LABORATORY MANUAL

FLUID MACHINE
ME- 315-F

LIST OF THE EXPERIMENTS

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2	To study the constructional details of a Francis turbine and draw its fluid flow circuit.		
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4	To study the working and constructional details of Hydro-power plant (H.P.P.).		
5	To study the constructional details and working of Hydraulic Ram.		
6	To study the constructional details of a Centrifugal pump and draw its characteristics curve.		
7	To study the constructional details of a Centrifugal Compressor.		
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9	To study the constructional details of Reciprocating pump and draw its characteristic curve.		
10	(a) To verify the momentum equation experimentally. (b) Comparison of change in force exerted due to shape of the vane.(Flat, Inclined and Curved).		
11	To draw the following performance characteristics of pelton turbine: Constant head, Constant speed and Constant efficiency curves.		
12	To draw the constant head, constant speed and constant efficiency performance characteristics of Francis turbine.		
13	To draw the constant head, speed and efficiency curves for a Kaplan turbine.		

NOTE : 1. At least ten experiments are to be performed in the Semester.
2. At least seven experiments should be performed from the above list. Remaining three experiments may either be performed from the above list or designed & set by the concerned institution as per the scope of the syllabus.

EXPERIMENT NO 1

Aim: - To study the constructional details of a Pelton Wheel turbine and draw its fluid flow circuit.

Apparatus Used: - Model of Pelton Wheel Turbine.

Theory:

Hydraulic machines are defined as those machines which convert either hydraulic energy (energy possessed by water) into mechanical energy or mechanical energy into hydraulic energy.

Turbines are defined as hydraulic machines which convert hydraulic energy into mechanical energy. Hydraulic turbines are of different types according to specification and Pelton wheel or turbine is one of the types of hydraulic turbines.

Pelton Wheel or Turbine:

The Pelton wheel or Pelton turbine is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric. The turbine is used for high heads and is named after L.A Pelton, an American Engineer.

Constructional Details: -

The main parts of the pelton turbine are: -

1. Nozzle and flow regulating arrangement.
2. Runner and buckets.
3. Casing.
4. Breaking Jet.

1. Nozzle and flow regulating arrangement:

The amount of water striking the buckets of the runner is controlled by providing a spear in the nozzle. The spear is a conical needle which is operated either by a hand wheel or automatically in an axial direction depending upon the size of the unit. When the spear is pushed forward into the nozzle the amount of water striking the runner is reduced. On the other hand if the spear is pushed back, the amount of water striking the runner increases.

2. Runner with buckets:

It consists of a circular disc on the periphery of which a number of buckets evenly spaced are fixed. The shape of the buckets is of a double hemispherical cup or bowl. Each bucket is divided into two hemispherical parts by a dividing wall which is known as splitter.

3. Casing:

The function of the casing is to prevent the splashing of the water and to discharge water to tail race. It also acts as a safeguard against accidents. It is made of cast iron or fabricated steel plates. As pelton wheel is an impulse turbine, the casing of the pelton wheel does not perform any hydraulic function.

4. Breaking Jet:

When the nozzle is completely closed by moving the spear in the forward direction the amount of water striking the runner reduces to zero. But the runner due to inertia goes on revolving for a long time. To stop the runner in a short time, a small nozzle is provided which directs the Jet of water on the back of the buckets. This Jet of water is called breaking Jet.

Working of Pelton wheel Turbine:

The water from the reservoir flows through the penstocks at the outlet of which a nozzle is fitted. The nozzle increases the kinetic energy of the water flowing through the penstock by converting pressure energy into kinetic energy. At the outlet of the nozzle, the water comes out in the form of a Jet and strikes on the splitter, which splits up the jet into two parts. These parts of the Jet, glides over the inner surfaces and comes out at the outer edge. The buckets are shaped in such a way that buckets rotates, runner of the turbine rotates and thus hydraulic energy of water gets converted into mechanical energy on the runner of turbine which is further converted into electrical energy in a generator/alternator.

Specifications: -

1. Type – Impulse (free jet) turbine.
2. Type of flow – Tangential.
3. Head – more than 250m (high)
4. Mainly Runner shaft is horizontal in pelton turbine.
5. Specific Speed – 8 to 30 for one nozzle (low)
   Up to 50 for more than one nozzle.
6. Discharge – low.

