth (B) =_____________*m*

SL. NO	Pressure Gauge Reading Kg/cm^2	Total Head of water *m*	Time For 10 cm raise of water (t) *sec*	Actual Discharge (Q_{act}) m^3/sec	Energy Meter Reading		Input power (P_i) *Kw*	Output power (P_o) *Kw*	Efficiency (η) %
					V	I			
								Mean Efficiency **η** =	

RESULT:

The performance characteristic of the submersible pump is studied and the efficiency is calculated _______________%

EX.NO:7

DATE:

PERFORMANCE TEST ON KAPLAN TURBINE

AIM:

To conduct load test on the Kaplan Turbine by keeping the speed as constant and to draw its characteristic curves.

APPARATUS REQUIRED:

1. Kaplan turbine set up
2. Sump tank
3. Notch tank
4. Centrifugal pump
5. Collecting Tank

THEORY AND DESCRIPTION OF SET UP:

A Kaplan turbine is a type of propeller turbine which was developed by the Austrian engineer V. Kaplan (1876-1934). It is an axial flow turbine, which is suitable for relatively low heads, and hence requires a large quantity of water to develop large amount of power. It is also a reaction type of turbine and hence it operates in an entirely closed conduit from the headrace to the tailrace. The main components of Kaplan turbine are scroll casing, stay ring, arrangement of guide vanes, and the draft tube. Between the guide vanes and the runner the water in a Kaplan turbine turns through a right angle into the axial direction and then passes through the runner. The runner of a Kaplan turbine has four or six blades and it closely resembles a ship's propeller. The blades attached to a hub so shaped that water flows axially through the runner. Ordinarily the runner blades of a propeller turbine are fixed, but the Kaplan turbine runner blades can be turned about their own axis, so that their angle of inclination may be adjusted while the turbine is in motion. This adjustment of the runner blades is usually carried out automatically by means of a servomotor operating inside the hollow coupling of turbine and generator shaft.

The whole arrangement is attached to a rectangular notch provided. The whole arrangement is attached to a pump. The loading on the turbine is achieved with an electrical alternator connected to a lamp bank. Control panel on the turbine has digital units to display the turbine speed, head on turbine and electrical energy.

FORMULA:

1. **DISCHARGE** $Q = C_d A B^2 \sqrt{2gh / (1-B^4)}$

A = $\pi d^2/4$ where d_1 = 150mm

B = 0.6

G = Acceleration due to gravity (9.81 m/s^2)

h = (P_1-P_2) X 10 m of water

2. **INPUT POWER (P_i)**

$$Pi = \frac{\rho g \times Q_{act} \times H}{1000} \quad \text{(Kw)}$$

Where,

ρ = Density of water (kg / m³)

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

H = Total head of water (m)

3. **OUTPUT POWER(P_o)**

$$P_o = \pi NDT / 60000 \quad \text{(Kw)}$$

D = Brake drum diameter

N = Turbine speed in RPM.

T = Resultant Load = $((T_2-T_1) + T_o)$ Kg

4. **EFFICIENCY (η)** $\eta = \frac{Output\ power}{Input\ power}$ **X 100 %**

PROCEDURE:

1. The butterfly valve is kept in fully closed position
2. The guide vane opening is kept at maximum position
3. The pump is switched 'ON' and allowed to pick up full speed
4. The butterfly valve is opened slowly to the full open condition
5. For a particular electrical loading condition, the propeller speed setting is adjusted between maximum and minimum and a constant speed of 1500 rpm is maintained
6. The time taken for two revolutions of the energy meter is noted
7. The pressure gauge reading and hook gauge reading are noted
8. The above procedure is repeated for different loadings and different butterfly valve opening.

GRAPH

Draw a Graph between efficiency (along Y axis) and % of full load. This is known as constant speed characteristic curve.

