8. LAB MANUAL

IMPACT OF JET ON VANES

AIM: to determine the impact of jet on vanes

THEORY:

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

EXPERIMENTAL SETUP:

The equipment consists of a high efficiency gun metal nozzle fitted to a 25 mm diameter pipe supply line with a gate valve. Vertically above the nozzle, a gun metal vane is fitted to a bracket of a differential lever which balances the upward force of the jet from the nozzle. The lever is provided with an adjustable no load screw mechanism. The force due to the jet on the lever is counter balanced by weights placed on a hanger. Different types of vanes can be fitted to the bracket.

The complete assembly is enclosed in framed structure housing with two leak proof transparent sides for visual observation. The water deflected by the vane is collected in the collecting tank of the hydraulic bench.

For experimental purposes, two brass nozzles with nozzle outlet diameters of 8mm and 10mm and two gunmetal vanes of the following shape are provided.

1. Semi-circular vane (180^0 Angle of deflection)
2. Horizontal flat vane (90^0.angle of deflection)

PROCEDURE:

1. Fit the required vane on the lever.
2. Measure the differential lever arms and calculate the ratio of lever arms (2.0 in this case)
3. Balance the lever systems by means of counter weight for no load.
4. Place a weight on the hanger.
5. Open the gate valve and adjust the jet, so that the lever arm is balanced.

6. Collect water in the collecting tank.
7. Note (a) the pressure gauge reading – P.
   (b) The weight placed – W.
   (c) Time for 5 cm. rise in the collecting tank –t
8. Repeat the procedure for different loads

CALCULATIONS:

Theoretical lifting force = Change in momentum per sec. In vertical direction

$F_{th} = m \text{ X } v \text{ X } (Sin\Theta_1 \text{ X } Sin\Theta_2)$

For Horizontal flat vane, $\Theta_1 = 90^0$ and $\Theta_2 = 0^0$

$F_{th} = mXv$……N

For semi circular vane $\Theta_1 = 90^0$ and $\Theta_2 = -90^0$.

$F_{th} = 2 \text{ X } m\, Xv$……

Actual lifting force = W X lever arm ratio

$F_{act} = 2.0\, W$

Where, W is the weight placed on hanger ………N

HYDRAULIC JUMP

AIM: The purpose of this experiment is to observe the hydraulic jump

APPARATUS:

Hydraulic jump instrument, shocks, stops watch, pipes.

THEORY:

The dynamics of hydraulic jump is governed by the flow continuity and the momentum equation. As we shall see, one of the major characteristic of a hydraulic jump is its large energy dissipation. Therefore, energy equation cannot be used at this point because the head loss is unknown (and not negligible). Using a control volume enclosing the jump, the continuity equation is expressed as

$$Q = bV_1h_1 = bV_2h_2 \qquad (1)$$

where

Q is the discharge,

V represents the averaged velocity and

h is the water depth.

The subscript "1" and "2" represent flow information upstream and downstream of the hydraulic jump, respectively. The momentum equation which takes into account the hydrostatic forces and the momentum fluxes, but ignores the friction at the channel bottom and at the side walls, can be shown as

$$1/2\ \rho g b h_1{}^2 - 1/2\ \rho g b h_2{}^2 = \rho Q\ (V2 - V1) \qquad (2)$$

ρ is the fluid density and g is the gravitational acceleration. If we define a momentumρin which function as

$$M = V\ 2h\ 2g + h\ 2\ 2 \qquad (3)$$

Then, using equation (1) we can show that equation (2) suggest

$$M1 = M2 \qquad (4)$$

From equation (1) and (2), it can be shown that the upstream and downstream flow depths are related by

$$\xi = h2/\ h1 = ½(\ \sqrt{1 + 8Fr_1{}^2} - 1) \qquad (5)$$

where Fr1 is the Froude number of the upstream flow and is defined as

$$Fr_1 = V_1 / \sqrt{gh_1} \qquad (6)$$

For a hydraulic jump, the upstream flow is supercritical and Fr1>1. On the other hand, the

Froude number Fr2 of the downstream subcritical flow needs to satisfy

$$Fr_2 = V_2\ gh_2 < 1 \qquad (7)$$

You can further apply conservation of energy for this open channel flow problem as

$$h_1 + V_1^2/2g = h_2 + V_2^2/2g + hL \qquad (8)$$

and show that the “head loss” hL for hydraulic jump is calculated as

$$h_L = h_2 - h_1^3/4h_1h_2 \qquad (9)$$

PROCEDURE:

The experimental procedure is as follows:

1. Start the pump and turn the flow control valve open.
2. Allow the flow to become established and a jet to be developed under the sluice gate (the water level in the reservoir behind the gate should be steady at this point).
3. Place the weir at the downstream end and adjust the weir carefully to create a hydraulic jump which is fixed at about the midsection of the flume.
4. Measure water depths before and after the jump using a point gage.
5. Record the discharge Q (l/sec) from the flow meter reading.
6. Repeat steps 2 through 5 for a total of five different values of Q. The value of Q can be changed by adjusting the flow control valve. The downstream weir is used to position the jump in the midsection of the flume.

PELTON WHEEL

AIM: Determination of efficiency of Pelton wheel at constant head.

APPARATUS: Pelton wheel test rigs, tachometer and weights.

DESCRIPTION:

Pelton wheel is an impulse turbine which is used to utilize high heads for generation of electricity. It consists of a runner mounted on a shaft. To this a brake drum is attached to apply brakes over the speed of the turbine. A casing is fixed over the runner. All the available head is converted into velocity energy by means of spear and nozzle arrangement. The spear can be positioned in 8 places that is, 1/8, 2/8, 3/8, 4/8, 5/8 6/8, 7/8 and 8/8 of nozzle opening. The jet of water then strikes the buckets of the Pelton wheel runner. The buckets are in shape of double cups joined at middle portion. The jet strikes the knife edge of the buckets with least resistance and shock. The jet is deflected through more than 160^o to 170^o. While the specific speed of Pelton wheel changes from 10 to 100 passing along the buckets, the velocity of water is reduced and hence the impulsive force is supplied to the cups which in turn are moved and hence the shaft is rotated. The supply of water is arranged by means of centrifugal pump. The speed of turbine is measured with tachometer.

PROCEDURE:

1. Keep the nozzle opening at about $3/8^{th}$ open position
2. Prime the pump if necessary
3. Close the deliver gate valve completely and start the pump.
4. Allow water in the turbine, and then the turbine rotates.
5. Adjust the deliver gate valve opening and note the Turbine inlet pressure.
6. Note the venturimeter pressure gauge readings.
7. Load the turbine by putting weights.
8. Note the speed of the turbine.
9. Note weight on hanger, W_1 and spring balance weight W_2 and weight of hanger W_0
10. Repeat the experiment for different loadings.

