LIST OF EXPERIMENTS

FLUID MACHINES LAB **UME-302**

1. To study the constructional details of a Pelton turbine and draw its fluid flow circuit.
2. To draw the performance characteristics of Pelton turbine constant head, constant speed and constant efficiency.
3. To study the constructional details of a Francis turbine and draw its fluid flow circuit.
4. To draw the constant head, constant speed and constant efficiency performance characteristics of Francis turbine.
5. To study the constructional details of a Kaplan turbine and draw its fluid flow circuit.
6. To draw the constant head, speed and efficiency curves for a Kaplan turbine.
7. To study the constructional details of a Centrifugal Pump and draw its characteristic curves.
8. To study the constructional details of a Reciprocating Pump and draw its characteristic curves.
9. To study the constructional details of a Hydraulic Ram and determine its various efficiencies.

EXPERIMENT NO: - 01

OBJECTIVE

To study the constructional details of a Pelton Turbine and draw its fluid flow circuit.

APPARATUS

Pelton turbine test rig.

DESCRIPTION

The Pelton wheel turbine is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. All the available energy of water is converted into kinetic energy or velocity head by passing it through a contracting nozzle provided at end of the penstock. This turbine is used for high head and is named after the American engineer Lester Pelton.

CONSTRUCTION DETAILS OF PELTON TURBINE

Components of the Pelton turbine are:-

1. **Penstock: -** It is large sized pipeline through which the water is provided to the turbine runner from the dam.
2. **Nozzle: –** it is the device provided at the end of the penstock which directs the water from penstock in the form of a stream (Called Jet of water) to the turbine runner.
3. **Spear: –** 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 pushed back, the amount of water striking the runner increased.
4. **Runner with bucket: –** Runner of Pelton wheel 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 symmetrical parts by a dividing wall which is known as splitter.

5. **Casing: –** The function of casing is to prevent the splashing of the water and to discharge water to tail race. It also acts as safeguard against accidents. It is made up of cast iron or fabricated steel plate. The casing of steel plate does not perform any hydraulic function.
6. **Breaking jet: –** 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 to 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 vanes. This jet of water is called breaking of jet.

DIAGRAM

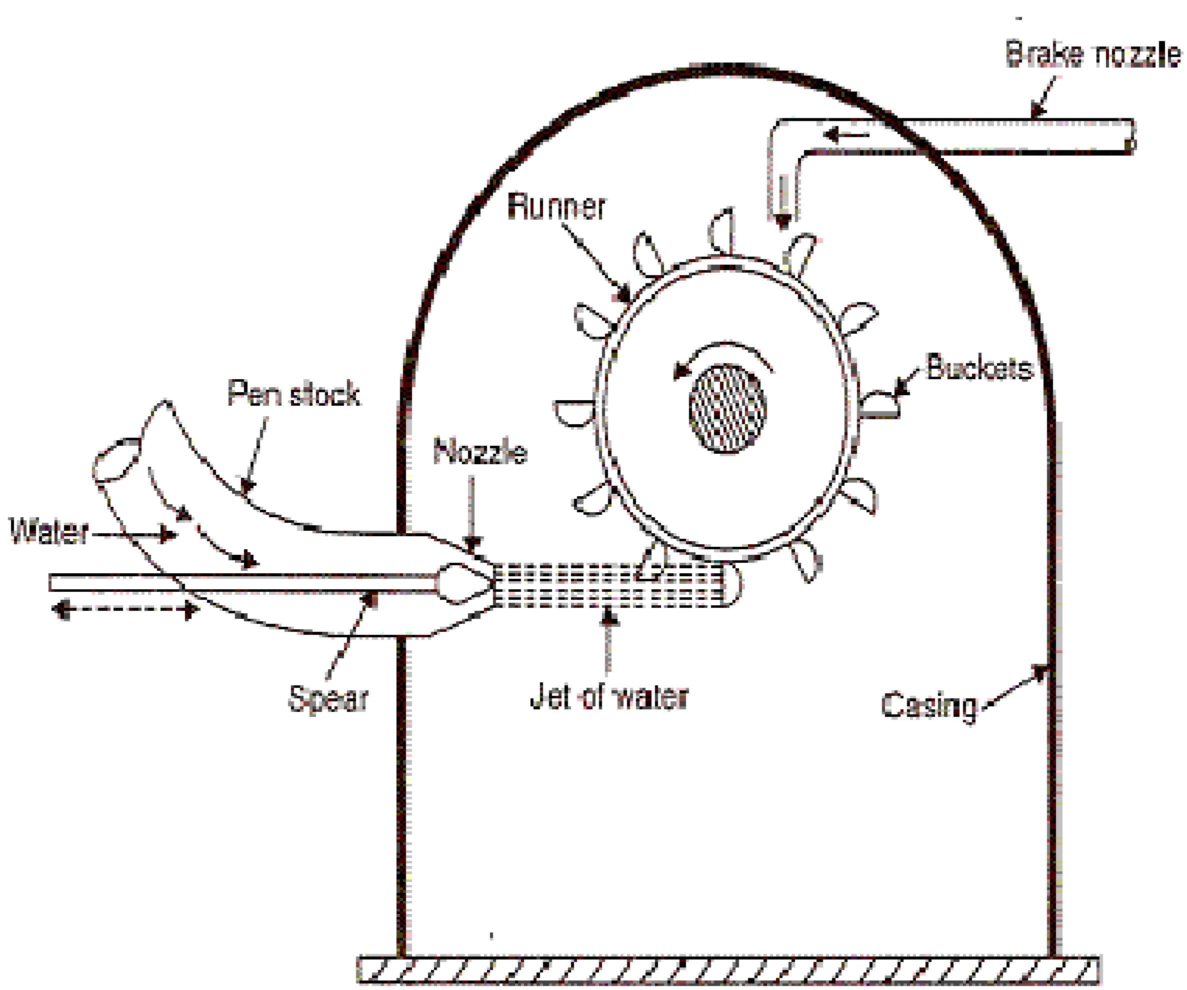


Figure 1.1 Schematic diagram of Pelton turbine

WORKING OF PELTON TURBINE

Water from the dam is provided to the turbine with the help of penstock through a nozzle which directs a jet of water on the buckets mounted on runner wheel which starts moving along the direction of jet by using the kinetic energy of jet and buckets comes in contact with jet one by one thus turbine starts running at constant speed.

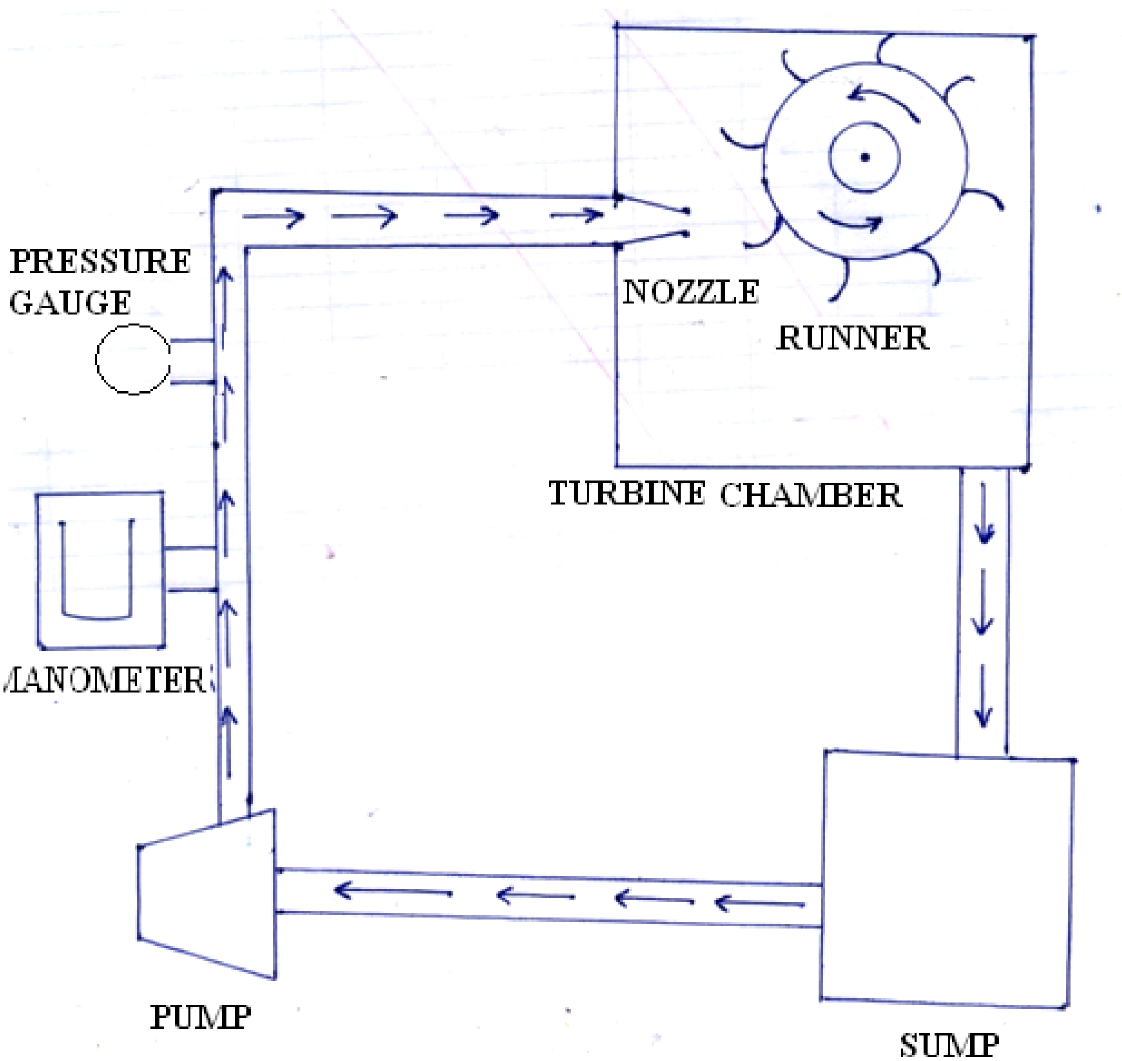


Figure 1.2 Fluid flow circuit for Pelton turbine.

EXPERIMENT NO: - 02

OBJECTIVE

To draw the performance characteristics of Pelton Turbine constant head, constant speed and constant efficiency.

APPARATUS

Peltonturbine test rig, stop watch, tachometer, and engineering scale.

SPECIFICATIONS

Type	: Centrifugal high speed, single suction, volute casing
Power required	: A. C. 5HP, 3 Phase, 420 Volts.
Speed	: 2870 rpm
Spring balance	: 25 Kg
No of buckets	: 14 no
Rated speed	: 1000 rpm
Power output	: 1.0 kilowatt
Flow measurement	: Pitot tube
Pressure gauge	: Bourdon type.
Control panel comprises of	
MCB	: For overload protection.

Standard make on/off switch, mains indicator, etc. the whole set-up is well designed and arranged in a good quality painted structure.

DESCRIPTION

The Pelton wheel turbine is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. All the available energy of water is converted into kinetic energy or velocity head by passing it through a contracting nozzle provided at end of the penstock. This turbine is used for high head and is named after the American engineer Lester Pelton.

THEORY

We know that Pelton Turbine is impulse turbine and in an impulse turbine, all the available energy of water is converted into kinetic energy by passing it through a contracting nozzle provided at the end of the penstock. The water coming out of the nozzle is formed into a free jet which impinges on a series of buckets of the runner thus causing it to revolve. The runner revolves freely in air. The water is contact with only a part of the runner at a time, and throughout its action on the runner.

DIAGRAM

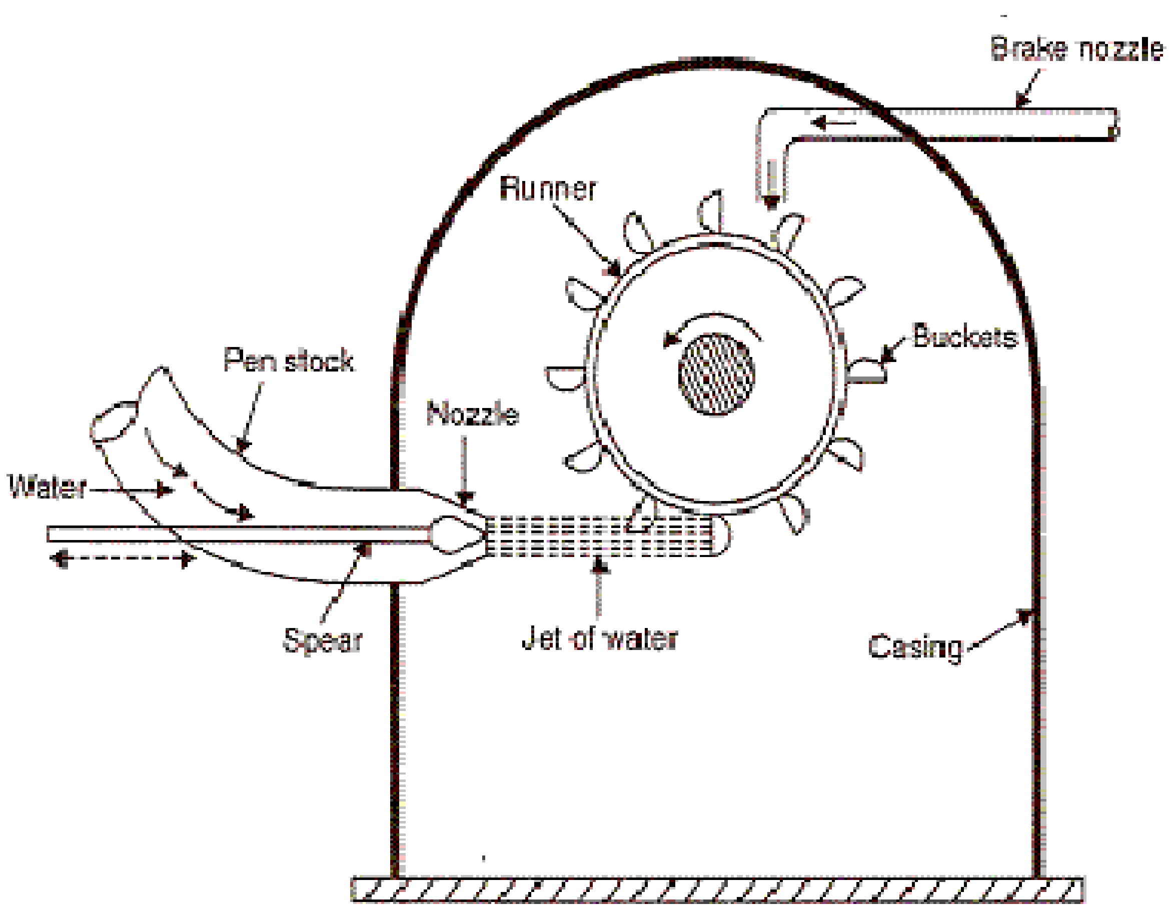


Figure 2.1 Schematic diagram of Pelton turbine

PROCEDURE

1. Clean the apparatus and make it dust free.
2. Close the drain valves provided.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Open flow control valves given on the water discharge line and control valve given on suction line.
5. Now switch on the main power supply (440 Volt AC, 50 Hz).
6. After two minutes close the by- pass valve.
7. Open the air release valve provided on the manometer, slowly to release the air from manometer and then close the air release valve.
8. Now regulate the spear position with the help of a hand wheel.
9. Now turbine is in operation.
10. Regulate the discharge by regulating the spear position.
11. Record the RPM of the pelton wheel by tachometer.
12. Record discharge pressure and suction from pressure and vacuum gauges.
13. Load the turbine with the help of hand wheel attached to the spring balance.
14. Note the manometer reading.
15. Note pressure gauge reading.
16. Note the rpm of the turbine
17. Note the spring balance readings
18. Repeat the same procedure for different load and different discharge.
19. Switch OFF the turbine first.