Governing mechanism:

Speed of the turbine runner is required to be maintained constant so that the electric generator coupled directly to the turbine shaft runs at constant speed under varying load conditions. With increase in load, the runner speed falls and consequently balls of the centrifugal governor move inwards. Through suitable linkages, the resulting downward movement of the governor sleeve is transmitted to a relay or control valve which admits oil under pressure to a servomotor. The oil exerts a force on the piston of the servomotor, and that pushes the spear to a position which increases the annular area of the nozzle flow passage. Quantum of water striking the buckets is then increased and the normal turbine speed is restored.

Viva Questions

1. **What do you mean by an impulse turbine?**
2. **How does an impulse turbine differ from a reaction turbine?**
3. **Why is a pelton wheel suitable for high head only?**
4. **What is the specific speed range of a pelton wheel?**

5. **What is meant by a speed ratio of a pelton wheel?**

EXPERIMENT NO 2

Aim: - To Study the constructional details of the Francis Turbine (Reaction turbine) and draw its fluid flow circuit.

Apparatus used: - Model of Francis Turbine.

Formula Used: -

1. Work done by water on the runner per second = $\rho Q\ (V_{W1}, V_1)$
2. Hydraulic efficiency = $V_{w1}\ U_1/gH$
3. Speed Ratio = $U_1/\ 2gH$ varies from 0.6 to 0.88
4. Flow Ratio = $V_{f1}/\ 2gH$ varies from 0.12 to 0.35

Where ρ = Density of water
Q = Discharge of water
V_{w1}= Whirl velocity of water at inlet
U_1= Runner velocity
V_{f1}= Velocity of flow at inlet
H= Net head

Theory: - Reaction Turbine: - In this type of turbine there is a gradual pressure drop and takes place continuously over the fixed and moving blades or over guide vanes and moving vanes. The function of the guides' vanes is that they alter the direction of water as well as increases its velocity. As the water passes over the moving vanes its kinetic energy is absorbed by them.

Francis Turbine: - The inward flow reaction turbine having radial discharge at outlet is known as Francis turbine, after the name of J.B Francis an American engineer who in beginning designed inward radial flow reaction turbine. In the modern Francis turbine, the water enters the runner of the turbine in the radial direction and leaves in the axial direction at the outlet of the runner. Thus the modern Francis turbine is a mixed flow type turbine.

Constructional details:-

The main parts of the Francis turbine are: -

1. Penstock
2. Casing
3. Guide mechanism
4. Runner
5. Draft tube

1. Penstock: - It is a long pipe at the outlet of which a nozzle is fitted. The water from reservoir flows through the penstock. The nozzle increases the kinetic energy of water flowing through the penstock.

2. Casing: - In case of reaction turbine, casing and runner are always full of water. The water from the penstocks enters the casing which is of spiral shape in which area of cross-section of the casing goes on decreasing gradually. The casing completely surrounds the runner of the turbine. The casing is made of spiral shape, so that the water may enter the runner at constant velocity through out the circumference of the runner. The casing is made of concrete or cast steel.

3. Guide Mechanism: - It consists of a stationary circular wheel all round the runner of the turbine. The stationary guide vanes are fixed on the guide mechanism. The guide vanes allow the water to strike the vanes fixed on the runner without shake at inlet. Also by a suitable arrangement, the width between two adjacent vanes of a guide's mechanism can be altered so that the amount of water striking the runner can vary.

4. Runner: - It is a circular wheel on which a series of radial curved vanes are fixed. The surface of the vanes is made very smooth. The radial curved vanes are so shaped that the water enters and leaves the runner without shock. The runners are made of cast steel, cast iron or stainless steel. They are keyed to the shaft.

5. <u>Draft tube</u>: - The pressure at the exit of the runner of a reaction turbine is generally less than atmosphere pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exit of the turbine to the tail race. This tube of
increasing area is called draft tube. The draft tube, in addition to serve a passage for water discharge, has the following two purposes also.

    1. The turbine may be placed above the tail race and hence turbine may be inspected properly.
    2. The kinetic energy rejected at the outlet of the turbine is converted into useful pressure energy.

Specifications:-

1. Type –Reaction Turbine
2. Type of flow – Mixed (Redial & Axial)
3. Head –Medium 45 to 250m
4. Specific speed – Medium 50 to 250
5. Shaft position – Mainly vertical (it may be horizontal also)
6. Discharge – Medium

Governing Mechanism:-

The governing mechanism changes the position of guide blades to affect a variation in the water flow rate in the wake of changing load condition of the turbine. When the load changes, the governing mechanism rotates all guide blades about their axis through the same angle so that the water flow rate to the runner and its direction essentially remain the same at the all passages between any two consecutive guide vans. The penstock pipe feeding the turbine is often fitted with a relief valve, also known as the pressure regulator. When guide vanes are suddenly closed, the relief valve opens and diverts the water direct to tail race. The simultaneous operation of guide vanes and relief valve is termed as double regulation.