OBSERVATIONS:

Venturimeter inlet Diameter, d_1= 0.065 m

Venture inlet area , a1=π/4 X $d1^2$

Venturimeter throat diameter, d_2= 0.039

Diameter of brake drum, D = 0.4 *m*

Diameter of rope = 0.015 *m*

CALCULATION:

- Inlet Pressure, P = Kg/cm^2
- Total Head, H = 10 x *P* m of Water
- Venturimeter inlet pressure, P_1 = Kg/cm^2
- Venturimeter throat pressure, P_2 = Kg/cm^2
- Venturi Head,dH = 10 x (p_2-p_1) m of water
- Discharge = $\frac{a_1 a_2 \sqrt{2gdH}}{\sqrt{a_1^2 - a_2^2}}$

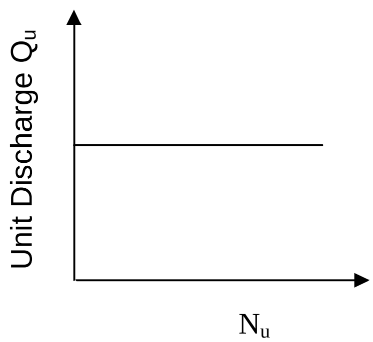
C

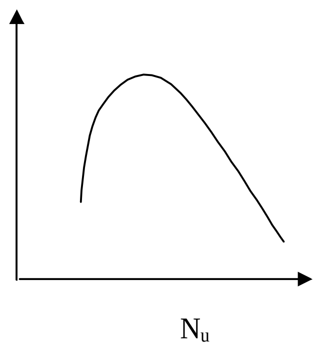
d

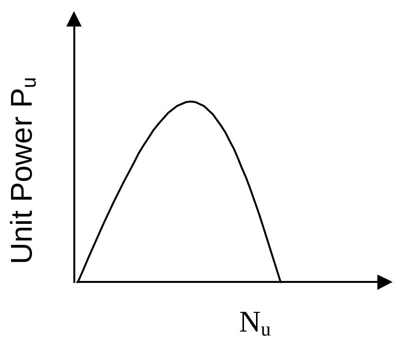
.

GRAPHS:

1. Unit Speed Vs
2. Unit Speed Vs Unit Output power
3. Unit Speed Vs Unit Discharge







RESULT

The efficiency of Pelton wheel Turbine at constant head =_________

FRANCIS TURBINE

AIM : Determine the efficiency of Francis Turbine at constant head

APPARATUS:

Francis turbine test rig, tachometer and weights.

DESCRIPTION:

Francis turbine consists of runner mounted on a shaft and enclosed in a spiral casing with guide vanes. The cross section of flow between the guide vanes can be varied, known as gate opening. It can be adjusted ¼, ½, ¾, or full gate opening. A brake drum is fixed to the turbine shaft. By means of this drum the speed of the turbine can be varied. The discharge can be varied by operating a throttle valve on the pipe line. The water after doing work leaves the turbine through a draft tube and flows down into the tail race. A Venturimeter is fitted to the pipe for measuring discharge.

PROCEDURE:

1. Keep the guide vane at required opening (say $3/8^{th}$)
2. Prime the pump if necessary.
3. Close the main gate valve and start the pump.
4. Open the gate valve for required discharge
5. Open the brake drum cooling water gate valve for cooling the brake drum.
6. Note the Venturimeter pressure gauge readings
7. Note the inlet pressure gauge & outlet vacuum gauge readings
8. Note weight on hanger, W_1 and spring balance weight W_2 and weight of hanger W_0.
9. Measure the turbine runner speed in rpm with tachometer.
10. Repeat the experiment for different loadings.

OBSERVATIONS:

- Venturimeter inlet Diameter, d_1= 0.1 m
- Venturimeter inlet area, a_1 $=\pi/4\ d1^2$
- Venturimeter throat diameter ,d_2= 0.06 m
- Venturimeter throat area, a_2 =

Speed (N) = *rpm*

- diameter of brake drum , D = 0.3 *m*
- Diameter of rope = 0.015 *m*

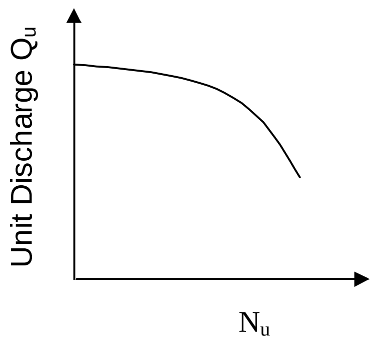
CALCULATION:

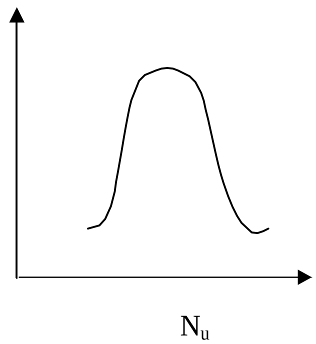
- Inlet Pressure, P = Kg/cm^2
- Outlet Vacuum, V = mm of Hg
- Venturimeter inlet pressure, P_1 = Kg/cm^2
- Venturimeter throat pressure, P_2 = Kg/cm^2
- Venturi Head , dH = 10 x (p_2 x p_1) meters of water

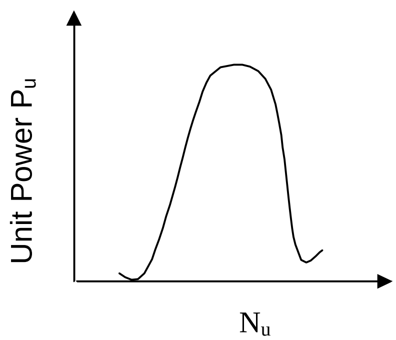
Efficiency of Turbine η=O.P/I.PX100

GRAPHS:

