METHODIST

COLLEGE OF ENGINEERING & TECHNOLOGY

Estd: 2008

Approved by AICTE New Delhi | Affiliated to Osmania University, Hyderabad

Abids, Hyderabad, Telangana, 500001

DEPARTMENT OF MECHANICAL ENGINEERING

LABORATORY MANUAL

FLUID MECHANICS & HYDRAULIC MACHINERY LABORATORY

BE IV Semester

AUTONOMOUS

Name: ....

Roll No: ....

Branch:..SEM:......................

Academic Year: ....

Empower youth - Architects of Future World

METHODIST

COLLEGE OF ENGINEERING & TECHNOLOGY

Estd: 2008

Approved by AICTE New Delhi | Affiliated to Osmania University, Hyderabad

Abids, Hyderabad, Telangana, 500001

VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

METHODIST

COLLEGEOF ENGINEERING & TECHNOLOGY

Approved by AICTE New Delhi | Affiliated to Osmania University, Hyderabad

Estd: 2008

Abids, Hyderabad, Telangana, 500001

DEPARTMENT OF MECHANICAL ENGINEERING

LABORATORY MANUAL

FLUID MECHANICS & HYDRAULIC MACHINERY LABORATORY (6PC455ME)

Prepared by

Dr. M. Udaya Kumar Associate Professor. Mech. Engg.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be a reputed centre of excellence in the field of mechanical engineering by synergizing innovative technologies and research for the progress of society.

MISSION

- To impart quality education by means of state-of-the-art infrastructure.
- To involve in trainings and activities on leadership qualities and social responsibilities.
- To inculcate the habit of life-long learning, practice professional ethics and service the society.
- To establish industry-institute interaction for stake holder development.

DEPARTMENT OF MECHANICAL ENGINEERING

After 3-5 years of graduation, the graduates will be able to:

PEO1: Excel as engineers with technical skills, and work with complex engineering systems.

PEO2: Capable to be entrepreneurs, work on global issues, and contribute to industry and society through service activities and/or professional organizations.

PEO3: Lead and engage diverse teams with effective communication and managerial skills.

PEO4: Develop commitment to pursue life-long learning in the chosen profession and/or progress towards an advanced degree

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES

Engineering Graduates will be able to:

Po1. Engineering knowledge: Apply the basic knowledge of mathematics, science and engineering fund a mentals along with the specialized knowledge of mechanical engineering to understand complex engineering problems.

PO2. Problem analysis: Identify, formulate, design and analyse complex mechanical engineering problems using knowledge of science and engineering.

Po3. Design/development of solutions: Develop solutions for complex engineering problems, design and develop system components or processes that meet the specified needs with appropriate consideration of the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Formulate engineering problems, conduct investigations and solve using research-based knowledge.

PO5. Modern tool usage: Use the modern engineering skills, techniques and tools that include IT tools necessary for mechanical engineering practice.

Po6.Theengineerandsociety: Apply the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities during professional practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10.Communication: Communicate effectively on complex engineering activities to various groups, ability to write effective reports and make effective presentations.

PO11. Project management and finance: Demonstrate and apply the knowledge to understand the management principles and financial aspects in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in Independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

Mechanical Engineering Graduates will be able to:

PSO1: Apply the knowledge of CAD/CAM/CAE tools to analyse, design and develop the products and processes related to Mechanical Engineering.

PSO 2: Solve problems related to mechanical systems by applying the principles of modern manufacturing technologies.

PSO 3: Exhibit the knowledge and skill relevant to HVAC and IC Engines.

CODE OF CONDUCT

1. Students should report to the concerned labs as per the time table schedule.

2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.

3. After completion of the experiment, certification of the concerned staff in-charge in the observation book is necessary.

4. Staff member in-charge shall award marks based on continuous evaluation for each experiment out of maximum 15 marks and should be entered in the evaluation sheet/attendance register.

5. Students should bring a note book of about 100 pages and should enter the readings/observationsintothenotebookwhileperformingtheexperiment.

6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff member in-charge.

7. Not more than three students in a group are permitted to perform the experiment on a setup for conventional labs and one student in case of computer labs.

8. The components required pertaining to the experiment should be collected from stores in-charge after duly filling in the requisition form.

9. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.

10. Any damage of the equipment or burn-out of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.

11. Students should be present in the labs for the total scheduled duration.

12. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.

DO'S

1. All the students are instructed to wear protective uniforms, shoes & identity cards before entering into the laboratory.
2. Please follow instructions precisely as instructed by your supervisor.
3. Students should come with thorough preparation for the experiment to be conducted.
4. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
5. Practical records should be neatly maintained.
6. Students should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
7. Theory regarding each experiment should be written in the practical record before procedure in your own words.
8. If any laboratory equipment is malfunctioning, making strange noise, sparking, smoke, or smell, inform the instructor or staff immediately. It is imperative that the instructor or staff knows of any equipment problems.

DON'TS

1. Don't operate any instrument with out getting concerned staff member's prior permission.
2. Using the mobile phones in the laboratory is strictly prohibited.
3. Do not leave the experiments unattended while in progress.
4. Do not crowd around the equipment& run inside the laboratory.
5. Do not wander around the lab and distract other students
6. Do not use any machine that smokes, sparks, or appears defective.

COURSE OBJECTIVES

The objectives of this course are to:

1.	Understand the working of pumps of different kinds and their behaviour.
2.	Understand the working of turbines of different kinds and their behaviour.
3.	Understand the theory of working of various flow measuring devices and their utility in industry.

COURSE OUTCOMES

CO No.	Course Outcomes	PO
CO 1	Determine the Coefficient of Discharge of Venturimeter and Orifice meter	1,2,9,12
CO 2	Evaluate the performance of Centrifugal, Reciprocating, Gear, Self priming pumps	1,4,5,9,12
CO 3	Evaluate the performance of Pelton ,Francis ,Kaplan Turbines	1,4,5,9,12
CO 4	Determine the coefficient of Jet on Vanes	1,2,9,12
CO 5	Explain the principles of Hydraulicand Pneumatic circuits and models	1,8,9,12

COURSE OUTCOMES VS POs MAPPING

S. NO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
6PC455ME.1	3.0	2.0	-	-	-	-	-	-	3.0	-	-	3.0	-	-	3.0
6PC455ME.2	3.0	-	-	3	3	-	-	-	3.0	-	-	3.0	-	-	3.0
6PC455ME.3	3.0	-	-	3	3	-	-	-	3.0	-	-	3.0	-	-	3.0
6PC455ME.4	3.0	2.0	-	-	-	-	-	-	3.0	-	-	3.0	-	-	3.0
6PC455ME.5	3.0	-	-	-	-	-	-	3	3.0	-	-	3.0	-	-	3.0
Avg	3.0	2.0	-	3	3	-	-	3.0	3.0	-	-	3.0	-	-	3.0

LIST OF EXPERIMENTS

LIST OF ADDITIONAL EXPERIMENTS

INDEX

Experiment No	Experiment Name	Date	Page No	Marks				Remarks/ Signature
				P	R	V	T	

Experiment No	Experiment Name	Date	Page No	Marks				Remarks/ Signature
				P	R	V	T	

EXPERIMENT - 01

EXPERIMENT ON ORIFICEMETER

AIM:

To demonstrate the use of Orificemeter as flowmeter and to determine the Co-efficient of discharge.

APPARATUS:

1. Measuring tank to measure flow rate.
2. A pipe line with Orificemeter.
3. Tappings with ball valves are provided at inlet & Throat of Orificemeter and those are connected to double column Manometer.
4. A constant steady supply of water with a means of varying the flow rate using Monobloc pump.
5. Stop watch

THEORY:

An Orifice meter is used to measure the discharge in any closed surface. Orifice meter works on the principle that by reducing the cross section area of the flow passage, a pressure difference between the two sections is developed and this difference enables the determination of the discharge through the pipe. In a water distribution system and in processing industries it is necessary to measure the volume of liquid flowing through a pipe line. The orifice meter is introduced in the pipeline to achieve this. Hence knowledge of the value of the coefficient of discharge of the orifice meter is a must. Orifice meter consists of a flat circular plate with a circular hole called orifice, which is concentric with the pipe axis pressure tapings are connected to pipe wall on the both sides of the plate. So that the difference in the fluid pressure on both sides of the orifice plate are measured. As the fluid passes through the orifice meter, a lot of eddies are formed and there is a loss of energy due to which the actual discharge Q_a , is far less than Q_{th} which is given by

$$Q_{th}=\frac{c_d a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2-a_2^2}}$$

Where c_d= Coefficient of discharge

a_1= area of inlet pipe of the Orificemeter

a_2= area of Orificemeter

Specifications:

- Area of Measuring tank A = 0.12 m^2
- Diameter of Orificemeter d = 12.5 mm
- Diameter of the inlet pipe of the Orificemeter D = 25 mm

PROCEDURE:

1. Fill-in the sump with clean water.

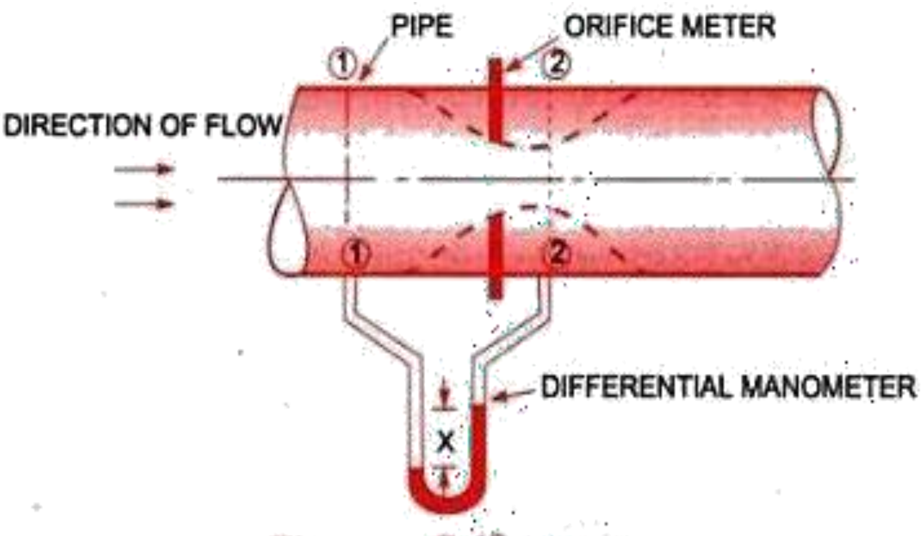


Fig. Orifice meter.

Tabular column :

S.NO	Manometer reading(cm)		t (sec)	H= $\frac{(h1+h2)*12.6}{100}$ (m)	$\sqrt{h}$	$Q_a = \frac{AR}{t}$ (m^3/sec)	Qth= $\frac{c_d a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$	$C_d = \frac{Qa}{Q_{th}}$
	h_1	h_2						
Average value of coefficient of discharge								

2. Keep the delivery valve open.
3. Adjust the flow through the control valve of the pump.
4. Note down the differential head reading in the manometer.(Expel if any air is there by opening the drain cocks provided with manometer).
5. Operate the butterfly valve to note down the collecting tank readings against the known time and keep it open when the readings are taken.
6. Change the flow rate & repeat the experiment.
7. The observations are tabulated and coefficient of discharge of Orificemeter is computed

Calculations:

1. Theoretical discharge

$$Qth = \frac{c_d a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$$

Where $C_d = 1$

a_1= area of inlet pipe of the Orificemeter$= \frac{\pi D^2}{4} m^2$

a_2= area of Orificemeter $= \frac{\pi d^2}{4} m^2$

H= Loss of head$= \frac{(h1 + h2) * 12.6}{100}$m

2. Actual discharge

$$Q_a = \frac{A \ X \ R}{1000 \ X \ t} \ m^3/sec$$

Where A = Area of Measuring tank in m^2.

R = Rise of Water level for time t sec in mtrs

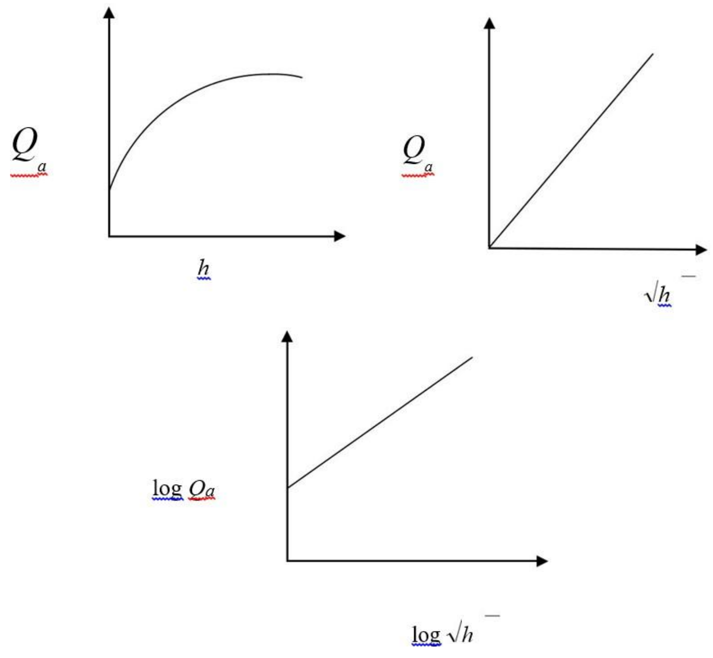
3. Coefficient of discharge

$$C_d = \frac{Actual \ discharge}{Theoretical \ discharge} = \frac{Qa}{Q_{th}}$$

Precautions:

1. All the joints should be leak proof and water tight
2. Manometer should be filled to about half the height with mercury
3. All valves on the pressure feed pipes and manometer should be closed to prevent damage and over loading of the manometer before starting the motor.
4. Ensure that gauge glass and meter scale assembly of the measuring tank is fixed vertically and water tight
5. Ensure that the pump is primed before starting the motor
6. Remove the air bubbles in differential manometer by opening air release valve
7. Take the differential manometer readings without parallax error
8. Ensure that the electric switch does not come in contact with water
9. The water filled in the sump tank should be 2 inches below the upper end.

Model graphs



Space For Calculations

RESULT & CONCLUSIONS:

Coefficient of discharge of Orificemeter (C_d) =

VIVA QUESTIONS:

- For which one, the coefficient of discharge is smaller, venturimeter or Orificemeter?
- What is the reason for smaller value of C_d ?
- What is Orifice meter?
- What is the principle of Orifice meter?
- For discharge measurement through pipes which is having cheaper arrangement and whose installation requires a smaller length?
- What are the parts of Orifice
- What is the thickness of the plate t?
- What is the diameter of the orifice?
- Where two pressure taps are provided?
- Where upstream pressure tap is located?
- At which section on the downstream side the pressure tap is provided quite close to orifice plate?
- Maximum possible pressure difference that exists between upstream side of the orifice plate and downstream side of the orifice plate is measured by means of what?
- Where there is a greater loss of energy, whether in venturi meter or in orifice meter?
- Why there is a greater loss of energy in orifice meter?
- What is value of c_d ?
- When an orifice is called large orifice?
- On what the position of downstream pressure tap depends?
- What is manometer liquid ?
- Where the velocity of flow is maximum and pressure is minimum?
- What is vena contract?
- Which diameter is less orifice or pipe?
- What is the range of bevel angle in Orificemeter?

