# Department
# Mechanical Engineering

## Lab Manual
# Fluid Machinery Lab

## B.Tech-VI Semester

# KCT COLLEGE OF ENGG. & TECH.
## VILLAGE FATEHGARH
### DISTT.SANGRUR

**EXPERIMENTS**

1. Conducting experiments and drawing the characteristic curves of Centrifugal pump Submergible pump.
2. Conducting experiments and drawing the characteristic curves of reciprocating pump.
3. Conducting experiments and drawing the characteristic curves of Gear pump.
4. Conducting experiments and drawing the characteristic curves of Pelton wheel.
5. Conducting experiments and drawing the characteristics curves of Francis turbine.
6. Conducting experiments and drawing the characteristic curves of Kaplan turbine.

# Experiment No:1

# Performance Test on Single Stage Centrifugal Pump

**Aim**

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

**Apparatus**

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

**Theory**

Centrifugal pumps are classified as rotodynamic 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. Now if more liquid is constantly made available at the center of rotation, a continuous supply of liquid at a higher level may be ensured. Since in these pumps the lifting of the liquid is due to centrifugal action, these pumps are called 'centrifugal pumps'. In addition to the centrifugal action, as the liquid passes through the revolving wheel or impeller, its angular momentum changes, which also results in increasing the pressure of the liquid. The main advantage of a centrifugal pump is that its discharging capacity is very much greater than that of a reciprocating pump which can handle relatively small quantity of liquid only. A centrifugal pump can be used for lifting highly viscous liquids such as oils, muddy and sewage water, paper pulp, sugar molasses, chemicals etc. A centrifugal pump can be operated at very high speeds with out any danger of separation and cavitation.

**Description of setup**

The experimental set up consists of centrifugal pump with electrical driving unit. The main component parts of centrifugal pump are impeller, casing, suction pipe and delivery pipe. Impeller is a wheel or rotor, which is provided with a series of backward, curved blades or vanes. It is mounted on a shaft, which is coupled to an external energy to the impeller thereby making it to rotate. Casing is an airtight chamber that surrounds the impeller. Suction pipe is a pipe that is connected at its upper end to the inlet of the pump or to the center of the impeller, which is commonly known as eye. The lower end of the suction pipe dips into liquid in a suction tank or a sump from which the liquid is to be pumped or lifted up. The lower end of the suction pipe is fitted with foot valve and strainer. The lower end of delivery pipe is connected to the outlet of pump. The upper end delivers the liquid to the required height. On the delivery pipe, a pressure gauge is fitted to measure the delivery pressure.

**Formulae**

% Efficiency of the pump $= \frac{P_0}{P_i} x100$

Output power from the pump $P_o = \omega Q_a H_p$ Watts

Where $\omega$ - Specific weight of water (9810 $N/m^3$)
- $Q_a$ - Actual discharge from the pump ($m^3/s$)
- $H_p$ - Total head in metres of water

Actual discharge $Q_a = \frac{AH}{t}$
- A - Area of the collecting tank in plan (Inner width x inner length) ($m^2$)
- H - Rise of the liquid in collecting tank (m)
- t - Time taken for 5 cm rise of liquid in the collecting tank (s)

Total head $H_p = H_s + H_d + x$
- $H_s$ = Suction head in metres of water
- $H_d$ = Delivery head in metres of water
- x = Difference in level between the centers of suction and pressure gauges.

Input power to the motor $P_i = \frac{3600 N_r}{N_e T} x1000$ watts
- $N_e$ - Energy meter constant in revolutions per kilo watt hour
- $N_r$ - Number of revolution in the energy meter disc
- T - Time taken for $N_r$ revolutions in the energy meter (s)

Specific Speed $N_s = \frac{N\sqrt{Q_a}}{H_p^{3/4}}$

N - Speed of the pump in rpm
$Q_a$ - Actual discharge corresponding to the maximum efficiency ($m^3/s$)
$H_p$ - Total head in metres of water corresponding to maximum efficiency

**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 discharge 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 $N_r$ revolutions of 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.

**Observation**

Speed of the pump = Energy
meter constant=
Internal plan dimensions of the collecting tank
Length l
=Breadt
h b =
Difference in level between the centers of vacuum and pressure gauge x in m

**Observation Table**

| Sl No. | Suction Head ($H_s$) | Delivery Pressure ($H_d$) | Time taken for $N_r$ revolution of energy meter disc | Time taken for 5 cm rise of liquid in the collecting tank |
|---|---|---|---|---|
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| 23456 | | | | |

**Calculation Table**

| Sl. No. | Total Head $H_p$ | Actual Discharge ($Q_a$) | Input Power | Output Power | Efficiency |
|---|---|---|---|---|---|

**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.

**Result**

The pump performance curves are drawn. The best driving condition is obtained corresponding to the maximum efficiency.