GRAPH TABLE

Sl. No.	X- axis		Y-axis
	Head *m*	**Output power** *Kw*	**Efficiency** *%*
1			
2			
3			
4			
5			

OBSERVATION:

Diameter of the brake drum (D) = ___ Diameter of the

rope (d) =_____________

Weight of lad hanger and rope =_____________

Sl. No	Inlet Pressure (P) *Kg/cm²*	Speed (N) *RPM*	Pressure gauge reading *Kg/cm²*			Discharge (Q) m^3/s	Load *Kg*		Net weight (T) (T2-T1 +T_o) *Kg*	Input power *(Kw)*	Output power *(kW)*	Efficiency (%)
			P_1	P_2	$h=P_1-P_2$		T_1	T_2				
1												
2												
3												
4												
5												

RESULT:

The best driving conditions of the Kaplan turbine for maximum efficiency condition are:

a. Maximum efficiency =_________________*%*

b. Maximum output power =_________________***Kw***

c. Maximum Speed =_________________***rpm***

EX.NO:6

DATE:

PERFORMANCE TEST ON PELTON WHEEL TURBINE

AIM:

To conduct load test on pelton wheel turbine and to study the characteristics of pelton wheel turbine.

APPARATUS:

1. Pelton wheel unit
2. Supply pump
3. Venturimeter
4. Brake drum
5. Dead Weight
6. Pressure gauge

THEORY AND DESCRIPTION OF THE SETUP

In an impulse turbine the pressure energy of water is converted into kinetic energy when passed through the nozzle and forms the high velocity jet of water. The formed water jet is used for driving the wheel. The pelton wheel turbine (named after the American engineer Lester Allen Pelton) is an impulse turbine. A Pelton wheel/turbine consists of a rotor, at the periphery of which is mounted equally spaced double hemispherical or double ellipsoidal buckets. Water is transferred from a high head source through penstock, which is fitted with a nozzle, through which the water flows out as a high-speed jet. A needle spear moving inside the nozzle controls the water flow through the nozzle and at the same time provides a smooth flow with negligible energy loss. All the available potential energy is thus converted into kinetic energy before the jet strikes the buckets of the runner. The pressure all over the wheel is constant and equal to atmosphere, so that energy transfer occurs due to purely impulse action. The Pelton turbine is provided with a casing the function of which is to prevent the splashing of water and to discharge water to the tailrace.

The experimental setup consists of a Pelton wheel turbine to which water is supplied with the help of a centrifugal pump. The centrifugal pump lifts the water from sump to the turbine through a supply pipe. This pipe is fitted with a venturimeter to measure the actual discharge into the turbine. At the inlet to the turbine a pressure gauge is fitted to read the supply head. The Pelton wheel shaft is coupled with a brake drum

FORMULA:

1. **DISCHARGE:(Q)**

Actual discharge to the turbine = $\mathbf{KC\sqrt{h}}$

K – Co-efficient of discharge of the venturimeter = 0.96

C – Constant for Venturimeter = $\frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^2 - a_2^2}}$ = 0.0057

2. **INPUT POWER (P_I)**

$$\mathbf{Pi = (\rho \times g \times Qact \times H)/1000 \ (Kw)}$$

Where,

ρ = Density of water (kg / m³)

g = Acceleration due to gravity (m / s²)

H = Total head of water (m)

3. **OUTPUT POWER(P_O)**

$$\mathbf{P_o = \pi NDT/60000 \quad (Kw)}$$

D= Brake drum diameter (Effective diameter of brake drum = 0.315 m)

N = Turbine speed in RPM.

T = Resultant Load = $((T_2\text{-}T_1) + T_o)$ Kg

4. **EFFICIENCY = Output power / Input power X 100 %**

PROCEDURE:

1. The Pelton wheel turbine is started.
2. All the weight in the hanger is removed.
3. The pressure gauge reading is noted down and it is to be maintained constant for different loads.
4. The venturimeter readings are noted down.
5. The spring balance reading and speed of the turbine are also noted down.
6. A 5Kg load is put on the hanger, similarly all the corresponding readings are noted down.
7. The experiment is repeated for different loads and the readings are tabulated.