EXPERIMENT - 02

EXPERIMENT ON VENTURIMETER

AIM:

To demonstrate the use of Venturimeter as flowmeter and to determine the coefficient of discharge.

APPARATUS:

1. Measuring tank to measure flow rate.
2. A pipe line with a Venturimeter.
3. Tappings with ball valves are provided at inlet & Throat of Venturimeter and those are connected to double column Manometer.
4. A constant steady supply of water with a means of varying the flow rate using Monobloc pump.
5. Stop watch

THEORY:

Venturimeter is a device invented by Ciemens Herchel in 1887 and named by him after Venturi, who experimented with diverging tubes for the measurement of rate of flow in pipe lines. The basic principle on which Venturimeter works is that by reducing the cross-sectional area of the flow passage, a difference of pressure is created and the measurement of the pressure difference enables the determination of the discharge through the pipes. The fluid flowing the pipe is led through a contracting section to a throat which has a smaller cross section area than the pipe, so that the velocity is accomplished by a fall in N/m^2 .The magnitude of which depends upon the rate of flow so that by measuring the pressure drop, the discharge can be calculated. Beyond the throat the fluid is in a pipe of slowly diverging section, the pressure increasing as velocity falls.

In a water distribution system and in processing industries it is necessary to measure the volume of liquid flowing through a pipe line. The Venturimeter is introduced in the pipeline to achieve this. Hence knowledge of the value of the coefficient of discharge of the Venturimeter is a must. The velocity of flow through a Venturimeter is obtained by applying Bernoulli's theorem. The theoretical discharge can be calculated by using the velocity obtained.

$$Q_{th} = \frac{c_d a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$$

Where c_d= Coefficient of discharge

a_1= area of inlet pipe of the Venturimeter ; a_2 = area of throat of Venturimeter

Specifications:

- Area of Measuring tank A = 0.12 m^2
- Diameter of the Venturimeter (Throat) d = 12.5 mm
- Diameter of the inlet pipe of the Venturimeter D = 25 mm

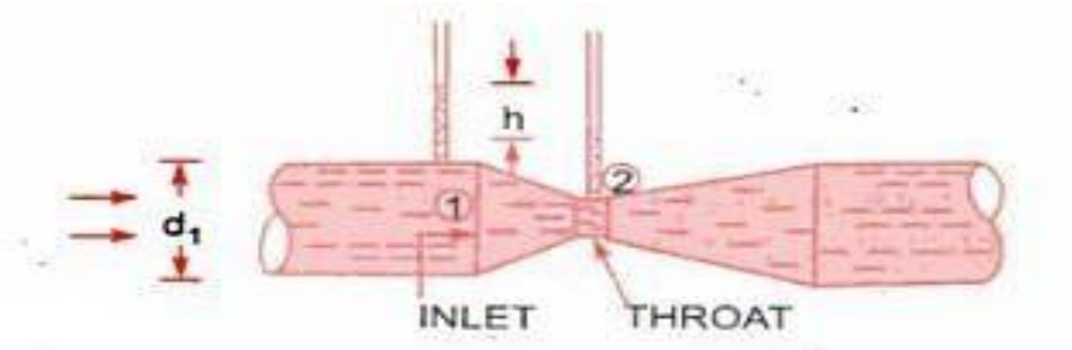


Fig. Venturimeter.

Tabular column:

S.NO	Manometer reading(cm)		t (sec)	H= $\frac{(h1+h2)*12.6}{100}$ (m)	$\sqrt{h}$	$Q_a = \frac{AR}{t}$ (m^3/sec)	Qth= $\frac{c_d a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$	$C_d = \frac{Qa}{Q_{th}}$
	h_1	h_2						
Average value of coefficient of discharge								

PROCEDURE:

1. Start the motor, Open the gate valve , allow the water to flow through pipe full
2. Reject the air bubbles if any by slowly raising the pinch cock
3. Note the manometric fluid levels h_1 and h_2 in the two limbs of the manometer
4. Collect the water in the collecting tank up to 10 cm rise(R) of water level and note down corresponding time (t)taken to rise that level
5. Repeat the above procedure by gradually increasing the flow and note down the required readings.
6. The observations are tabulated and coefficient of discharge of Venturimeter is computed.

Calculations :

1. Theoretical discharge

$$Q_{th} = \frac{c_d a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$$

Where $c_d = 1$

a_1= area of inlet pipe of the Venturimeter= $\frac{\pi D^2}{4}$ m^2

a_2= area of Venturimeter = $\frac{\pi d^2}{4}$ m^2

H= Loss of head= $\frac{(h1 + h2) *(13.6-1)}{100}$ m

2. Actual discharge

$$Q_a = \frac{A\ X\ R}{1000\ X\ t} \quad m^3 / sec$$

Where A = Area of Measuring tank in m^2.

R = Rise of Water level for time t sec in mtrs

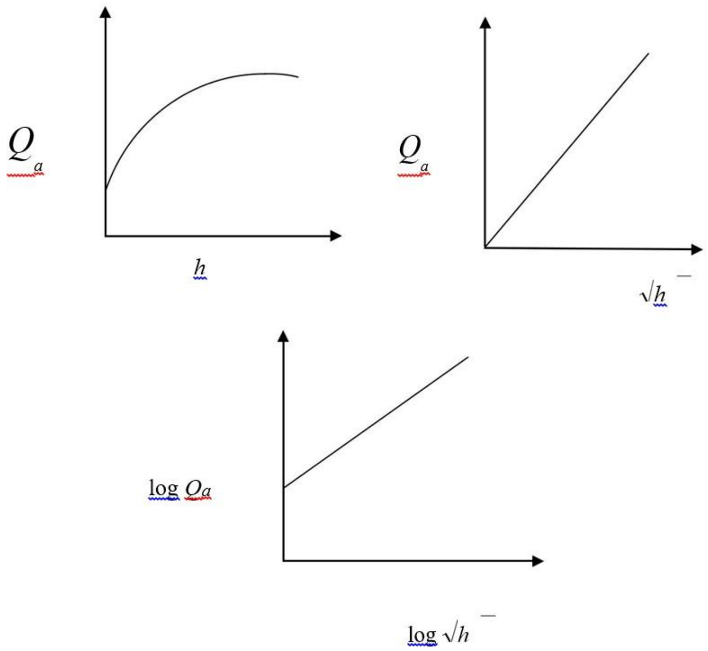
3. Coefficient of discharge

$$C_d = \frac{Actual\ discharge}{Theoretical\ discharge} = \frac{Qa}{Q_{th}}$$

Precautions:

1. All the joints should be leak proof and water tight
2. Manometer should be filled to about half the height with mercury
3. All valves on the pressure feed pipes and manometer should be closed to prevent damage and over loading of the manometer before starting the motor.
4. Ensure that gauge glass and meter scale assembly of the measuring tank is fixed vertically and water tight
5. Ensure that the pump is primed before starting the motor
6. Remove the air bubbles in differential manometer by opening air release valve
7. Take the differential manometer readings without parallax error
8. Ensure that the electric switch does not come in contact with water
9. The water filled in the sump tank should be 2 inches below the upper.

Model graphs :



Space For Calculations

RESULT & CONCLUSIONS:

Coefficient of Venturimeter (C_d) =

VIVA QUESTIONS:

- What is the basic principle of Venturimeter?
- What are the parts of Venturimeter?
- What is convergent cone?
- What is throat of Venturi meter?
- What is divergent cone?
- Where pressure taps are provided?
- Which part is smaller, convergent cone or divergent cone? Why?
- Which cross-sectional area is smaller than cross sectional area of inlet section?
- Where velocity of flow greater?
- Between which sections the pressure difference can be determined? Which part is smaller, convergent cone or divergent cone? Why?
- Where velocity of flow greater?
- What we should do for getting greater accuracy in the measurement of the pressure difference?
- Where separation of flow occurs?
- Between which section the pressure difference can be determined?
- How pressure difference is determined?
- Where pressure is low in Venturimeter?
- Which cross-sectional area is smaller than cross sectional area of inlet section?
- Which portion is not used for discharge measurement?
- Where separation of flow occurs?
- How pressure difference is determined?
- Where pressure is low in Venturimeter?
- Which portion is not used for discharge measurement?

EXPERIMENT - 03

IMPACT OF JET ON VANES

AIM:

To determine the coefficient of impact of jet- vane combination by comparing the actual force with theoretical force for stationary vanes of different shapes Viz., Hemi-spherical, flat and inclined plate.

THEORY:

It is a closed circuit water re-circulation system consisting of sump tank, Monobloc pump set, jet/ vane chamber, rotameter for flow rate measurement, direct reading, and digital force indicator. The water is drawn from the sump tank by Monobloc centrifugal pump and delivers it vertically to the nozzle through rotameter. The rotameter is a direct indicating flow rate instrument which gives the discharge in LPM (liters per minute) which is determined by the top position of the float. The flow control valve is also provided for controlling the water into the nozzle. The water is issued out of nozzle as jet. The jet is made to strike the vane, the force of which is transferred directly to the force indicator (mechanical). The force is read in kgf. A provision is made to change the size of nozzle/ jet and the vanes of different shapes.

When the jet of water is directed to hit the vane of any particular shape, the force is exerted on it by the fluid in the opposite direction. The amount of force exerted depends on the diameter of jet, shape of vane, fluid density and flow rate of water. More importantly, it also depends on whether the vane is moving or stationary. In our present case, we are concerned about the force exerted on the stationary vanes. The following are the theoretical formulae for different shapes of vane, based on flow rate.

1. Hemi- spherical $F_t = \frac{2\rho A V^2}{g}$
2. Flat plate $F_t = \frac{\rho A V^2}{g}$
3. Inclined plate $F_t = \frac{\rho A V^2}{g} \sin\theta \sin\theta$

Where $g = 9.81$ m / s^2

A = area of jet in $m^2 = \frac{\pi}{4} d^2$ (d= diameter of the nozzle)

ρ = density of water = 1000 kg/m^3

V = Velocity of jet in m/s^2

θ =Angle made by the deflected jet with the axis of the striking jet = 60^0

F_t = theoretical force.

F_a = actual force developed as indicated by force indicator in kg

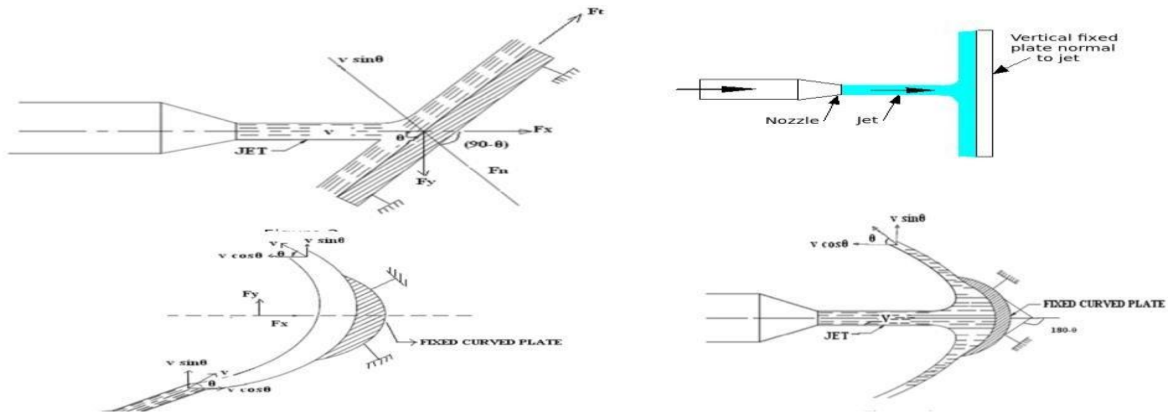


Fig : Impact of jet on vanes in Flat, Inclined and Hemi-spherical vanes

Tabular coloumn:

S.NO	Vane type	Discharge (LPM)	Actual force F_a (Kgf)	Velocity (m/sec)	Theoretical force F_t (kgf)	Coefficient of force F_a / F_t

PROCEDURE:

1) Fix the required diameter jet, and the vane of required shape in position and zero the force indicator

2) Keep the delivery valve closed and switch on the pump

3) Close the front transparent cover tightly

4) Open the delivery valve and adjust the flow rate of water as read on the Rota meter

5) Note down the water flow rate (LPM), actual force, head at nozzle and tabulate the readings.

6) Repeat the experiment for different flow rate of water.

7) Switch off the pump after the experiment is over and close the delivery valve.

Precautions:

1) Unload the motor before switch off
2) Take the rotameter reading without parallax error.
3) Don't switch on the motor when the jet chamber door is open.

Formulae:

1. Discharge Q = a x V

   Velocity $V = \frac{Q}{a}$

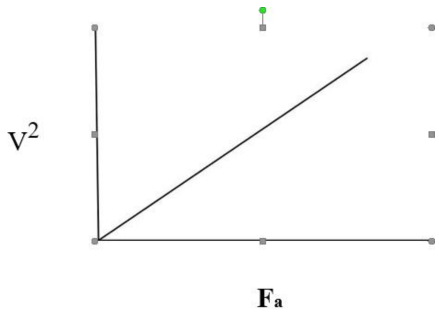
2. Hemi- spherical $F_t = \frac{2\rho AV^2}{g}$

   Flat plate $F_t = \frac{\rho AV^2}{g}$

   Inclined plate $F_t = \frac{\rho AV^2}{g} \sin\theta \sin\theta$

3. Coefficient of force = $\frac{F_a}{F_t}$

Model graph:



Space For Calculations

RESULT & CONCLUSIONS:

The coefficient of impact of jet vane combination for different type of vanes is found to be ---
............-

VIVA QUESTIONS:

- Define the term Impact of Jet?
- Write the formula for force exerted by a jet of water on a stationary & moving plate?
- Write the formula for force exerted by a jet of water on a curved plate at center & at one of the tips of the jet?
- What is an impulse momentum equation?
- Define the terms momentum, moment & impulse?
- Explain the term dynamic machines.

EXPERIMENT - 04

PERFORMANCE TEST ON RECIPROCATING PUMP

AIM:

To conduct a test at various heads and estimate the performance of given reciprocating pump.

APPARATUS:

- Reciprocating pump
- Stop watch
- Collecting tank

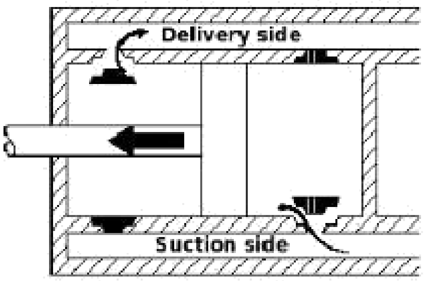
THEORY:

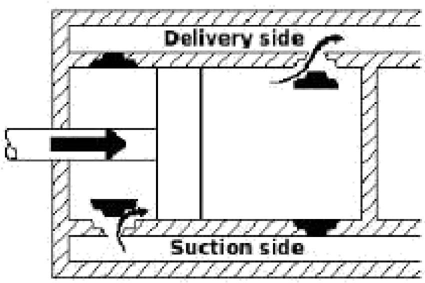
Pump is a mechanical device which converts the mechanical energy into hydraulic energy. Pumps are classified into two categories, they are rotodynamic pumps and positive displacement pumps. Reciprocating pumps will come under positive displacement pumps. It has a plunger (Piston) move to and fro in a closed cylinder. The cylinder is connected to suction and delivery pipes and are fitted with non-return valves to admit the liquid in one direction only. The suction non-return valve allows liquid only to enter into the cylinder and delivery non-return valve allows the liquid only to escape out from the cylinder into the delivery pipe.