Maximum efficiency (η) =Head
($H_p$) =
Discharge (Q) =
Output power =
Specific Speed ($N_s$) =

## Experiment No:2

## Performance Test on Reciprocating Pump

**Aim**

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

**Apparatus**

1. Reciprocating pump with driving unit  2. Pressure gauges
3. Stop watch  4. Collecting tank  5. Metre scale  6. Techometer

**Theory**

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

**Description of setup**

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.

**Formulae**

% Efficiency of the pump = $\frac{P_0}{P_i} x100$

Output power from the pump $P_o = \omega Q_a H_p$ Watts

Where $\omega$ - Specific weight of water (9810 N/m$^3$)

$Q_a$ - Actual discharge to the turbine (m$^3$/s)

$H_p$ - Total head in metres of water

Actual discharge $Q_a = \frac{AH}{t}$

A - Area of the collecting tank in plan (Inner width x inner length) (m$^2$)

H - Rise of the liquid in collecting tank (m)

t - Time taken for 5 cm rise of liquid in the collecting tank (s)

Total head $H_p = H_s + H_d + x$

$H_s$ = Suction head in metres of water
$H_d$ = Delivery head in metres of water
x = Difference in level between the centers of suction and pressure gauges.

Input power to the motor $P_i = \frac{3600 N_r}{N_e T} x 1000$ watts

$N_e$ - Energy meter constant in revolutions per kilo watt hour
$N_r$ - Number of revolution in the energy meter disc
T - Time taken for $N_r$ revolutions in the energy meter (s)

Theoretical discharge $Q_t = \frac{naNl}{60}$

N - Number of strokes
A - Cross sectional area of the cylinder in $m^2$

$$A = \frac{\pi d^2}{4}$$

d - Diameter of the cylinder in (0.045 ) m
l - Length of the stroke (0.045 m)
N - Crank speed in rpm

$$\% \, Slip = \frac{(Q_t - Q_a)}{Q_t} x100$$

Co-efficient of discharge $C_d = \frac{Q_a}{Q_t}$

**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 $N_r$ revolutions 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.

**Observation**

Energy meter constant =
Internal plan dimensions of the collecting tank
Length l
=Breadt
h b =
Difference in level between the centers of vacuum and pressure gauge x in m

**Graph**

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

**Result**

The pump characteristic curves are drawn. The best driving condition is obtained corresponding to the maximum efficiency.

Maximum efficiency (η) =
At maximum efficiency
Head ($H_p$) =
Discharge (Q) =

Output power

=Maxi

mum Slip =

## Performance Test on Gear Pump

### Aim

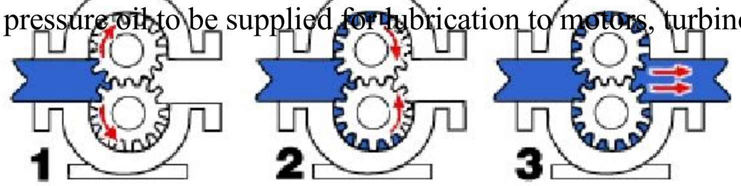
To determine the best driving conditions of the gear oil pump at constant speed and to draw the characteristic curves.

### Apparatus

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




### Formulae

% Efficiency of the pump $= \frac{P_0}{P_i} x100$

Output power from the pump $P_o = \omega Q_a H_p$ Watts

Where $\omega$ - Specific weight of oil (0.8 x 9810 N/m$^3$)

$Q_a$ - Actual discharge from the pump (m$^3$/s)

$H_p$ - Total head in metres of oil

Actual discharge $Q_a = \frac{AH}{t}$

A - Area of the collecting tank in plan (Inner width x inner length) (m$^2$)

H - Rise of the liquid in collecting tank (m)

t - Time taken for 5 cm rise of liquid in the collecting tank (s)

Total head $H_p = H_s + H_d + x$

$H_d$ = Delivery head in metres of oil
x = Difference in level between the centers of suction and pressure gauges.