GRAPH

The graph is drawn between speed along x-axis and output power and efficiency along y-axis. At the point of maximum efficiency output power and speed are noted from the graph and the specific speed is computed.

GRAPH TABLE

Sl. No.	**X-axis**	**Y- axis**	
	Speed ***rpm***	**Output power** ***(Kw)***	**Efficiency** ***(%)***
1			
2			
3			
4			
5			

OBSERVATION:

Diameter of the brake drum (D) = __ Diameter of the

rope (d) =______________

Weight of lad hanger and rope (T_o) =______________

Sl. No	Inlet Pressure (P) Kg/cm²	Speed (N) rpm	Pressure gauge reading Kg/cm²			Discharge (Q) m^3/s	Load kg		Net weight (T) (T_2-T_1+T_o) Kg	Input power (kW)	Output power (kW)	Efficiency (%)
			(h_1)	(h_2)	$h=h_1-h_2$ m		T2	T1				
1												
2												
3												
4												
5												

RESULT:

The best driving conditions of the Pelton Wheel turbine for maximum efficiency condition are:

i. Maximum efficiency =________________%

ii. Maximum output power =_________________Kw

iii. Maximum Speed =________________rpm

Ex.No:9

DATE:

CHARACTERISTICS CURVES OF FRANCIS TURBINE

AIM:

To conduct load test on Francis turbine and to study the characteristics of Francis turbine.

APPARATUS REQUIRED :

1. Francis wheel unit
2. Supply pump
3. Venturimeter
4. Brake drum
5. Dead Weight
6. Pressure gauge

THEORY AND DESCRIPTION OF THE SETUP:

A Francis turbine is an inward flow reaction turbine with mixed flow runner, in which water enters at high pressure. Around the runner, a set of stationary guide vanes direct the water into the moving vanes. The guide vanes also serve as gates. The gate openings can be adjusted by a handle. The guide vanes are surrounded by a chamber called 'spiral chamber'. On the discharge side, the water passes to the tailrace by a tube 'Draft tube'. The draft tube enables the turbine to be set at a higher level without sacrifice in head. Moreover, it entails regaining of pressure energy, thus increasing the efficiency of the turbines.

The input power supplied to the turbine is calculated from the net supply head on the turbine and the discharge through the turbine. The output power from the turbine is calculated from the readings taken on the rope brake drum and the speed of the shaft. A tachometer is used to measure the speed of the shaft. The efficiency of the turbine is computed from the output and the input.

FORMULA:

1. **DISCHARGE Q** $= \mathbf{Cd\ AB^2}\ \overline{2gh/(1-B^4}$

A = $\pi d^2/4$ where d_1 = 150mm

B = 0.6

g = Acceleration due to gravity (9.81 m/s^2)

h = P_1-P_2X 10 m of water

2. **INPUT POWER (P_I)**

$$\mathbf{Pi} = \frac{\rho X g X Q_{act} X H}{1000} \quad \mathbf{(Kw)}$$

Where,

ρ = Density of water *(kg / m³)*

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

H = Total head of *water* *(m)*

3. **OUTPUT POWER(P_O)**

$$\mathbf{P_o = \pi DNT/60000} \quad \mathbf{\textit{(Kw)}}$$

D= Brake drum diameter (Effective diameter of brake drum = 0.315 m)

N = Turbine speed in RPM.

T = Resultant Load = ((T_2-T_1) +To) Kg

4. **EFFICIENCY (η) = Output power/ Input power X 100** *%*

PROCEDURE:

1. The Francis turbine is started
2. All the weights in the hanger are removed
3. The pressure gauge reading is noted down and this is to be maintained constant for different loads
4. Pressure gauge reading is ascended down
5. The pressure gauge reading and speed of turbine are noted down

6. The experiment is repeated for different loads and the reading are tabulated

GRAPH:

The graph is drawn between speed along x-axis and output power and efficiency along y-axis. At the point of maximum efficiency output power and speed are noted from the graph and the specific speed is computed.