Viva Questions:-

1. What is the radial flow turbine?
2. Differentiate between inward and outward flow turbine?
3. What are guide vanes?
4. What is a draft tube?
5. What are the specifications of a Francis turbine?

EXPERIMENT NO 3

Aim: - To Study the constructional details of a Kaplan Turbine and draw its fluid flow circuit.

Apparatus Used: - Model of Kaplan Turbine.

Theory: - Axial flow Turbine: - 1. Kaplan Turbine (Adjustable blades)
2. Propeller (Blades are fixed)

Kaplan Turbine: - Kaplan Reaction turbines are axial flow turbines in which the flow is parallel to the axis of the shaft. They are low head, high discharge turbine. In this water turn at right angles between the guide vanes, runner & then flow parallel to the shaft. It is inward flow reaction turbine. The flow was along the radius from periphery to the centre of the runner. (From outer dia to the inner dia of runner). It is capable of giving high efficiency at overloads (up to 15-20%), at normal loads (up to 94%). The runner of this turbine is in the form of boss or hub which extends in a bigger dia. Casing with proper adjustment of blades during running. The blade angles should be properly adjusted so that water enters & flow through the runner blades with out shock.

Constructional details:-

1. **Penstock**
2. **Spiral or scroll casing**
3. **Guide mechanism**
4. **Runner**
5. **Draft tube**

1. Penstock: - It is the water way used to carry the water from the reservoir to the turbine. At the inlet of the penstock trash cracks are used to prevent the debris from going into the turbine.

2. Spiral or Scroll casing: - In case of reaction turbine casing and runner are always full of water. The water from the penstock enters the casing which is of spiral shape in which area of cross-section of the casing goes on decreasing gradually. The casing completely surrounds the runner of

the turbine. The casing is made of spiral shape, so that the water may enter the runner at constant velocity through out the circumference of the runner.

3. Guide Mechanism: - It consists of a stationary circular wheel all round the runner of the turbine. The stationary guide vanes are fixed on the guide mechanism. The guide vanes allow the water to strike the vanes fixed on the runner without shock at inlet. Also by a suitable arrangement, the width between two adjacent vanes of a guide mechanism can be altered so that the amount of water striking the runner can be varied. A space, called whirl
   Chamber, is provided between the guide vanes and the runner. In this chamber, the flow turns by 90° & move as a free vortex i.e without the aid of any external torque. The radial component changes into axial component due to the guidance from the fixed housing.

4. Runner: - It is a circular wheel, also called 'hub' or 'bass' on which a series of radial curved vanes are fixed. The surface of the vanes is made very smooth. The radial curved vanes are so shaped that water enters and leaves the runner without shock. The runners are made of cast steel, cast iron or stainless steel. In Kaplan turbine, the shaft is the extended part of runner with smaller diameter.

5. Draft tube: - The pressure at the exit of an axial turbine is generally less than atmospheric pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exit of the turbine to the tail race. This tube of increasing area is called draft tube.

Specifications:-

1. Type – Reaction turbine
2. Type of flow – Axial
3. Head – Low (below 40 m)
4. Number of blades on runner – 3 or 4 (max. 6)
5. Specific speed – High - 250 to 850
6. Discharge - High

Viva Questions:-

1. What is a parallel flow turbine?
2. How is a Kaplan turbine different from a Francis turbine?
3. What is the speed ratio of Kaplan turbine?
4. What do you mean by an reaction turbine?
5. Why are hydraulic losses less in a Kaplan turbine then in a Francis turbine?

EXPERIMENT NO 4

Aim: - To study the working & constructional details of Hydro-power plant (H.P.P)

Apparatus Used: - Model of Hydro-power plant.

Theory: - Hydro-power Plant can be classified as follows:-

1. Based on Utilization of water:-

(a). Run-of-River plants (R.P.P) : are low head plant
  (i) Run of River plants with pondage
  (ii) Run of River plants without pondage

(b). Storage Reservoir Plants (S.R.P): - are made for generating power and also for controlling the floods, irrigation purpose and for fishing etc. They are called multipurpose projects, e.g. Bhakra Nangal, Damoder Valley projects.