OBSERVATIONS

S no	**RPM (N)**	**Pr Gauge Reading P(Kg/cm^2)**	**Differential Pressure. h (Cm)**	**Dead weight w_1(Kg)**	**Spring balance w_2(kg)**
1.	1750	4.0	2.20	2	0.150
2.					
3.					

FORMULA USED

H = 10 X P m of water

Discharge Q = AXVm^3/sec

Where

V = C_V (m/sec), where w =w1-w2,

g =9.81 m/sec^2

h = from observation table in meters

C_v =0.98

A =0.002123m^2 Area of pipe.

Turbine input = ρ_w QH /75 HP,

ρ_w densityof water = 1000 Kg/m^3

Turbine output=(W_1+ W_3- W_2) X Re X 2 π N/4500 HP

Re = (D+2d)/2 Effective radius for brake drum

Diameter of Brake drum (D) = 0.2m

Diameter of Rope (d) = 0.012m

W_1= spring balance weight, W_3=weight of rope =0.1 Kg

, W_2=adjustableweight

Turbine efficiency = (Turbine output / Turbine input) x 100

CALCULATIONS

S no	RPM	Total head H(m of water)	Discharge Q(m^3/sec)	Output HP	Input HP	Turbine Efficiency(%age)
1.	1750	40	4.85 X 10^{-3}	0.599	2.586	23.15
2.						
3.						

PLOTTING CHARACTERISTIC CURVS FOR PELTON TURBINE

1. **Curves for Constant Head**

H =Constant

GO= Constant

N = at different loads

P=
Q =   } Variables
$\acute{\eta}_0$ =

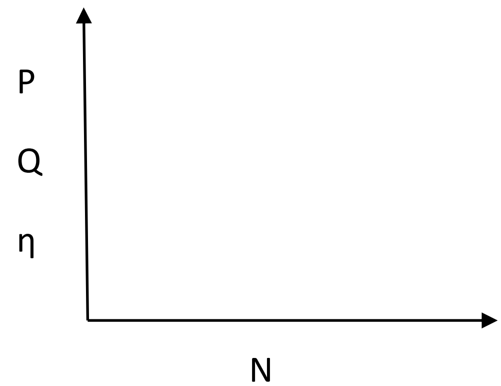


Figure 2.2 constant head curves

Where

P=Power output of turbine

Q= Discharge

η=Efficiency

N= RPM of turbine

GO=Gate Opening

H=head

For constant head curves plot the curves by plotting the speed along the x-axis and power, discharge and efficiency on y-axis as shown in figure 2.2

2. **Constant speed curves**

N =Constant

H =Constant

P=
Q =   } Variables
$\acute{\eta}_0$ =

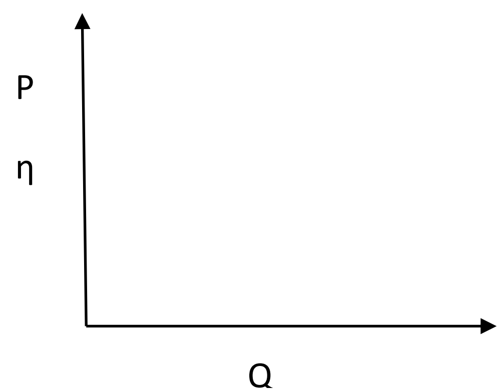
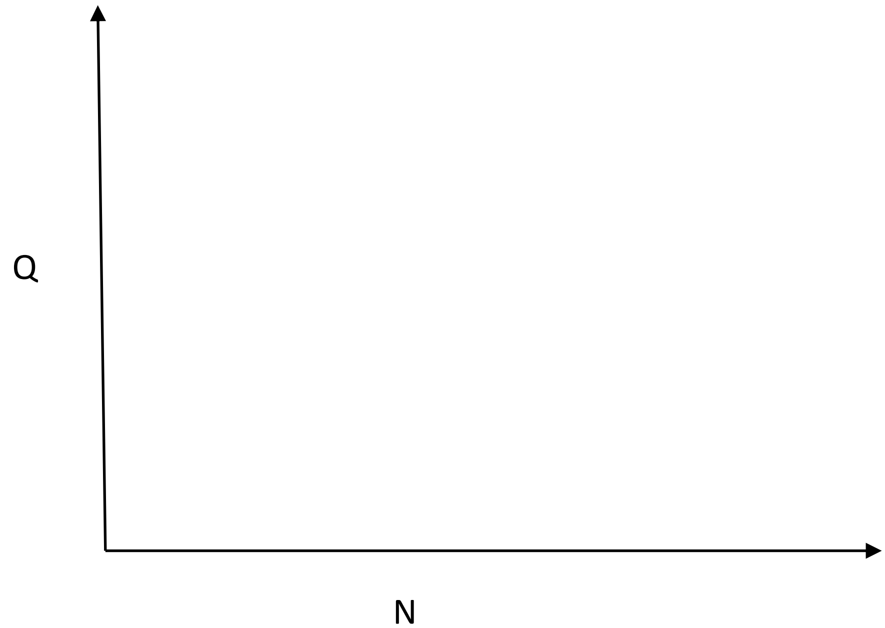


Figure 2.3 constant head curves

For constant speed curves plot the curves by plotting discharge on x-axis and, power and efficiency on y-axis as shown in figure 2.3

3. **Constant efficiency curves**

For plotting the constant efficiency curves, horizontal lines representing the same efficiency are drawn on $\acute{\eta}_0$ Vs speed curves. The points, at which these lines cut the efficiency curves at various gate openings, are transferred to the corresponding Q Vs speed curves. The points having the same efficiency are then joined by smooth curves. These smooth curves represent the iso-efficiency curves shown in figure 2.4



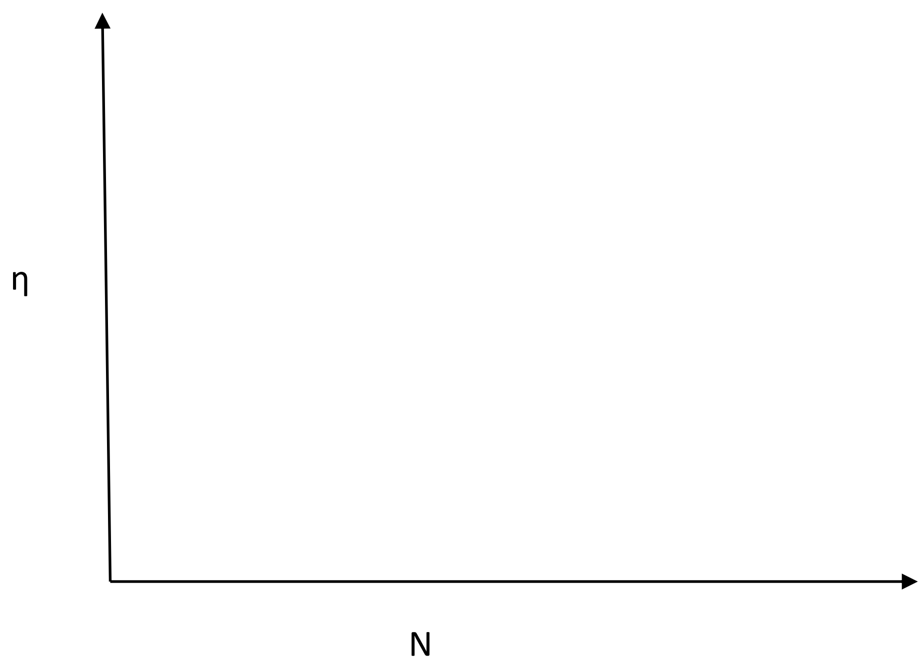


Fig 2.4 constant efficiency curves

DISCUSSION OF RESULTS

The maximum efficiency of turbine is **…………….**at …..……….rpm.

PRECAUTIONS

1. Do not run the pump at low voltage i.e. less than 390 volts.
2. To prevent clogging of moving parts, run pump at least once in ten days.
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, run pump at least once in three month.
5. Use grease / oil to the rotating parts, once in three month.
6. If apparatus not in use then drains the apparatus completely after

EXPERIMENT NO: - 03

OBJECTIVE

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

APPARATUS

Francis Turbine test rig.

DISCRIPTION

Francis **Turbine, named** after James Bichens **Francis,** is a reaction type of turbine for medium high to medium low heads and medium small to medium large quantities of water. The Reaction Turbine operates with its wheel submerged in water. The water before entering the turbine has pressure as well as kinetic energy. The moment on the wheel is produced by both kinetic and pressure energies. The water leaving the turbine has still some of the pressure as well as kinetic energy.

THEORY

The Francis turbine is an inward flow reaction turbine. 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. Originally the Francis turbine was designed as a purely radial flow type reaction turbine but modern Francis turbine is a mixed flow turbine in which water enters the runner radially inwards towards the centre and discharges out axially. It operates under medium heads and requires medium quantity of water.

CONSTRUCTION DETAILS OF FRANCIS TURBINE

Components of the Francis turbine:-

1. **Penstock:** – It is a large sized shaped; where the water is provided to the turbine runner from the dam
2. **Spiral casing:** – It is casing around the turbine wheel and it evenly distributes the water around the circumference of the wheel. Area of cross-section of scroll casing reduces uniformly from maximum at the entrance to zero at the tip. Since the quantity of water reduces from maximum to zero correspondingly otherwise, velocity will vary all around the circumference of the wheel and water will not enter the runner with constant velocity. Material used for the casing is generally concrete for low head rolled steel for medium heads and cast steel for high heads.

DIAGRAM

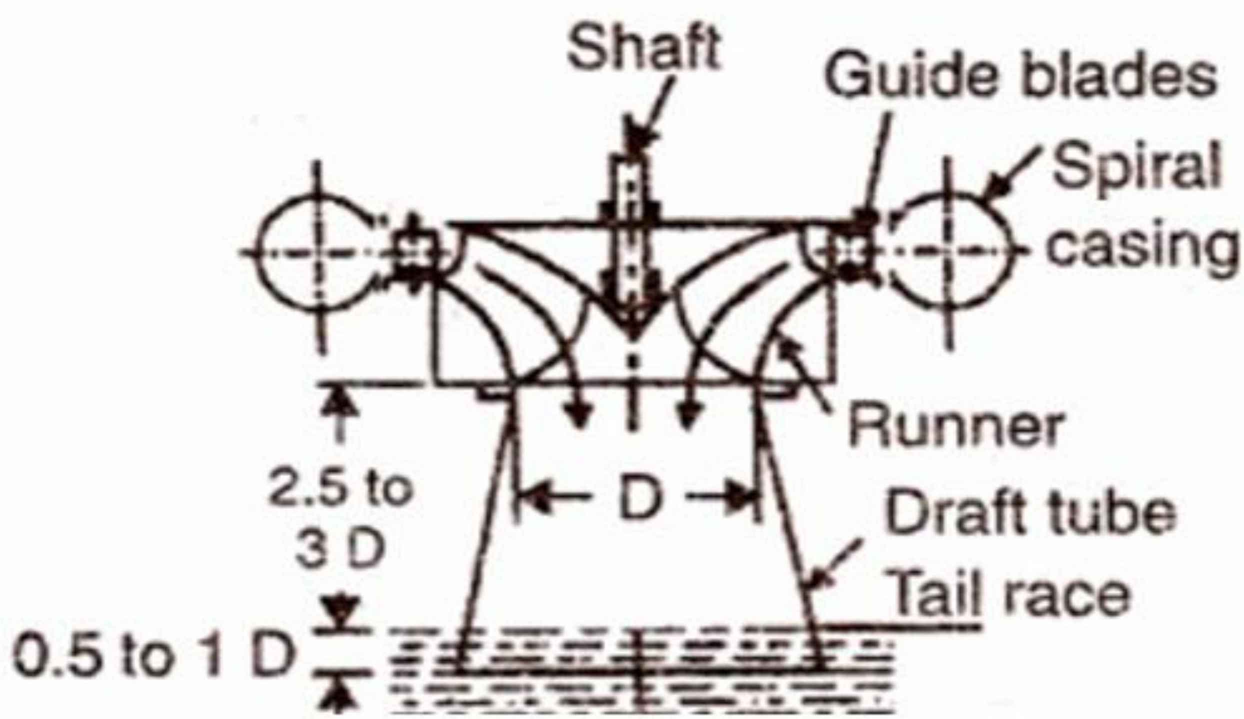


Figure 3.1 Francis Turbine

3. **Guide vanes:** – A series of airfoil shaped vanes called the guide vanes are arranged inside the casing to form a number of flow passages between the casing and the runner blades. Guide vanes are fixed in position (they do not rotate with rotating runner).

4. **Guide wheel and governing mechanism: –** 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 or guide mechanism has a guide wheel consisting of guide vanes
5. **Runner and runner blades: –** The runner of Francis turbine is a circular wheel on which a series of radial curved vanes are fixed. The radial curved vanes are so shaped that the water enters and leaves the runner without shock. The number of runner blades varies between 16 to 24. Runner of the Francis turbine is a rotor which has passages formed between the draft tube and scroll casing.
6. **Draft tube: –** After passing through the runner, the water is discharged to the tail race through a gradually expanding tube. The pressure at the exit of the runner of a reaction turbine is generally less than atmospheric pressure. The water cannot be directly discharged to the tail race. A tube or pipe of gradually increased 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.

WORKING OF FRANCIS TURBINE

Water from the penstock flows through the spiral casing where the pressure energy of gets converted into kinetic energy then the water is guided by the guide vanes to flow through the runner vanes which make the runner wheel working and hence the turbine starts running.

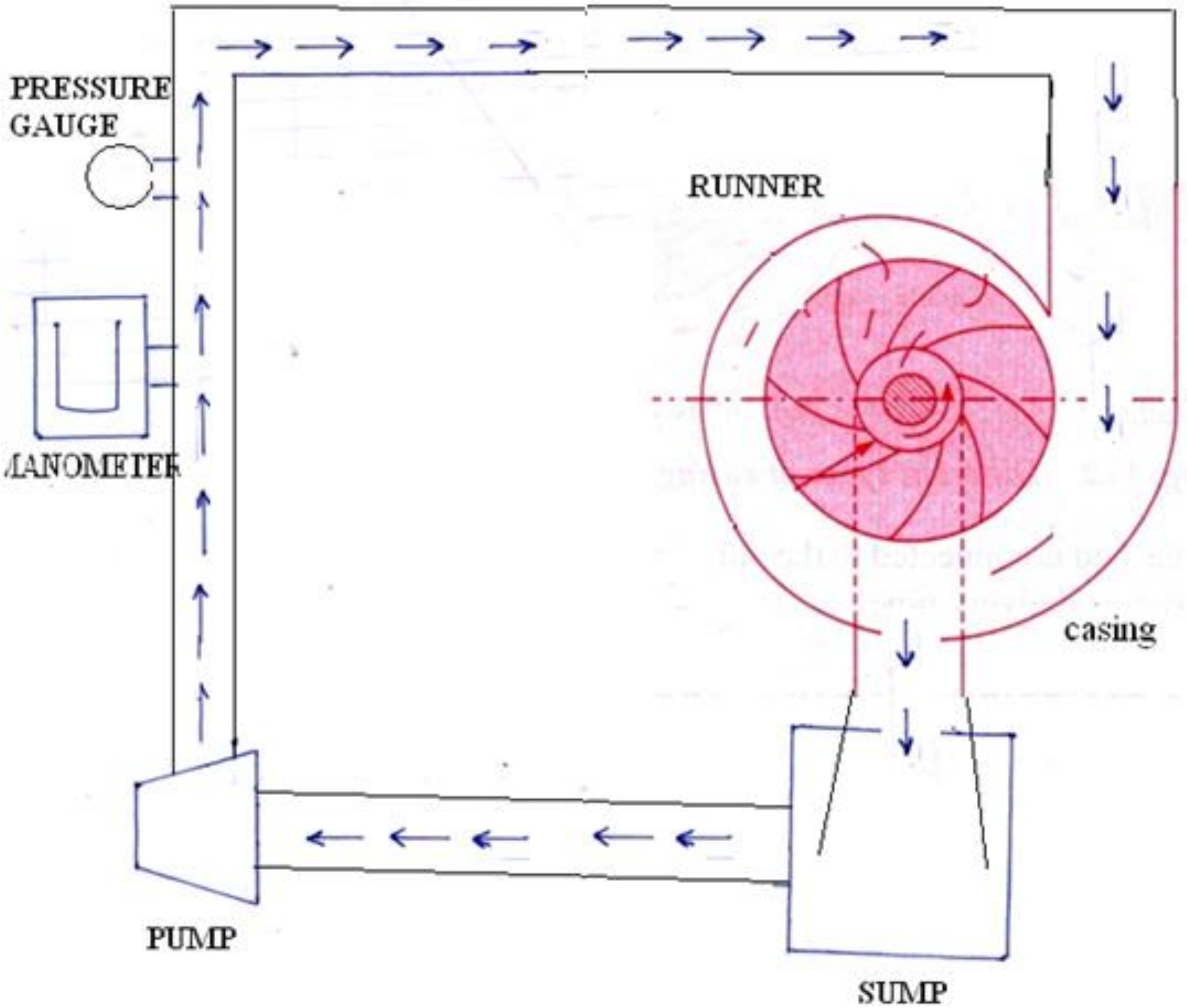


Figure 3.1 Fluid flow circuit diagram for Francis turbine

EXPERIMENT NO: - 04

OBJECTIVE

To draw the constant head, constant speed and constant efficiency performance characteristic curves of Francis Turbine.