The piston is connected to a crank by means of connecting rod. As the crank is rotated at uniform speed by prime mover, the plunger moves to and fro thus creating continuous flow of liquid. For more uniform flow, an air vessel is fitted before the suction valve and delivery after delivery valve. This contributes for more uniform flow of liquid and also saves energy input to the pump from the prime mover. These pumps are used for high head and low flow rate application.

Principle:-

Reciprocating pump is a positive displacement pump, which causes a fluid to move by trapping a fixed amount of it then displacing that trapped volume in to the discharge pipe. The fluid enters a pumping chamber via an inlet valve and is pushed out via an outlet valve by the action of the piston or diaphragm. They are either single acting; independent suction and discharge strokes or double acting; suction and discharge in both directions.





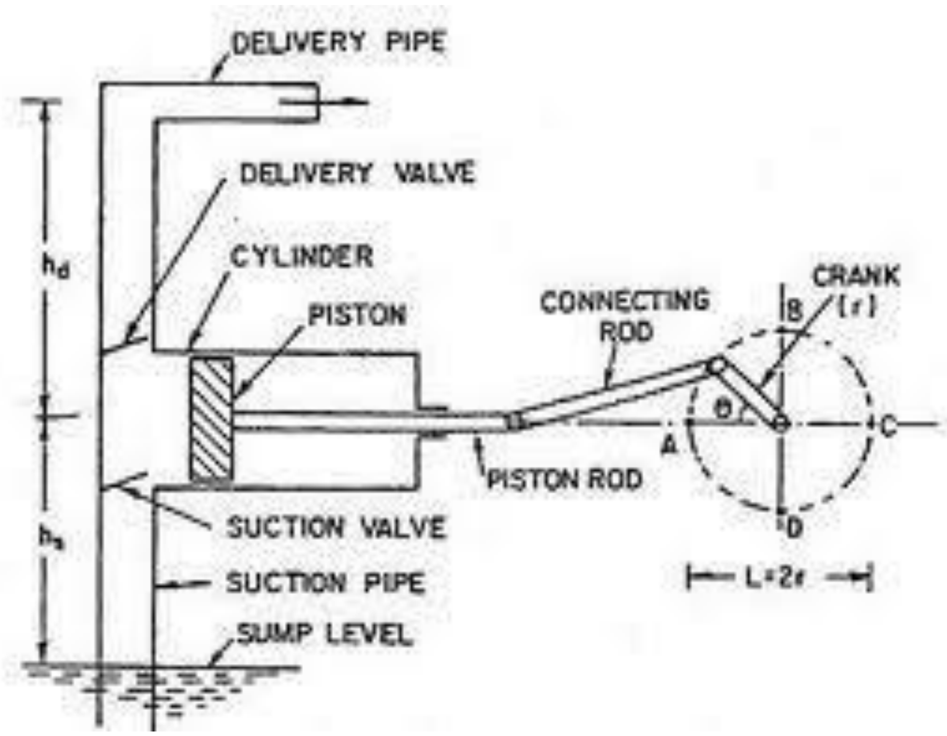


Fig : Reciprocating pump

Specifications:

- Area of the collecting tank A = (0.25 x 0.25) m^2
- Energy meter constant C = 3200 rev/Kwh
- Datum head Z= distance between pressure and vaccume gauge in meters= 0.25 m

Tabular column:

S.no	Delivery Pressure Kg/cm^2	Suction pressure mm of Hg	Time taken for 5 blinks of energy meter (t) Sec	Time for 10 cm rise of water level in collecting tank (T) sec	Total Head (H) meters	Discharge (Q) m^3/sec	Input power Kw	Output power Kw	η %

Reciprocating pumps are self priming and are suitable for very high heads at low flows. They deliver reliable discharge flows and is often used for metering duties because of constancy of flow rate. The flow rate is changed only by adjusting the rpm of the driver. These pumps deliver a highly pulsed flow. If a smooth flow is required then the discharge flow system has to include additional features such as accumulators. An automatic relief valve set at a safe pressure is used on the discharge side of all positive displacement pumps.

PROCEDURE:

1. Start the motor keeping the delivery valve fully open.
2. Note down vaccume gauge and pressure gauge reading by adjusting the delivery valve to required head say 0.2 meter.
3. Note down the time required for the rise of 10 cm water in the collecting tank by using stop watch.
4. Note down the time taken for X revolutions of energy meter disk.
5. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve.

Precautions:

- Unload the motor before switch off.
- Take the reading without parallax error.

Formulae:

1. ***Total head (H)*** = Delivery head + Suction head + Datum Head

Delivery head = Kg/cm² x 10 = meters.

Suction head = $\frac{mm\ of\ Hg \times 13.6}{1000}$

Datum head = Distance between pressure and vacuum gauge in meters

2. ***Discharge*** Q = $\frac{AXh}{t}$ m^3/sec

Where t = time taken for 10 cm raise of water level in seconds.

3. ***Input power*** **(I.P)** = $\frac{X \times 3600 \times 0.70 \times 0.80}{C \times T} kw$

Where X = no. of blinks of light of energy meter (say 5)

T = Time for energy meter blinking in seconds

C = Energy meter constant (3200)

0.70 = Motor efficiency

0.80 = Belt efficiency (or) Transmission efficiency

4. ***Output power (O.P.)*** = $\frac{W \times Q \times H}{1000}\ kw$

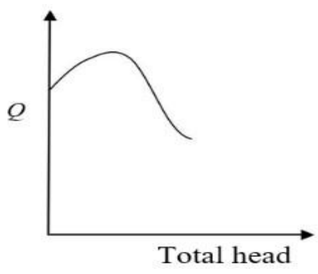
Where W = Specific weight of water (9810 N/m^3)

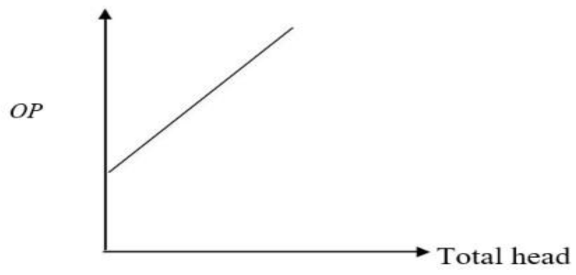
Q = Discharge

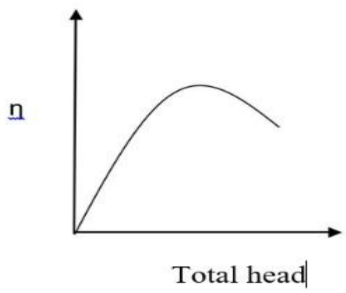
H = Total head

5. ***Hydraulic efficiency*** **(ƞ)** = $\frac{O.P}{I.P}$ %

Model graphs:







Space For Calculations

RESULT & CONCLUSIONS:

The efficiency of reciprocating pump is found to be ----------------------

VIVA QUESTIONS:

- What is an air vessel?
- What is negative slip in case of reciprocating pump?
- What do you understand by single acting & double acting pump?
- What is the function of air vessel in a reciprocating pump?
- Define slip of a pump?
- Define a reciprocating pump?
- What are the main parts of the reciprocating pump?
- Define slip of reciprocating pump?
- How do you classify the reciprocating pumps
- What is the working principle of a reciprocating pump?
- Define indicator diagram.
- Write the formulae for discharge of a single acting and double acting reciprocating pump.
- What are the factors that influence the speed of the reciprocating pump.

EXPERIMENT - 05

PERFORMANCE TEST ON CENTRIFUAGAL PUMP

AIM:

To conduct a test at various heads of given centrifugal pump and to find its efficiency.

APPARATUS:

- Centrifugal pump
- Stop watch
- Collecting tank

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. Pumps are classified into two categories, they are Rotodynamic and positive displacement pumps. Centrifugal pump will comes under Rotodynamic pumps. Centrifugal pumps consist of an impeller rotating inside a casing. The impeller is a wheel with series of backward curved vanes. Depending upon the cover plates provide to the impeller vanes the impeller are divided as closed, semi-closed and open impellers. The casing is an air tight chamber. It consists of suction and delivery arrangements and supporting for bearings. Commonly used casing are volute casing, vortex casing and casing with guide blades. Due to the centrifugal force developed by the rotation of impeller, water enters at the eye of the impeller and leaves at the outward periphery. In the casing a part of the velocity head (kinetic energy) of the water into pressure head.

Centrifugal 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.

Specifications:

- Area of collecting tank = 0.3 x 0.3 m^2
- Energy meter constant = 3200 imp/kwh
- Datum head = difference between suction and delivery gauges Z = 0.28 m

PROCEDURE:

1. Remove the air pocket present in the casing of the pump by performing the priming operation.
2. Switch on motor and open the delivery valve fully. Note down the pressure values in the suction (in mm of Hg) and delivery (kg/cm^2) pipes.

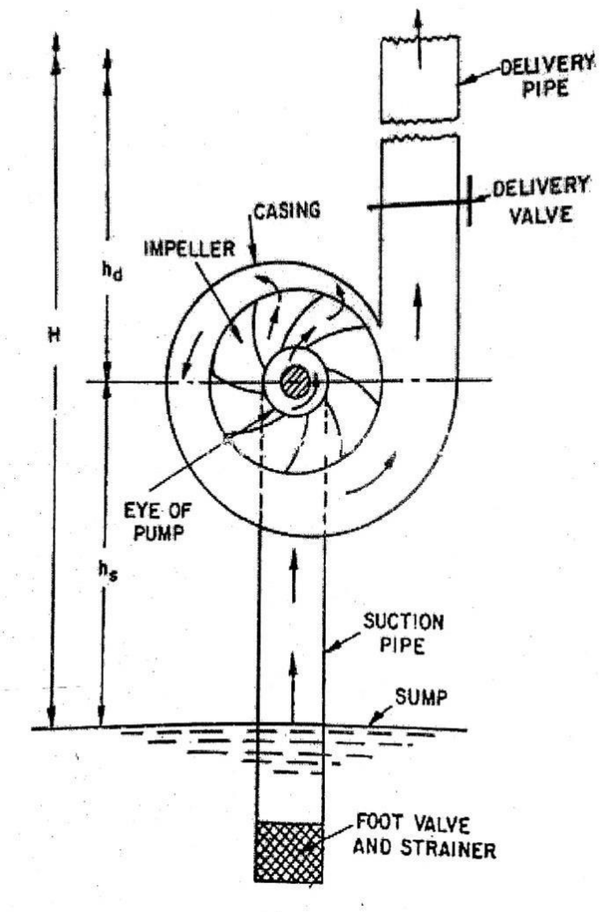


Fig: Centrifugal pump

3. Remove the air pocket present in the casing of the pump by performing the priming operation.
4. Switch on motor and open the delivery valve fully.
5. Note down the pressure values in the suction (in mm of Hg) and delivery (kg/cm^2) pipes.
6. By closing the gate valve of the collecting tank note down the time taken for 10 cm raise of water level using stopwatch.
7. Note down the time taken for 5 blinks of energy meter using stop watch.
8. Repeat the above procedure for various delivery pressures.

Tabular column:

S.no	Delivery Pressure Kg/cm^2	Suction pressure mm of Hg	Time taken for 5 blinks of energy meter (t) Sec	Time for 10 cm rise of water level in collecting tank (T) sec	Total Head (H) meters	Discharge (Q) m^3/sec	Input power Kw	Output power Kw	η %

Formulae:

1. ***Total head (H)*** = Delivery head + Suction head + Datum Head

Delivery head = Kg/cm² x 10 = meters.

Suction head = $\frac{mm\ of\ Hg \times 13.6}{1000}$

Datum head = Distance between pressure and vacuum gauge in meters

2. ***Discharge*** Q = $\frac{AXh}{t}$ m^3/sec

Where t = time taken for 10 cm raise of water level in seconds.

3. ***Input power (I.P)*** = $\frac{X \times 3600 \times 0.70 \times 0.80}{C \times T}\ kw$

Where X = no. of blinks of light of energy meter (say 5)

T = Time for energy meter blinking in seconds

C = Energy meter constant (3200)

0.70 = Motor efficiency

0.80 = Belt efficiency (or) Transmission efficiency

4. ***Output power (O.P.)*** = $\frac{W \times Q \times H}{1000}\ kw$

Where W = Specific weight of water (9810 N/m^3)

Q = Discharge

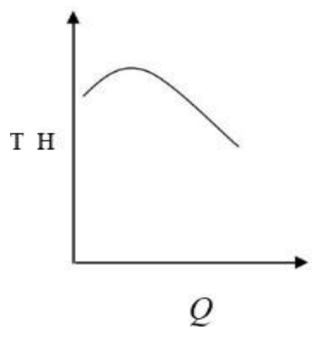
H = Total head

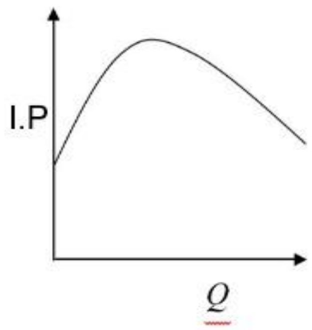
5. ***Hydraulic efficiency*** **(η)** = $\frac{O.P}{I.P}$ %

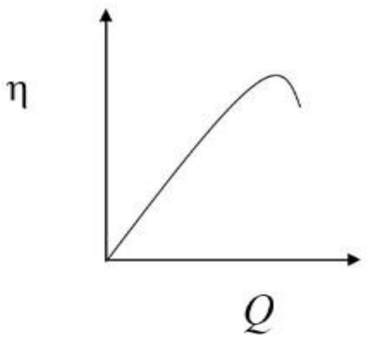
Precautions:

- Unload the motor before switch off.
- Take the readings without parallax error.
- Don’t run the pump when the air pockets are present in the casing.

Model graphs:







Space For Calculations

RESULT & CONCLUSIONS:

The efficiency of centrifugal pump is found to be -----------------

VIVA QUESTIONS:

- What is priming of a pump?
- Why it is necessary to prime a pump?
- What is cavitation? Where does it occur in a centrifugal pump?
- Write the effects of cavitation?
- What are the main parts of a centrifugal pump?
- Distinguish between the positive and non-positive displacement pumps.
- The centrifugal pump acts as a ---- reverse of an inward radial flow reaction turbine
- Define pumps?
- Define a centrifugal pump?
- Write the working principle of a centrifugal pump?
- Define the following terms:
- Write the Efficiencies of a centrifugal pump?
- Define specific speed of centrifugal pump?
- Define the characteristic curves and why these curves are necessary?
- Write the types of the characteristic curves?
- What is priming of centrifugal pump?
- What is the principle of working of a Centrifugal Pump?
- Classify hydraulic pumps.

EXPERIMENT - 06

PELTON WHEEL

AIM:

To estimate the performance of the Pelton wheel.

APPARATUS:

- Pelton wheel test rig
- Tachometer

THEORY:

Turbine is a hydraulic machine which converts hydraulic energy into mechanical energy further the mechanical energy will be converted into electrical energy by coupling the turbine shaft with the shaft of an electrical generator. There are two types of turbines viz., impulse and reaction turbines. Impulse turbines in which only Kinetic energy available at the inlet whereas in case of a reaction turbine both kinetic energy and pressure energy will be available at inlet.