1. Unit Speed *Vs*
2. Unit Speed *Vs* Output power
3. Unit Speed *Vs* Unit Discharge

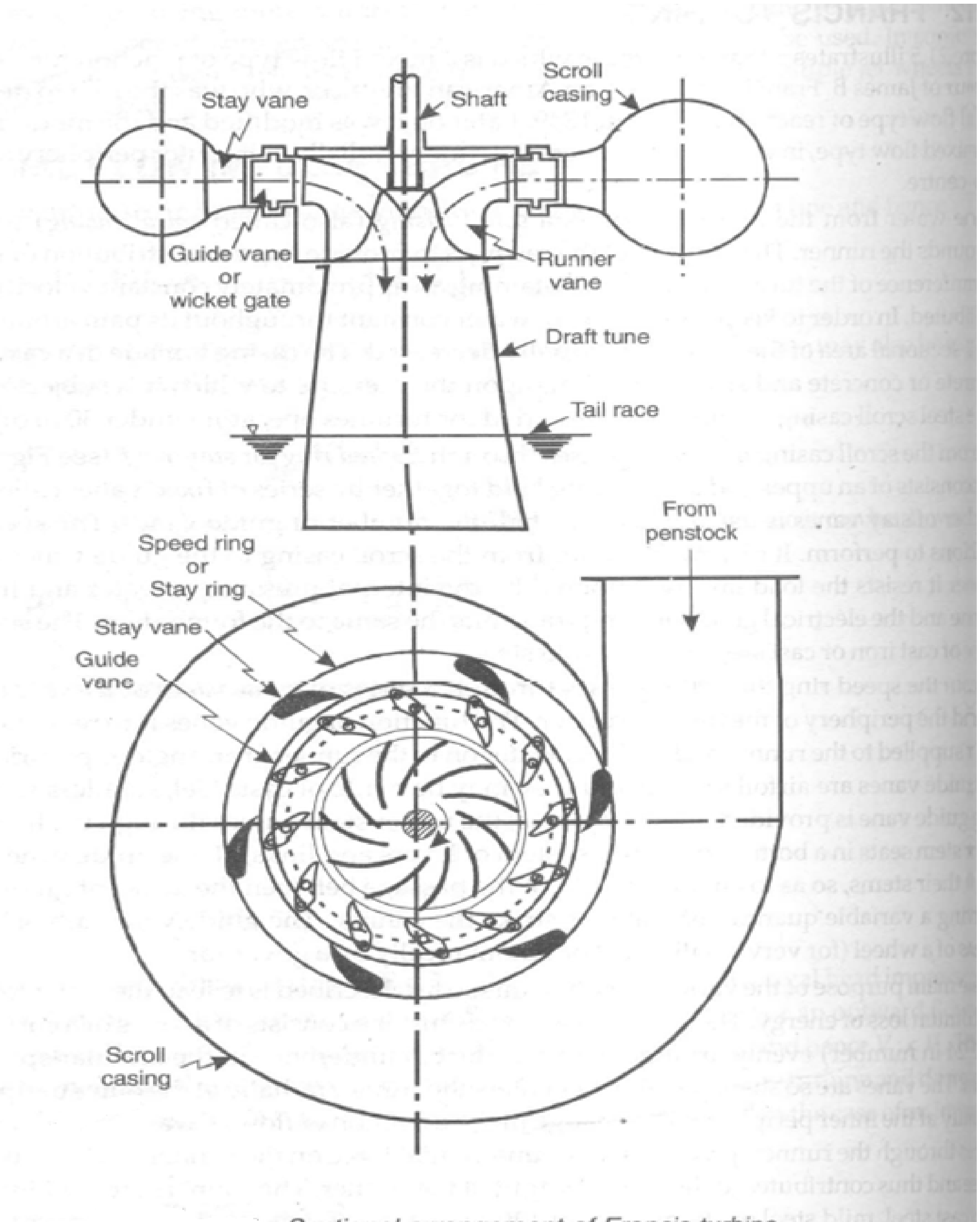






RESULT

The efficiency of Francis Turbine at constant head =_____



Sectional arrangement of Francis turbine

KAPLAN TURBINE

AIM: Determine the efficiency of Kaplan Turbine at constant head

APPARATUS:

Kaplan turbine test rig, tape and hook gauge

THEORY

Hydraulic (or Water) turbines are the machines, which use the energy of water (Hydro-Power) and convert it into mechanical energy. Thus the turbines become the prime mover to run the electrical generators to produce the electricity, Viz, Hydro-electric power.

The turbines are classified as Impulse & Reaction types. In impulse turbine, the head of water is completely converted into a jet, which impulses the forces on the turbine. In reaction turbine, it is the pressure of the following water, which rotates the runner of the turbine. Of many types of turbine, the pelton wheel, most commonly used, falls into the category of impulse turbines. While Francis & Kaplan falls in category of reaction turbines.

Normally, Pelton wheel (impulses turbine) requires high head & low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory size turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

Kaplan turbine, the reaction type which is of present concern consists of main components such as propeller (runner) scroll casing and draft tube. Between the scroll casing and the runner, the water turns through right angle into axial direction and passes through the runner and thus rotating the runner shaft. The runner has four blades, which can be turned about their own axis so that the angle inclination may be adjusted while the turbine in motion. When runner blade angles are varied, high efficiency can be maintained over wide range of operating conditions. In the other words even at parts loads, when a low discharge is following through the runner, a high efficiency can be attained in case of Kaplan turbine, whereas this provision does not exist in Francis and propeller turbines where, the runner blade angles are fixed and integral with hub.

The actual experimental facility supplied consists of a centrifugal pump set, turbine unit, sump tank, notch tank arranged in such a way that the whole unit works on re circulating water system. The centrifugal pump set supplies the water from the sump tank to the turbine through gate valve, which has the marking to the meter the known quantity of water. The water after passing through the turbine units enters the collecting tank through the draft tube. The water then flows back to the sump tank through the notch tank with copulate notch for the measurement of flow rate. Additionally, the provision is also made to estimate the rate of flow of water using the “Bend Meter”.

Electrical AC generator connected to lamp tank achieves the loading of the turbine. The provision for; measurement electrical energy AC voltmeter and ammeter turbine speed (digital RPM indicator), Head on the turbine (pressure gauge), are built-in on to the control panel.

PROCEDURE:

1. Keep the gate closed.
2. Keep the electrical load at maximum, by keeping all the switches at ON – position.
3. Press the green button of the supply pump starter and then release.
4. Slowly, open the gate so that turbine rotor picks up the speed and Attains maximum at full opening of thegate**.**
5. Note down the voltage and current, speed, pressure, vacuum on the control panel, head over the notch, and tabulate results.
6. Close the gate & then switch off the supply water pump set.
7. Follow the procedure described below for taking down the reading for evaluating the performance characteristics of the Kaplan turbine.

❖ **TO OBTAIN CONSTANT SPEED CHARACTERISTICS: (Operating Characteristics)**

1. Keep the gate opening at maximum.
2. For different electrical loads on turbine / generator, change the gate position, so that the speed is held constant. Say at 1500 rpm. See that the voltage does not exceed 250V to avoid excess voltage on Bulbs.
3. Reduce the gate opening setting to different position and repeat (2) for

different speed 1500 rpm, 1000 rpm and tabulate the results.

4. The above readings will be utilized for drawing constant speed characteristics
   i. Percentage of full load *Vs* Efficiency.
   ii. Efficiency and BHP *Vs* Discharge characteristics.

- **TO OBTAIN CONSTANT HEAD**

1. Select the guide vane angle position.
2. Keep the gate closed, and start the pump.
3. Slowly open the gate and set the pressure on the gauge.
4. For different electrical loads, change the rotor pitch position and maintain the constant head and tabulate the results given in Table – II.

PERFORMANCE UNDER UNIT HEAD – UNIT QUANTITIES:

In the order to predict the behavior of a turbine working under varying conditions and to facilitate the comparison between the performances of the turbines of the same type but having different outputs and speeds and working under different heads, it is often convenient to express the test results in the terms of certain unit quantities.

PRECAUTIONS:

1. Do not start pump set if the supply voltage is less than 300V
2. To start and stop the supply pump, always keep Gate closed.
3. Gradual opening and closing of the Gate Valve is recommended for smooth operation.
4. Fill the water enough so that the pump does not choke.