APPARATUS

Francis Turbine test rig, stop watch, tachometer, engineering scale.

SPECIFICATIONS

Type	: Centrifugal type
Power required	: 3 phase, 420 VAC, 50Hz
Spring balance	: 10 Kg
Flow measurement	: Pitot tube
Pressure gauge	: Bourdon type.
Control panel comprises of	
MCB	: For overload protection.

Standard make on/off switch, mains indicator, etc. the whole set-up is well designed and arranged in a good quality painted structure.

DISCRIPTION

Francis Turbine, named after James Bichens Francis, is a reaction type of turbine for medium heads and medium small to medium large quantity of water. The Reaction Turbine operates with its wheel submerged in water. The water before entering the turbine has pressure as well as kinetic energy. The moment on the wheel is produced by both kinetic and pressure energies. The water leaving the turbine has still some of the pressure as well as kinetic energy.

The Francis turbine consists of spiral casing, an outer bearing pedestal and rotor assembly with runner shaft and brake drum, all mounted on sturdy cast iron base plate. A transparent hollow perplex cylinder is provided in between the draught bend and the casing for the purpose of observation of flow at exit of runner. a rope brake arrangement is provided to load the turbine. the net supply head on the turbine is measured by a pressure and vacuum gauge.

DIAGRAM

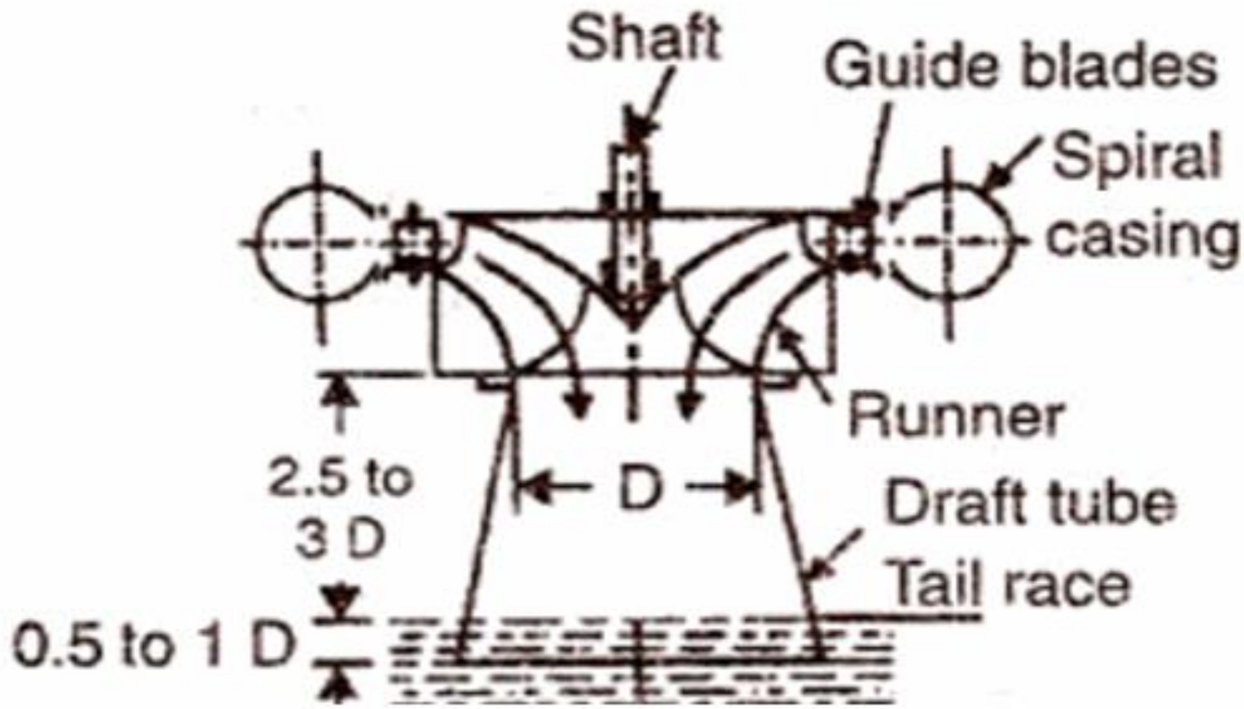


Figure 4.1 Francis Turbine

PROCEDURE

1. Clean the apparatus and make it dust free.
2. Close the drain valves provided.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Open flow control valves given on the water discharge line and control valve given on suction line.
5. Now switch on the main power supply (420 V AC, 50 Hz).

6. Open the air release valve provided on the manometer, slowly to release the air from manometer and then close the air release valve.
7. Now regulate the discharge with the help of a hand wheel.
8. Now turbine is in operation.
9. Regulate the discharge by regulating the guide vanes position.
10. Record the RPM of the Francis turbine by tachometer .
11. Record discharge pressure and suction from pressure and vacuum gauges.
12. Load the turbine with the help of hand wheel attached to the spring balance.
13. Note the manometer reading.
14. Note pressure gauge reading.
15. Note the rpm of the turbine
16. Note the spring balance readings
17. Repeat the same procedure for different load and different discharge.
18. Switch OFF the turbine first.

Observations

S no	RPM (N)	Vacuum pressure (P_d) mm of Hg	Pr Gauge Reading P(Kg/cm^2)	Differential Pressure. $h = h_2 - h_1$ (Cm)	Dead weight w_1(Kg)	Spring balance w_2(kg)
1.	1255	58	1.8	4.8	2	0.600
2.						
3.						

FORMULA USED

$H = 10 \times \{P + (P_d/760)\}$ m of water

Discharge Q $= A \times V m^3/sec$

Where

V = C_V (m/sec), where w =w1-w2,

g =9.81 m/sec^2

h = from observation table in meters

C_v =0.98

A = ...

Turbine input = ρ_w QH /75 HP,

ρ_w densityof water = 1000 Kg/m^3

Turbine output=(W_1+ W_3- W_2) x Re x 2 π N/4500 HP

Re = (D+2d)/2 Effective radius for brake drum

Diameter of Brake drum (D) = ...

Diameter of Rope (d) = ...

So Re =0.115

W_1= dead weight, W_3=weight of rope W_2= spring balance

Turbine efficiency = (Turbine output / Turbine input) x 100

CALCUTIONS

S no	Total head H (m)	Velocity V m/Sec	Discharge Q (m^3/sec)	Output Power HP	Input Power HP	Turbine efficiency ή %age
1.	18.75	3.37	1.69 X 10^{-2}	0.483	4.23	11.43
2.						
3.						

PLOTTING CHARACTERISTIC CURVS FOR FRANCIS TURBINE

1. **Curves for Constant Head**

H =Constant

GO= Constant

N = at different loads

P=
Q = } Variables
ή0 =

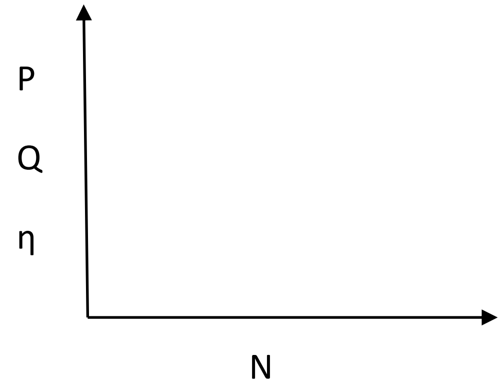


Figure 4.2 constant head curves

Where

P=Power output of turbine — N= RPM of turbine

Q= Discharge — GO=Gate Opening

η=Efficiency — H=head

For constant head curves plot the curves by plotting the speed along the x-axis and power, discharge and efficiency on y-axis as shown in figure 4.2

2. **Constant speed curves**

N =Constant

H =Constant

P=
Q = } Variables
ή0 =

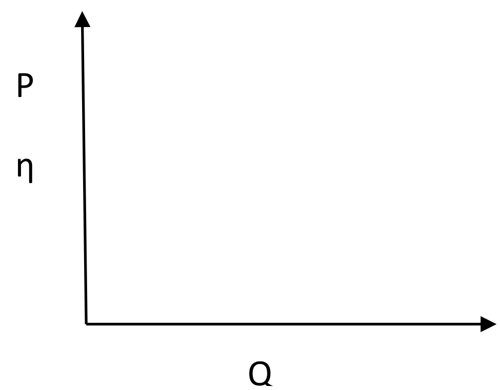


Figure 4.3 constant head curves

For constant speed curves plot the curves by plotting discharge on x-axis and, power and efficiency on y-axis as shown in figure 4.3

3. **Constant efficiency curves**

For plotting the constant efficiency curves, horizontal lines representing the same efficiency are drawn on $ή_0$ Vs speed curves. The points, at which these lines cut the efficiency curves at various gate openings, are transferred to the corresponding Q Vs speed curves. The points having the same efficiency are then joined by smooth curves. These smooth curves represent the iso-efficiency curves shown in figure 4.4

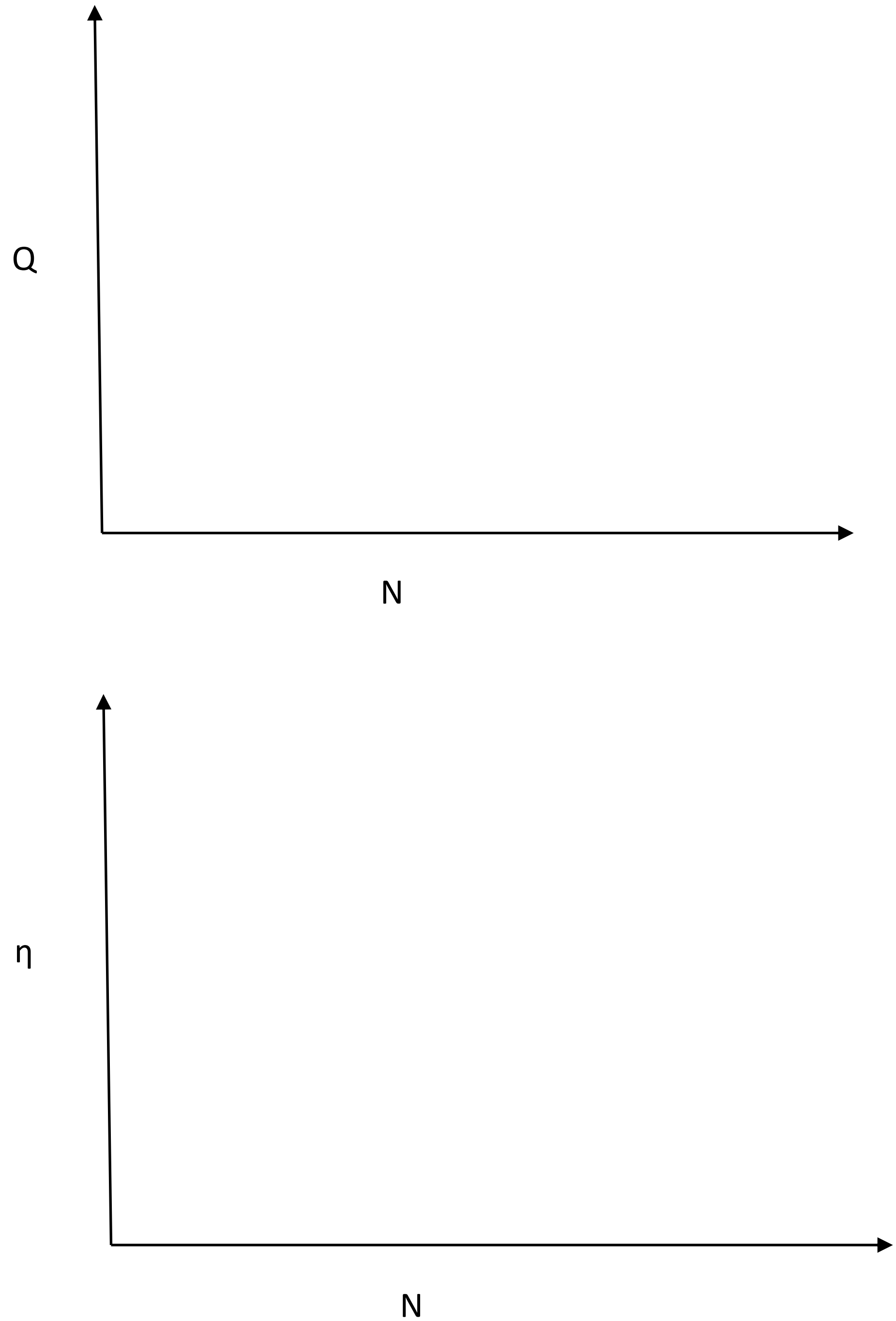


Fig 4.4 constant efficiency curves

DISCUSSION OF RESULTS

The maximum efficiency of turbine is obtained as………….. With…..…….Gate opening

PRECAUTIONS

1. Do not run the pump at low voltage i.e. less than 390 volts
2. Never fully close the delivery line valves .
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, run turbine at least once in three month.
5. Always use clean water.
6. Use grease / oil to the rotating parts, once in three month.
7. If apparatus not in use then drains the apparatus completely after 15 days.
8. Do not touch the switches with wet hands.

EXPERIMENT NO: - 05

OBJECTIVE

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

APPARATUS

Kaplan Turbine test rig.

DISCRIPTION

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. This was 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. Victor Kaplan obtained his first patent for an adjustable blade propeller turbine in 1912. But the development of a commercially successful machine would take another decade. Kaplan struggled with cavitations problems, and in 1922 abandoned his research for health reasons.

CONSTRUCTION DETAILS OF KAPLAN TURBINE

Components of the Kaplan turbine:-

1. **Scroll casing: –** The Kaplan turbine is high discharge low head turbine. So it needs a scrool casing in order to increase the velocity and keep it constant for fixed load. The water firs enters the spiral casing in which area of cross section decreases continuously .It is made of cast iron or rolled steel.
2. **Guide vanes: –** It is the blade in which guides the water and control the water passage or we can say they impart a tangential and a radial inward velocity to the liquid. (i.e. how much the water flow goes in the turbine).
3. **Draft tube: –** After passing through the runner, the water is discharged to the tail race through a gradually expanding tube. The pressure at the exist of the runner of a reaction

turbine is generally less than atmospheric pressure. The water cannot be directly discharged to the tail race . atube or pipe of gradually increased 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 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.