Input power to the motor $P_i = \frac{3600 N_r}{N_e T} x 1000$ watts

$N_e$ - Energy meter constant in revolutions per kilo watt hour
$N_r$ - Number of revolution in the energy meter disc
T - Time taken for $N_r$ revolutions in the energy meter (s)

Specific Speed $N_s = \frac{N\sqrt{Q_a}}{H_p^{\frac{3}{4}}}$

N - Speed of the pump in rpm
$Q_a$ - Actual discharge corresponding to the maximum efficiency ($m^3/s$)
$H_p$ - Total head in metres of water

**Procedure**

The pump is switched on. By adjusting the delivery valve, the pressure gauge is set. For this particular pressure gauge reading the time taken T for $N_r$ revolution in the energy meter, time taken t for a particular volume in the collecting tank and the vacuum gauge reading are recorded. The experiment is repeated for different delivery pressures and the observations are tabulated. The internal plan dimension of collecting tank and energy meter constant are noted.

**Observation**

Speed of the pump = rpm Energy meter constant= rev./ kwhr Internal plan dimensions of the collecting tank Length l = mBreadth b = m
Difference in level between the centers of vacuum and pressure gauge x in m

**Observation Table**

| Sl No. | Suction Head ($H_s$) M of oil | Delivery Pressure ($H_d$) kg / m² | Time taken for $N_r$ revolution of energy meter disc s | Time taken for 5 cm rise of liquid in the collecting tank s |
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**Calculation Table**

| Sl. No. | Total Head $H_p$ | Actual Discharge ($Q_a$) | Input Power | Output Power | Efficiency |
|---|---|---|---|---|---|
| | m | $m^3/s$ | Watts | Watts | % |
| 1 | | | | | |
| | | | | | |
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## Graph

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

**Graph Table**

| Sl. No. | X-axis Head in m | Y-axis Actual Discharge | | |
|---|---|---|---|---|
| | | Actual Discharge ($Q_a$) | Output power (Watts) | Efficiency (%) |
| 1 | | | | |
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## Result

The pump performance curves are drawn. The best driving condition is obtained corresponding to the maximum efficiency.

Maximum efficiency (η) = %

At maximum efficiency

Head ($H_p$) = m

Discharge (Q) = $m^3/s$

Output power = Watts

Specific Speed ($N_s$) = SI units

# Experiment No:3

## Performance Test on Pelton Wheel Turbine

### Aim

To study and draw the characteristic curves and also to determine the specific speed $N_s$ at (a) constant gate opening, (b) with variable speed.

### Apparatus

| | | |
|---|---|---|
| 1. Pelton wheel unit | 2. Supply pump | 3. Venturimeter |
| 4. Brake drum | 5. Tachometer | 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 Peltonwheel 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. A rope is wound round the brake drum with its upper and by screw with a spring balance. A load hanger is attached to the lower end. Power developed by the turbine shaft is absorbed by the friction offered by the rope under tension wound round the brake drum.

### Formulae

Actual discharge to the turbine = $KC\, h$

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

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

% Efficiency of the turbine = $\dfrac{P_0}{P_i} x100$

Input power to the turbine $P_i = \omega Q_a H$ Watts

Where ω - Specific weight of water

$Q_a$ - Actual discharge to the turbine

H - Net supply head

Output power from the turbine $P_o = \dfrac{2\pi NT}{60}$

Where T - Torque developed = $(W_B - S)\left(\dfrac{D+d}{2}\right)$

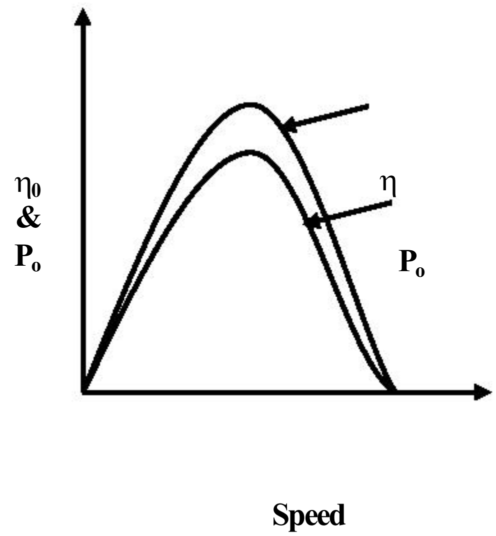
N - Speed of the shaft in rpm

D - Diameter of the brake drum in m

d - Diameter of the rope

S - Spring balance reading in N

$W_B$ - Total break load in N




Characteristic curves

Specific Speed $N_s = \dfrac{N\sqrt{P_o}}{H^{\frac{5}{4}}}$

$P_o$ - Maximum output power in kw

N - Speed corresponding to maximum output power in rpm

H - Head corresponding to maximum output power in metre

Speed ratio $N_r = \dfrac{\pi DN}{60\sqrt{2gH}}$

N - Speed in rpm corresponding to maximum output power

H - Head corresponding to maximum output power in metres

**Procedure**

1. The supply pump is first started with the discharge valve completed closed
2. Full gate opening is set by means of spear wheel
3. The delivery valve is opened and set to a suitable position so as to attain a design head
4. Keeping it intact, different loads on turbine shaft, are applied. Each time, the following observations are recorded.
   i) Manometer reading $h_1$ and $h_2$
   ii) Shaft speed (N rpm)
   iii) Dead weight on the load hanger ($W_B$)
   iv) Spring balance reading (S)

The same procedure is repeated for different gate openings. The observations are tabulated.