Pelton wheel is an impulse turbine which is used to utilize high heads for generation of electricity. The flow in turbine is in tangential direction. 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.

The performance of the turbine can be evaluated with the help of main and operating characteristic curves. Head supplied to the turbine kept constant for getting the main characteristic curves, whereas by keeping speed constant operating characteristic curves are obtained. Unit quantities like unit speed, unit discharge and unit power are useful to predict the behavior of the turbine at various working heads. Specific speed can be useful for comparing the different types of turbines. The specific speed of Pelton wheel ranges from 8.5 to 50.

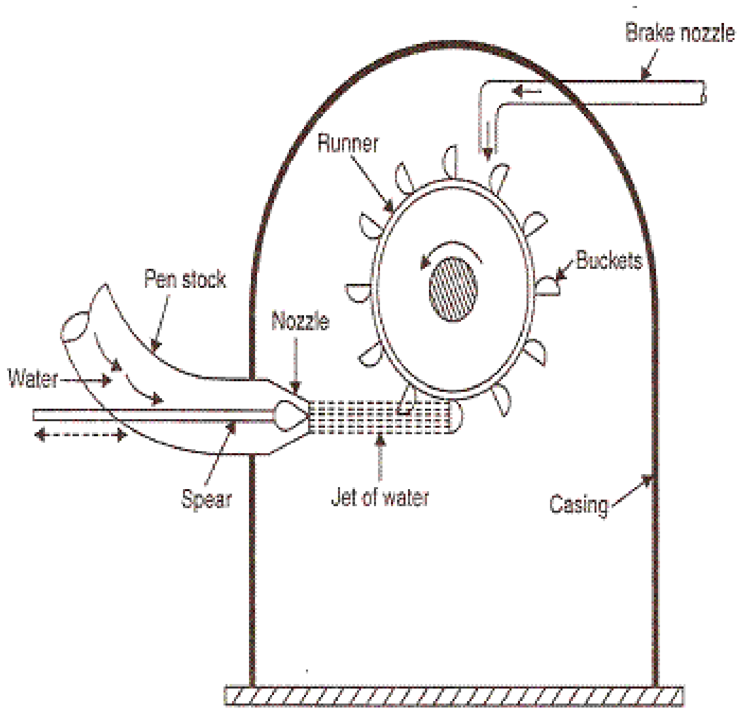


Fig : Pelton wheel

Tabular column:

S.no	Speed rpm	Pressure gauge readings			Discharge m^3/sec	Brake weight $(W_2 - W_1)$ kg	Input power Kw	Output power Kw	η
		P_1	P_2	P_3					
Average efficiency =									

PROCEDURE:

1. Close the gate valve fully and start the pump.
2. See that the pump rotator rotes in proper direction.
3. Open the gate valve to get rated speed and the turbine inlet pressure, Venturimeter inlet pressure and Venturimeter throat pressure.
4. Repeat the above procedure for different loads keeping the speed constant by operating the gate valve.
5. Remove the load completely, close the gate valve and stop the pump.

Formulae:

1. ***Discharge Q*** = $\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3/sec

   Where h= (P_1- P_2) X 10 m

   P_1= inlet pressure; P_2 = Throat pressure

   d_1= diameter of Venturimeter at inlet = 50 mm

   d_2= diameter of Venturimeter at throat = 25 mm

   $a_1 = \frac{\pi}{4} d_1^2$ m^2; $a_2 = \frac{\pi}{4} d_2^2$ m^2

2. ***Input power*** = 9.81 X supply head in meters (H) X discharge KW

   Where supply head H = P_3 X 10 m

3. ***Output power*** = $\frac{2\pi NT}{60000}$ KW

   Where N = R.P.Mof the turbine shaft

   T = Torque of the turbine shaft = ($w_2 - w_1$) X R X 9.81

   ($w_2 - w_1$) = load applied on the turbine

   R = radius of the brakedrum with rope in meters = 0.13 m

4. ***Efficiency*** = $\frac{output\ \ power}{input\ power \times frictional\ efficiency}$ x 100

   Where frictional efficiency = 0.28

Precautions:

- Keep away from the rotating elements of the machine

Graphs:

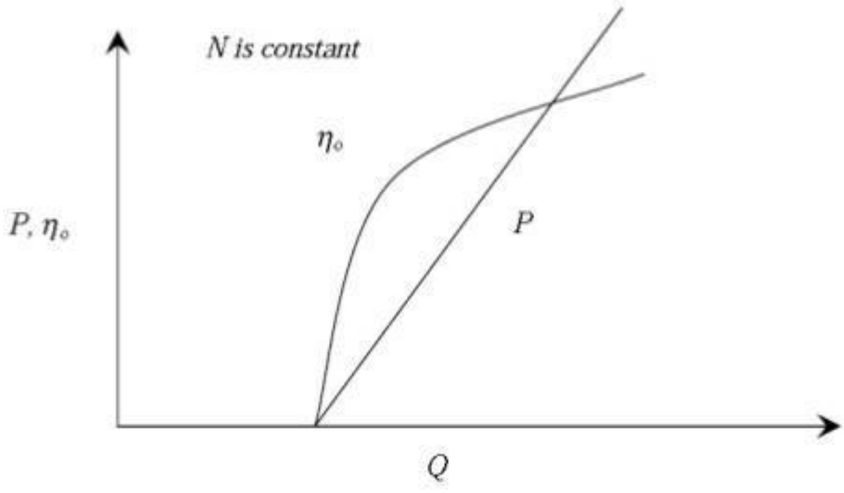


Fig: Operating characteristic curves of a turbine

Space For Calculations

RESULT & CONCLUSIONS:

The efficiency of the Pelton wheel at constant speed is found to be ------------

VIVA QUESTIONS:

- What is the basic difference between an impulse & reaction turbine?
- What is the basic difference between a tangential flow & radial flow turbine?
- What is basic difference between axial flow & mixed flow turbine?
- What do you mean specific speed of a turbine?
- Define unit speed, unit power & unit discharge?
- Define hydraulic machines?
- Define turbines?
- The study of hydraulic machines consists of what?
- Define the term Gross head.
- Define net head?
- Define Hydraulic efficiency?
- Define Mechanical efficiency?
- Define Volumetric efficiency?
- Define Overall efficiency?
- The pelton wheel (or) pelton turbine is----- a tangential flow impulse turbine
- Write the classification of hydraulic turbines according to the type of energy at inlet?
- Write the classification of hydraulic turbines according to the direction of flow through runner?
- Write the classification of hydraulic turbines according to the head at the inlet of turbine?
- Write the classification of hydraulic turbines according to the specific speed of the turbine?
- Why the draft tube is not used for Pelton turbine?

EXPERIMENT - 07

KAPLAN TURBINE

AIM:

To determine efficiency of Kaplan turbine

APPARATUS:

Kaplan turbine test rig.

THEORY:

Hydraulic or water turbines are the machines which use the energy of water (hydropower) and convert it into mechanical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce the electricity viz., hydro electric power.

The turbines are classified as impulse and reaction turbines. In impulse turbine, the head of water is completely converted into a jet, which impulses the force on the turbine. In reaction turbine, it is the pressure of the flowing water, which rotates the runner of the turbine.

Kaplan turbine is an axial flow reaction turbine. It consists of a runner mounted on a shaft and enclosed in a special casing with guide vanes. The cross section of flow between the guide vanes can be varied. This is known as gate opening which usually kept as 1/4, 1/2, 3/4 or full. The water enters the volute casing which completely surrounds the runner. From the casing the water passes between stationary guide vanes, mounted all around the periphery of the runner. The function of these guide vanes is to direct the water on to the runner at the required angle. Each vane is pivoted by a suitable mechanism so that all may be turned in synchronism so as to alter the flow rate of machine and it passage through the runner. The water is deflected by runner blades so that angular momentum is changed.

The Kaplan turbine 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 and passes through the runner and thus rotating the shaft. When guide vane angles are varied, high efficiency can be maintained over wide range of operating conditions.

Specifications:

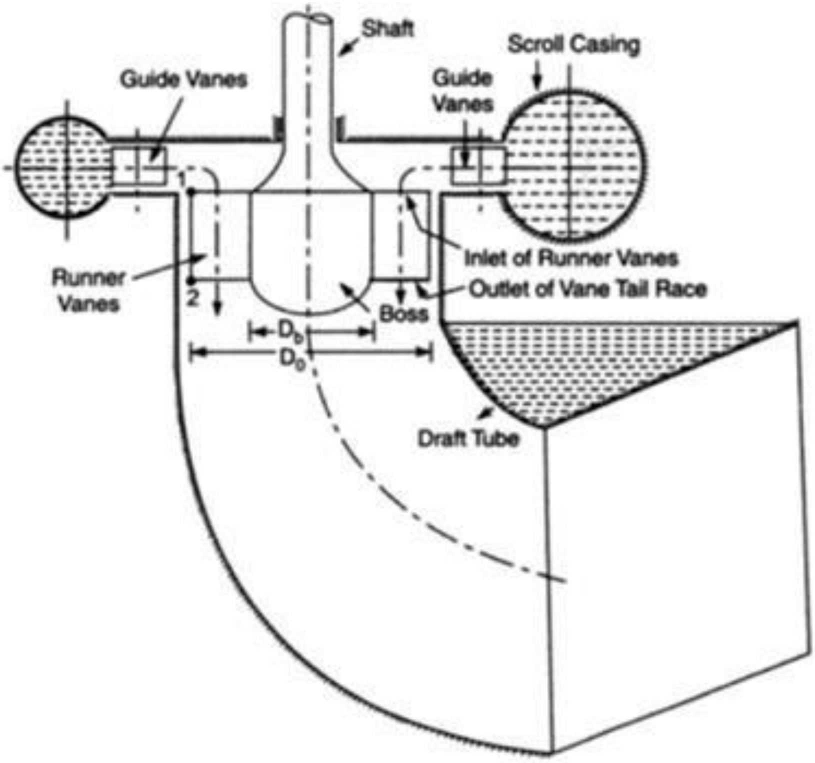
- Brake drum radius = 0.15 m
- Inlet diameter of Venturimeter = 0.15 m
- Throat diameter of Venturimeter = 0.075 m
- Co-efficient of discharge = 0.80

PROCEDURE:

1. Keep the butter fly valve (or) gate valve closed.

2. Keep the load on brake drum (spring balance) at minimum.

3. Press the green button of the supply pump starter and then release.



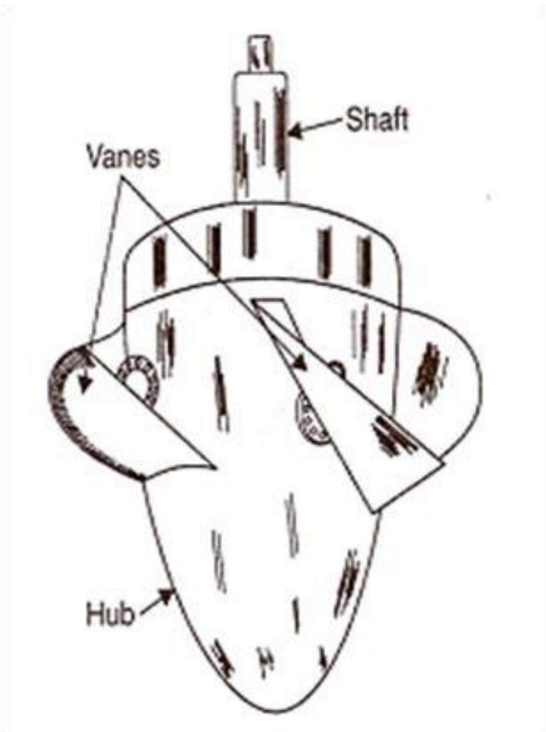


Fig: Kaplan turbine

For constant head:

S.NO	Speed of the turbine r.p.m	Pressure on the turbine kg/cm^2	Load			Venturimeter pressures		Draft tube pressure mm of Hg
			F_1 kg	F_2 kg	(F_1-F_2) kg	P_i kg/cm^2	P_t kg/cm^2	

For Constant speed:

S.NO	Speed of the turbine r.p.m	Pressure on the turbine kg/cm^2	Load			Venturimeter pressures		Draft tube pressure mm of Hg
			F_1 kg	F_2 kg	(F_1-F_2) kg	P_i kg/cm^2	P_t kg/cm^2	

4. a) Slowly open the gate so that the turbine rotor picks up the speed and attains the Maximum at full opening of the gate.
   b) Slowly open the brake drum cooling valve and allow very little water before loading the brake drum.
   c) Slowly operate the hand wheel on the rope of spring balance to increase the load on the brake drum. Set the spring balance reading.
   d) For different loads on the brake drum, note down the speed, head on turbine, Venturimeter pressure gauge readings and draft tube vaccume.
5. Close the gate then switch off the supply water.
6. Follow the procedure described below for taking down the reading for evaluating the performance characteristics of the Kaplan turbine.

To obtain constant head characteristics:

1. Keep the gate valve closed and start the pump.
2. Slowly open the gate valve and set the pressure on the gauge.
3. For different load on the brake drum, set the head constant by operating the gate valve and Tabulate the readings.

To obtain constant speed characteristics:

1. For different loads on the brake drum, change the gate valve position, so that the speed is held constant.
2. Repeat the experiment for different speeds, say 1500 rpm, 1000 r.p.m and tabulate the results.
3. The above readings will be utilized for drawing constant speed characteristics Viz.,
   a) load Vs efficiency
   b) Discharge VS efficiency

Formulae:

1. ***Head on turbine*** **H** = $10(P + \frac{P_V}{760})$ m

   Where P is pressure gauge reading in kg/cm^2

   P_V is the vaccume gauge reading

2. ***Discharge of water(flow rate) through turbine*** = flow rate by Venturimeter

$$Q = C_d \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

For constant head:

S.NO	Speed of the turbine N r.p.m	Head on turbine H meters	Discharge Q m^3/sec	Hydraulic input power Kw	Shaft power output Kw	η_{eff}
Average efficiency of the turbine =						

For constant speed:

S.NO	Speed of the turbine N r.p.m	Head on turbine H meters	Discharge Q m^3/sec	Hydraulic input power Kw	Shaft power output Kw	η_{eff}
Average efficiency of the turbine =						

Where C_d = Coefficient of discharge = 0.80

a_1= area of inlet section= $\frac{\pi D^2}{4}$ m^2

a_2= area of throat section= $\frac{\pi d^2}{4}$ m^2

Loss of head h= 12.6 x (P_i-P_t) x 0.76 m of water

Where (P_i-P_t) = differential head across Venturimeter in kg/cm^2

760 mm of Hg = 1 kg/cm^2

3. ***Turbine output (mechanical output)***= $\frac{2\pi NT}{4500}$ HP

$$= \frac{2\pi N(F_i - F_t)}{4500} \; HP$$

4. ***Hydraulic input to turbine*** = $\frac{WQH}{75} \; HP$

W= Specific weight of water =9810 N/m^3

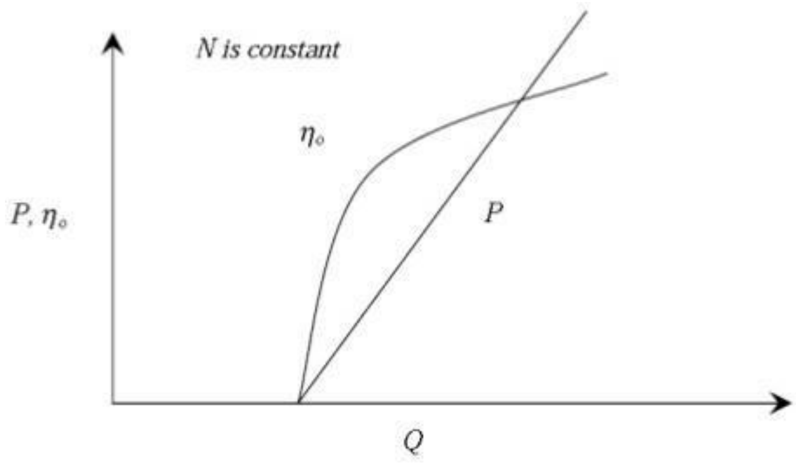
5. ***Turbine efficiency*** η_{eff} = $\frac{\text{Mechanical output}}{\text{Hydraulic input}}$ x 100

Precautions:

- Don't shutdown when the loads present on the brake drum.
- Keep away from the rotating elements of the machine.