GRAPH TABLE:

Sl. No.	X-axis	Y- axis	
	Speed *Rpm*	Output power *kW*	Efficiency *%*
1			
2			
3			
4			
5			

OBSERVATION:

Diameter of the brake drum (D) = ________________

Diameter of the rope (d) = ______________

Weight of lad hanger and rope = ______________

Sl. No	**Inlet Pressure (P)** *Kg/cm²*	**Speed (N)** *RPM*	**Pressure gauge reading** *Kg/cm²*			**Discharge (Q)** m^3/s	**Load** *kg*		**Net weight (T)** $(T_2-T_1+T_o)$ *Kg*	**Input power** *Kw*	**Output power** *kw*	**Efficiency** *%*
			P_1	P_2	$h = (P_1-P_2)$		T_2	T_1				
1												
2												
3												
4												
5												

RESULT:

The best driving conditions of the Francis turbine for maximum efficiency condition are:

1. Maximum efficiency = ________________*%*
2. Maximum output power = ________________***Watts***
3. Maximum Speed = ________________***rpm***

EX.NO:10

DATE:

FLOW THROUGH PIPE VENTURIMETER

AIM :

Determine the co-efficient of discharge of the Venture meter than a given pipe size.

APPARATUS REQUIRED:

1. Venture meter fitted with a pipe line setup
2. Stop watch
3. Measuring scale / Measuring Tape

FORMULAE:

The theoretical discharge through a flow meter is given by the following formula

1. **Co-efficient of discharge (Cd) = Qa / Qt**

2. **Actual Discharge (Q_{act})**

$$Q_{act} = \frac{Ah}{t} \ m^3/s$$

Where, A = Area of the collecting tank in meters
h = 10 cm rise of water level in the collecting tank
t = Time taken for 10 cm rise of water level in collecting tank.

3. **Theoretical Discharge (Q_{th})**

$$Q_{th} = K\sqrt{H}$$

$$K = a_1 a_2 \sqrt{2g} / \sqrt{a_1^2 - a_2^2}$$

H = Differential head in manometer in m of water

Where, a_1 = Area of the pipe in m^2

a_2 = Area of the Venturimeter throat in m^2

g = Acceleration due to gravity (9.81)

S.No	Venturimeter size	Throat Diameter
1	20mm	11.83
2	25 mm	14.79

PROCEDURE:

- ❖ The diameter of pipe and internal cross sections of collecting tank are note down.
- ❖ First start the motor, slowly press the delivery valve and adjust to the required total head.
- ❖ Note down the monometer reading and also value down the time for rise of water level in the tank(say 10 cm).
- ❖ The central discharge is measured with the help of the measuring tank.
- ❖ Repeat the above procedure for different manometer reading by adjusting the gate valves.

TABULATION:

Diameter of Pipe 1 =___________mm

Diameter of Pipe 2 =___________mm

S.No	Manometer Reading			Total Head	Time taken 10cm rise of water level	Discharge (Q) m^3/sec		Co-efficient of discharge (Cd)
	h1	h2	$x = h_1 - h_2$ *mm*	*m*	*seconds*	Actual discharge (Qa)	Theoretical discharge (Qt)	%

GRAPH :

- ➢ Head (H) (Vs) Actual discharge (Qa)
- ➢ Head (H) (Vs) Theoretical discharge (Qt)
- ➢ Head (H) (Vs) Co-efficient of discharge

RESULT:

Thus the co-efficient of discharge of Venturimeter C_d = ____________________

EX.NO:11

DATE:

FLOWS THROUGH PIPE ORIFICEMETER

AIM :

Determine the co-efficient of discharge of the Orifice meter for a given pipe size.

APPARATUS REQUIRED:

1. Orifice meter fitted with a pipe line setup
2. Stop watch
3. Measuring scale / Measuring Tape

FORMULAE:

The theoretical discharge through a flow meter is given by the following formula

1. **Co-efficient of discharge (Cd) = Qa / Qt**

2. **Actual Discharge (Q_{act})**

$$Q_{act} = \frac{Ah}{t} \ m^3/s$$

Where, A = Area of the collecting tank in meters

h = 10 cm rise of water level in the collecting tank

t = Time taken for 10 cm rise of water level in collecting tank.