DIAGRAM

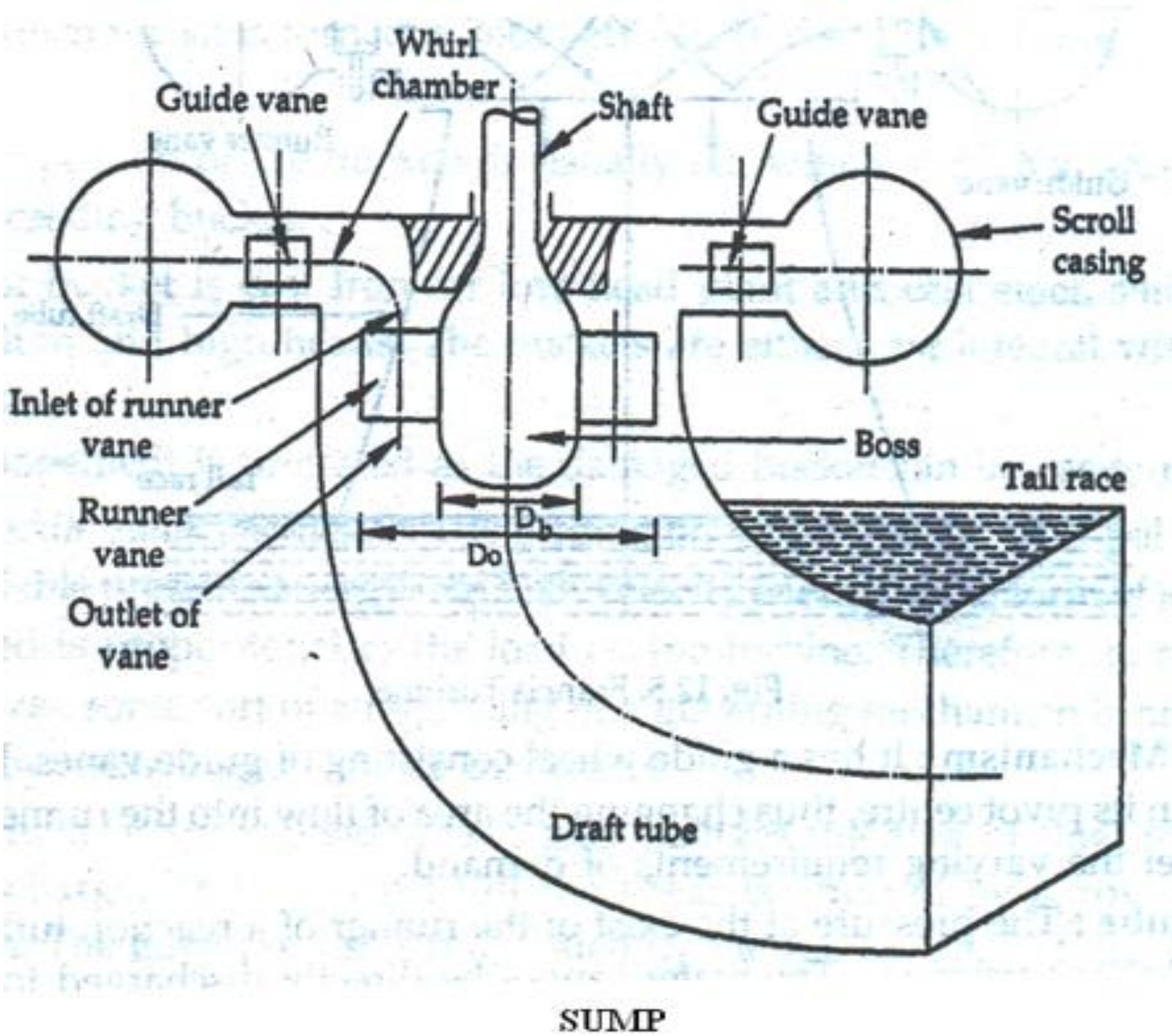


Figure 5.1 Diagram of Kaplan turbine

4. **Runner: –** In Kaplan turbine the runner blades are adjustable and can be rotated about pivot fixed to the boss of the runner. It is the cashing in which we pass the water to the runner in the turbine. It is an important part of the turbine which is connected to the shaft of the generator and consist movable vanes and hub (boss).
5. **Whirl chamber: -** a space is provided between the guide vanes and the runner, it is called as whirl chamber. In this chamber the flow is turned through 90^0 and moves as free vortex.

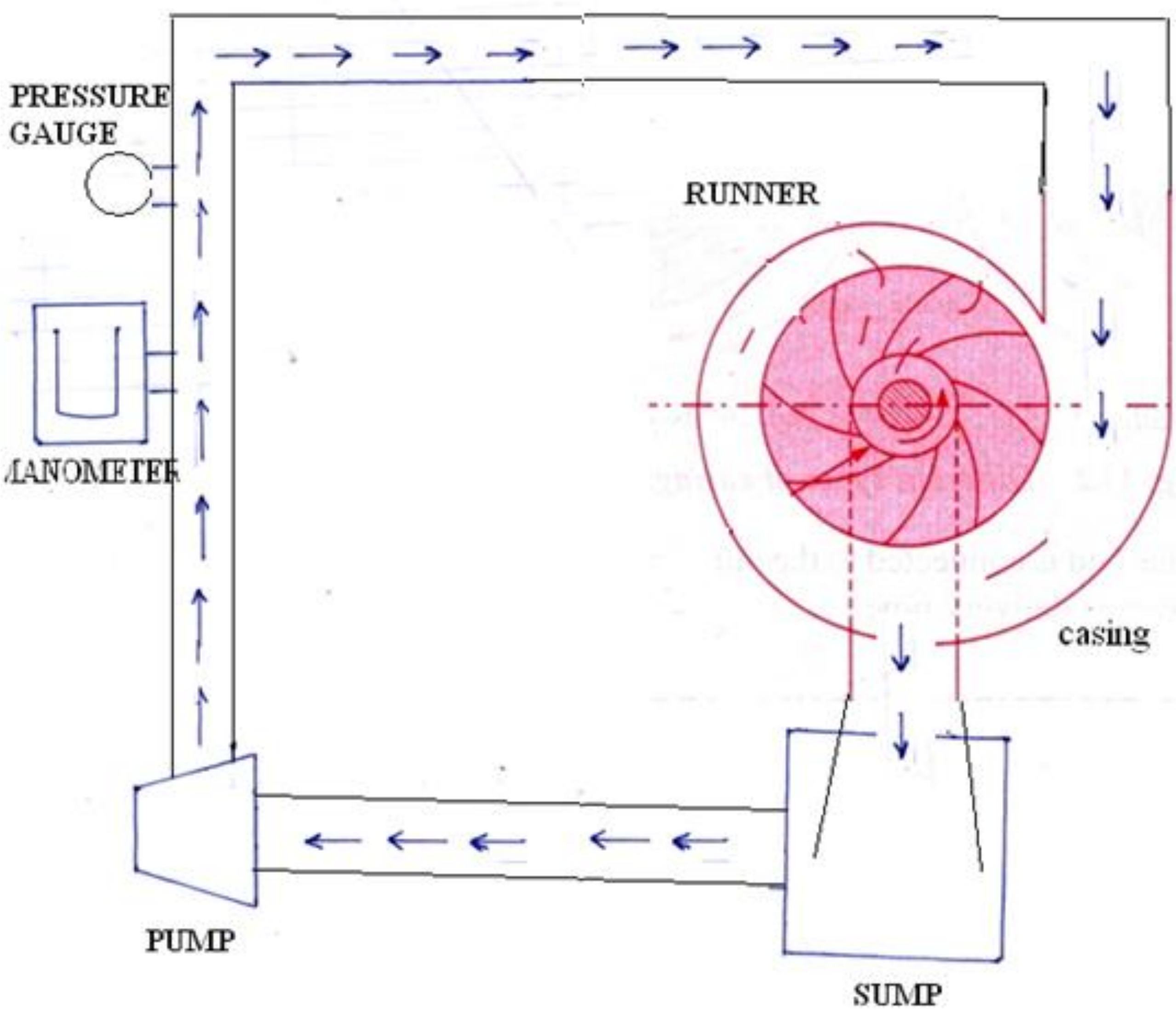


Figure 5.2 Fluid flow circiut of Kaplan turbine

EXPERIMENT NO: - 06

OBJECTIVE

To draw the constant head, constant speed and constant efficiency curves of Kaplan Turbine.

APPARATUS

Kaplan Turbine test rig , stop watch , tachometer, engineering scale.

SPECIFICATIONS

Type	: Centrifugal type
Power required	: A. C. 5 HP, 3 Phase, 440 Volts.
Spring balance	: 10 Kg ,5 kg
No of guide vanes	: 8 nos
Flow measurement	: Pitot tube
Pressure gauge	: Bourdon type.
Control panel comprises of	
MCB	: For overload protection.

Standard make on/off switch, mains indicator, etc. the whole set-up is well designed and arranged in a good quality painted structure

DISCRIPTION

The vertical shaft Kaplan turbine consists mainly of a spiral casing with supporting legs, an outer bearing pedestal, and rotor assembly with adjustable blade runner, shaft and brake drum and brake arrangement all mounted on a suitable blade runner shaft and brake drum and brake arrangement all mounted on a suitable cast iron base plate. A straight conical draft tube is provided with a draught bend immediately after the runner, for the purpose of regaining the kinetic energy from the exit water. A transparent hollow Perspex cylinder is provided in between the draught bend and the casing for observation of flow behind the runner. A rope brake arrangement is provided to load the turbine the net supply head on the turbine is measured by a pressure gauge, and tachometer is used for the measurement of speed.

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. This was 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. Victor Kaplan obtained his first patent for an adjustable blade propeller turbine in 1912. But the development of a commercially successful machine would take another decade. Kaplan struggled with cavitations problems, and in 1922 abandoned his research for health reasons.

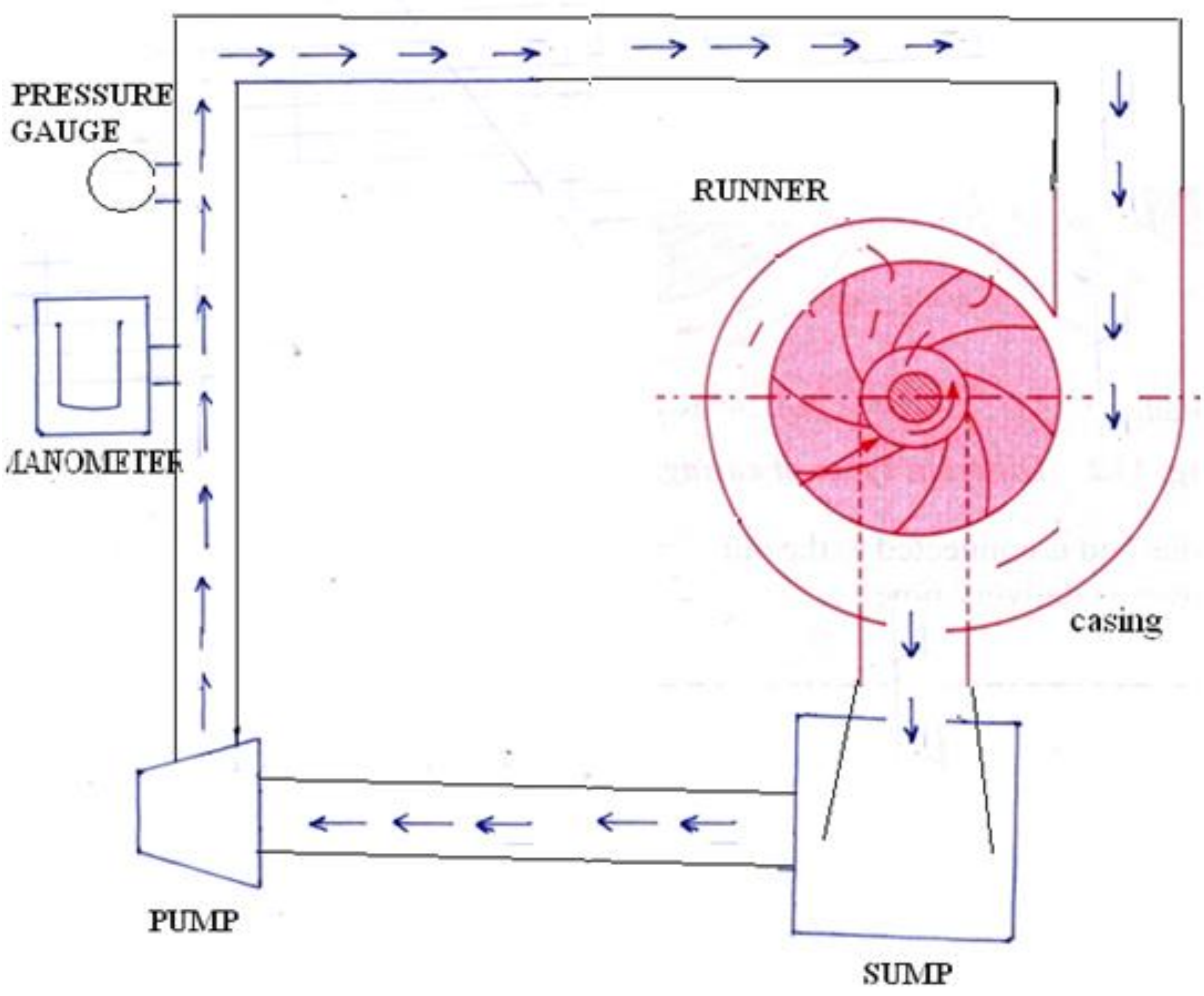


Figure 6.1 Kaplan turbine test rig.

PROCEDURE

1. Clean the apparatus and make it dust free.
2. Close the drain valves provided.
3. Fill sump tank ¾ with clean water and ensure thet no foreign particles are there.
4. Open flow control valves given on the water discharge line and control valve given on suction line.
5. Fill manometer fluid i. e. hg in manometer.
6. Ensure that there is no load on the brake drum.
7. Now switch on the main power supply (440 V AC, 50 Hz).
8. Open the air release valve provided on the manometer, slowly to release the air from manometer and then close the air release valve.
9. Now regulate the discharge with the help of a hand wheel.
10. Now turbine is in operation.
11. Regulate the discharge by regulating The guide vanes position.
12. Note the maximum RPM of the turbine obtained by regulating the position of guide vanes.
13. Note the fixed and adjustable spring balance readings.
14. Record the RPM of the Kaplan turbine by tachometer .
15. Record discharge pressure and suction from pressure and vacuum gauges.
16. Load the turbine with the help of hand wheel attached to the spring balance.
17. Note the manometer reading.
18. Note pressure gauge reading.
19. Note the rpm of the turbine

20. Note the spring balance readings
21. Repeat the same procedure for different load .
22. Switch OFF the turbine first.

OBSERVATIONS

S no	RPM (N)	Vacuum Gauge Reading Ps(Kg/cm^2)	Pr gauge reading P_D (kg/cm^2)	Differential Pressure. h= (h_2-h_1) (m)	Load on tray W_1 (kg)	Spring balance W_2(kg)
1.	1972	0.07	0.85	11	10	2.7
2.						
3.						