Constant Head Characteristics

S.No.	Turbine Speed, N, rpm	Head on Turbine		Net Head on Turbine 'T_h', m of water	Head over Notch 'h' in m of water	Discharge (Flow Rate) 'Q_a' m^3/sec	No. of Bulbs on	No. of Revolution of energy meter, n	Time for n revolution of energy meter, t sec.	Hydraulic input power KW	Turbine Electrical output BP_{elcl}	Turbine output BP_{shaft}	
		Pressure 'P' in Kg/cm^2	Vacuum 'P_v' in $mm\ of\ H_g$										

Constant Speed Characteristics

Turbine Speed in RPM	Head on Turbine		Net Head on Turbine 'H' in *mts*	Head over Notch (Flow Rate), 'h' in *mts*	Discharge (Flow Rate) 'Q' in m^3/sec	Load on Generator		Wattage of Bulb in action	Energy meter reading Time For 5 Rev in sec	HP_{hyd}	BHP	
	Pressure 'P' in Kg/cm^2	Vacuum 'P_v' in *mm of* H_g				'V' Volts	'I' Amps					

Unit Quantities under Unit Head

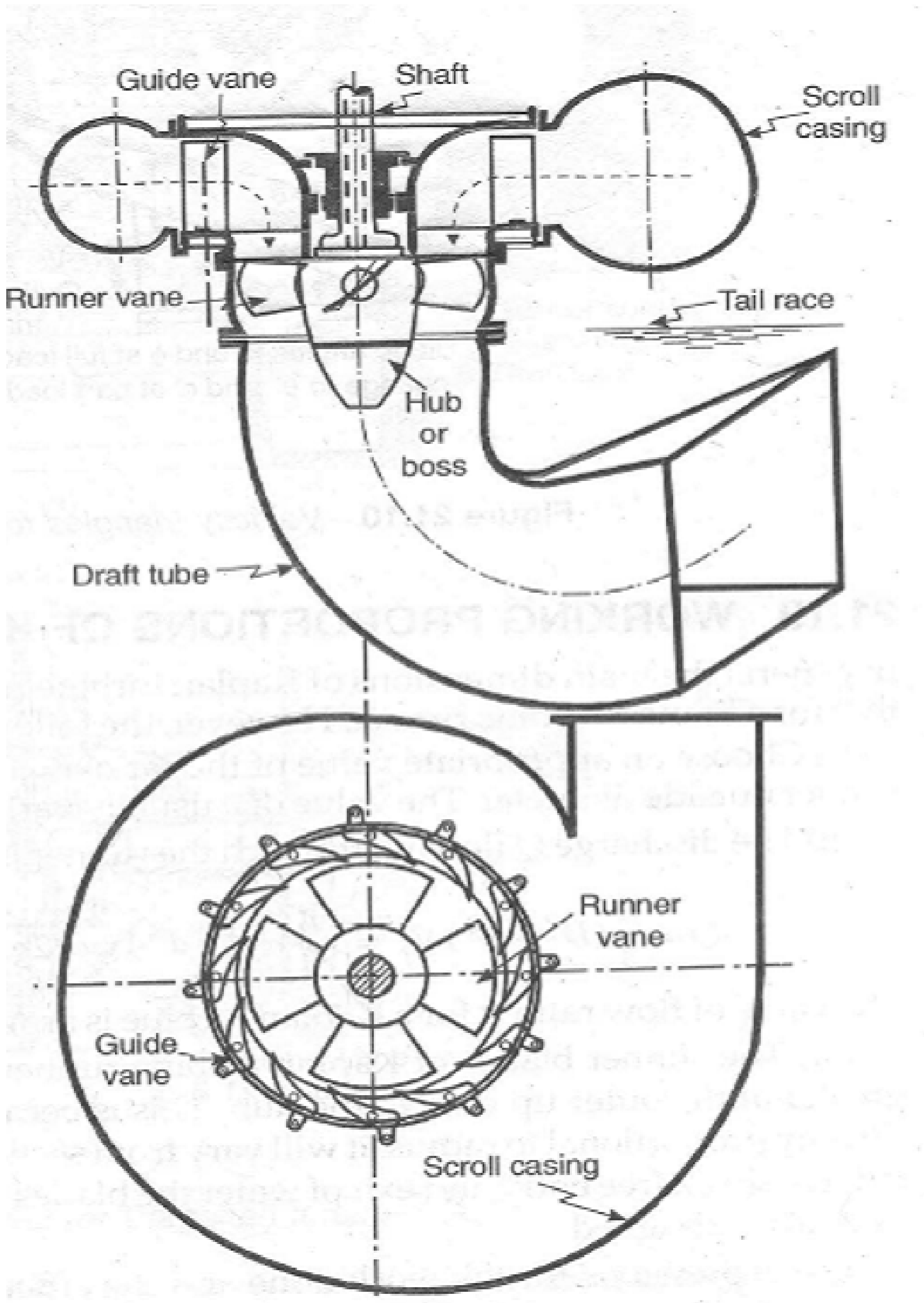
Net Head on Turbine 'H' in mts	Unit Speed N_u	Unit Power P_u	Unit Discharge Q_u	Specific Speed N_s	$\%_{tur}$

GRAPHS:

1. Unit Speed Vs
2. Unit Speed Vs Unit Output power
3. Unit Speed Vs Unit Discharge

RESULT

The efficiency of Kaplan Turbine at constant head =_________



Sectional arrangement of Kaplan turbine

SINGLE STAGE CENTRIFUGAL PUMP

AIM: To determine the efficiency of a single stage centrifugal pump and plot the operating characteristic curves.

THEORY:

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

The centrifugal pump which is of present concern falls into the category of Rotodynamic pumps. In this pump, the liquid is made to rotate in a closed chamber (volute casing) thus creating a centrifugal action which gradually built up the pressure gradient towards outlet, thus resulting in the continuous flow. These pumps compared to reciprocating pumps are simple in construction, more suitable for handling viscous, turbid (muddy) liquids, can be directly coupled to high speed electric motors (without any speed reduction) & easy to maintain. But, their hydraulic heads at low flow rates is limited, and hence not suitable for very high heads compared to reciprocating pump of same capacity. But, still in most cases, this is the only type of pump which is being widely used for agricultural applications because of its practical suitability.

DESCRIPTION :

The present Pump Test Rig is a self-contained unit operated on Closed circuit (Re circulation) basis. The Centrifugal pump, AC Motor, Sump tank, Collecting tank, and Control panel are mounted on rigid frame work with Anti-vibration mounts and arranged with the following provisions:

- For conducting the experiments at three speeds using AC Motor.
- To measure overall input power to the AC motor using Power meter.

- For recording the Pressure & Vacuum.
- For recording the speed using Digital RPM Indicator.
- For changing the Pressure (Delivery Head) and Vacuum (Suction Head) by operating the valves.
- For measuring the discharge by Collecting Tank – Piezo meterprovision.
- For recirculation of water back to the sump tank by overflowprovision.

APPARATUS

- Centrifugal pump
- Collecting tank with piezometer
- Pressure gauge
- Suction gauge
- Stop watch
- Energy meter
- Meter scale

PROCEDURE

Fill in the Sump Tank with clean water.

1. Keep the delivery valve closed and suction valve open, after initially priming the pump.
2. Switch-ON the Mains, so that the Mains-ON Indicator glows. Now, Switch- ON the Starter.
3. Open the delivery valve slightly, so that the delivery pressure is readable.
4. Operate the Butterfly Valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken.
5. Note down the Discharge Pressure, Suction pressure gauge readings
6. Note down Time for 'n' number of revolutions of Energy meter.
7. Repeat the experiment for different openings of the Delivery Valve.
8. After the experiment is over, keep the delivery valve in closed position.