3. **Theoretical Discharge (Q_{th})**

$$Q_{th} = K\sqrt{H}$$

$$K = a_1 a_2 \sqrt{2g} / \sqrt{a_1^2 - a_2^2}$$

H = Differential head in manometer in m of water

Where, a1 = Area of the pipe

a2 = Area of the Orifice through pipe

g = Acceleration due to gravity (9.81)

PROCEDURE :

- The diameter of pipe and internal cross sections of collecting tank are note down.
- First fully open the inlet gate valve of all the apparatus.
- Adjust the control valve kept at the exits end of the apparatus to a desired rate and maintain the flow steadily.
- Note down the manometer reading. And also note down the time for rise of water in the collecting tank (Say 10 cm).
- Repeat the above procedure for different manometer reading by adjusting the gate values.

ORIFICE METER

Diameter of Pipe1 =_____________*mm*

Diameter of Pipe2 =_____________*mm*

S.No	Manometer Reading			Total Head *m*	Time taken 10cm rise of water level *sec*	Discharge (Q) m^3/sec		Co-efficient of discharge (Cd)
	h_1	h_2	$x = h_1 - h_2$			Actual discharge (Qa)	Theoretical discharge (Qt)	

GRAPH :

- Head (H) (Vs) Actual discharge (Qa).
- Head (H) (Vs) Theoretical discharge (Qt).
- Head (H) (Vs) Co-efficient of discharge (Cd).

RESULT:

Thus the co-efficient of discharge of Orifice meter by using for the given pipe size is determined C o-efficient of discharge Cd =_________________

EX.NO: 12

DATE:

TO VERIFY BERNOULLIS THEOREM

AIM :

To determine the verified Bernoulli's theorem.

APPARATUS REQUIRED :

1. A Tapered inclined pipe (piezometer tubes fitted at difference point / seconds
2. A supply tank of water
3. A measuring tank
4. A Stop watch
5. A scale

BRIEF THEORY:

Bernoulli's theorem state that in a steady flow of an ideal fluid the total energy per unit mass of a fluid (at any section) remains constant along a stream line flow. Neglecting losses,the total energy at sections 1 and 2 will have the following relation.

$$(P_1/W)+(V_1^2/2g)+Z_1= (P_2/W)+(V_2^2/2g)+Z_2$$

Where ,

(p/w)=Pressure head

$(v_2/2g)$ =velocity head

Z=Datum head

PROCEDURE:

1. By slowly opening the inlet value allow the water to flow from the supply tank.
2. Adjust the flow in such a manner that a constant head of water is available in the supply tank(i.e inflow=outflow)
3. Note down the quantity of water collected (q) in the measured tank for a given intervalof the time using a stop water.
4. Compute the area of cross section (A1 and A2) under the piezometer tubes.
5. Use the continuity equation to get v1 and v2 as follows

$$Q = A_1V_1 = A_2V_2 , \quad V_1=Q/A_1 \quad , \quad V_2=Q/A_2$$

6. Read the pressure head (p/w) directly from the piezo meter tubes as the concerned section

7. Note down the datum head (z) at different sections for horizondal pipe line "z"

8. Tabulation the various values as shown table.

OBSERVATION:

Area at section (A_1)= ____________

Area at section (A_2) =____________

TABULATION: (TO VERIFY BERNOULLIS THEOREM)

S.No	Datum head		Measuring tank m^3			Time taken (T)	Discharge (Q)	Velocity Head $V=V^2/2g$		Total head $=(P/W)+(V^2/2g)+Z$	
	H_1	H_2	Initial reading (a)	Final reading (b)	Quantity (a-b)=	*Sec*	*m^3/s*	V_1	V_2	H_1	H_2

RESULT :

Hence the Bernoulli's theorem is verified .