**Observation**

Diameter of the brake drum (D) =

Diameter of the rope (d) =

Weight of lad hanger and rope =

**Observation Table**

| Sl. No. | Manometer reading | | Pressure Gauge reading | Dead weight on load hanger | Spring balance reading | Shaft speed (N) |
|---|---|---|---|---|---|---|
| | $h_1$ | $h_2$ | | | | |
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**Calculation Table**

| Sl. No. | Venturihead | Head over turbine | Discharge | Input power | Total brake load | Torque | Output power | Efficiency |
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**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.

**Result**

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

i) Maximum efficiency = %
ii) Maximum output power = Watts
iii) Maximum Speed = rpm
iv) Specific Speed = SI units

**Experiment No:4**

# Performance Test on Francis Turbine

**Aim**

To study and draw the characteristic curves and also to determine the specific speed $N_s$ at (a) constant gate opening, (b) with variable speed.

**Apparatus**

1. Francis wheel unit 2. Supply pump 3. Venturimeter
4. Brake drum 5. Tachometer 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. Pressure gauge and vacuum gauge are set to measure the heads at certain points. The supply to the turbine is effected by means of a centrifugal pump. The discharge passing into the turbine is measured by a venturimeter. The difference in pressure is measured by a differential manometer.

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.

For any particular setting of the guide vanes, first the turbine is run for sometime at a light load. Then the brake loading is gradually increasing by adding dead weights on the load hanger. The net supply head on the turbine can be maintained constant at the required value by adjusting the discharge valve of the pump.

**Formulae**

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

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

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

% Efficiency of the turbine $= \frac{P_0}{P_i} x100$

Input power to the turbine $P_i = \omega Q_a H$ Watts

Where $\omega$ - Specific weight of water

$Q_a$ - Actual discharge to the turbine

H - Net supply head

Output power from the turbine $P_o = \frac{2\pi NT}{60}$

Where T - Torque developed $= (W_B - S)\frac{(D+d)}{2}$

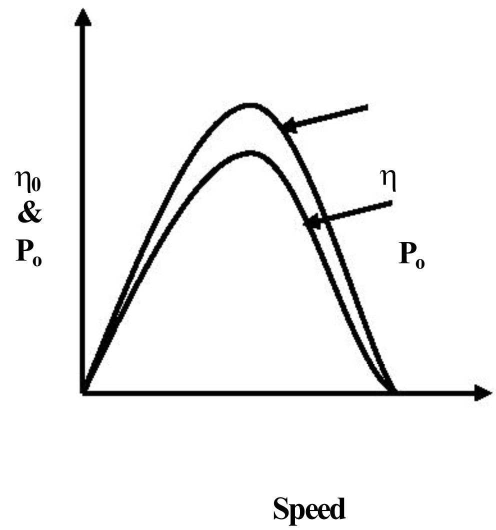
N - Speed of the shaft in rpm

D - Diameter of the brake drum in m

d - Diameter of the rope

S - Spring balance reading in N

$W_B$ - Total break load in N




**Characteristic curves**

Specific Speed $N_s = \frac{N\sqrt{P_o}}{H^{\frac{5}{4}}}$

$P_o$ - Maximum output power in kw

N - Speed corresponding to maximum output power in rpm

H - Head corresponding to maximum output power in metre

Unit speed of the turbine $N_u = \frac{N}{\sqrt{H}}$

Unit power of turbine $P_u = \frac{P_o}{H^{\frac{3}{2}}}$

Where, $P_o$ = Maximum output power in watts

N = Speed corresponding to maximum output power in rpm

H = Total head corresponding to maximum output power in m

**Procedure**

1. The supply pump is first started with the discharge valve completed closed
2. Full gate opening is set by means of spear wheel
3. The delivery valve is opened and set to a suitable position so as to attain a design head
4. Keeping it intact, different loads on turbine shaft, are applied. Each time, the following observations are recorded.

   Manometer reading $h_1$ and $h_2$

   Shaft speed (N rpm)

   Dead weight on the load hanger ($W_B$)

   Spring balance reading (S)

The same procedure is repeated for different gate openings. The observations are tabulated.