OBSERVATIONS

Energy Meter Constant ,K = 750

Area of Collecting Tank, A = 0.242 m^2

CALCULATION:

- Discharge head (h_d)= p_d x10…........................*m* of water
- Total head (T_h) = $(h_s + h_d)$= .... *m* of water
    - Output Power (Delivered by the Pump)

$$P_{pump}\ (W X Q_a X T_h)$$

1000 = kw

Where, Specific weight of water, W = $9810\ N/m^3$

Q_{act} Actual Discharge.

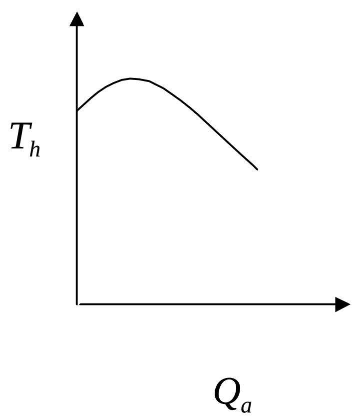
T_h,, Total Head

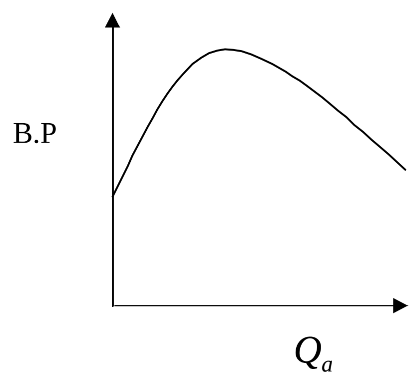
- Pump Efficiency

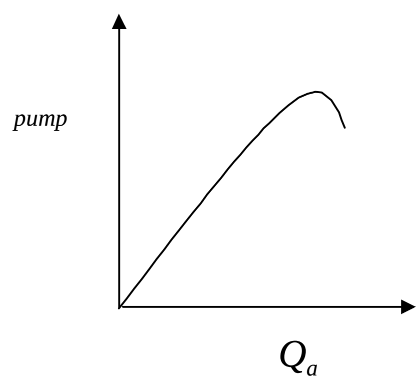
$$\eta_{pump} = \frac{O.P_{pump}}{I.P_{shaft}} \times 100$$

MODEL GRAPHS

1. Discharge Vs Total Head
2. Discharge Vs Pump output
3. Discharge Vs Pump efficiency





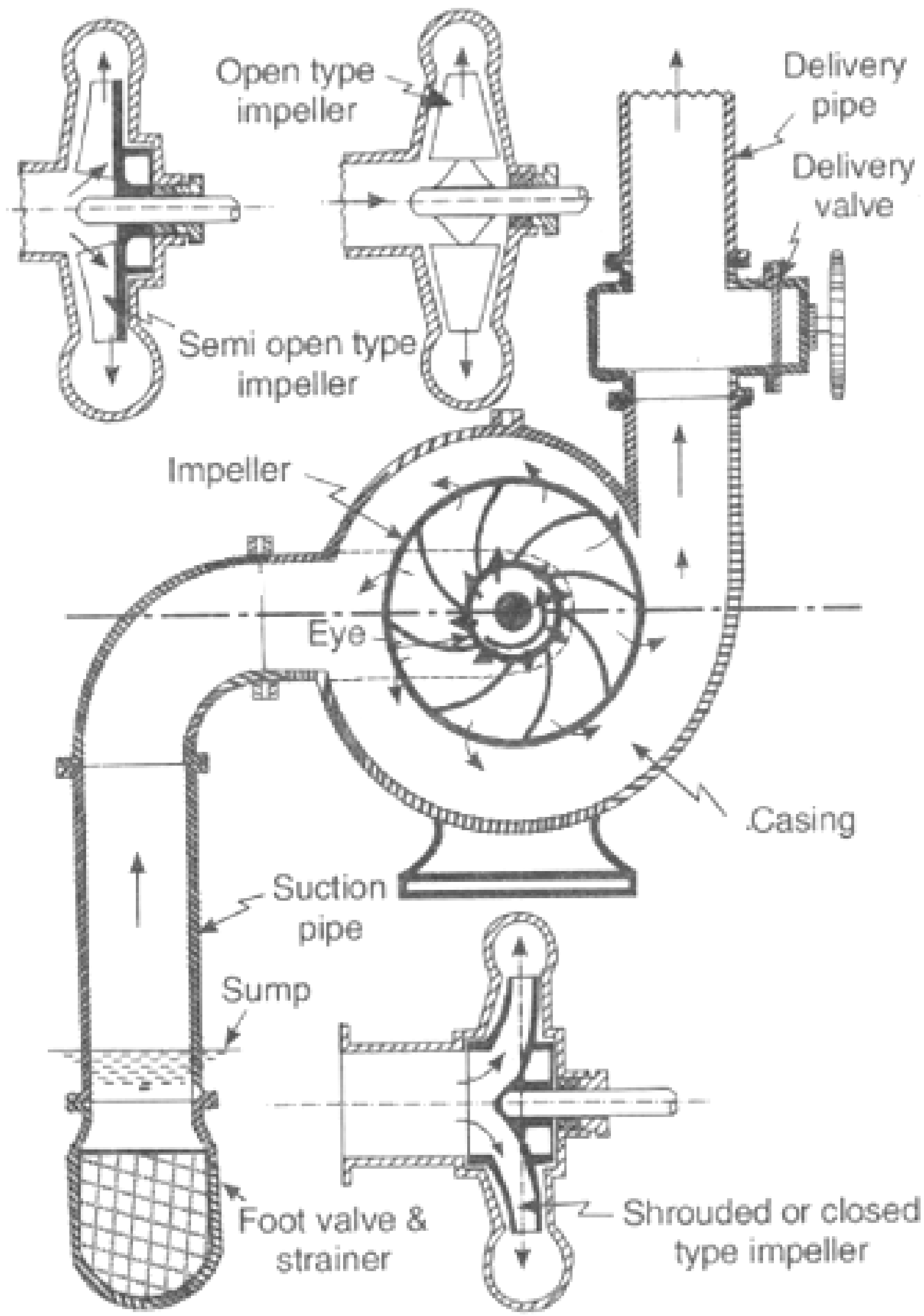


PRECAUTIONS:

- Reading should be taken without any parallax error
- The delivery valves id completely closed before experiment started

RESULT

- The average efficiency of Centrifugal pump=……………



Component parts of a centrifugal pump

MULTI STAGE CENTRIFUGAL PUMP

AIM: To determine the efficiency of a multi stage centrifugal pump and plot the operating characteristic curves.

THEORY:

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

A centrifugal pump consists of an impeller in a volute casing. The impeller has number of vanes (curved) to the eye of the pump a suction pipe is connected. At the other end of this pipe a foot valve with a strainer is connected. The water enters at the centre and flows out ward to the periphery of the impeller. In the delivery side of a pipe a delivery pipe with a valve is fixed. The energy supplied to the motor is measured by means of an energy meter. Suction and delivery pressure gauges are fitted to suction and delivery pipes respectively near the pump.