Graphs:

- Discharge Vs shaft power
- Discharge vs efficiency



Space For Calculations

RESULT & CONCLUSIONS:

The efficiency of Kaplan turbine is found to be (i) at constant head -------------

(ii) at constant speed-----------

VIVA QUESTIONS:

- What is meant by a turbine?
- What are the differences between turbine and pump?
- What are the different types of turbines?
- Kaplan comes under impulse turbine (or) reaction turbine?
- What is the difference between Pelton wheel and Kaplan turbine applications wise?
- Which type of flow will exist in Kaplan turbine?
- What is meant by Draft tube?
- Draft tubes are required in Impulse turbines (or) reaction turbines?
- Where draft tube will be fitted for reaction turbines?
- Is draft tube is compulsory in reaction turbines?
- What is meant by specific speed of the turbine?
- What is the formula for input power of a Kaplan turbine?
- What is meant by Performance characteristic curves?
- What are the different types of performance characteristic curves?
- What is the equipment used for measuring the discharge in Kaplan turbine?
- How maintain the constant speed during the experiment with the applying of load.
- What is meant by unit quantities?
- What is the difference between specific speed and unit speed?

EXPERIMENT - 08

GEAR PUMP

AIM:

To determine the efficiency of gear pump.

APPARATUS:

- Gear pump test rig
- Stop watch

THEORY:

In general a gear 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 present gear pump test rig is a self contained unit operated on closed circuit (recirculation) Basis. Main components are gear pump, D.C. motor, collecting tank and sump, control panel. All these are mounted on rigid frame work.
The test rig has the following provisions:

1. To run the pump at various speeds using D.C.motor thyristor speed controller.
2. To measure the input/shaft horse power to the pump using torque weighing system connected to stator of D.C.motor.
3. To measure the overall input horse power to the D.C.motor using digital voltmeter and ammeter.
4. To measure the speed/RPM of the pump.
5. To measure the delivery and suction heads using pressure and vaccume gauges separately.(the delivery head pressure tapping is connected upstream of delivery valve and that of the suction tapping downstream of suction valve)
6. To change the head and flow rate using control valves.
7. To measure the discharge using collecting tank fitted with tank level indicator/gauge glass.

PROCEDURE:

1. Keep the delivery valve open and suction valve open.
2. Keep the speed control knob at zero.

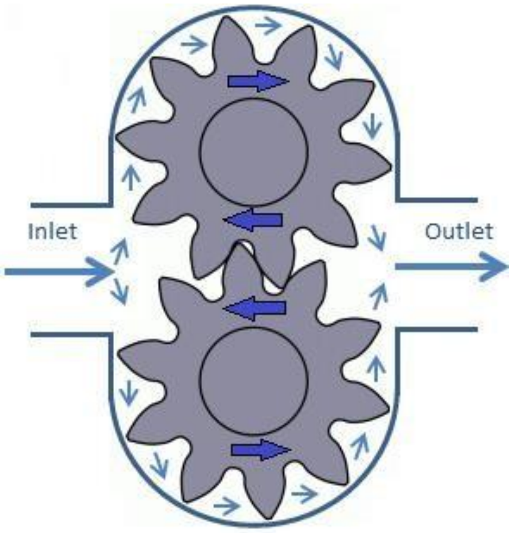


Fig: External gear pump

Tabular column:

S.NO	Pump speed RPM	Delivery pressure kg/cm^2	Vaccume pressure mm of Hg	Spring force F kg	Voltage V Volts	Current I amps	Time taken for rise of 10 cm oil Sec

Results table:

S.NO	Discharge Q) m^3/sec	Total head H meters	Shaft power HP_{shaft} Kw	Hydraulic Power HP_{pump} kw	η_{eff}

3. Switch on the mains, so that the mains on indicator glow. Now switch on the starter then the oil starts flowing to the measuring tank.
4. Set the desired speed using controller knob & digital rpm indicator.
5. Close the delivery valve slightly and observe the delivery pressure.
6. Now set the desired pressure by operating delivery valve.
7. Note down the pressure gauge and vaccume gauge readings.
8. Note down voltage and current readings.
9. Note down the spring balance reading after keeping the two pointers in line with each other by operating the wheel provided on the swinging field by dynamometer.
10. Operate the butterfly valve to note down the collecting tank reading against the known time.
11. Repeat the steps for different openings of the delivery valve and tabulate the readings.
12. Calculate the efficiency of the gear pump using the formulae given.

Formulae:

1. ***Basic data/constants***

   1 HP=736 watts

   1 kg/cm^2 = 760 mm of Hg

   Density of water = 1000 kg/ m^3

   Energy meter constant = 750 Rev/KWH

2. ***Shaft horse power as indicated by swinging field dynamometer (input)***

   $$HP_{shaft} = \frac{2\pi NT\times(0.1\times F)}{4500} HP$$

   Where 0.1 is the radius of swinging field arm

   F is the force in spring balance.

   N is the RPM of D.C. motor/pump.

   Density of hydraulic oil, SAE 10 grade= 890 kg/m^3

3. ***Discharge Q*** = $\frac{A\times h}{t}$ m^3/sec

   Where A= area of collecting tank

   h= The height of water collected in cm

4. ***Total head H*** = 10(delivery pressure+vaccume pressure)

   $$= 10\left(P+\frac{P_v}{760}\right) \text{ meters}$$

Where P is the pressure in kg/cm^2

P_V is the vaccume in mm of Hg

5. ***Hydraulic horse power (delivered by the pump) (Output)***

$HP_{pump} = \frac{WQH}{75} HP$

Where W = 890 kg/m^3

Q = discharge

H = Head

6. ***Pump efficiency*** $\eta_{eff} = \left(\frac{HPpump}{HPshaft}\right) \times 100$

Graphs:

- Head Vs Discharge
- Efficiency Vs Speed
- Efficiency Vs Head

Space For Calculations

RESULT & CONCLUSIONS:

The efficiency of gear pump is found to be-------------------

VIVA QUESTIONS:

- What is meant by a gear pump ?
- What are the different types of gear pumps?
- Which type gear pump is using in this laboratory?
- What is the oil using in this lab for experimentation?
- What is the difference between Centrifugal pump and Gear pump
- What are the applications of Gear pump?
- What is the formula for Output power developed by the Gear pump.

EXPERIMENT - 09

FRANCIS TURBINE

AIM:

To determine efficiency of Francis turbine

APPARATUS:

Francis turbine test rig.

THEORY:

The turbines are classified as impulse and reaction types. In impulse turbine, the head of water is completely converted into a jet, which impulses the forces on 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 turbines .while Francis and Kaplan falls in the category of impulse reaction turbines.
Normally, pelton wheel (impulse turbine) requires high heads and low
Discharge .while Francis and Kaplan (reaction turbines) require relatively low heads and high discharge.
While the impulse turbine is discussed elsewhere in standard text books, Francis turbine, the reaction type which is of present concern consists of main components such as (runner) scroll casing and draft tube. Between the scroll casing and the runner, the water turns through
right angle into the axial direction and passes through the runner and thus rotating the runner shaft. The runner has eight fixed blades since it is transparent
You can visualize all the inside parts of flow in the scroll casing.
The actual experimental facility supplied consists of a centrifugal pump set, turbine unit, sump tank, arranged in such way that the whole unit works on recalculating water system. The centrifugal pump set supplies the water from the sump tank to the turbine through control valve. And then flow through the venturimeter. The water after passing through the turbine unit enters the sump tank through the draft tube.

The loading of turbine is achieved by electrical AC generator connected to lamp bank .the provisions for measurement of electrical energy by energy meter & voltmeter and ammeter, turbine speed by digital RPM indicator , head on the turbine and draft tube vacuum by digital pressure indicator, to venturimeter measure the discharge into the turbine,.

Specification:

- Supply pump / motor capacity : 10 HP ,3 PH ,440 Volts
- Turbine : 150 mm dia impeller
  Run away speed 3000 RPM (Approx)
- Loading : a) AC Generator
  b) Head on turbine by digital pressure indicator and draft tube vacuum By pressure gauge and vacuum gauge.

  c) Electrical loading change by switches
  d)Load measure by energy meter
  e) Turbine speed by digital RPM indicator.

f) Supply water control by gate valve.

- Electrical supply: 3 ph, 440 v. A.C. 20 A with neutral and earth.

PROCEDURE:

1. Connect the supply pump / motor unit to3 ph, 440 v, 20 A, electrical supply, with neutral and earth connections and ensure the correct direction of pump /motor unit.
2. Keep the gate closed.
3. Keep the electrical load at minimum, by keeping all the switches at 'OFF' position.
4. Press the green button of the supply pump starter and then release.
5. Slowly open the gate so that the turbine rotor picks up the speed and attains maximum at full opening of the gate.
6. Note down the voltage and current, speed, pressure, vacuum on the control panel, venturimeter reading.
7. gate valve/ guide vanes also can be used for speed control.and head control
8. Close the gate and then switch 'OFF' the supply set.
9. Follow the procedure described below for taking down the reading for evaluating the performance characteristic of the Francis turbine.

To Obtain Constant Speed Characteristics:

(Operating charecterstics)

1. Keep the gate opening at maximum.
2. for different electrical loads on the turbine / generator , change the control valve so that the speed is held constant.
3. Reduce the gate opening setting to different position and repeat (2) for Different speeds 1500 RPM ,1000 RPM and tabulate the results.
4. The above readings will be utilized for drawing constant speed.

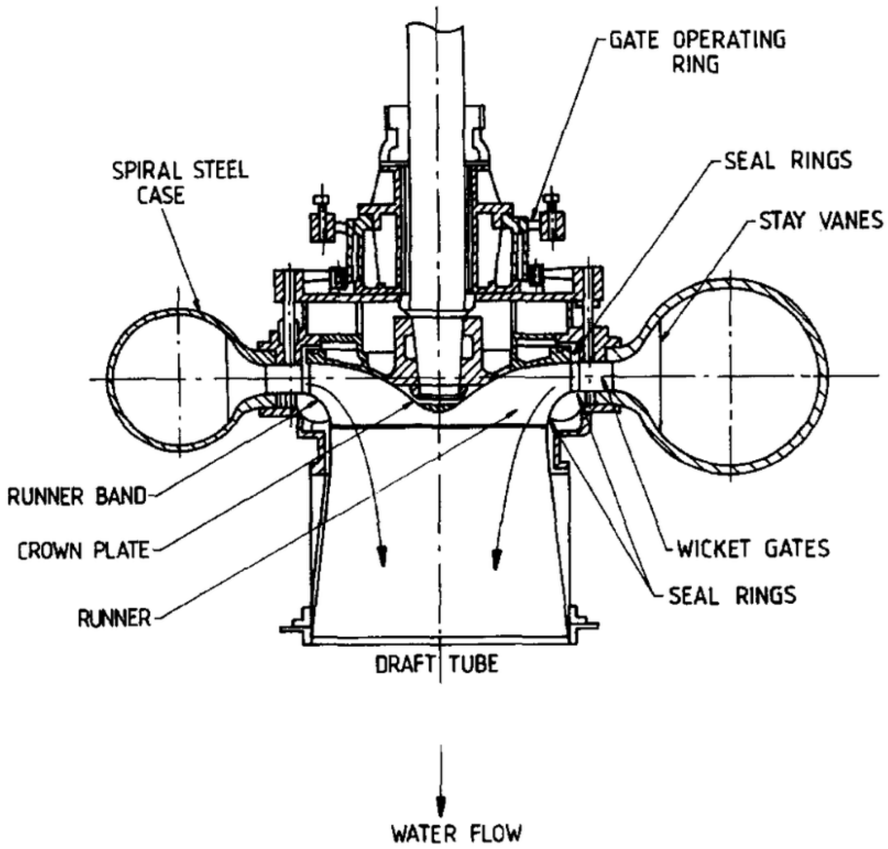
   Characteristics viz.,

   a) Percentage of full load Vs efficiency.
   b) Efficiency and BHP vs Discharge Characteristics.

***To Obtain Constant Head Characteristics*:**

(Main characteristics)

1. Keep the gate closed, and start the pump.
2. Select control valve position.
3. Slowly open the gate and set the pressure on the gauge.
4. For different electrical loads, change the gate valve position, and maintain the constant head and tabulate the result as given in table II.



Francis Turbine

Calculations:

DATA:

Venturi Meter Details

Inlet dia : 100 mm

venturi dia : 50 mm

Density of Water = 1000 kg / m^{-3}

Energy Meter Constant = 3200 Rev./ sec.

1. Head on the Turbine
   'H' in mts of water = $10\left(P + \frac{Pv}{7600}\right)$

   Where 'P' is the pressure reading in

   Kg / cm^2 and 'Pv' is the draft tube reading in kg /cm^2

2. Discharge (flow Rate) of
   Water through the turbine = Flow Rate by venturimeter.

   Q = cd k m^3 / sec

where cd is 0.9

K is venturimeter constant

$$K = \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A1^2 - A2^2}}$$

Q1 Is area of at inlet of the venturimeter

$$A_1 = \frac{\Pi d1^2}{4} \, m^2$$

d_1 = dia of the venturi meter inlet = 100 mm

Q_2 Is area at out let of the venturi meter

$$A_2 = \frac{\pi d_2^2}{4} \, m^2$$

d_2 = dia of the venturi = 50 mm

h is the differential head across venturimeter in mm

h = 10 (p_i - p_t) mt

Where (pi - p_t) is the differential head in kg / cm^2

3. Hydraulic Input to the Turbine :

$$HP_{hyd} = \frac{\rho gQH}{1000} \, KW$$

Where, W = 1000kg / m^3

Q = Flow Rate of water in m^3 / sec

H = Head on Turbine in mts.

4. brake horse power of the turbine

$$HP_{elec} = \frac{N \times 60 \times 60}{(EM)\, t}$$

Where EM = Energy meter

Constant = 3200 Imp / KW / hr

't' time taken in secs for 'N' Imp

$$BHP = \frac{HP_{elec}}{0.70}$$

5. Turbine efficiency, $\% \eta_{tur} = BHP / HP_{hyd} \times 100$

6. Percentage full load

$$= \frac{\text{Part load BHP}}{\text{Max .load BHP}} \times 100$$

At any particular speed.