FORMULA USED

Total head =H= 10(PD+PS) m,

Discharge Q = AXVm^3/sec

Where

V = C_V (m/sec), where w =w1-w2,

g =9.81 m/sec^2

h = from observation table in meters

C_v =0.98

A =0.053m^2 Area of pipe

Turbine input = ρ_w QH /75 HP,

ρ_w densityof water = 1000 Kg/m^3

Turbine output=(W_1+ W_3 + W_4- W_2) X Re X 2 π N/4500 HP

Re = (D+2d)/2 Effective radius for brake drum

Diameter of Brake drum (D) = 0.3m

Diameter of Rope (d) = 0.015m

So Re =0.165

W_1= dead weight, W_3=weight of hanger=1.0 Kg, W_2= spring balance

W_4=weight of rope (Negligible)

Turbine efficiency = (Turbine output / Turbine input) x 100

CALCULATIONS

S no	Total head H M of water	Velocity V m/sec	Discharge Q m^3/sec	Output Power (HP)	Input power (HP)	Turbine efficiency ή %
1.	9.2	5.11	0.271	3.76	33.24	11.33
2.						
3.						

PLOTTING CHARACTERISTIC CURVS FOR KAPLAN TURBINE

1. **Curves for Constant Head**

H =Constant

GO= Constant

N = at different loads

P=
Q =
$ή_0$ =
} Variables

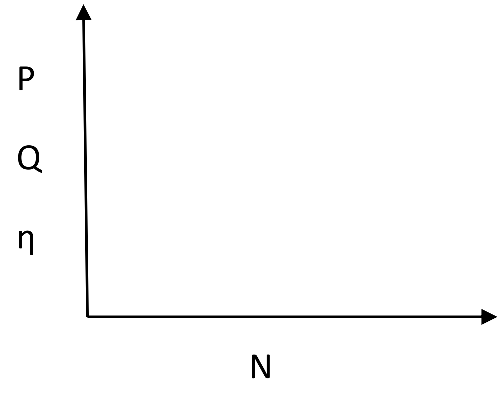


Figure 6.2 constant head curves

Where

P=Power output of turbine N= RPM of turbine

Q= Discharge GO=Gate Opening

η=Efficiency H=head

For constant head curves plot the curves by plotting the speed along the x-axis and power, discharge and efficiency on y-axis as shown in figure 6.2

2. Constant speed curves

N =Constant

H =Constant

P= }
Q = } Variables
$\acute{\eta}_0$ = }

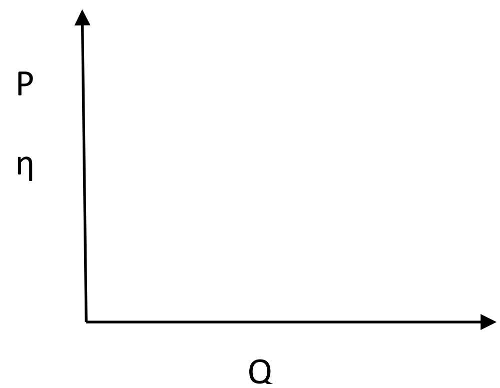
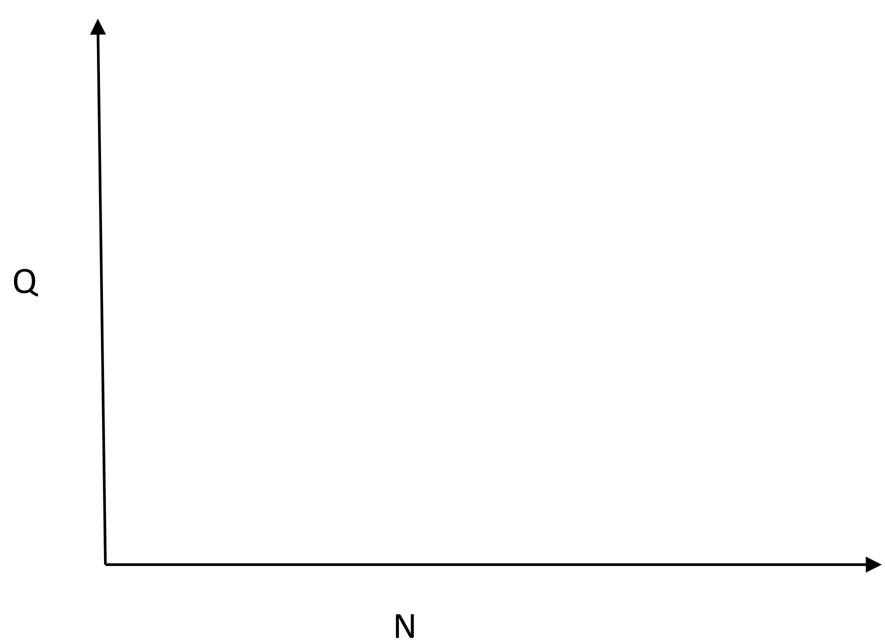


Figure 6.3 constant head curves

For constant speed curves plot the curves by plotting discharge on x-axis and, power and efficiency on y-axis as shown in figure 6.3

3. Constant efficiency curves

For plotting the constant efficiency curves, horizontal lines representing the same efficiency are drawn on $\acute{\eta}_0$ Vs speed curves. The points, at which these lines cut the efficiency curves at various gate openings, are transferred to the corresponding Q Vs speed curves. The points having the same efficiency are then joined by smooth curves. These smooth curves represent the iso-efficiency curves shown in figure 6.4



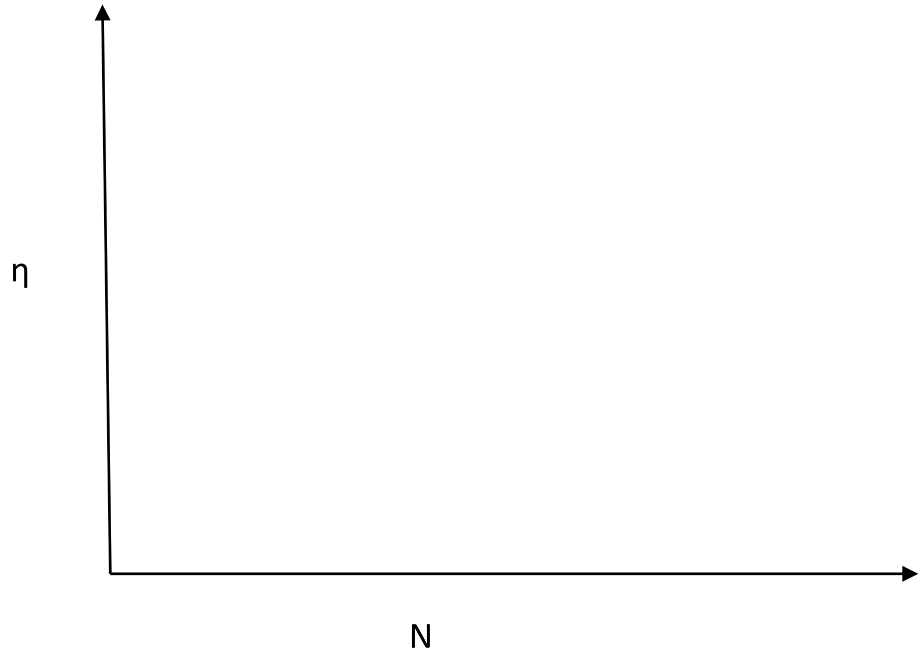


Fig 6.4 constant efficiency curves

DISCUSSION OF RESULTS

The maximum efficiency of turbine is obtained as………………With……..…….Gate opening.

PRECAUTIONS

1. Do not run the pump at low voltage i.e. less than 390 volts.
2. Never fully close the delivery line valves.
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, run turbine at least once in three month.
5. Always use clean water.
6. Use grease / oil to the rotating parts, once in three month.
7. If apparatus is not in use drain the apparatus completely after 15 days.
8. Do not touch the switches with wet hands.

EXPERIMENT NO: - 07

OBJECTIVE

To study the constructional details of a Centrifugal Pump and draw its characteristic curves.

APPARATUS

Centrifugal pump test rig, stop watch, tachometer and engineering scale.

SPECIFICATIONS

Pump	: Capacity 1HP /0.75KW,2900 RPM, single phase ,220 volts
Pressure gauge	: bourdon type.
Control panel comprises of	
RPM measurement	: digital RPM indicator with Proximity sensor.
Energy measurement	: L&T make ,Electronic Energy meter.
MCB	: for overload protection.

Standard make on/off switch, mains indicator, etc. the whole set-up is well designed and arranged in a good quality painted structure.

DESCRIPTION

Centrifugal test rig consists of a sump, a centrifugal pump, an AC motor and measuring tank. To measure the head, pressure and vacuum gauges are provided. To measure the discharge, a measuring tank is provided. Flow diversion system provided to divert flow from sump tank to measuring tank to sump tank. A valve is provided in pipeline to change the rate of flow.

THEORY

The hydraulic machines, which convert the mechanical energy into hydraulic energy, are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump. The centrifugal pump acts as a reversed of an inward radial flow reaction turbine. This means that the flow in centrifugal pumps is in the radial outward directions.

WORKING OF CENTRIFUGAL PUMP

The centrifugal pump works on the principle of forced vortex flow, which means that when an external torque rotates certain mass of liquid, 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 tangential velocity of (i.e. rise in pressure head = V^2 /2g or $\omega^2 r^2$ / 2g) the liquid at that point. Thus, at the outlet of impeller where 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 high pressure head, the liquid can be lifted to a high level.

Centrifugal pump is a mechanical device, which consists of a body, impeller and a rotating mean i.e. motor, engine etc. impeller rotates in a stationary body, suck the fluid through its axes, and delivery through its periphery. Impeller has an inlet angel, outlet angel and peripheral speed, which affect the head discharge. Impeller is rotated by motor or i.e. engine or any other device.

CONTRUCTIONAL DETAILS OF CENTRIFUGAL PUMP

The followings are the main parts 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 out let of the impeller is converted into pressure energy before the water leaves the casing and enters the delivery pipe.
3. **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 into water in a sump is known as suction pipe. A foot valve which is a non-return valve or one way type of valve is fitted at the lower end of

the suction pipe .the foot valves opens only in the upward direction .A strainer is also fitted at the lower end of the suction pipe. Strainer is provided in order to prevent mud, sand or any foreign material from entering the pipe.

4. **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.

DIAGRAM

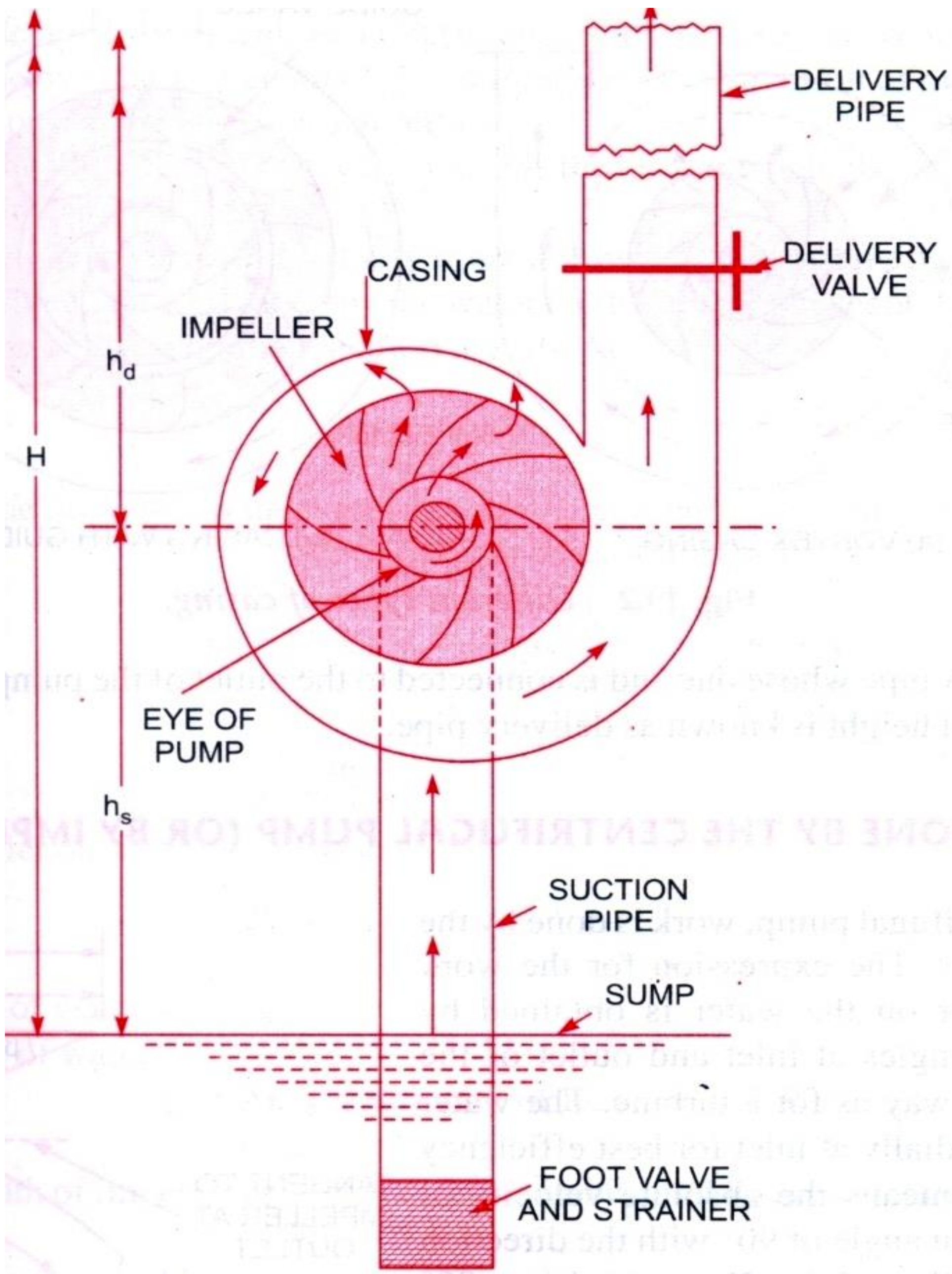


Figure 7.1 Main parts of Centrifugal Pump

PROCEDURE

1. Clean the apparatus and make it dust free.
2. Close the drain valves provided.
3. Fill sump tank ¾ with clean water and ensure thet no foreign particles are there.
4. Open flow control valves given on the water discharge line and control valve given on suction line.
5. Set the desire speed of motor/ pump with the help of step cone puley arrangements.
6. Now switch on the pump.
7. Operate the control valve to regulate the suction of the pump.
8. Record the RPM of the motor by tachometer .
9. Record discharge pressure and suction from pressure and vacuum gauges.
10. Record the power consumption by energy meter,with the help of stop watch.
11. Measure the flow of water, discharge by the pump, using stop watch and measuring tank.
12. Repeat the same procedure for different pressure head.
13. Repeat the same procedure for different RPM with help of step cone pulley.
14. Switch OFF the pump first.

OBSERVATIONS

S no.	RPM of The pump	Gauge Pressure (kg/cm^2)(G)	Vacuum (mm of Hg)(V)	Water height in Tank,R(cm) $=R_2-R_1$	Time for R,t (sec)	t/10pulses (sec) t_1
1	2976	0.3333	45	3.5	20	18.63
2						
3						

FORMULA USED

(1).H.P. Elec. = P/t_1 X 3600/EMC X 1000/746 HP

Where P =Number of pulses,

t_1 = time for P pulses

EMC = 3200 (energy meter constant) so

H.P. Elec. =P/t_1 X 3600/3200 X 1000/746 HP

(2) H.P. Shaft= HP Elec. x $\acute{\eta}_{motor}$

$\acute{\eta}_{motor}$ = 0.8 (given)

(3) Actual discharge = Q= AXR / (t X 100) (m^3/sec)

A= area of measuring tank = 0.128 m^2

R= height of water in measuring tank is cms.

t = time for R in sec.

(4) Total head H= 10((delivery pressure (kg/cm^2) +vacuum pressure (mm of hg) /760) +1)

H = 10X ((G+V /760) +1) meter of water.