A centrifugal pump may be driven with a constant speed or a variable speed motor.

The flow rate can be adjusted by operating the valve provided on the delivery pipe line. The pressure drops a cross the pump is measured by the pressure gauges. These centrifugal pumps are coming under rotodynamic pumps type and these centrifugal pumps are used for more discharge and its working on the principle of forced vortex. The main parts are impeller, casing suction pipe with strainer delivery pipe, foot step valve with strainer.

In the case of centrifugal pump, work is done by the impeller on the water. The expression for the work done by the impeller on the water is obtained by drawing velocity triangles at inlet and outlet of the impeller on the same way as for a turbine. The water enters the impeller radially at inlet for best efficiency of the pump. Which means the absolute velocity of water at inlet makes an angle of 90^0 with the direction of motion of impeller at inlet and work done by the impeller

APPARATUS

Centrifugal pump

Collecting tank with piezometer

Pressure gauge

Suction gauge

Stop watch

Energy meter

Meter scale

PROCEDURE

1. Keep the delivery valve in closed and suction valve open position
2. Start the motor
3. Close the delivery valve slightly, so that the delivery pressure is readable.
4. Read the delivery pressure and suction pressure
5. Note down the time taken to 5 revolutions of energy meter
6. Measure the diameter of the collecting tank
7. Collect the water in collecting tank say 1cm or 2cm and note down the initial reading.
8. Collect the water in the collecting tank up to the level more than ¾th of the collecting tank and note down the rise(R) of water level and corresponding time (t)taken to rise that level
9. Operate the delivery valve and change the flow rate
10. Repeat the experiment for different openings of the delivery valve

➢

➢ Measuring tank :

OBSERVATIONS

Diameter of collecting tank (D) =…............................. m

Energy meter constant = ---------------------

CALCULATION:

- Suction head (h_s) = $\frac{S_m \text{ x } p_s}{S_w \text{x} 1000}$ …………… m of water

  S_m = Specific Gravity of mercury = 13.6

  S_w = Specific Gravity of Water = 1

- Discharge head (h_d)= p_d x10…........................ m of water
- Total head (T_h) = $2Xh_s$ x h_d = ... m of water
- Area of collecting tank (A)= $\frac{\pi}{4} D^2$.................................... m^2
- Raise of water level in the collecting tank (R) = ... m
- Volume of water collected in Tank (V) = A x R =................ m^3

Input power (IP)= … kw

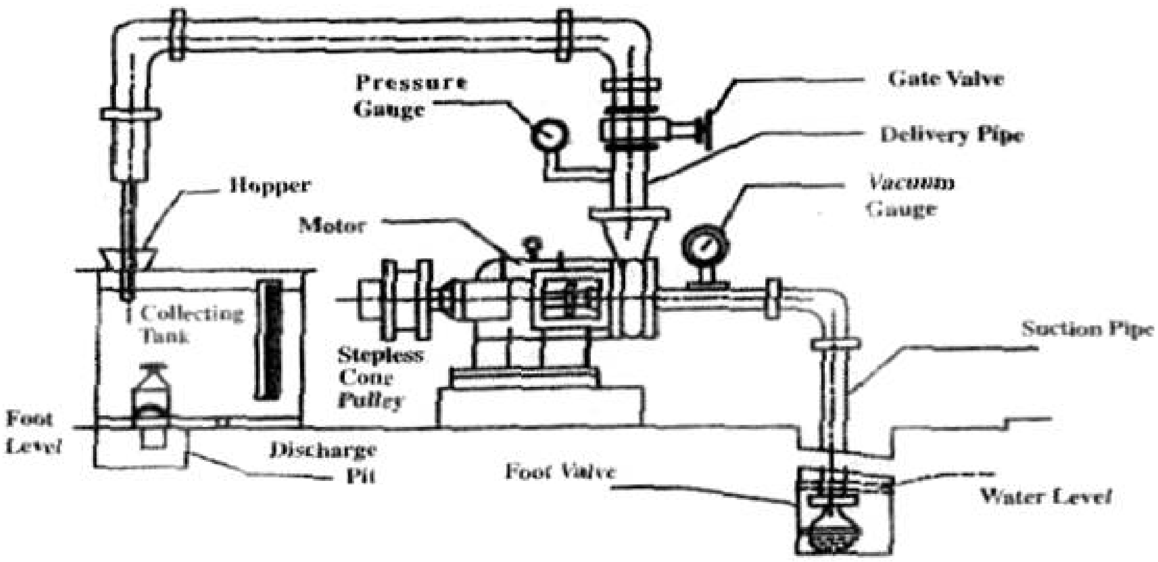
Efficiency of pump ___

PRECAUTIONS :

- Reading should be taken without any parallax error
- The delivery valve is completely opened closed before experiment is started

RESULT

- The average efficiency of multistage Centrifugal pump=……………



MULTI STAGE CENTRIFUGAL PUMP

RECIPROCATING PUMP

AIM: To determine the efficiency of a reciprocating pump and plot the operating Characteristics of the Pump

DESCRIPTION:

Single acting reciprocating pump which consists of a piston which moves forwards and backwards in a close fitting cylinder. The movement of piston is obtained by connecting rod. The crank is rotated by means of electric motor suction and delivery pipes with suction valve are connected to the cylinder the suction and delivery valves are one way or non return valves. Which allow the water to flow in one direction by rotating the crank in the position $\theta = 0^o$ to 180^0 and $180^0 - 360^0$ we get the valves.

$$\text{Discharge (Q)} = \frac{ALN}{60}$$

Work done =

PROCEDURE:

1. Switch on the pump and open the discharge valve of the pump fully
2. After steady state is attained note down the suction pressure and delivery pressure
3. Note down time taken for 20revolutions in the energy meter
4. Measure the diameter of the collecting tank
5. Collect the water in collecting tank say 1 *cm* or 2 *cm* and note down the initial reading.
6. Collect the water in the collecting tank up to the level more than ¾th collecting tank and note down the rise(R) of water level and corresponding time taken to rise that level
7. Operate the delivery valve and change the flow rate
8. Repeat the procedure for different flow rate by regulating discharge valve from maximum to minimum

OBSERVATIONS

Diameter of collecting tank (D) =…..............................m

Energy meter constant , K= --------------------

CALCULATION:

- Suction head (h_s)= $\frac{S_m P_s S_w}{1000}$ …………… m of water

  S_m = Specific Gravity of mercury = 13.6

  S_w = Specific Gravity of Water = 1

- Discharge head (h_d)= P_d x10……………………… m of water
- Total head (T_h)= h_s x h_d = ...m of water
- Area of collecting tank
- Rise of water level in the collecting tank (R) =..................... m
- Volume of water collected in Tank
- Time taken for collecting R m rise of water (t)=…................sec
- Actual discharge Q_a = $\frac{V}{t}$ .... m^3/sec
- Output power (O.P) = $\frac{W Q T_h}{1000}$ ………. kw
- Number of Revolutions of energy meter (n) =
- Time taken for 'n' number of revolutions of the energymeter (t_m)