Table of Reading – 1

Constant speed characteristics

METHOD: By changing the gate constant and

By changing the guide vane position

SL NO.	TURBINE SPEED IN RPM	HEAD ON TURBINE		venturimeter reading In kg/cm^2		Energy meter reading	Load on generator		NO. of Bulb in action. in watts
		Pressure ' p'in kg/cm^2	Draft tube vacuum 'P_V' kg/cm^2	Throat pr. kg/cm^2	In let pr. kg/cm^2	time for 5pulses in secs	Voltage in VOLTS	'current' in AMPS	

Table of Reading – 2

Constant head characteristics

METHOD: By changing the gate constant and

By changing the guide vane position

SL NO.	TURBINE SPEED IN RPM	HEAD ON TURBINE		venturimeter reading In kg/ cm^2		Energy meter reading	Load on generator		NO. of Bulb in action. in watts
		Pressure ‘ p’in kg / cm^2	Draft tube vacuum ‘P_V’ kg / cm^2	Throat pr. kg/ cm^2	In let pr. kg/ cm^2	time for 5pulses in secs	Voltage in VOLTS	‘current’ in AMPS	

Table of Calculations-1

Constant speed characteristics

Turbine Speed in RPM	Net head on turbine 'H' in mtrs.	Discharge (flow rate) 'Q' In m^3 / sec	HP $_{hyd}$	BHP	% η_{tur}	% of full load

Table of Calculations-2

Constant head characteristics

Turbine Speed in RPM	Net head on turbine 'H' in mtrs.	Discharge (flow rate) 'Q' In m^3 / sec	HP $_{hyd}$	BHP	% η_{tur}	% of full load

Precautions:

1. Do not start pump set if the supply voltage is less than 400 v
2. do not forget to give electrical earth and neutral connections correctly otherwise, the RPM indicator gets burns if connections are wrong
3. Frequently, at least once in three months, grease all visual moving parts.
4. finally, fill in the with clean water free from foreign material
   Change the everyday / week.
5. At least every day operate the unit for five minutes to prevent any clogging of The moving parts.
6. To start and stop the supply pump, always keep gate valve closed.
7. Gradual opening and closing of the gate valve is recommended for smooth operation.
8. In case of any major fault, please write to manufacturer, and do not attempt to repair.

Graphs:

- Discharge Vs shaft power
- Discharge vs efficiency

Space For Calculations

RESULT & CONCLUSIONS:

The efficiency of Francis turbine is found to be (i) at constant head -------------

(ii) at constant speed-----------

VIVA QUESTIONS:

- What is meant by a turbine?
- What are the differences between turbine and pump?
- What are the different types of turbines?
- Francis comes under impulse turbine (or) reaction turbine?
- What is the difference between Pelton wheel and Francis turbine applications wise?
- Which type of flow will exist in Francis turbine?
- What is meant by Draft tube?
- Draft tubes are required in Impulse turbines (or) reaction turbines?
- Where draft tube will be fitted for reaction turbines?
- Is draft tube is compulsory in reaction turbines?
- What is meant by specific speed of the turbine?
- What is meant by Performance characteristic curves?
- What are the different types of performance characteristic curves?
- How maintain the constant speed during the experiment with the applying of load.
- What is meant by unit quantities?
- What is the difference between specific speed and unit speed?

EXPERIMENT - 10

SELF-PRIMING PUMP

AIM:

To determine the efficiency of self priming pump.

APPARATUS:

- Self priming pump
- Stop watch
- Collecting tank

THEORY:

A self-priming centrifugal pump has two phases of operation: priming mode and pumping mode

In its priming mode, the pump essentially acts as a liquid-ring pump. The rotating impeller generates a vacuum at the impeller's 'eye' which draws air into the pump from the suction line. At the same time, it also creates a cylindrical ring of liquid on the inside of the pump casing. This effectively forms a gas-tight seal, stopping air returning from the discharge line to the suction line. Air bubbles are trapped in the liquid within the impeller's vanes and transported to the discharge port. There, the air is expelled and the liquid returns under gravity to the reservoir in the pump housing.

Gradually, liquid rises up the suction line as it is evacuated. This process continues until liquid replaces all the air in the suction piping and the pump. At this stage, the normal pumping mode commences, and liquid is discharged.

When the pump is shut off, the design of the priming chamber (normally involving a 'goose-neck' on the suction piping) ensures that enough liquid is retained so that the pump can self-prime on the next occasion it is used. If a pump has not been used for a while, it is important to check for losses from the casing due to leaks or evaporation before starting it.

Specifications:

- Area of collecting tank = 0.4 x 0.4 m^2
- Energy meter constant = 3200 imp/kwh
- Datum head = difference between suction and delivery gauges Z = 0.3 m

PROCEDURE:

1. Remove the air pocket present in the casing of the pump by performing the priming operation.
2. Switch on motor and open the delivery valve fully.Note down the pressure values in the suction (in mm of Hg) and delivery (kg/cm^2) pipes.
3. Remove the air pocket present in the casing of the pump by performing the priming operation.
4. Switch on motor and open the delivery valve fully.
5. Note down the pressure values in the suction (in mm of Hg) and delivery (kg/cm^2) pipes.
6. By closing the gate valve of the collecting tank note down the time taken for 10 cm raise of water level using stopwatch.
7. Note down the time taken for 5 blinks of energy meter using stop watch.
8. Repeat the above procedure for various delivery pressures.

Tabular column:

S.no	Delivery Pressure Kg/cm^2	Suction pressure mm of Hg	Time taken for 5 blinks of energy meter (t) Sec	Time for 10 cm rise of water level in collecting tank (T) sec	Total Head (H) meters	Discharge (Q) m^3/sec	Input power Kw	Output power Kw	η %

Formulae:

1. ***Total head (H)*** = Delivery head + Suction head + Datum Head

Delivery head = Kg/cm² x 10 = meters.

Suction head = $\frac{mm\ of\ Hg \times 13.6}{1000}$

Datum head = Distance between pressure and vacuum gauge in meters

2. ***Discharge*** $Q = \frac{AXh}{t}$ m^3/sec

Where t = time taken for 10 cm raise of water level in seconds.

3. ***Input power (I.P)*** = $\frac{X \times 3600 \times 0.70 \times 0.80}{C \times T}\, kw$

Where X = no. of blinks of light of energy meter (say 5)

T = Time for energy meter blinking in seconds

C = Energy meter constant (3200)

0.70 = Motor efficiency

0.80 = Belt efficiency (or) Transmission efficiency

4. ***Output power (O.P.)*** = $\frac{W \times Q \times H}{1000}\, kw$

Where W = Specific weight of water (9810 N/m^3)

Q = Discharge

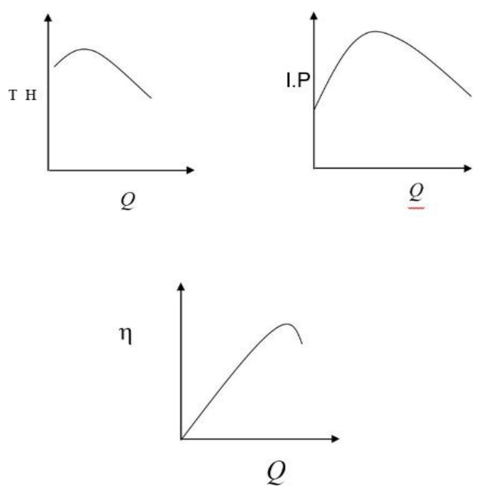
H = Total head

5. ***Hydraulic efficiency*** **(η)** = $\frac{O.P}{I.P}$ %

Precautions:

- Unload the motor before switch off.
- Take the readings without parallax error.
- Don't run the pump when the air pockets are present in the casing.

Model graphs:



Space For Calculations

RESULT & CONCLUSIONS:

The efficiency of self priming pump is found to be -----------------

VIVA QUESTIONS:

- What is priming of a pump?
- Why it is necessary to prime a pump?
- Write the effects of cavitation?
- What are the main parts of a self priming pump?
- Distinguish between the positive and non-positive displacement pumps.
- Define pumps?
- Write the working principle of a self priming pump?
- Define specific speed of self priming pump?
- Define the characteristic curves and why these curves are necessary?
- Write the types of the characteristic curves?
- Classify hydraulic pumps.

EXPERIMENT - 11

STUDY OF PNEUMATIC CIRCUITS

AIM:

To study the components of pneumatic circuit.

THEORY:

Components for pneumatic system

1. ***Air generation and distribution***

The compressed air supply for a pneumatic system should be adequately calculated and made available in the appropriate quality.

Air is compressed by the air compressor and delivered to an air distribution system in the factory. To ensure the quality of the air is acceptable air service equipment is utilized to prepare the air before being applied to the control system.

Malfunction can be considerably reduced in the system if the compressed air is correctly prepared. A number of aspects must be considered in the preparation of the service air.

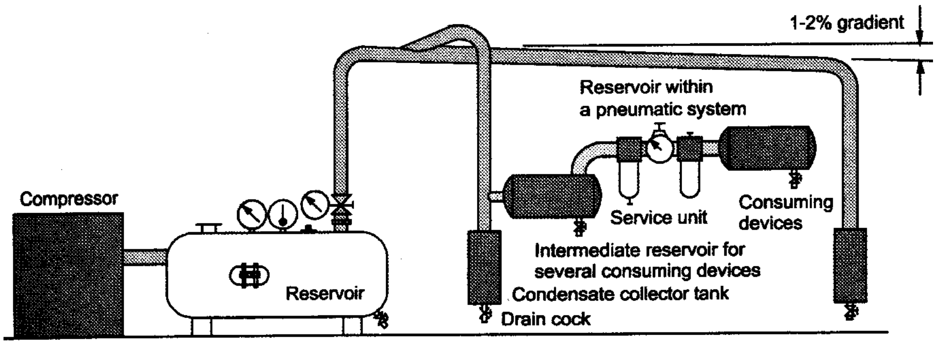
- Quantity of air required to meet the demands of the system
- Type of compressor to be used to produce the quantity required
- Pressure requirements
- Storage required
- Requirements for air cleanliness
- Acceptable humidity levels to reduce corrosion and sticky operation
- Lubrication requirements, if necessary
- Temperature of the air and effects on the system
- Line size and valve sizes to meet demand
- Material selection to meet environmental and system requirements
- Drainage points and exhaust outlets in the distribution system
- Layout of the distribution system to meet demand

As a rule pneumatic components are designed for a maximum operating pressure of 800-1000 kPa(8-10 bar) but in practice it is recommended to operate at between 500-600kpa(5 and 6 bar) for economic use. Due to the pressure losses in the distribution system the compressor should deliver between 650-700kpa(6.5 and 7)bar to attain these figures.

A reservoir should be fitted to reduce pressure fluctuations. In some cases, the team 'receiver' is also used to describe a reservoir. The compressor fills the reservoir, which is available as storage tank.

The pipe diameter of the air distribution system should be selected in such a way that the pressure loss from the pressurized reservoir to the consuming device ideally does not exceed approx. 10kPa(0.1 bar). The selection of the pipe diameter is governed by:

- Flow rate
- Line length
- Permissible pressure loss
- Operating pressure
- Number of flow control points in the line



Air Distribution System

Ring circuits are most frequently used as main lines. This method of installing pressure lines also achieve a constant supply in the case of high air consumption. The pipelines must be installed in the direction of flow with a gradient of 1 to 2%. This is particularly important in the case of branch lines. Condensate can be removed from the lines at the lowest point.

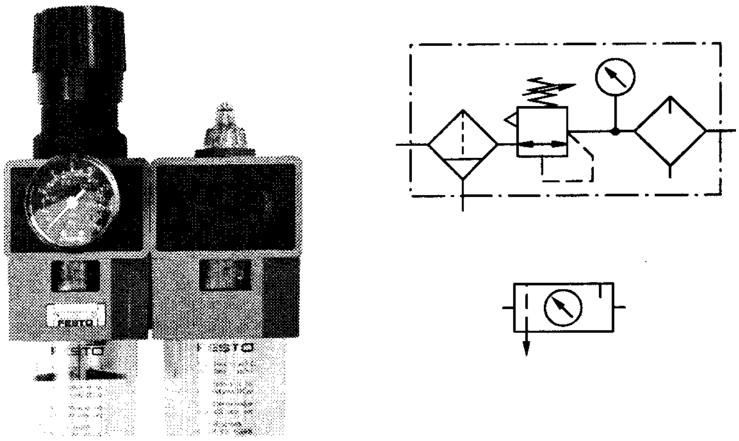
Any branching of air consumption points where lines run horizontally should always be installed on the upper side of the main line.

Branching for condensate removal are installed on the underside of the main line.

Shut-off valves can be used to block sections of compressed air lines if these are not required or need to be closed down for repair or maintenance purposes.

The air service unit is a combination of the following:

- Compressed air filter (with water separator)
- Compressed air regulator
- Compressed air lubricator
- However, the use of lubricator does not need to be provided for in the power section of a control system unless necessary, since the compressed air in the control section does not necessary need to be lubricated.
- The correct combination, size and type of these elements are determined by the application and the control system demand. An air service unit is fitted at each control system in the network to ensure the quality of air for each individual task.
- The compressed air filter has the job of removing all contaminates from the compressed air flowing through it as well as water, which has already condensed.
- The compressed air enters the filter bowl through guide slots. Liquid particles are larger particles of dirt are separated centrifugally collecting in the lower part of filter bowl. The collected condensate must be drained before the level exceeds the maximum condensate mark, as it will otherwise be re-entrained in the air stream.



Air service unit

- The purpose of the regulator is to keep the operating pressure of the system (secondary pressure) virtually constant regardless of fluctuations in the line pressure (primary pressure) and the air consumption.
- The purpose of the lubricator is to deliver a metered quality of oil mist into a leg of the air distribution system when necessary for the operation of the pneumatic system.

2. *Valves*

The function of valves is to control the pressure or flow rate of pressure media. Depending on design, these can be divided into the following categories:

- Directional control valves
  - Input/signaling elements
  - Processing elements
  - Control elements
- Non-return valves

- Flow control valves
- Pressure control valves
- Shut-off valves

***Directional Control Valves*:**

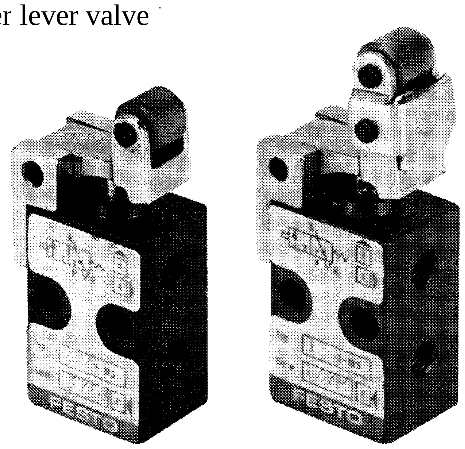
The directional control valves control the passage of air signals by generating, canceling or redirecting signals.

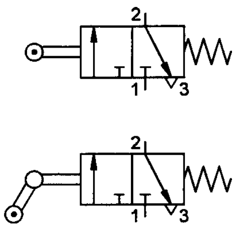
The valve is described by:

- Number of ports or openings (ways): 2-way, 3-way, 4-way, etc
- Number of positions: 2 position, 3 positions, etc
- Methods of actuation of the valve: manually actuated,
  Mechanically actuated,
  Pneumatically actuated,
  Electrically actuated.
- Methods of return actuation: Spring return, air return, etc

As a signaling element the directional control valve is operated for example, by a roller lever to detect the piston rod position of a cylinder.