(5) HP Pump = ρ Q H / 75 (HP)

Where

ρ= density of water (kg/m^3)

Q= actual discharge (m^3 /sec)

H= total head (meter of water)

(6) Efficiency pump = (H.P. pump / H.P. shaft) X 100

(7) Efficiency overall = (H.P. pump / HP Elec.) X 100

CALCULATION TABLE

S no.	H.P. elec. (HP)	H.P. Shaft (HP)	Actual Discharge Q(m^3 / s)	Total head H(m of water)	H.P. Pump *(HP)*	pump %	overall %
1	0.809	0.6475	2.24 x 10^{-4}	13.92	0.0415	6.42	5.13

2							
3							

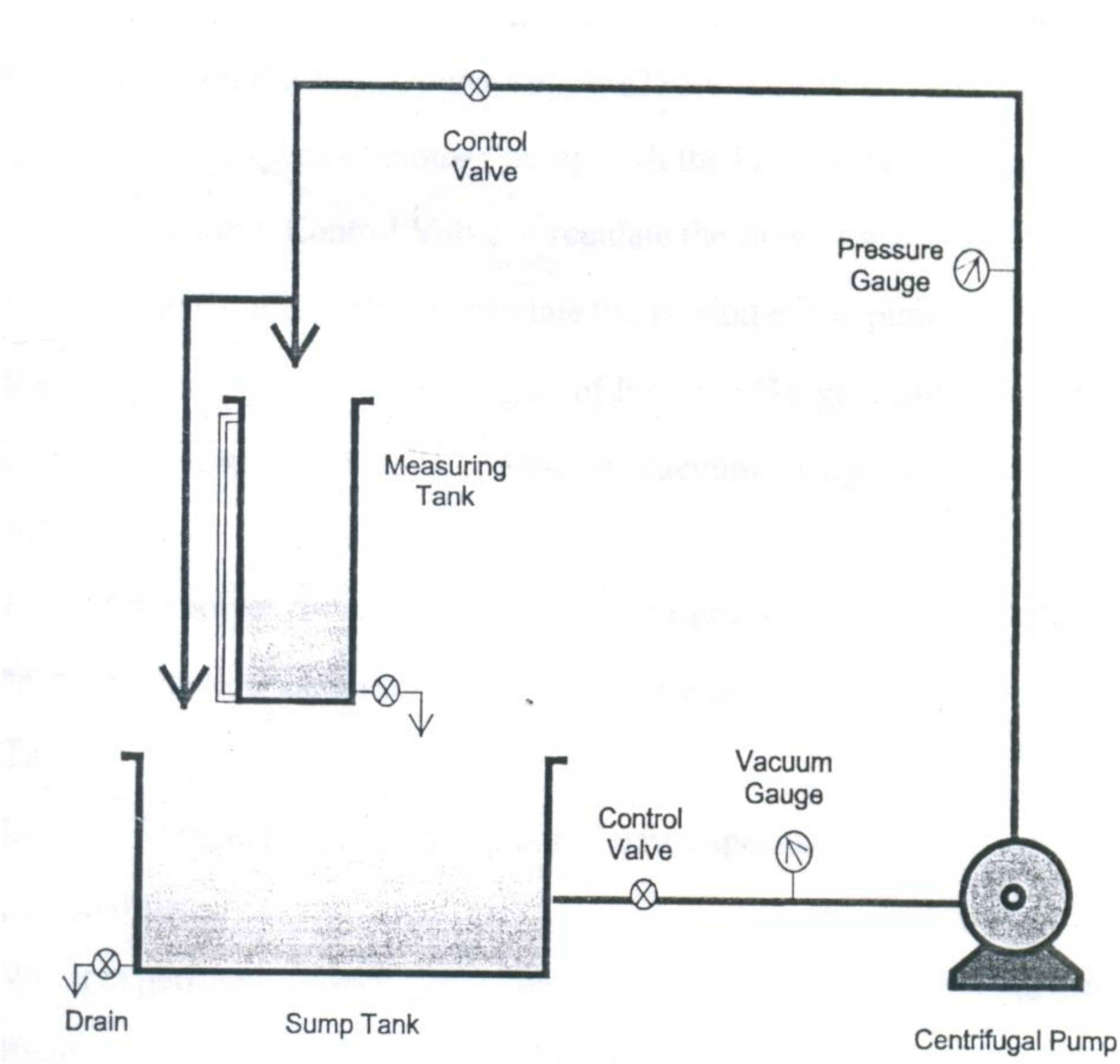


Figure 7.2 Centrifugal pump test rig.

CHARACTERISTIC CURVES FOR CENTRIFUGAL PUMP

Plotting characteristic curves for centrifugal pump includes the plotting of following curves

(1) Constant speed curves

(2) Constant head curves

(3) Constant efficiency curves

1. **Constant HeadCurves**

H =Constant

N =

P=

Q = } Variables

ή0 =

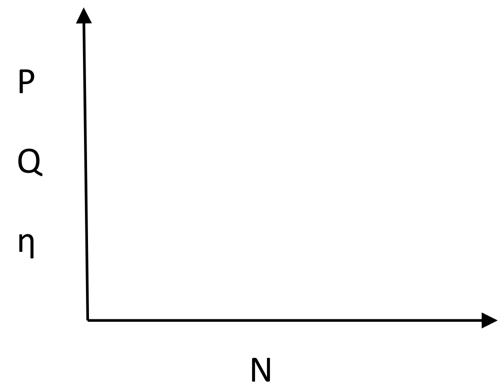


Figure 7.3 constant head curves

Where

P=Power output of turbine N= RPM of turbine

Q= Discharge η=Efficiency

H=head

For constant head curves plot the curves by plotting the speed along the x-axis and power, discharge and efficiency on y-axis as shown in figure 7.3

2. **Constant speed curves**

N =Constant

H =

P=

Q = } Variables

ή0 =

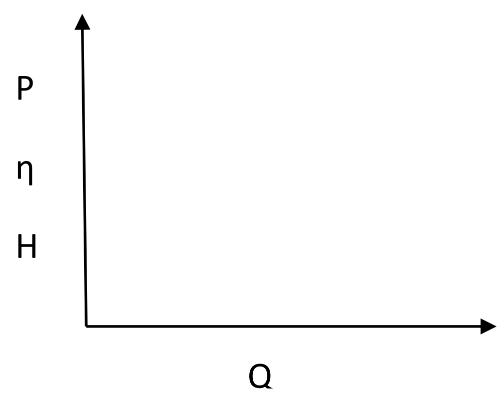


Figure 7.4 constant head curves

For constant speed curves plot the curves by plotting discharge on x-axis and, power and efficiency on y-axis as shown in figure 7.4

3. Constant efficiency curves

For plotting the constant efficiency curves, horizontal lines representing the same efficiency are drawn on $\acute{\eta}_0$ Vs Discharge. The points, at which these lines cut the efficiency curves at various speeds, are transferred to the corresponding H Vs Discharge. The points having the same efficiency are then joined by smooth curves. These smooth curves represent the iso-efficiency curves shown in figure 7.5

Fig 7.5 constant efficiency curves

DISCUSSION OF RESULTS

The maximum efficiency of pump is………………..%

PRECAUTIONS

1. Do not run the pump at low voltage i.e. less than 180 volts.
2. Never fully close the delivery line and by –pass line valves simultaneously.
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, run pump at least once in three month.
5. Use grease / oil to the rotating parts, once in three month.
6. If apparatus not in use drain the apparatus completely after 15 days.
7. Do not touch the switches with wet hands.

EXPERIMENT NO:-08

OBJECTIVE

To study the constructional details of a Reciprocating Pump and draw its characteristic curves.

APPARATUS

Reciprocating pump test rig, stop watch, tachometer, engineering scale.

SPECIFICATIONS

Pump	: 1HP /0.75KW, 280 RPM, single phase, 220 volts
Pressure gauge	: Bourdon type.
Control panel comprises of	
RPM measurement	: Digital RPM indicator with Proximity sensor.
Energy measurement	: L&T make, Electronic Energy meter.
MCB	: For overload protection.

Standard make on/off switch, mains indicator, etc. the whole set-up is well designed and arranged in a good quality painted structure.

DESCRIPTION

The apparatus consists of a double acting-single cylinder reciprocating pump is operated on closed circuit basic. An AC motor with 3 speeds is provided to regulate the rpm of the pump. Suction and delivery head can be varied by the valves provided and Pressure & Vacuum gauges can measure it. Measuring tank and stop- watch is provided with the set-up. Discharge can be calculated with the help of measuring tank and stop-watch.

THEORY

A pump is a device which lifts water from a lower level to a higher level at the expense of mechanical energy. Pump can be broadly classified into two categories, positive displacement and roto-dynamic or dynamic pressure pump. In a positive displacement pump a small quantity of liquid is taken inside the pump and is bodily displaced and forced out of the pump under pressure. The liquid inside a positive displacement pump may be subjected either to a reciprocating motion. Reciprocating pump consist a piston having a reciprocatory motion inside a cylinder with the help of connecting rod and a crank rotated by a electric motor, I. C. engine, or any another suitable means. The cylinder is connected to the sump by the suction pipe and to the reservoir by the delivery pipe. Valves are provided at suction and delivery side are non-returnable so that to allow the fluid in direction only. These pumps are applied where the fluid is required in a small quantity but at a higher pressure. Reciprocating pumps are applied for vehicle washing and For the water supply to multi-story buildings, industries etc.

DIAGRAM

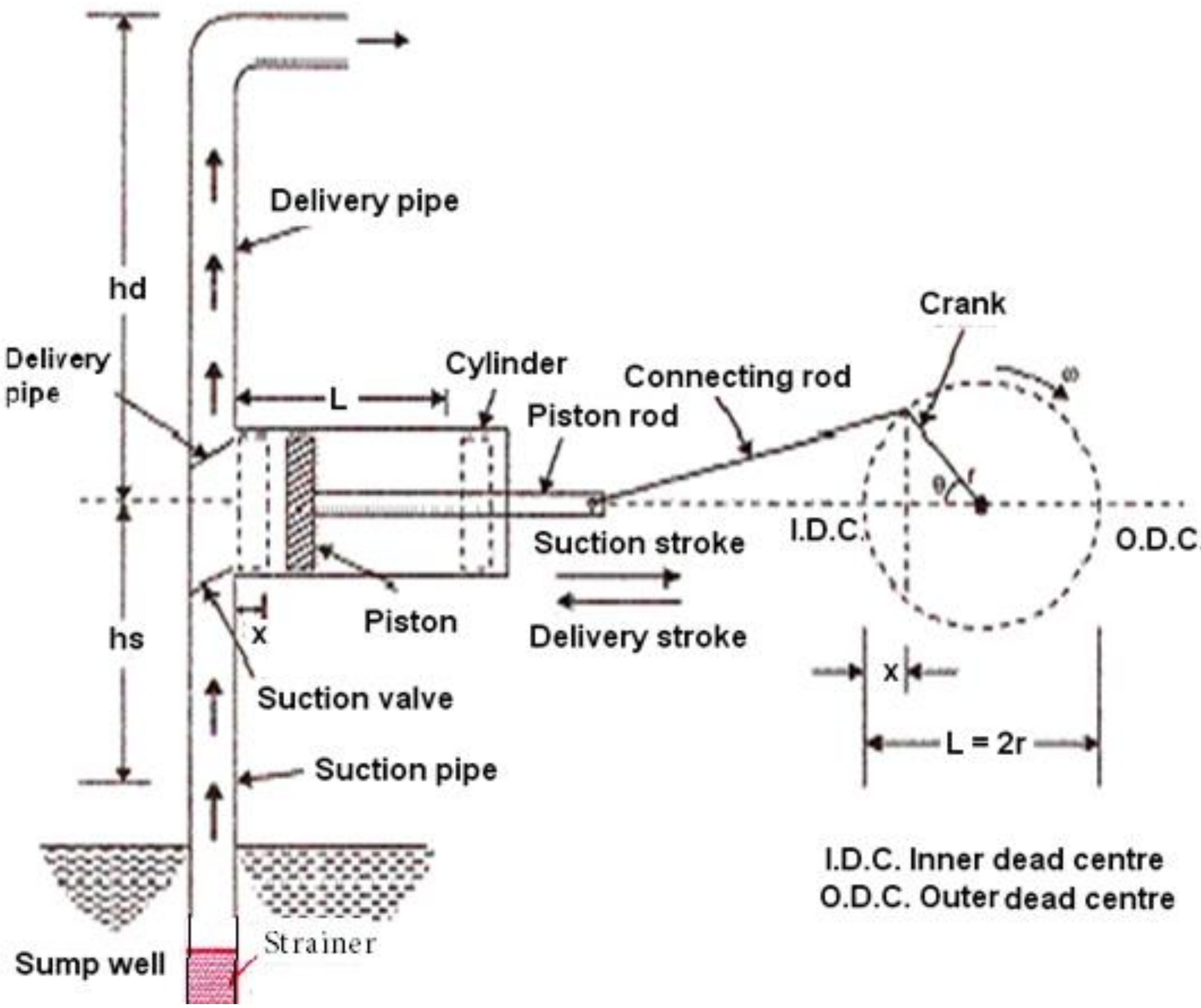


Figure 8.1 Schematic diagram of reciprocating pump

CONTRUCTION DETAILS OF A RECIPROCATIN PUMP

Components of reciprocating pumps:-

1. **Piston or plunger: –** A piston or plunger that reciprocates in a closely fitted cylinder.
2. **Crank and Connecting rod: –** Crank and connecting rod mechanism operated by a power source. Power source gives rotary motion to crank. With the help of connecting rod we translate reciprocating motion to piston in the cylinder.
3. **Suction pipe with strainer: –** One end of suction pipe remains dip in the liquid and other end attached to the inlet of the cylinder. A strainer is also fitted at the lower end of suction

pipe , strainer is provided in order to prevent mud, sand or any other foreign material from entering to the pipe. One end of delivery pipe attached with delivery part and other end at discharge point.

4. **Suction and Delivery valve: –** suction and delivery values are provided at the suction end and delivery end respectively. These values are non-return values.

WORKING OF RECIPROCATING PUMP

Operation of reciprocating motion is done by the power source (i.e. electric motor or I.C. engine, etc. Power source gives rotary motion to crank; with the help of connecting rod we translate reciprocating motion to piston in the cylinder (i.e. intermediate link between connecting rod and piston). When crank moves from inner dead centre to outer dead centre vacuum will create in the cylinder and when piston moves outer dead centre to inner dead centre and piston force the water at outlet or delivery valve.

PROCEDURE

1. Clean the apparatus and make it dust free.
2. Close the drain valves provided.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Open flow control valves given on the water discharge line and control valve given on suction line.
5. Set the speed of motor with the help of 3- speed step cone pulley.
6. Now switch on the pump.
7. Operate the control valve to regulate the suction of the pump.
8. Record the RPM of the motor by tachometer.
9. Record discharge pressure and suction from pressure and vacuum gauges.
10. Record the power consumption by energy meter, with the help of stop watch.
11. Measure the flow of water, discharge by the pump, using stop watch and measuring tank.

12. Repeat the same procedure for different pressure head.
13. Repeat the same procedure for different RPM with help of step cone pulley.

OBSERVATION TABLE

S no.	Rpm of The pump	Gauge Pressure (kg/cm^2)	Vacuum (mm/hg)	Water height in Tank R(cm)	Time for R,t (sec)	time /10 pulses. t (sec)
1.	1950	1.8	45	5.1	10	19.19
2.						
3.						

FORMULA USED

(1) H.P. Elec. =P/t_1 X 3600/EMC X 1000/746 HP

Where P = Number of pulses,

t_1 = time for P pulses

EMC = 3200 (energy meter constant)

H.P. Elec. = P/t_1 X 3600/3200 X 1000/746 HP

(2) H.P. Shaft= HP Elec. x $ή_{motor}$

$ή_{motor}$ 0.8 (given)

(3) Actual discharge Q= AXR / t X 100 (m^3/sec)

A= area of measuring tank = $0.1m^2$

R= height of water in measuring tank is cms.

t = time for R in sec.