(c). Pump Storage Plants (P.S.P): - Also called reservoir turbine with high efficiency used for power head race level.

(d). Peak Load Plants (P.L.P): - Work during peak load hours.

Based on availability of Head:

(a). Low Head Plant (L.H.P.): - Head <45 m, Kaplan & Propeller type turbine are used

(b). Medium Head Plant (M.H.P): - Head =45-250m, fore bays, surge tanks are used to avoid the effect of water hammer (W.H).

(c). High Head plant (H.P.P).

Constructional details or components of hydro power plant are: -

1. <u>Water reservoir</u> (W.R): - May be either (i) Natural that can be found in high mountains from where the water is through down through tunnels. (ii). artificial: - Are made by Dams across the river.

2. <u>Head Works</u>: - Equipment used to control the flow of water into the water ways on the head race side (H.R.S) is called head works. It has (i) Gates: - types are plain, sliding gates, roller & wheeled gates etc. (ii). Valves: - Used are butterfly & needle type valves. (iii). Fish type &

Trash racks: - These are nets used to keep the fish away from the debris from going into the water ways. And made of rectangular cross-sectional steel bars, some sort of
cleaning device is also provided to remove the debris from the trash racks. (iv). Heating arrangements to melt the ice of the mountains at the inlet.

3. <u>Water ways</u> (W.W): - (Tunnel, power channels or penstock with for bay & necessary apparatuses such as intake structure, air vent valve, surge tanks. These are the passage through which water is brought from reservoir to the power house.
   (a). A tunnel has to be cut through a hill if it comes between the reservoir & power house.
   (b). Open channel: - Are to be provided when the distance of the water storage & the power house is considerable.
   (c) : - Penstock are the steel or reinforced concrete pipes used in the last stage of the water travel from reservoir to the power house.

4. <u>For bays Or Surge Tanks</u>: - For bays is just a small water storage to meet the load fluctuations. For small periods, as for a day. These are made at the end of the tunnel or the open channel as the case may be. In case of open channel, a fore bay can be made by enlarging the channel just before the penstock starts. When the distance between the reservoir and the power house is less and only penstock to be used, the reservoir itself is a fore bay. Fore bays is used case of medium & low head plants where length of the penstock is small.

   <u>Surge Tanks</u>: - Also act as a small reservoir for the water to the turbine. When the load on the turbine is reduced, water has to be restarted but it takes time to do so; the excess flow of water is temporarily stored in the surge tank & the level of the water in the surge tank becomes higher then the average. When the load on turbine increases, the increased supply of water is made partially by the direct flow of water and partially be the surge tank containing the water. It also avoids the water hammer effects. They are must for high and medium head plants and should be located as close to the turbine as possible. It is a cylindrical open tapped tank and the normal level of water in it. To be at the level of reservoir minus the head losses in transition from the reservoir to the

surge tank. To reduce the height of the surge tank, it is usually located at the junction of penstock and the pressure channel.

5. Power House: - It contains turbines, generators, governing mechanism and other equipment.
6. Tail Race: - It is a water way which carries the water from the turbine out let into some reservoir, river or channel.

Viva Questions:-

1. What is the function of surge tank?
2. What is meant by water hammer?
3. How are hydro power plants classified?
4. Name the major parts of a hydro power plant?

EXPERIMENT NO 5

Aim: - To study the constructional details and working of Hydraulic Ram.

Apparatus Used: - Model of Hydraulic Ram.

Theory: - Hydraulic System: - is an arrangement to transmit forces and energy through an incompressible fluid.

They are of two types:-

1. Hydrostatic System: - In this system transmission is due to hydraulic pressure. The main elements are: -
   (a). Pumping Unit: - That acts as a power source to develop the hydraulic pressure from mechanical work- Usually it is a rotary or a reciprocating pump.
   (b). Transmission line or passage: - Through which power and energy are to be transmitted from the place of production to the place of its necessity.
   (c). Hydraulic motor: - To reconvert the hydraulic pressure into mechanical work. Again this can be of rotary or reciprocating type in the form of cylinder & piston. Piston in the cylinder is moved by the fluid pressure providing useful work. e.g. Hydraulic press, crane, lift etc.
2. Hydro Kinematics System: - In this transmission is due to change in the velocity and the direction of fluid flow. With a negligible change in the pressure of the fluid. It has two main elements: -
   (a). Pump- impeller driven by the driving shaft (centrifugal pump).
   (b). Turbine Runner to run the driven shaft: - There is circulation of oil from the pump impeller to the runner that transmits power. For e.g. Hydraulic Ram: - It is a pump which raises small quantity of water to a greater height, if large qty. of water is available at a lower height without using any external power.