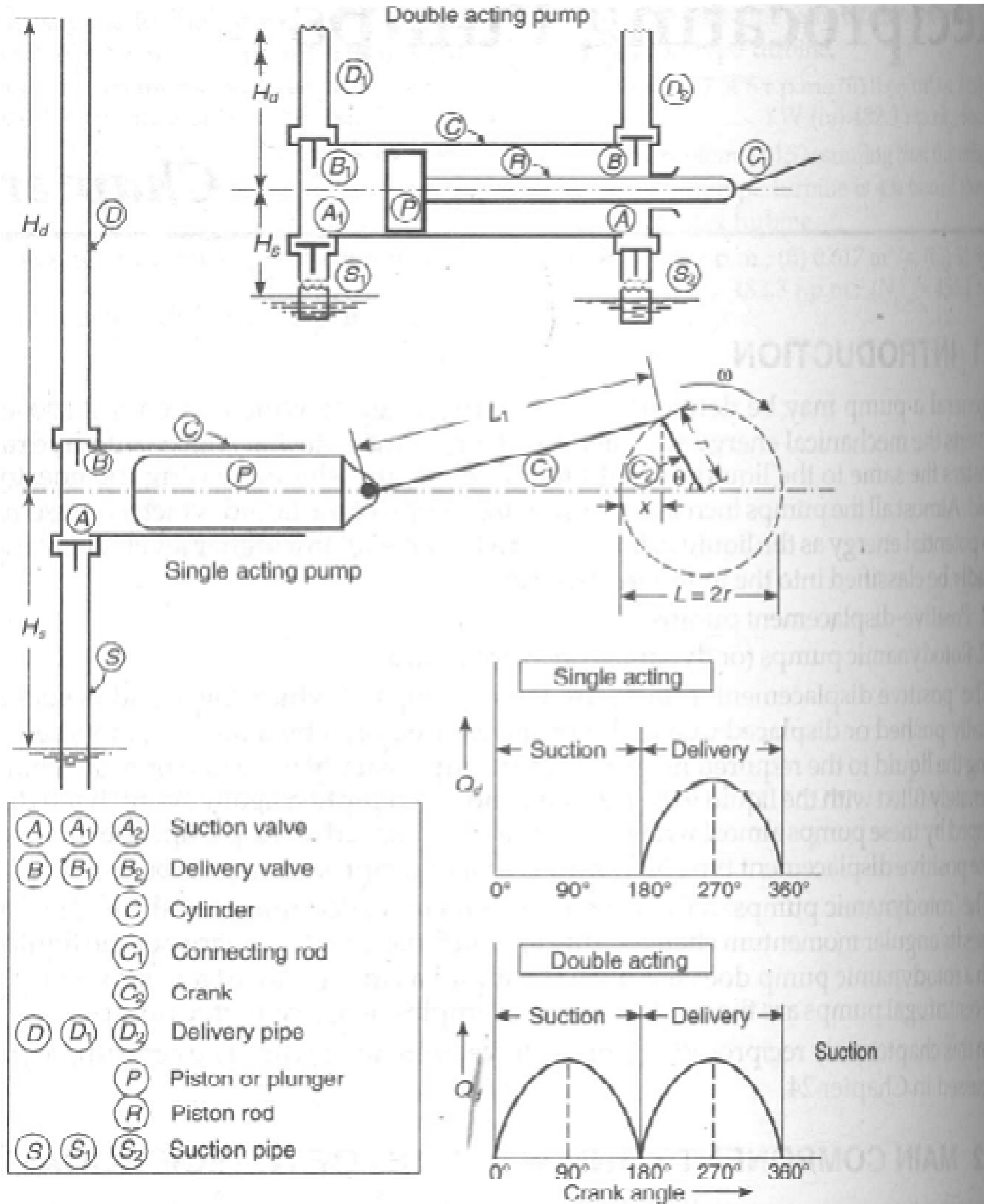
Indicated power(IP)=

PRECAUTIONS :

- Reading should be taken without any parallax error
- The suction and delivery valves are completely opened before experiment started

RESULT

- The average efficiency of Reciprocating pump=……………



Single acting and double acting reciprocating pumps

DETERMINATION OF COEFFICIENT OF DISCHARGE

AIM: Calibrate the given V-notch by establishing the relationship between the flow rate and the head over notch.

PROCEDURE:

1. Fix the notch plate under test at the end of the approach channel in a Vertical plane with the sharp edge on the upstream side.
2. Fill the channel with water upto the crest level and adjust the hook gauge reading to zero.
3. Adjust the by-pass valve to give maximum possible discharge without flooding the notch.
4. Note the final hook gauge reading. This gives the head over the notch 'H'.
5. Collect the water discharging from the notch in the measuring tank of known dimension and measure the rise of water level 'R' in the measuring tank for a known time 't' sec.
6. Conditions are allowed to steady before the head and rise of water level are recorded.
7. Lower the water level in the approach channel in stages by adjusting the flow control valve and record the series of readings 'H', 'R' and 't' at each stage.

OBSERVATIONS & CALCULATIONS:

V NOTCH:

S.NO	Gauge Reading (cm)		Head over Notch in m, H = h1 ~ h2	Time taken for 'R' m rise of water
	h1	h2		

1. Theoretical discharge through V-notch, QTH

Where,

H = height of water surface above the apex of the notch.

(θ/2) = half the notch angle = 30˚

2. Actual Discharge, QA

Where,

A = Area of collecting tank = 0.125 m^2.

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

3. Co-efficient of Discharge, C_d

Where,

QA = Actual Discharge.

QTH = Theoretical Discharge from 'V' Notch.

9. VIVA QUESTION AND ANSWERS

1. Define density or mass density.
Ans: Density of a fluid is defined as the ratio of the mass of a fluid to its volume.
Density, ρ = mass/volume (Kg/m3)
ρwater = 1000 Kg/m3

2. Define specific weight or weight density.
Ans: Specific weight or weight density of a fluid is defined as the ratio between theweight of a fluid to its volume.
Specific weight, γ = weight/volume (N/m3)
γ = ρgγ
Water = 9810 N/m3

3. Define specific volume.
Ans: Specific volume of a fluid is defined as the volume of fluid occupied by an unit wtor unit mass of a fluid.
Specific volume vs = volume/ wt = 1/γ = 1/ρg----- for liquids
Specific volume vs = volume/ mass = 1/ρ----- for gases

4. Define dynamic viscosity.
Ans: Viscosity is defined as the property of fluid which offers resistance to themovement of one layer of fluid over another adjacent layer of the fluid.
duζ = μ ---------dy
μ – dynamic viscosity or viscosity or coefficient of viscosity (N-s/m2)
1 N-s/m2= 1 Pa-s = 10 Poise

5. Define Kinematic viscosity.
Ans: It is defined as the ratio between the dynamic viscosity and density of fluid.
ν = μ/ρ(m2/s)
1 m2 /s = 10000 Stokes(or)1 stoke = 10-4m2/s

6. Types of fluids.
Ans: Ideal fluid, Real fluid, Newtonian fluid, Non-Newtonian fluid, Ideal Plastic fluid.

7. Define Compressibility.
Ans: It is defined as the ratio of volumetric strain to compressive stress.
Compressibility, β = (d Vol/ Vol) / dp(m2/N)

8. Define Surface Tension.
Ans: Surface tension is defined as the tensile force acting on the surface of the liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membrane under tension.
Surface Tension, σ = Force/Length(N/m)
water = 0.0725 N/m
σ of Mercury= 0.52 N/m

9. Differentiate surface tension of different droplets
Ans: Surface tension on liquid droplet,
$\sigma = pd/4$
Surface tension on a hollow bubble,
$\sigma = pd/8$
Surface tension on a liquid jet,
$\sigma = pd/2$

10. What are the components of the pelton wheel?
Ans:

- Nozzle
- Spear
- Runner
- Casing
- Breaking jet.