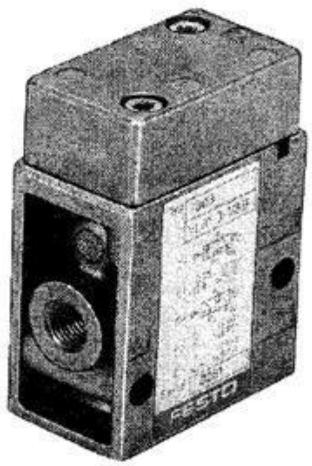
3/2 Roller lever valve

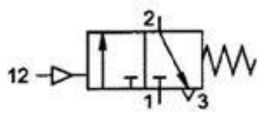




With idle return

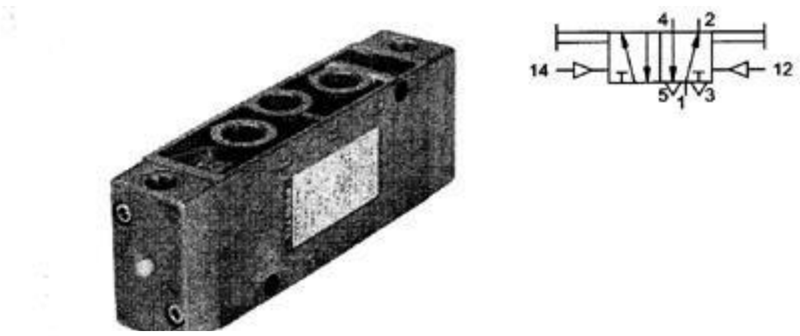
As a processing element the directional control valve redirects or cancels signals depending on the signal inputs received.





3/2 Single Pilot Valve, with spring return

As a control element the directional control valve must deliver the required quantity of air to match the power component requirements.

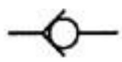


5/2 way Double Pilot Valve

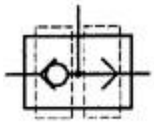
Non-return valves:

The non-return valve allows a signal to flow through the device in one direction and in the other direction blocks the flow. Amongst others, this principle is applied in shuttle valves or quick exhaust valves. The non-return valve in the form of basic element of other valve types is shown in a broken outline in the illustration below

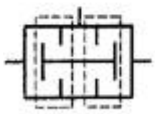
Check Valve



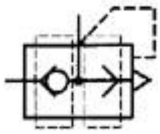
Shuttle Valve



Dual-pressureValve



Quick Exhaust Valve



Non-return valves & its derivatives

***Flow control valves*:**

The flow control valve restricts or throttles the air in a particular direction to reduce the flow rate of the air and hence control the signal flow. Ideally it should be possible to infinitely vary the restrictor from fully open to completely closed. The flow control valve should be fitted as close to the working elements as is possible and must be adjusted to match the requirements of the application. If the flow control valve is fitted with a check valve then the function of flow-control is unidirectional with full fee flow in one direction.

Flow control valve, adjustable

One-way flow control valve

Flow control valves

Pressure control valves:

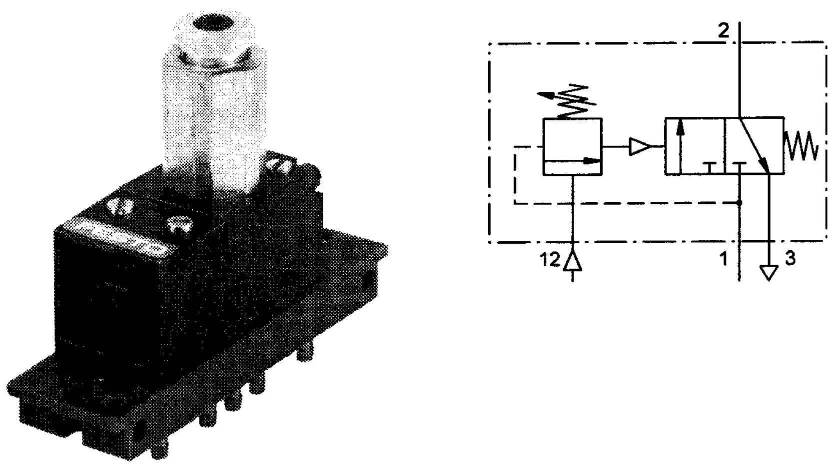
Pressure control valves are utilized in pneumatic systems. These are three main groups

- Pressure limiting valves
- Pressure regulating valves
- Pressure sequence valves

The pressure limiting valves are utilized on the up-stream side of the compressor to ensure the receiver pressure is limited, for safely and that the supply pressure to the system is set to the correct pressure.

The pressure-regulating valve keeps the pressure constant irrespective of any pressure fluctuations in the system. The valve regulates the pressure via a built-in diaphragm.

The pressure sequence valve is used if a pressure-dependent signal is required for the advancing of a control system.



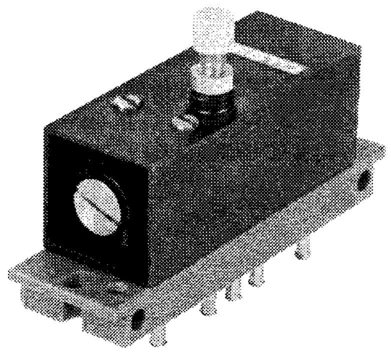
Pressure sequence valve

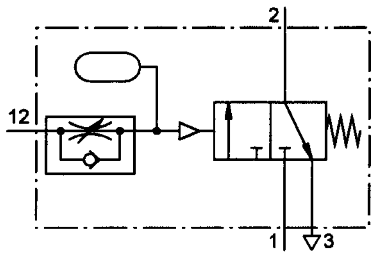
When the applied control signal reaches the set pressure, the3/2-way valve incorporated at this point is actuated. Conversely, the valve reverses, if the control signal falls below the set pressure.

***Combination valves*:**

The combined functions of various elements can produce a new function. An example is the time delay valve, which is the combination of a one-way flow control valve, a reservoir and a 3/2-way directional control valve.

Depending on the setting of the throttling screw, a greater or lesser amount of air flows per unit of time into the air reservoir. When the necessary control pressure has built-up, the valve switches to through flow. This switching position is maintained for as long as the control signal is applied.





Time Delay Valve

Other combinational valves include the

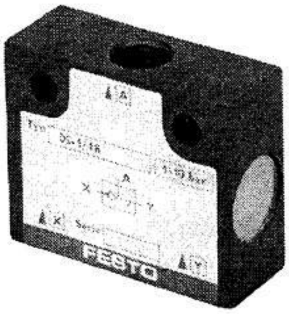
- Two-hand start unit.
- Pulse generator.
- Stepper modules
- Memory modules

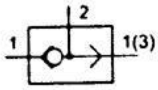
3. *Processing elements (processors):*

To support the directional control valves at the processing level, there are various elements, which condition the control signals for a task. The elements are:

- Dual pressure valve (AND function)
- Shuttle valve (OR function)

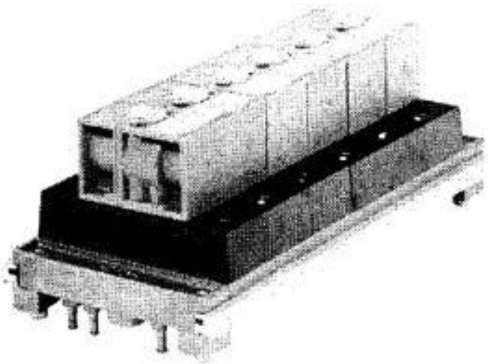
A shuttle valve permits the combination of two input signals into an OR function. The OR gate has two inputs and one output. An output signal is generated, if pressure is applied at one of the two inputs.

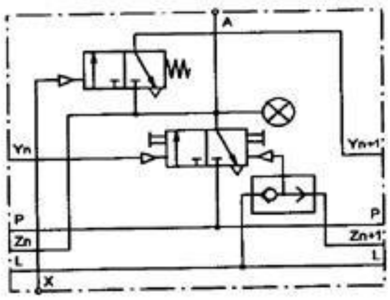




Shuttle Valve

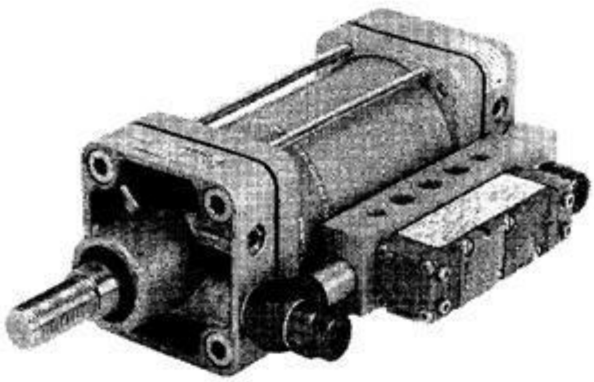
The further development of processing elements in pneumatics has brought about the modular systems, which incorporate directional control valve functions and logic elements to perform a combined processing task. This reduces size, cost and complexity of the system.





4. *Power components*

The power section consists of control elements and power components or actuators. The actuator group includes various types of linear and rotary actuators of varying size and construction. The actuators are complemented by the control elements, which transfer the required quantity of air to drive the actuator. Normally this valve will be directly connected to the main air supply and fitted close to the actuator to minimize losses due to resistance.



Actuator with control element

Actuators can be further broken down into groups:

- Linear actuators
    - Single-acting cylinder
    - Double-acting cylinder
- Rotary actuators
    - Air motors
    - Rotary actuators

Linear and Rotary Actuators

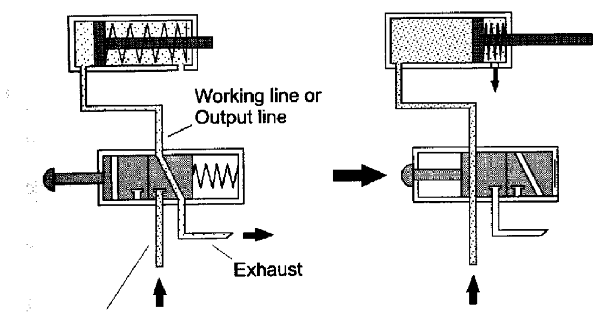
5. *Systems*

Generally, the actuation of a cylinder is effected via a directional control valve. The choice of such a directional control valve (number of connections, number of switching positions, type of actuation) is dependent on the respective application.

Control circuit for the single-acting cylinder

The piston rod of a single-acting cylinder is to advance when a push button is operated. When the push button is released, the piston is to automatically return to the initial position. A 3/2-way valve controls the single-action cylinder. The valve switches from the initial position into the flow position, when the push-button actuator is pressed. The circuit includes the following primary features:

- Single-acting cylinder, spring return
- 3/2-way directional control valve: push button for operation and spring for return force
- Supply air source connected to the 3/2-way valve.
- Air connection between valve and cylinder.



Control of a single-acting cylinder

The 3/2 way control valve has 3 ports. The supply port, the exhaust port and the outlet port. The relationship between these ports is determined by the passages through the valve. The possible switching positions are shown in the above illustration.

Initial position:

The initial position (left-hand circuit) is defined as the ‘rest’ position of the system. All connections are made and there is no manual intervention by the operator. The air supply is shut off and the cylinder piston rod retracted (by spring return). In this valve position, the piston chamber of the cylinder is exhausted.

Push-button operation:

Pressing the push button moves the 3/2-way valve against the valve return spring. The diagram (right-hand-circuit) shows the valve in the actuated or working position. The air supply is now connected via the valve passage to the single-acting cylinder port. The build-up of pressure causes the piston rod of the cylinder to extend against the force of the cylinder return spring. As soon as the piston rod arrives at the forward end position, the air pressure in the cylinder body reaches a maximum level.

Push-button releases:

As soon as the push button is released, the valve return spring returns the valve to its initial position and the cylinder piston rod retracts.

Note: The advancing speed and the retracting speed are different because:

- The piston reset spring creates a counteracting force when advancing.
- When retracting, the displaced air escapes via the valve. A flow resistance must therefore be overcome.

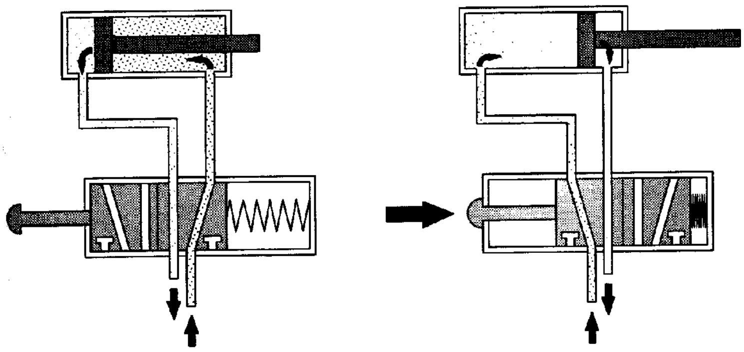
21rmally, single-acting cylinders are designed in such a way that the advancing speed is greater than the retracting speed.

Control circuit for the double-acting cylinder

The piston rod of a double-acting cylinder is to advance when a push button is operated and to return to the initial position when the push button is released. The double-acting cylinder can carry out work in both directions of motion, due to the full air supply pressure being available for extension and retraction.

A 5/2-way directional control valve controls the double-acting cylinder. A signal is generated or reset on the valve, if a push-button actuator is pressed or released. The circuit inclues:

- Double-acting cylinder
- 5/2-way directional control valve: push button for operation and spring for return force.
- Supply air source connected to the 5/2-way valve
- Air connections between valve and cylinder



Control of Double Acting Cylinder

Initial position:

In the initial position (left-hand circuit) all the connections are made and there is no manual intervention by the operator. In this unactuated position, air is applied at the cylinder piston rod side, while the pressure on the piston side of the cylinder is exhausted.

Push button operation:

Pressing the push button operates the 5/2-way valve against the valve return spring. The diagram (right-had circuit) shows the valve in the operated or actuated position. In this position, the supply pressure is connected to the piston side of the cylinder, while the piston rod side is exhausted. The pressure on the piston side advances the piston rod. Once full extension is reached, the air pressure on the pistion side reaches a maximum.

Push button release:

Once the push button is released, the valve return spring pushes the valve into the initial position. The supply pressure is now connected to the piston rod side, while the piston side exhausted via the exhaust port or the valve. The piston rod retracts.

Note The advancing speed and the retracting speed are different due to the fact that the cylinder volume on the piston rod side is smaller than on the piston side. Thus, the amount of supply air required during retraction is smaller than during extension, and the return stroke is faster.

RESULT & CONCLUSIONS:

VIVA QUESTIONS:

1. What is the function of a pneumatic valve?
2. How do you classify pneumatic valves?
3. What is the function of a Direction control valve?
4. What are functions of a check valve?
5. What is the last element in pneumatic circuit?
6. What is the operating cost of pneumatic circuit when compared with the hydraulic circuit?
7. What are the components of a pneumatic circuit ?

EXPERIMENT - 12

STUDY OF HYDRAULIC CIRCUITS

AIM:

To study the componenets of pneumatic circuit.

THEORY:

The application of circuits in Industrial Control Systems and Machine Tools using Hydraulic Components are innumerable.

Here follow few of such circuits within scope of components supplied with the trainer. Accompanying circuit diagrams are self explanatory. The 'T' branch connections are shown where they actually exist. Thus. Students need not interpreted the diagrams and correlate with actual components on the board. Only thing the student to do is, connect the pipes as shown in diagram and complete the experiment.