Constructional details: - its main parts are: -

Supply line, Supply tank, Waste valve, Delivery valve, Valve chamber, Delivery pipe, Delivery tank, Air vessel, Non-return valve, Drain cock, Pressure gauge.

Working principle: - It works on the principle of water hammer effectors inertia force of water in a pipe line. When a flowing fluid is brought to rest suddenly a rise of pressure occurs, which can be utilized to raise a portion of water to a higher level. It does not require any external power for its operation.

It consist of a valve chamber fitted with two valves, a wattle valve & a delivery valve, both being none return valves. The delivery valve opens into an Air vessel to carry the air compressed. A delivery pipe is connected to the air vessel to carry the water to a delivery tank. A supply pipe connects the available water source to the valve chamber.

At a particular moment assume that the delivery valve is closed and the waste valve is open. Water flows down the supply pipe in to the valve chamber and then through the waste valves into waste water tunnel. As the velocity of water in the pipe in creases, the dynamic pressure on the underside of the waste valve becomes high. This closes the waste valve which was open due to its own weight. With the sudden closure of the waste valve, the velocity reduces to zero and the pressure in the valve chamber. The high pressure of water forcibly opens the delivery

EXPERIMENT NO 6

Aim: - To study the constructional details of a centrifugal pump and draw its characteristics curve.

Apparatus used: - Centrifugal pump test rig.

Theory: - The hydraulic machine which converts the mechanical energy in to pressure energy by means of centrifugal force acting on the fluid is called centrifugal pump.

The centrifugal pump acts as a reverse of an inward radial flow reaction turbine. This means that the flow in centrifugal pump is in the radial outward directions. The centrifugal pump works on the principle of forced vertex flow which means that when a certain mass of liquid is related by an external torque, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of the tangential velocity of the liquid at that point. Thus at the outlet of the impeller radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with a high pressure head. Due to this pressure head, the liquid can be lifted to a high level.

Constructional details:-

Main part of a centrifugal pump:-

1. Impeller:-The rotating part of a centrifugal pump is called "Impeller". It consists of a series of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor.

2. Casing: - The casing of a centrifugal pump is similar to the casing of a reaction turbine. It is an air-tight passage surrounding the impeller and is designed in such a way that the kinetic energy of the water discharged at the outlet of the impeller is converted in to pressure energy before the water leaves the casing and enters the delivery pipe. The following three types of casing are commonly adopted:-

(i) Volute casing
(ii) Vortex casing
(iii) Casing with guide blade

2. Suction pipe with a foot-valve and a strainer: - A pipe whose one end is connected to the inlet of the pump and other end dips in to water in a sump is known as suction pipe. A foot valve which is a non-return valve or one way valve is fitted at the lower end of the suction pipe. The foot valve opens only in the upward direction. A strainer is also fitted at the lower end of the suction pipe.
3. Delivery pipe: - A pipe whose one end is connected to the outlet of the pump and other end delivers the water at a required height is known as delivery pipe.

Formulae used:-

Inlet pressure head = P_1m
Discharge pressure head = P_2m
Flow rate = Qm^3/s
In centrifugal pump, we take
Manometer head H = Total head at inlet- Total head at outlet
Datum head = Z_2m
Total head across pump H = $(P_1-P_2) + Z_2$
Torque T = (load. arm distance)
Input power P = (2π. speed in r.p.s. T) Watts
Water power Po = (ρ. g. H .Q) Watts
Efficiency ή % = Water power /Input power .100s

Observation table:-
Position of delivery pressure gauge (datum head) = Z_2m
Arm distance = m
ρg = 9810
Area of collecting tank, a = cm^2

Sl no	Discharge measurement			Discharge Q m^3/s	Pump speed r.p.s	Suction head m	Delivery head m	Manometric head m	Load kg	Torque Kg m	Water power w	Input power w	η %
	Initial h_1 m	Final h_2 m	Time s										

Procedure:-

1. Note down the area of collecting tank, position of delivery pressure gauge and arm distance of the spring from the centre of shaft.
2. Priming the pump set before starting.
3. The speed control on the motor is set to a value and at the same time the flow regulating valve was adjusted to give the maximum possible discharge.
4. Conditions were allowed to steady before the rate of discharge Q, suction head, load on the motor and r.p.s. value were recorded.
5. The flow rate is reduced in stages and the above procedure is repeated.
6. The procedure is repeated other type of values.