11. Describe Runner with bucket
Ans: Runner of Pelton wheel consists of a circular disc on the periphery of which a number of buckets evenly spaced are fixed.

12. Define breaking jet.
Ans: When the nozzle is completely closed by moving the spear in the forward direction the amount of water striking the runner reduce 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 providing which directs the jet of water on the back of vanes. This jet of water is called breaking jet.

13. Explain Governing mechanism
Ans: Speed of turbine runner is required to be maintained constant so that electric generator coupled directly to turbine.

14. Describe the working of pelton turbine
Ans: The amount of water striking the vanes (buckets) of the runner is controlled by providing a spear (flow regulating arrangement) in the nozzle. Then the efficient nozzle converts the hydraulic energy into a high speed jet. The turbine rotor is called runner. The impact jet of water is striking on the runner and runner revolves at constant with the help of governing mechanism. The runner shaft is connected with the generator; thus the electricity is produce with the help of generator.

15. Differentiate efficiencies of pelton turbine.
Ans:

- Mechanical efficiencies: – It is ratio of the shaft power to the water power.
- Hydraulic efficiencies: – It is ratio of the power developed at the turbine runner to the power supplied by the water jet at entrance to the turbine.
- Volumetric efficiencies: – It is ratio of the theoretical to the actual discharge.
- Overall efficiencies: – It is ratio of the shaft power to the water power.

16. Describe Kaplan turbine.

Ans: Kaplan-type hydraulic turbine in which the positions of the runner blades and the wicket gates are adjustable for load change with sustained efficiency, it is a purely axial flow turbine with a vertical shaft disposition. Designed and developed by the Australian engineer Viktor Kaplan. Kaplan turbine has adjustable runner blades with less number of blades (i.e. 3 to 8 blades). Kaplan turbines are now widely used throughout the world in high-flow, low-head power production.

17. What are the Components of the Kaplan turbine.

Ans:

- Scroll casing
- Guide vanes
- Draft tube
- Runner
- Hub

18. What is meant by draft tube?

Ans: After passing through the runner, the water is discharged to the tail race through a gradually expanding tube.

19. Explain the working of kaplan turbine

Ans: The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The design combines radial and axial features.

The inlet is a scroll-shaped tube that wraps around the turbine's wicket gate. Water is directed tangentially, through the wicket gate, and spirals on to a propeller shaped runner, causing it to spin. The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy.

The turbine does not need to be at the lowest point of water flow, as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube. The resulting pressure drop may lead to capitation.

20. Mention efficiency of Kaplan turbine.

Ans: Variable geometry of the wicket gate and turbine blades allows efficient operation for a range of flow conditions. Kaplan turbine efficiencies are typically over 90%, but may be lower in very low head applications.

21. What are the applications of Kaplan turbine.

Ans: Kaplan turbines are widely used throughout the world for electrical power production. They cover the lowest head hydro sites and are especially suited for high flow conditions.

Inexpensive micro turbines are manufactured for individual power production with as little as two feet of head.

Large Kaplan turbines are individually designed for each site to operate at the highest possible efficiency, typically over 90%. They are very expensive to design, manufacture and install, but operate for decades.

22. Explain variations of Kaplan turbine

Ans: The Kaplan turbine is the most widely used of the propeller-type turbines, but several other variations exist. Propeller turbines have non-adjustable propeller vanes. They are used in low cost, small installations. Commercial products exist for producing several hundred watts from only a few feet of head.

23. Describe Francis turbine

Ans: The Francis turbine is an inward flow reaction turbine which was designed and developed by the American engineer James B. Francis. Francis turbine has a purely radial flow runner; the flow passing through the runner had velocity component only in a plane of the normal to the axis of the runner. Reaction hydraulic turbines of relatively medium speed with radial flow of water in the component of turbine are runner.

24. Mention some of the Components of the Francis turbine.

Ans: Pen stoke, Scroll casing, Guide vanes, Runner and runner blades, Draft tube

25. What is penstock

Ans: It is a large sized shaped; where the water is provided to the turbine runner from the dam.

26. Elaborate governing mechanism of guide wheel

Ans: It changes the position of guide blades to affect variation in the water flow rate in the wake of changing load conditions on the turbine. When the load changes, the governing mechanism rotates all the guide blades about their axis through the same angle so that the water flow rate to the runner.

27. What is draft tube?

Ans: After passing through the runner, the water is discharged to the tail race through a gradually expanding tube.

28. Explain Working of Francis Turbine

Ans: The amount of water falls on the vanes (buckets) of the runner. The turbine rotor is called runner. Runner revolves at constant with the help of governing mechanism. The runner shaft is connected with the generator; thus the electricity is produce with the help of generator. And the water is discharge from the tail race.

29. Explain the theory of operation of Francis turbine

Ans: The Francis turbine is a reaction turbine, which means that the working fluid changes pressure as it moves through the turbine, giving up its energy. A casement is needed to contain the water flow. The turbine is located between the high pressure water source and the low pressure water exit, usually at the base of a dam.

The inlet is spiral shaped. Guide vanes direct the water tangentially to the runner. This radial flow acts on the runner vanes, causing the runner to spin. The guide vanes (or wicket gate) may be adjustable to allow efficient turbine operation for a range of water flow conditions.

As the water moves through the runner its spinning radius decreases, further acting on the runner. Imagine swinging a ball on a string around in a circle. If the string is pulled short, the ball spins faster. This property, in addition to the water's pressure, helps inward flow turbines harness water energy.

At the exit, water acts on cup shaped runner features, leaving with no swirl and very little kinetic or potential energy. The turbine's exit tube is specially shaped to help decelerate the water flow and recover kinetic energy.

30. What are the applications of Francis Turbine?

Ans: Francis Inlet Scroll, Grand Coulee Dam Large Francis turbines are individually designed for each site to operate at the highest possible efficiency, typically over 90%. They are best suited for sites with high flows and low to medium head. Francis Turbines are very expensive to design, manufacture and install, but operate for decades.

In addition to electrical production, they may also be used for pumped storage; where a reservoir is filled by the turbine (acting as a pump) during low power demand, and then reversed and used to generate power during peak demand.

Francis turbines may be designed for a wide range of heads and flows. This, along with their high efficiency, has made them the most widely used turbine in the world.