**Observation**

Diameter of the brake drum (D) =Diameter of the rope (d) =Weight of lad hanger and rope =

**Observation Table**

| Sl. No. | Manometer reading | | Pressure Gauge reading | Dead weight on load hanger | Spring balance reading | Shaft speed (N) |
|---|---|---|---|---|---|---|
| | $h_1$ | $h_2$ | | | | |
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**Calculation Table**

| Sl. No. | Venturihead | Head over turbine | Discharge | Input power | Total brake load | Torque | Output power | Efficiency |
|---|---|---|---|---|---|---|---|---|
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| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |

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**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.

**Result**

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

1. Maximum efficiency =
2. Maximum output power =
3. Maximum Speed =4.

Specific Speed =5.

Unit speed =6.

Unit power =

## Experiment No:5

## 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

1. Kaplan turbine set up
2. Centrifugal pump
3. Sump tank
4. Collecting Tank
5. Notch 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 or boss are 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. When both guide-vane angle and runner-blade angle may thus be varied, a high efficiency can be maintained over a wide range of operating conditions. The outlet of turbine is connected to a draft tube. The quantity of discharge can be measured with the help of a rectangular notch provided. 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.

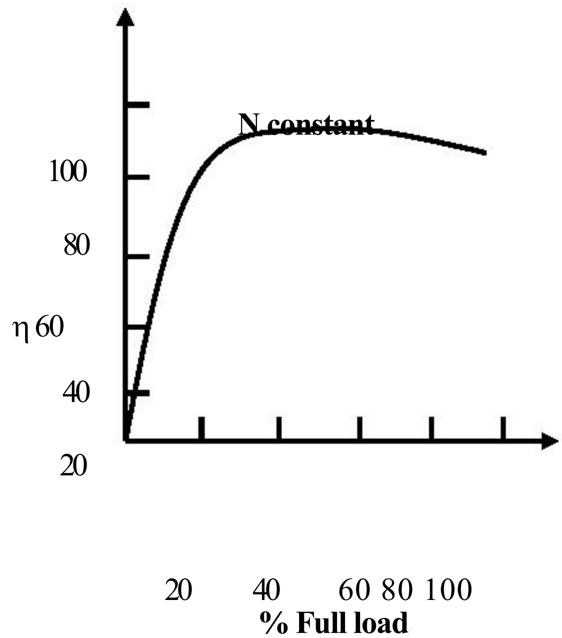
### Procedure

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.

**Observations**

Energy meter constant (Ne) =
Initial hook gauge reading ($h_1$) =
Alternator efficiency = 0.85
Coefficient of discharge of the notch = 0.60
Final hook gauge reading =
Width of the notch (b) = 0.5 m




**Characteristic curve**

**Formulae**

$$Actual\ discharge\ (Q) = \frac{2}{3} C_d\, b \sqrt{2g}\, h^{3/2}$$

$$Input\ Power\ (P_i) = \omega Q H\ watts$$

$$Output\ Power\ (P_o) = \frac{3600 \times N_r \times 1000}{N_e \times T \times 0.85}\ watts$$

$$\%\ Efficiency\ (\eta) = \frac{P_0}{P_i} \times 100$$

$$Specific\ Speed\ (N_s) = \frac{N\sqrt{P_o}}{H^{5/4}}\ \text{(SI unit)}$$

[Substitute **N** in rpm, $\mathbf{P_0}$ in kw and **H** in metres to determine Specific speed of the turbine]
(Note: The specific speed of a turbine is the speed in rpm of a turbine geometrically similar to the actual turbine but of such a size that under corresponding conditions it will develop 1 metric horse power when working under unit head.)

**Observation Table**

| Sl. No. | Butterfly Valve opening | Turbine Speed | Pressure on turbine | Head over the notch | Alternator output voltage | No. of bulbs in action | Time take for '$N_r$' revolution |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | 1.0 | | | | | 5 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | 1.0 | | | | | 3 | |
| | 1.0 | | | | | 2 | |
| 2 | 0.75 | | | | | 3 | |
| | 0.75 | | | | | 23 | |
| | 0.5 | | | | | 2 | |
| | 0.5 | | | | | 1 | |

**Calculation Table**

| | | | | |
|---|---|---|---|---|
| Sl. No. | Discharge (Q) | Input Power | Output power | Efficiency |
| | | | | |
| 1 | | | | |
| 234567 | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Graph**

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

**Result**

The best driving conditions of the given Kaplan turbine for maximum efficiency are:
Maximum Efficiency
=Maxi
mum output power
=Maxi
mum head
=Speci
fic speed =