Result:-

Viva Questions:-

1. What is pump?
2. The centrifugal pump is works on which principle?

EXPERIMENT NO 7

Aim: - To study constructional details of a centrifugal compressor.
Apparatus: - Model of centrifugal compressor.
Theory: - The centrifugal compressor are used to apply large quantity of air at low pressure, the compressor consist of a rotating impeller diffuser and casing. The impeller consists of a disc on which radial blades are attached. The impeller of a centrifugal compressor can be run at a speed of 20,000 to 30,000 rpm. The diffuser is other important part of compressor which surrounds the impeller and delivery passage for air flow. The air coming out from the diffuser is other important part of compressor which surrounds the impeller and delivery passage for air flow. The air coming out from the diffuser is collected in casing and then taken out from outlet. The air enters with low velocity and atmospheric pressure. The air moves radially outwards passing through the impellor increases the momentum of air flowing through it. Causing rise in pressure and temperature of air. The air leaving due impeller enters diffuser where its velocity is reduced by providing more cross-sectional for flow. The part of K.E of air if converted into pressure energy and pressure of air for flow. The part of K.E is converted into pressure energy and pressure of air further increased nearly half of the total pressure rise is achieved by impellor and remaining half in diffuser. A pressure ratio of ‘4’ can be achieved in a single stage compressor for high pressure ratio of 12:1 is possible with multistage compressor. The change of pressure and velocity of air shown. The impeller which are generally used are can of the two type and subjected to equal and axial forces in opposite direction which is advantage of single eye impellor.

Viva Questions:-

1. What are the uses of compressed air?
2. Classify the centrifugal compressor?

EXPERIMENT NO 8

Aim:- To study the constructional details of gear pump and draw its characteristic curve.

Apparatus Used:- Model of oil gear pump.

Theory:- The gear pump is a rotary pump in which two gear mesh to provide the pumping action. This type of pump is mostly used for cooling water and pressure oil to be supplied for lubrication to turbine, machine tool etc. Although the gear pump is rotating machinery yet it action on liquid to be pumped is not dynamic it nearly displaces. The liquid from one side to other. The flow of liquid to be supplied is continues and uniform.

Constructional details:- A gear pump has following parts:-

(1) Casing
(2) Gear wheel
(3) Suction and delivery pipe

Casing:- The function of casing in this type of pump is only to make the liquid which is to be transferred in contact with gear wheel. The width of gear wheel casing also contains bearing in its body.

Gear wheel:- In gear wheel pump there are two identical intermeshing gear working in a fine clearance. One of the gear is keyed to shaft know as driving shaft. The other gear revolves due to driving shaft. These two gears are constructed with a definite clearance. The space between gear teeth and casing is filled with oil. The oil is carried between the gears from suction pipe to delivery pipe.

Suction pipe:- These pipe are in circular shape connect the gear to suction and delivery.

Viva Questions:-

1. Define working of rotary pump?
2. Which type of pump is mostly used in cooling water?

EXPERIMENT NO 9

Aim:-To study constructional details of reciprocating pump and draw its characteristic curve.

Apparatus Used:- Pump, Pipe work system with all necessary control pipe or valve, Collecting tank, Pressure gauge located on suction and discharge side.

Theory:- The reciprocating pump is positive displacement pump i.e. it operates on the principles of actual displacement or pushing of liquid by a piston or plunger that executes a reciprocating motion in a closely fitted cylinder. The liquid is alternatively drawn from the pump and filled into suction side of the cylinder. The liquid fed to discharge side of the cylinder and emptied to the delivery pipe. The piston or plunger gets its reciprocating motion by means of a crank and connecting rod mechanism.

Working:- To start with when the crank angle θ is zero or the piston is towards extreme left as the crank moves from inner dead to outer dead centre i. e. from $\theta=0^o$ to $\Theta=180$. The piston moves from extreme left to extreme right end. This movement of piston called backward stroke. So during the backward stroke volume of air in the cylinder increase, resulting fall in pressure or partial vacuum. The air in suction pipe being at atmospheric pressure rush to the cylinder. This by the end of backward stroke air in the suction pipe and the cylinder is rearranged and started otherwise partial pressure of some degree is created .During the forward stroke of the piston as the crank moves from $\theta = 180^o$ to $\theta = 360^o$.The air in cylinder is forced out through the delivery pipe. Thus after a few backward stroke and forward stroke sufficient partial vacuum is created. A stage come in backward stroke, the liquid due to the atmospheric pressure existing on the surface is sucked in and forced out during the backward stroke, the liquid sucked is forced out through the non return delivery valve it is called discharge stroke or delivery stroke.