(4) Total head H= 10((delivery pressure (kg/cm^2) +vacuum pressure (mm of hg) /760) +1)

H =10X ((G+V /760) +1) meter of water.

(5) HP Pump = $\rho Q_a H / 75$ (HP)

Where

P = density of water (kg/m^3)

Q= actual discharge (m^3 /sec)

H= total head (meter of water)

(6) Efficiency of pump = (H.P. pump / H.P. shaft) X 100

(7) Efficiencyoverall = H.P. pump / HP Elec. X 100

(8) Efficiency volumetric= (Q_a / Q_t) X 100

Theoretical discharge Q_t =a x L x N / 60

Where a = area of cylinder in m^2 = $2.375x10^{-3}$ m^2

L = length of stroke in meter =0.04 m

N = speed of crank rpm

Calculation table

S no.	H.P. elec.	H.P. shaft	Theoretical Discharge Q (m^3/sec	Actual Discharge Q(m^3 / s	Total head H(m of water)	H.P. pump	pump %	overall %	volumetric %
1.	0.78	0.63	$3.08x10^{-3}$	$0.652x10^{-3}$	28.59	0.248	39.45	31.56	21.16
2.									
3.									

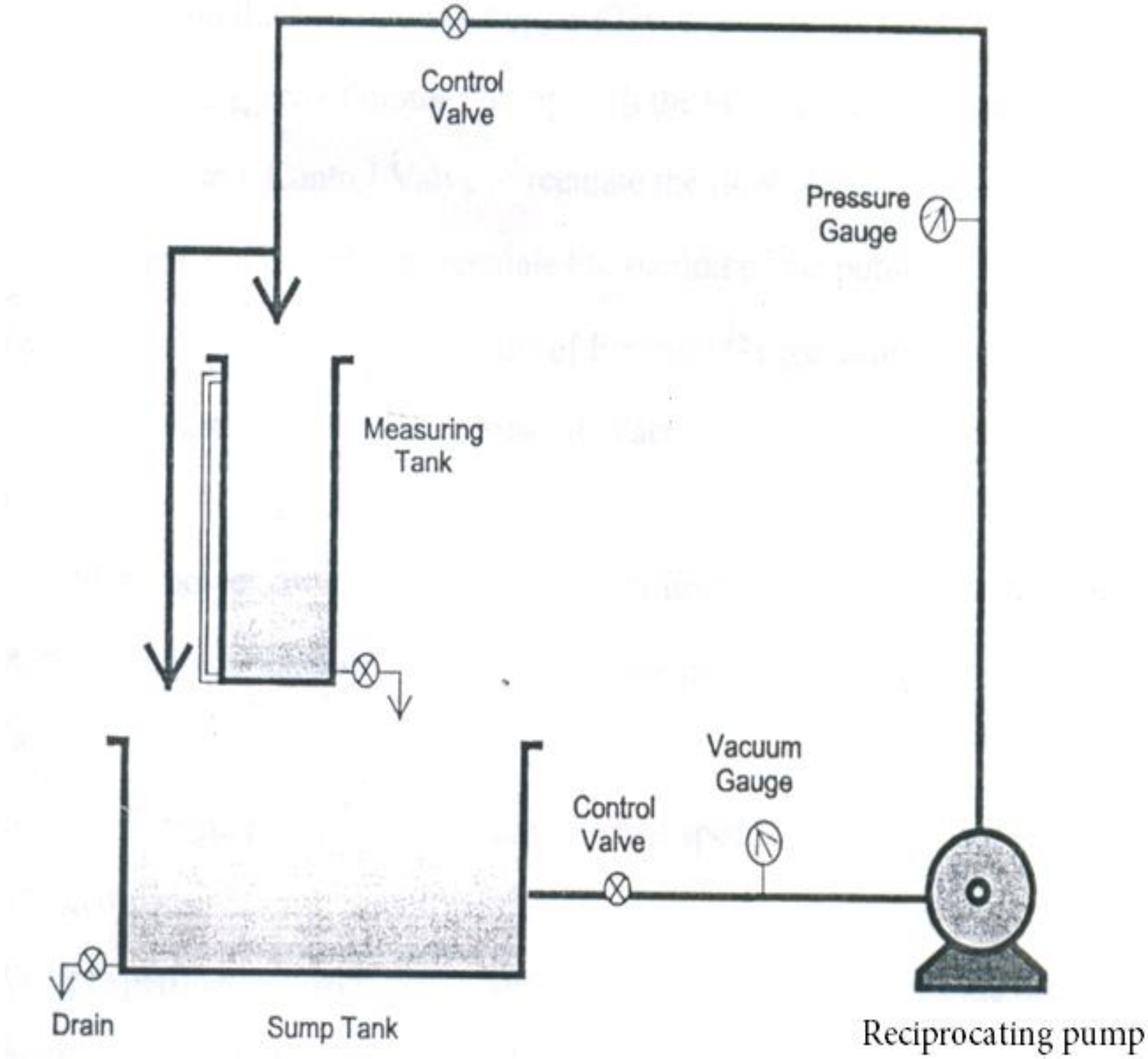


Figure 8.2 Reciprocating pump test rig.

CHARACTERISTIC CURVES FOR CENTRIFUGAL PUMP

Plotting characteristic curves for centrifugal pump includes the plotting of following curves

(1) Constant speed curves

(2) Constant head curves

(3) Constant efficiency curves

1) Constant HeadCurves

H =Constant

N =
P=
Q = } Variables
$\acute{\eta}_0$ =

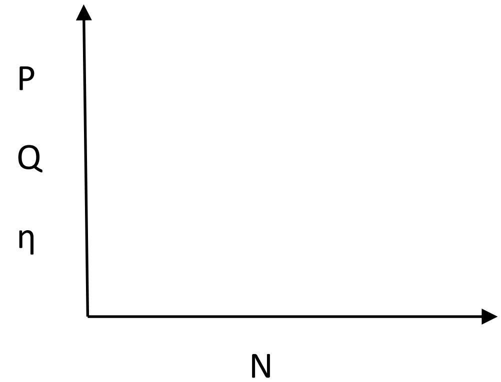


Figure 8.3 constant head curves

Where

P=Power output of turbine N= RPM of turbine

Q= Discharge η=Efficiency

H=head

For constant head curves plot the curves by plotting the speed along the x-axis and power, discharge and efficiency on y-axis as shown in figure 8.3

3. Constant speed curves

N =Constant

H =
P=
Q = } Variables
$\acute{\eta}_0$ =

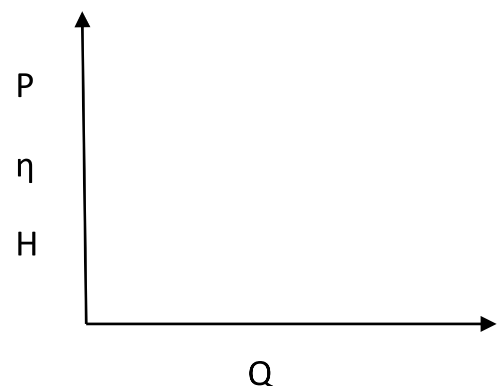


Figure 8.4 constant head curves

For constant speed curves plot the curves by plotting discharge on x-axis and, power and efficiency on y-axis as shown in figure 8.4

4. Constant efficiency curves

For plotting the constant efficiency curves, horizontal lines representing the same efficiency are drawn on $\acute{\eta}_0$ Vs Discharge. The points, at which these lines cut the efficiency curves at various speeds, are transferred to the corresponding H Vs Discharge. The points having the same efficiency are then joined by smooth curves. These smooth curves represent the iso-efficiency curves shown in figure 8.5

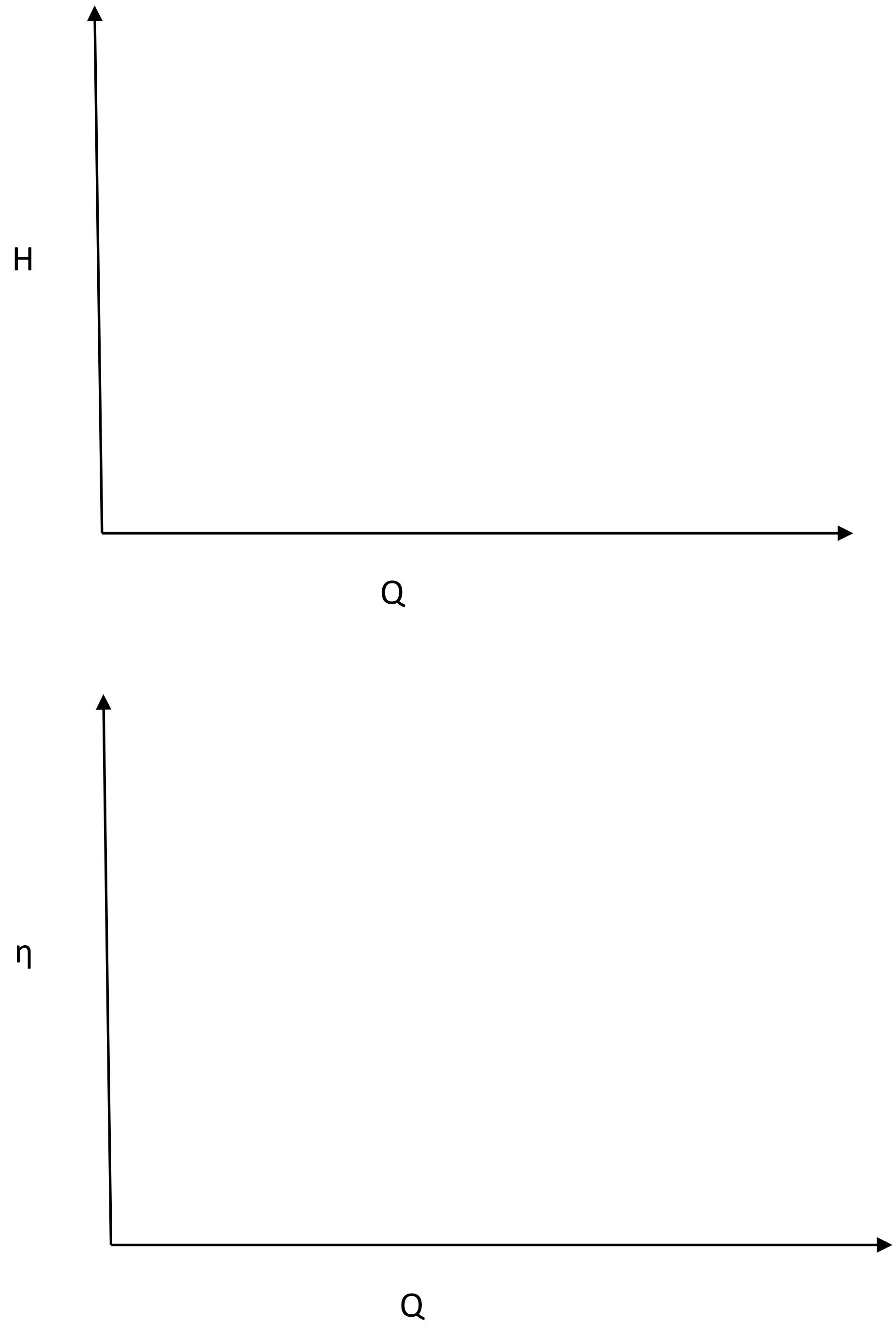


Fig 8.5 constant efficiency curves

DISCUSSION OF RESULTS

The maximum efficiency of pump is………………..%

PRECAUTIONS

1. Do not run the pump at low voltage i.e. less than 180 volts.
2. Never fully close the delivery line and by –pass line valves simultaneously.
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, run pump at least once in three month.
5. Use grease / oil to the rotating parts, once in three month.
6. If apparatus is not in use drain the apparatus completely after 15 days.
7. Do not touch the switches with wet hands.

EXPERIMENT NO: - 09

OBJECTIVE

To study the constructional details of Hydraulic Ram and determine its various efficiencies.

APPARATUS

Hydraulic Ram test rig, stop watch, tachometer, engineering scale, measuring cylinder.

DISCRIPTION

The Hydraulic Ram is a contrivance utilizing the water hammer principle. Ram is used when a natural source of water like a spring or stream at low head is available at a nearby place to pump a part of water to higher heads. The Ram requires no external energy. The work done by a large quantity of water in falling through a small height is used to raise a small part of water to a greater height. Or the hydraulic ram is a pump which raises water without any external power for its operation. When large quantity of water is available at a small height, a small quantity of water can be raised to a greater height with the help of hydraulic ram.

THEORY

A quantity of water is first allowed to pass through a long column of pipe connected to hydraulic ram and discharged through a waste valve. The momentum of the water flowing through the pipe is then suddenly destroyed by the automatic closing of the waste valve which pumps the small quantity of water to high head tank. When the moving column of water is brought to rest, the waste valve opens and the cycle is repeated automatically. The Ram requires no external energy. The work done by a large quantity of water in falling through a small height is used to raise a small part of water to a greater height.

WORKING OF HYDRAULIC RAM

When the inlet valve fitted to the supply pipe is opened, water starts flowing from the supply tank to the chamber, which has two valves at B and C. The valve B is called waste valve and valve C is called delivery valve. The valve C is fitted to an air vessel. As the water is coming into the chamber from the supply tank, the level of water rises in the chamber and waste valve B starts moving upward. A stage comes, when the waste valve B suddenly closes. This sudden closer of waste valve creates high pressure inside the chamber. This high pressure force opens the delivery valve C. The water from chamber enters the air vessel and compresses the air inside the air vessel. This compressed air exerts force on the water in the air vessel and small quantity of water is raised to a greater height. When the water in the chamber loses its momentum the waste valve B opens in the downward direction and flow of water from supply tank starts flowing to the chamber and the cycle will be repeated.