$(P_1/W)+(V_1^2/2g)+Z1= (P2/W)+(V_2^2/2g)+Z_2$

EX. No: 13

DATE:

IMPACT JET

AIM:

To determine the co efficient of impact for vanes

APPARATUS REQUIRED:

- Collecting tank,
- Transparent cylinder,
- Two nozzle of diameter 10mm & 12mm
- Vane of different shape (Flat, Inclined, Curved)

PROCEDURE :

- Note down the relevant dimension or area of collecting tank, diameter of nozzle, and density of water.
- Install any type vane (i.e flat , inclined or curved)
- Install any size of nozzle (i.e 10mm or 12mm)
- Note down the position of upper disk, when jet is not running
- Note down the reading of height of water in the collecting tank.
- As the jet strike the vane, position of upper disk is changed, note the reading in the scale to which vane is raised.
- Put the weight of various values one by one to bring the vane to its initial position .
- At this position finds out the discharge also.
- The procedure is repeated for each value of flow rate by reducing the water supply
- This procedure can be repeated for different type of vane and nozzle.

OBSERVATION:

Diameter of nozzle =

Mass density of water =

Area of collecting tank =

Area of nozzle =

Horizontal Flat Vane

When jet is not running, position of upper disk is at =

TABULATION:

S. No	**Discharge measurement**				**Balancing**		**Theoretical Force $F=\rho Q^2/a$ *N***	**Error $=F-F'/F'$ %**
	Initial *cm*	**Final** *cm*	**Time** *sec*	**Discharge** *cm^3/s*	**Mass(W)** *gm*	**Force (F)** *N*		

Inclined vane

When jet is not running, position of upper disk is at =

Angle of inclination at $\beta = 45°$

S. No	**Discharge measurement**				**Balancing**		**Theoretical Force $F=\rho Q^2(1-\cos\beta)/a$ *N***	**Error $=F-F'/F'$ %**
	Initial *cm*	**Final** *cm*	**Time** *sec*	**Discharge** *cm^3/s*	**Mass (W)** *gm*	**Force (F)** *N*		

CURVED HEMISPHERICAL VANE:

When jet is not running, position of upper disk is at =

S. No	Discharge measurement				Balancing		Theoretical Force $F=2\rho Q^2/a$ *N*	Error =F-F'/F' %
	Initial *cm*	Final *cm*	Time *sec*	Discharge *cm^3/s*	Mass (W) *grams*	Force (F) *N*		

ESULT :

To determined impact jet of vane =_________________

Ex.No:14

DATE:

METACENTRIC HEIGHT OF SHIP

AIM:

To determine metacentric height of a ship.

APPARATUS REQUIRED:

Model of a ship

Tank (containing water)

Weights

PROCEDURE:

1. Find the weight W of the model ship out side.
2. Place the ship model in water and with movable weight (w1) at any position adjust the screw S to gets zero reading on the scale.
3. Move the Weight W across the deck through a certain distance (z) it will result in tilting of the ship model
4. Note down the angle of tilt.
5. Note down the more reading by either

   (i) Varying the load W1 and keeping the distance "z" constant

   (ii) Keeping the load W1 constant and varying the distance "z"

FORMULA :

$$MG = W_1.Z/(W \tan\theta)$$

MG= metacentric height.

W_1 =known weight (Hooked movable)

Z = Distance

θ = Angle between

W =Weight of the ship

TABULATION:

SL.NO	Weight of the ship (w) *kg*	Known weight of (hooked movable) w_1 *kg*	Deck through a certain Distance (z) *cm*	Certain Angle (θ) *Degree*	Metacentric height MG= $\frac{W1.Z}{W.\tan\theta}$	Remarks

RESULT:

To determined metacentric measured height with difference in position of its weight =_____________

EX.NO:15

DATE:

FLOW THROUGH TRIANGULAR NOTCH

AIM:

To determine the coefficients of discharge of a triangular notch.