From above we find that pump has a capacity to create partial vacuum resulting in the suction of the liquid by itself property is called self priming.

It may be observed that a single acting single cylinder pump liquid is swept and only once in one revolution of the crank where is in double acting, it is swept twice for each revolution of the crank.

Observation table:- Area of collecting tank, a = cm^2

$\rho g = 9810$

Sl no	Discharge measurement			Discharge Q m^3/s	Delivery head m	Water power w	Input power w	η %
	Initial h_1 m	Final h_2 m	Time s					

Procedure:-

1. Note down the area of collecting tank
2. Priming the pump set before starting.
3. Before starting ensure that pump is free to rotate.
4. Flow regulating valve was adjusted to give the max. Possible discharge.
5. Conditions were allowed to steady before the rate of discharge Q, discharge and load on the motor were recorded.
6. The flow rate is reduced in stages and the above procedure is repeated.

Result:-

Viva Questions:-

1. What is priming?
2. The reciprocating pump is based on which principle

EXPERIMENT NO 10

Aim:- (a) To verify the momentum equation experimentally.

(b) Comparison of change in force exerted due to shape of the vane. (flat, inclined or curved)

Apparatus Used:- Collecting tank, Transparent cylinder, Two nozzles of dia 10 mm & 12mm, Vane of different shape (flat,inclind or curved)

Theory:- Momentum equation is based on Newton's second law of motion which states that the algebric sum of external forces applied to control volume of fluid in any direction is equal to the rate of change of momentum in that direction. The external forces include the component of the weight of the fluid & of the forces exerted externally upon the boundary surface of the control volume. If a vertical water jet moving with velocity is made to strike a target, which is free to move in the vertical direction then a force will be exerted on the target by the impact of jet, according to momentum equation this force (which is also equal to the force required to bring back the target in its original position) must be equal to the rate of change of momentum of the jet flow in that direction.

Formula Used:-

$$F' = \rho\, Q\, v(1-\cos\beta)$$

$$F' = \rho\, Q^2\, (1-\cos\beta) \quad \text{as} \quad v = Q/a$$

Where F' =force (calculated)

ρ = density of water

β=angle of difference vane

V =velocity of jet angle

Q =discharge

A =area of nozzle ($\pi/4d^2$)

(i) for flat vane $\beta=90^o$

$$F = \rho Q^2/a$$

(ii) for hemispherical vane $\beta=180^o$

for % error =F- F'/ F'x100

$F = 2 \, Q^2/a$

F = Force (due to putting of weight)

Procedure:-

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

Precautions:-

1. Water flow should be steady and uniform.
2. The reading on the scale should be taken without any error.
3. The weight should be put slowly & one by one.
4. After changing the vane the flask should be closed tightly.

Viva Questions:-

1. Define the terms impact of jet and jet propulsion?
2. Find the expression for efficiency of a series of moving curved vane when a jet of water strikes the vanes at one of its tips?

EXPERIMENT NO. 11

Aim: - To draw the following performance characteristics of Hydraulic turbine- constant head, constant speed and constant efficiency curves.

Equipment: - Model of Pelton Turbine.

Theory: - Characteristic Curves: - Characteristic curves of hydraulic turbines are the curves, with the help of which the exact behavior and performance of the turbine under different working conditions can be known. These curves are plotted from the results of the tests performed on the turbine under different working conditions.

1. Speed (N)
2. Head (H)
3. Discharge (Q)
4. Power (P)
5. Overall efficiency (η_0)
6. Gate opening.

Out of the above six parameters, three parameters namely speed (N) Head (H), Discharge (Q) are independent parameters.

Out of the three independent parameter (Power (P), Overall efficiency (η_0), Gate opening) one of the parameter is kept constant (say H) and variation of the remaining two independent variables (say N & Q) are plotted and various curves are obtained. These curves are called characteristic curves. The following are important characteristic curves of a turbine.