DIAGRAM

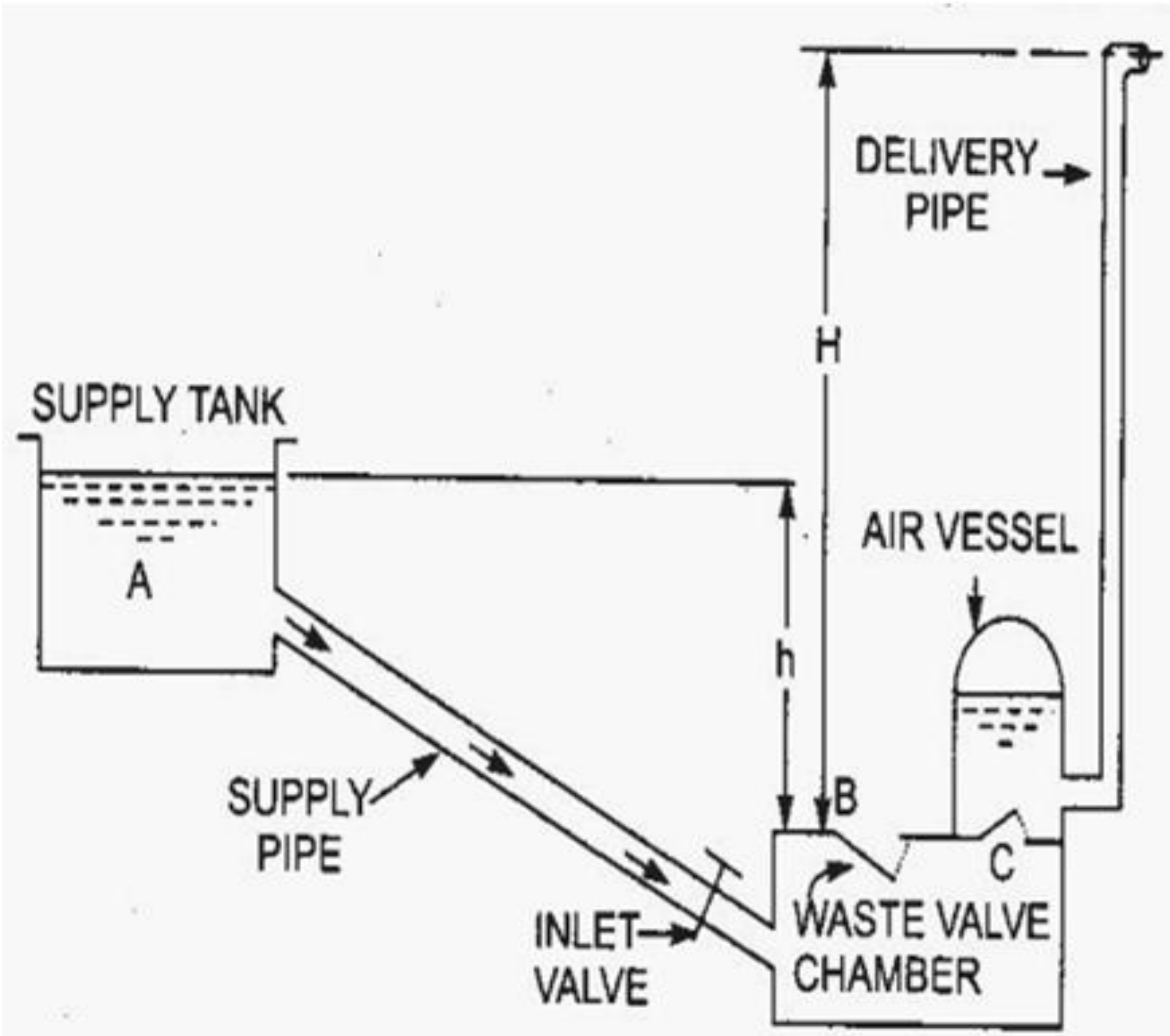


Figure 9.1 Schematic diagram of hydraulic ram

CONTRUCTIONAL DETAILS OF HYDRAULIC RAM

1. **Supply tank: -** Supply tank is the reservoir that supplies the water to the ram.
2. **Supply pipe: -** Supply pipe is the pipe that connects the hydraulic ram chamber to the supply tank.
3. **Inlet valve: -** The valve that allows water from supply pipe to entering to the ram chamber.
4. **Chamber: -** Chamber is the closed container of ram in which valves are there ,waste valve and non returning valve.

5. **Waste valve and delivery valve: -** The other end of the supply pipe that enters top the chamber in the chamber there is two valves one is waste valve that allows waste water to pass out from the chamber and other valve who is nonreturnable type that allows water to flow to the delivery pipe that is called delivery valve.
6. **Air vessel: -** The working of air vessel is when the water from the chamber enters the air vessel and compresses the air inside the air vessel. This compressed air exerts force on the water in the air vessel.
7. **Delivery pipe: -** When the water is compressed in the air vessel and it exerts water to raise to the height and the pipe which allows water to flow from air vessel to the raised height that is called delivery pipe.

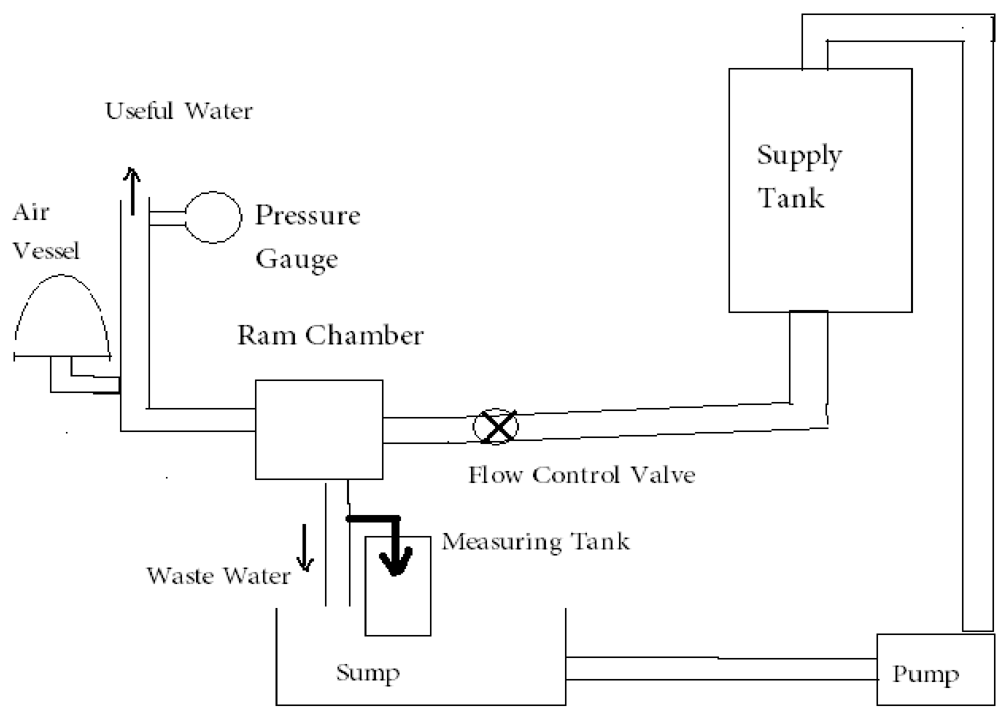


Figure 9.2 Hydraulic Ram test rig

PROCEDURE

1. Clean the apparatus and make it dust free.
2. Close the drain valves provided.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Open flow control valves given on the water discharge line and control valve given on suction line.

5. Now switch on the main power supply.
6. Fill overhead tank with water.
7. Adjust the ram stroke at minimum.
8. When overhead tank overflows, open control valve of valve of ram.
9. Now ram is in operation.
10. Adjust stroke of ram to vary the head developed by the ram.
11. Open slightly the control valve provided at useful water discharge line of air vessel.
12. Record Pr gauge reading in air vessel.
13. Measure flow rate of useful water & waste water discharged by the ram using stop watch and measuring tanks.
14. Repeat experiment at different flow rates of useful water discharged by the ram by regulating the control valve provided at useful water discharged line of air vessel.
15. Repeat the same procedure for different flow rates.
16. Switch OFF the pump first.

OBSERVATIONS

S no.	Useful water collected (ltr)Q_C	Time taken for collecting Useful water,t_1(sec)	Water height of waste water R R_2-R_1(cm)	Time taken For R_0 t_2 (sec)	Pressure (kg/cm$^{2)}$ (P)
1.	1	82	6.4	15	0.31
2.					
3.					

FORMULA USED

(1) Discharge of waste water (Q) = A x R / (t_2 X100)

A= Area of measuring tank in m^2 = 0.1215

R=Height of waste water in measuring tank in cm

t_2 =Time for R

(2) Useful water discharge (q) = Q_c / (t_1 x 1000)

Where

Q_c = useful water collected in liters

t_1 = time for Q_c.

(3) Delivery head (H_d) =10 x P m of water

Where

P = gauge pressure of delivery water in kg / cm^2

(4) D' Aubuisson's Efficiency = $ή_A$ =q H_d / {(q +Q) h_s}

Where

h_s = 1 meter (For the given setup)

So $ή_A$ = {q H_d / (q +Q)}X 100

(5) Rankine' efficiency $ή_R$ = q H_d / (Q x h_s) X 100

Where

h_s = 1 meter (For the given setup)

CALCULATION TABLE

Sno	Discharge of waste water (Q)	Discharge of useful water,(q)	Delivery Head (H_d)	Efficiency $ή_A$	Efficiency $ή_R$
Units	**m^3/sec**	**m^3/sec**	**M**	**%**	**%**
1.	5.184×10^{-4}	1.2195×10^{-5}	3.1	7.12	7.29
2.					
3.					

DISCUSSION OF RESULTS

The average efficiency of ram are $ή_A$ =……………..%

$ή_R$ =…………….%

PRECAUTIONS

1. Do not run the pump at low voltage i.e. less than 180 volts.
2. Never fully close the delivery line and by –pass line valves simultaneously.
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, run pump at least once in three month.
5. Use grease / oil to the rotating parts, once in three month.
6. If apparatus is not in use drain the apparatus completely after 15 days.
7. Do not touch the switches with wet hands.

EXPERIMENT NO: - 10

OBJECTIVE

To study the constructional details of a Centrifugal Blower.

APPARATUS

Centrifugal blower test rig.

DISCRIPTION

Blower consists of a motor, impeller and its body. Three impellers i.e. Forward curved, backward curved and radial curved vane are provided with the set up. These are interchangeable and may one of them can be fixed on the motor shaft. To find out the outlet velocity, the Pitot tube is provided. Differential manometer is fixed to find out the differences of pressure of Pitot tube at Blower outlet. Energy meter is provided to find out the input HP to blower so that to find out the overall efficiency of blower for changing the discharge and head, butterfly valve are provided at outlet of the air.

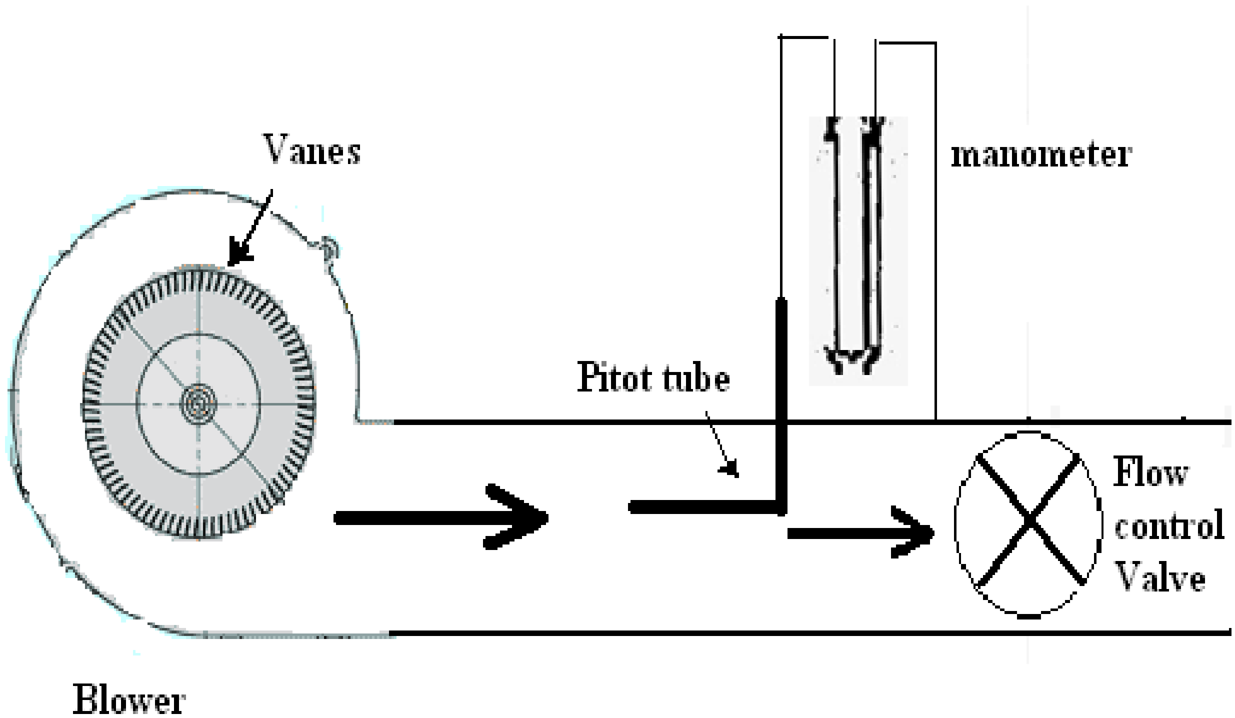


Fig 10.1 Centrifugal blower test rig

CONSTRUCTIONAL DETAILS

1. **Motor: -** An electric motor is used to run the blower. Blower vanes are directly mounted on the motor shaft.
2. **Impeller: -** The rotating part of a centrifugal blower is called impeller. It consists of a series of (backward Curved, forward curved or straight) vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor.
3. **Vanes:** - Three types of vanes are used in the blower. Depending upon the curvature of the vanes these are classified as backward curved vanes, forward curved vanes and straight vanes as shown in the figure 10.2.

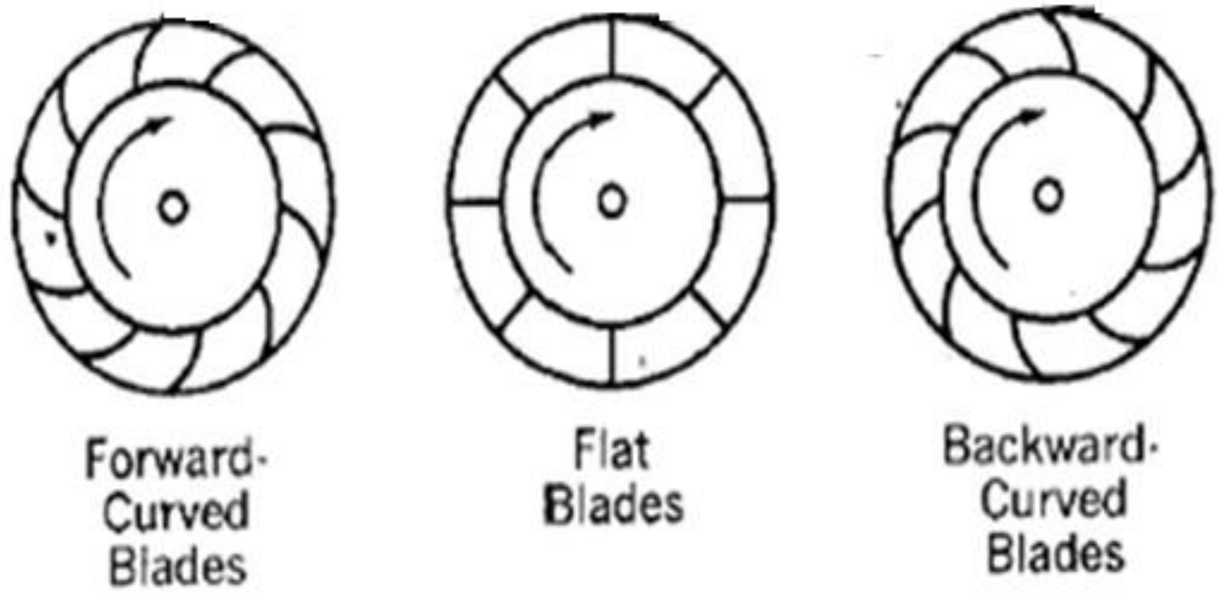


Figure 10.2 Backward Curved, forward curved or straight vanes

4. **Casing: -** The casing of a centrifugal blower is vortex casing (increasing cross-sectional area). It surrounds the impeller and is designed in such a way that the kinetic energy of the impeller is transferred to air gets converted in to pressure energy before the air leaves the casing and enters the delivery pipe.
5. **Pitot tube:** - it is the cylindrical tube provided in the delivery pipe and its one end is connected to the manometer to indicate the differential pressure and hence to measure the flow rate of air delivered.
6. **Flow control valve:-** A butterfly type valve is used to control the flow rate of the delivered air. It is provided in the delivery pipe. It can easily be set at the position of $1/4^{th}$,$1/2^{nd}$ and $3/4^{th}$ opening position of the valve.
7. **Delivery pipe:-** delivery pipe is the circular tube provided to delivered the air at desired location. This is generally made up of iron.

WORKING OF CENTRIFUGAL BLOWER

The centrifugal blower works on the principle of forced vortex flow, which means that when an external torque rotates certain mass of fluid, the rise in pressure head of the rotating fluid takes place. The rise in pressure head at any point of the rotating fluid is proportional to the square of tangential velocity of (i.e. rise in pressure head = V^2 /2g or $\omega^2 r^2$ / 2g) the liquid at that point. Thus, at the outlet of impeller where radius is more, the rise in pressure head will be more and the fluid (air) will be discharged at the outlet with a high pressure head.