APPARATUS REQUIRED:

1. Hydraulic bench Notches
2. Rectangular, triangular,
3. Hook and point gauge
4. Calibrated collecting tank
5. Stop watch

PROCEDURE:

1. Insert the given notch into the hydraulic bench and fit tightly by using bolts in order to prevent leakage.

2. Open the water supply and allow water till over flows over the notch. Stop water supply, let excess water drain through notch and note the initial reading of the water level "h0"using the hook and point gauge. Let water drain from collecting tank and shut the valve of collecting tank after emptying the collecting tank.

3. After initial preparation, open regulating valve to increase the flow and maintain water level over notch. Wait until flow is steady.

4. Move hook and point gauge vertically and measure the current water level 'h' to find the water head 'h' above the crest of the notch.

5. Note the piezometric reading "Z_0" in the collecting tank while switch on the stopwatch.

6. Record the time taken 'T' and the piezometric reading "Z_1" in the collecting tank after allowing sufficient water quantity of water in the collecting tank.

OBSERVATION:

Area of the collecting tank A = ____________

Angle of the V notch θ = ____________

SL. NO	Point gauge Reading			Rise of water level in the measuring tank (Z)	Actual discharge (Q_{act})	Theoretical discharge (Q_{the})	Co-efficient of discharge Cd= Qa/Qt
	Initial *cm*	**Final** *cm*	**Difference (H)** *cm*	*cm*	*m^3/s*	*m^3/s*	

FORMULA:

Actual discharge **Qa =Ah/t** *m^3/s*

Theoretical discharge **Qt =$8/15\sqrt{2g}.\tan\theta/2\ H^{5/2}$** *$m^3/s$*

Co efficient of discharge **Cd = Qa/ Qt**

RESULT:

Co-efficient of discharge for triangular notch was found to be=_______________

EX.NO:16

DATE:

FLOW THROUGH RECTANGULAR NOTCHE

AIM:

To determine the coefficients of discharge of the rectangular notches

APPARATUS REQUIRED:

1) Hydraulic bench
2) Notches
3) Rectangular,
4) Hook and point gauge
5) Calibrated collecting tank
6) Stop watch

PROCEDURE:

1. Insert the given notch into the hydraulic bench and fit tightly by using bolts in order to prevent leakage.

2. Open the water supply and allow water till over flows over the notch. Stop water supply, let excess water drain through notch and note the initial reading of the water level "h" using the hook and point gauge.

3. Let water drain from collecting tank and shut the valve of collecting tank after emptying the collecting tank.

4. After initial preparation, open regulating valve to increase the flow and maintain water level over notch. Wait until flow is steady.

5. Move hook and point gauge vertically and measure the current water level 'h1' to find the water head „H" above the crest of the notch.

6. Note the piezometric reading 'z0' in the collecting tank while switch on the stopwatch.

7. Record the time taken „T" and the piezometric reading 'z1' in the collecting tank after allowing sufficient water quantity of water in the collecting tank.

8. Repeat step 3to step 6 by using different flow rate of water, which can be done by adjusting the water supply. Measure and record the H, the time and piezometric reading in the collecting tank until sets of data have been taken. If collecting tank is full, just empty it before the step no 3.

9. To determine the coefficient of discharge for the other notch.

OBSERVATION:

Breadth of the rectangular notch (b) = ___________________

Depth of the rectangular notch(d) =______________________

Area of collecting tank (A) =___________________

TABULATION:

SL. NO	Point gauge Reading			Rise of water level in the measuring tank (Z) *cm*	Actual discharge (Q_{act}) m^3/s	Theoretical discharge (Q_{the}) m^3/s	Co-efficient of discharge Cd= Qa/Qt
	Initial *cm*	Final *cm*	Difference (H) *cm*				

FORMULA:

RECTANGULAR NOTCH:

Coefficient of discharge **(C_d) = Q_a/Q_t**

Actual discharge **(Qa) =Ah/t** m^3/s

Theoretical discharge **(Qt) =$2/3\sqrt{2g}h.H^{3/2}$** m^3/s

RESULT:

Co-efficient of discharge for rectangular notch was found to be=________________