1. Main characteristic curves or constant head curves: - Main characteristic curves are obtained by maintaining a constant head and a constant gate opening (G.D) on the turbine. The speed of the turbine is varied by changing load on the turbine. For each valve of the speed, the corresponding valves of the power (P_0 and discharge (Q) are obtained. Then the overall efficiency (η_0) for each valve of the speed is calculated. From these readings the values of Unit Speed (N_u), Unit

power (P_u) and Unit discharge (Q_u) are determined. Taking N_u as abscissa, the values of Q_u, P_u, P and η_0 are plotted. By changing the gate opening, the values of Q_u, P_u, η_0 and N_u are determined and taking N_u as abscissa the values of Q_u, P_u and η_0 are plotted. Figure shows the main characteristic curves for a pelton wheel.

2. Operating characteristic curves or constant speed curves: - These curves are plotted when the speed on the turbine is constant. In case of turbines the head is generally constant. As mentioned there are three independent parameter namely N,H and Q. For operating characteristics N and H are constant. And hence the variation of power and efficiency with respect to discharge Q are plotted. The power and efficiency curves will be slightly a way from the original on the x-axis-as to overcome initial friction certain amount of discharge will be required.

3. Constant efficiency curves or Muschel curves or Is Q efficiency curves: - These curves are obtained from the speed vs efficiency and speed vs discharge curves for different gate openings. For a given efficiency from the Nu vs η_0 curves, there are two speeds. From the N_u vs Q_u curves, corresponding to two values of speeds there are two values of discharge. Hence for a given efficiency there are two values of discharge for a particular gate opening. This means for a given efficiency there are two values of speeds and two values of the discharge for a particular gate opening. If the efficiency is maximum there is only one value. These two values of speed and two values of discharge corresponding to a particular gate opening are plotted. The procedure is repeated for different gate openings and the curves Q vs N are plotted. The points having the same efficiency are joined. The curves having the same efficiency are called so efficiency curves. These curves are helpful for determining the zero of constant efficiency and for predicating the performance of the turbine at various efficiencies.

Observation table:-

Dia of nozzle =

Mass density of water ρ =
Area of collecting tank =
Area of nozzle =

Horizontal flat vane

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

SNO	Discharge measurement				Balancing		Theoretical Force F'= $\rho Q^2/a$	Error in % = F-F'/F'
	Initial (cm)	Final (cm)	Time (sec)	Discharge (cm^3/sec) Q	Mass W (gm)	Force F (dyne)		

Inclined vane

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

Angle of inclination $\beta = 45^0$

SNO	Discharge measurement				Balancing		Theoretical Force F'= $\rho Q^2(1-\cos\beta)/a$ (dyne)	Error in % = F-F'/F'
	Initial (cm)	Final (cm)	Time (sec)	Discharge (cm^3/sec) Q	Mass W (gm)	Force F (dyne)		

Curved hemispherical vane

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

SNO	Discharge measurement				Balancing		Theoretical Force F'= $2\rho Q^2/a$ (dyne)	Error in % = F-F'/F'
	Initial (cm)	Final (cm)	Time (sec)	Discharge (cm^3/sec) Q	Mass W (gm)	Force F (dyne)		

Precautions:-

1. **Water flow should be steady and uniform.**
2. **The reading on the scale should be taken without any error.**
3. **The weight should be put slowly & one by one.**
4. **After changing the vane the flask should be closed tightly.**

Viva Questions:-

1. **Define the terms impact of jet and jet propulsion?**
2. **Find the expression for efficiency of a series of moving curved vane when a jet of water strikes the vanes at one of its tips?**

FLUID MACHINES LAB ME-315 E

List of experiment:-

1 To study the constructional details of a pelton turbine and draw its fluid flow circuit.

2 To study the constructional details of a Francis turbine and draw its fluid flow circuit.

3 To study the constructional details of a Kaplan turbine and draw its fluid flow circuit.

4 To study the working and constructional details of Hydro-power plant (H.P.P.).

5 To study the constructional details and working of Hydraulic Ram.

6 To study the constructional details of a Centrifugal pump and draw its characteristics curve.

7 To study the constructional details of a Centrifugal Compressor.

8To study the constructional details of Gear pump and draw its characteristic curve.

9 To study the constructional details of Reciprocating pump and draw its characteristic curve.

10 (a) To verify the momentum equation experimentally.
(b) Comparison of change in force exerted due to shape of the vane.(Flat, Inclined and Curved).

11 To draw the following performance characterstics of pelton turbine: Constant head, Constant speed and Constant efficiency curves.