1. Study of 4 / 3 Way Tandem Center Direction Control Valve

- Connect components as per circuit diagram. At the central position of the direction control valve pressurized oil will be bypassed to reservoir, thus no pressure will be developed.
- When spool of direction valve is shifted in front oil will flow from 'P' port to 'A' of Direction Control valve. 'B' port will be connected to drain port 'T'. Rod of double acting cylinder will extend on one side and when reaches extreme position it will stop. Now full system pressure will be built-up and relief valve will release the oil pressure. When Spool of direction valve is shifted in back position the cylinder rod will retract reversibly in the same manner as explained above.
- As single shaft extension cylinder is used velocities in both directions will be unequal and inversely proportional to areas on both sides. Force will develop upon the pressure setting of relief valve and piston area.

Study of Pressure Relief Valve

- Connect components as per circuit diagram. At the central position of the direction control valve pressurized oil will be bypassed to reservoir, thus no pressure will be developed.
- When spool of direction valve is shifted in front oil will flow from 'P' port to 'A' of Direction Control valve. 'B' port will be connected to drain port' T' rod of double acting cylinder will extend on one side and when reaches extreme position it will stop. When Spool of direction valve is shifted in back position the cylinder rod will retract in the same manner as explained above.
- Observe the speed of the piston rod of cylinder in both the operation above.
- Now, reduce the pressure setting on the Pressure Relief Valve, by rotating the knob anticlockwise direction and repeat the procedure as above.
- It is noticed that the speed of the cylinder decreases in both forward and reverse direction due to decrease in flow of oil to it. This is due to the reason that most of the oil received

from the pump is being bypassed or bleed off to the reservoir tank by the 'T' port of the Pressure Relief Valve.

Study of Operation/Speed Control of Double Acting Cylinder

- Repeat the procedure same as mentioned in the Circuit No.1. The cylinder extend and retract position is observed.
- Now, for Speed Control follow the procedure given below.
- Increase the flow of oil by rotating the knob of Flow Control Valve in anticlockwise Direction, the speed of the Cylinder increases both in the forward and reverse direction.
- Now, Decrease the flow of oil by rotating the knob of Flow Control Valve in Clockwise Direction, the speed of the cylinder decreases both in the forward and reverse direction.

Study of Meter-In Circuit:

- If supplied fluid rate to cylinder is controlled by any type of flow control valve, it is called as Meter In type Flow Control Circuit.
- For this, select the hose with the Throttle Check valve fitted inline. Connect the same to the port 'A' of the Double acting cylinder as shown in the circuit. Check the symbol marked on the valve. Connect the port, 'B' by another ordinary hose.
- Due to this type of circuit the flow of oil going to the cylinder can be increased or decreased and the speed of the cylinder in forward stroke can be increased or decreased.

Study of Meter Out Circuit:

- If the flow rate of Oil coming out or returning from the cylinder is controlled, it is called as Meter Out type circuit. This is to be done by connecting the hose with Throttle check valve to the port 'B' of the cylinder. By adjusting the sleeve of the throttle check valve flow rate can be changed. In this case the speed of retraction can be increased or decreased.

RESULT & CONCLUSIONS:

VIVA QUESTIONS:

1. What are the basic components of Hydraulic Circuit?
2. What is meant by an actuator? How it is used?
3. What are the various types of pumps used in hydraulic circuit?
4. What are the properties of oils used in hydraulic system?
5. What are the applications of Hydraulic System?
6. What is the use of pressure regulating valve?
7. What are the various types of valves used in hydraulic circuit?

EXPERIMENT - 13

STUDY OF POSITIVE DISPALCEMENT AND ROTO DYNAMIC PUMPS

AIM:

To study the positive displacement and roto dynamic pumps with the help of models.

THEORY:

Pump is a hydraulic Machine which converts Mechanical energy into Hydraulic energy. Pumps are mainly classified into two types viz., Positive displacement pumps and roto dynamic pumps.

Positive displacement pump:

A positive displacement (PD) pump moves a fluid by repeatedly enclosing a fixed volume and moving it mechanically through the system. The pumping action is cyclic and can be driven by pistons, screws, gears, rollers, diaphragms or vanes.

Reciprocating positive displacement pumps:

- A Reciprocating Positive Displacement pump works by the repeated back-and-forth movement (strokes) of either a piston, plunger or diaphragm (Figure 1). These cycles are called reciprocation.
- In a piston pump, the first stroke of the piston creates a vacuum, opens an inlet valve, closes the outlet valve and draws fluid into the piston chamber (the suction phase). As the motion of the piston reverses, the inlet valve, now under pressure, is closed and the outlet valve opens allowing the fluid contained in the piston chamber to be discharged (the compression phase). The bicycle pump is a simple example. Piston pumps can also be double acting with inlet and outlet valves on both sides of the piston. While the piston is in suction on one side, it is in compression on the other. More complex, radial versions are often used in industrial applications.
- Plunger pumps operate in a similar way. The volume of fluid moved by a piston pump depends on the cylinder volume; in a plunger pump it depends on the plunger size. The seal around the piston or plunger is important to maintain the pumping action and to avoid leaks. In general, a plunger pump seal is easier to maintain since it is stationary at the top of the pump cylinder whereas the seal around a piston is repeatedly moving up and down inside the pump chamber.
- A diaphragm pump uses a flexible membrane instead of a piston or plunger to move fluid. By expanding the diaphragm, the volume of the pumping chamber is increased and fluid is drawn into the pump. Compressing the diaphragm decreases the volume and expels some fluid. Diaphragm pumps have the advantage of being hermetically sealed systems making them ideal for pumping hazardous fluids.
- The cyclic action of reciprocating pumps creates pulses in the discharge with the fluid accelerating during the compression phase and slowing during the suction phase. This can cause damaging vibrations in the installation and often some form of damping or smoothing is employed. Pulsing can also be minimized by using two (or more) pistons, plungers or diaphragms with one in its compression phase whilst the other is in suction.

- The repeatable and predictable action of reciprocating pumps makes them ideal for applications where accurate metering or dosing is required. By altering the stroke rate or length it is possible to provide measured quantities of the pumped fluid.

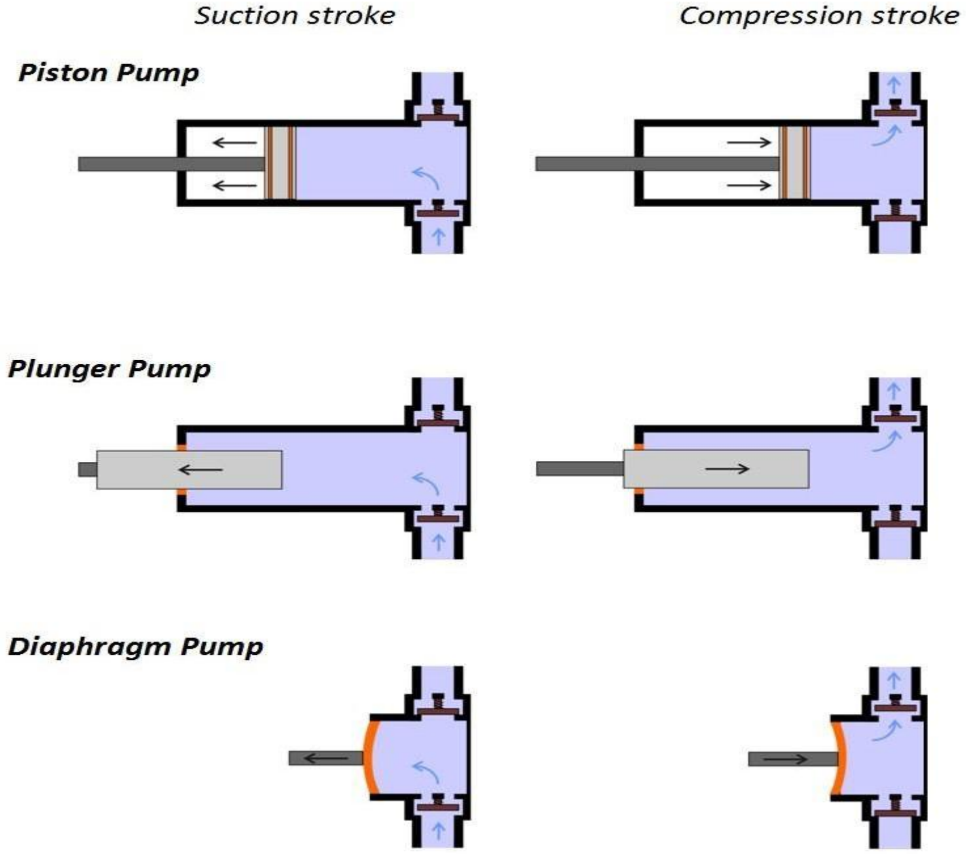


Figure 1. Basic reciprocating pump designs

Rotary positive displacement pumps

- Rotary positive displacement pumps use the actions of rotating cogs or gears to transfer fluids, rather than the backwards and forwards motion of reciprocating pumps. The rotating element develops a liquid seal with the pump casing and creates suction at the pump inlet. Fluid, drawn into the pump, is enclosed within the teeth of its rotating cogs or gears and transferred to the discharge. The simplest example of a rotary positive displacement pump is the gear pump. There are two basic designs of gear pump: external and internal (Figure 2).
- An external gear pump consists of two interlocking gears supported by separate shafts (one or both of these shafts may be driven). Rotation of the gears traps the fluid between the teeth moving it from the inlet, to the discharge, around the casing. No fluid is transferred back through the center, between the gears, because they are interlocked. Close tolerances between the gears and the casing allow the pump to develop suction at the inlet and prevent fluid from leaking back from the discharge side. Leakage or "slippage" is more likely with low viscosity liquids.
- An internal gear pump operates on the same principle but the two interlocking gears are of different sizes with one rotating inside the other. The cavities between the two gears

are filled with fluid at the inlet and transported around to the discharge port, where it is expelled by the action of the smaller gear.

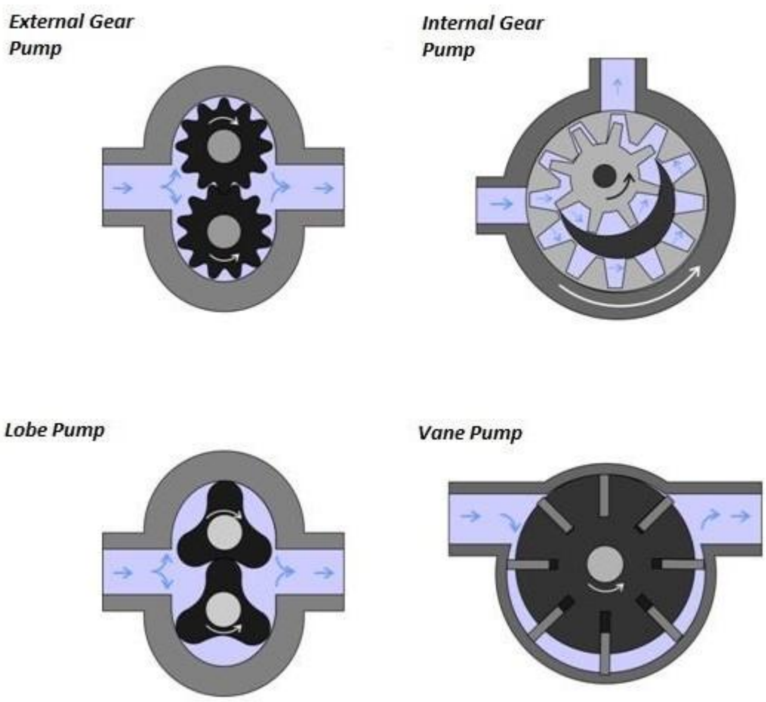


Figure 2. Rotary positive displacement pump designs

- Gear pumps need to be lubricated by the pumped fluid and are ideal for pumping oils and other high viscosity liquids. For this reason, a gear pump should not be run dry. The close tolerances between the gears and casing mean that these types of pump are susceptible to wear when used with abrasive fluids or feeds containing entrained solids.
- Two other designs similar to the gear pump are the lobe pump and vane pump.
- In the case of the lobe pump, the rotating elements are lobes instead of gears. The great advantage of this design is that the lobes do not come into contact with each other during the pumping action, reducing wear, contamination and fluid shear. Vane pumps use a set of moveable vanes (either spring-loaded, under hydraulic pressure, or flexible) mounted in an off-center rotor. The vanes maintain a close seal against the casing wall and trapped fluid is transported to the discharge port.
- A further class of rotary pumps uses one or several, meshed screws to transfer fluid along the screw axis. The basic principle of these pumps is that of the Archimedes screw, a design used for irrigation for thousands of years.

Roto dynamic Pumps:

In this pump, the volume of the liquid delivered for each cycle depends on the resistance offered to flow. A pump produces a force on the liquid that is constant for each particular speed of the pump. Resistance in a discharge line produces a force in the opposite direction. When these forces are equal, a liquid is in a state of equilibrium and does not flow. If the outlet of a non positive-displacement pump is completely closed, the discharge pressure will rise to maximum for a pump operating at a maximum speed. These pumps are also called Non-positive displacement pump.

Types of roto dynamic pumps:

Rotodynamic pumps can be classified on various factors such as design, construction, applications, service etc.

- According to the types of stages:
  - Single stage pumps:
    - It is known as single impeller pump.
    - It is simple in design and easy in maintenance.
    - It is ideal for large flow rates and low pressure installations.
  - Two stage pump:
    - It has two impellers operating side by side.
    - It is used for medium use applications.
  - Multistage Pumps:
    - It has three or more impellers in series.
    - They are used for high head applications.
- According to the type of case – split:
  - Axial split:
    - In these types of pumps the volute casing is split axially and split line at which the pump casing separates is at the shaft's center – line.
    - They are typically mounted horizontally due to ease in installation and maintenance.
  - Radial split:
    - In it pump case is split radially, the volute casing split is perpendicular to shaft centre line.
- According to the types of impeller design.
  - Single suction:
    - It has single suction impeller which allows fluid to enter blades only through a single opening.
    - It has a simple design but the impeller has higher axial thrust imbalance due to flow coming through one side of impeller.
  - Double Suction:
    - It has double suction impeller which allows fluid to enter from both the sides of blades.
    - They are most common types of pumps.
- According to the type of volute:
  - Single volute pump:
    - It is usually used for low capacity pumps, as it has small volute size.
    - Small size volute casting is difficult but is good in quality.
    - They have higher radial loads.
  - Double volute pump:
    - It has two volutes which are placed 180 degrees apart.
    - It has a good capability of balancing radial loads.
    - It is the most common design used.
- According to the shaft orientation:
  - Horizontal Centrifugal pumps:
    - Easily available.
    - Easy to install, inspect, maintain and service.

    - It is suitable for low pressure.
- Vertical Centrifugal pumps:
    - Requires large headroom for installation, servicing and maintenance.
    - It can easily withstand higher pressure loads.
    - It is more expensive than horizontal pumps.

Centrifugal pump is the most commonly used roto dynamic pump.

RESULT & CONCLUSIONS:

VIVA QUESTIONS:

- What is priming of a pump?
- Why it is necessary to prime a pump?
- What are the main parts of a centrifugal pump?
- Distinguish between the positive and non-positive displacement pumps.
- The centrifugal pump acts as a ---- reverse of an inward radial flow reaction turbine
- Define pumps?
- Define a centrifugal pump?
- Classify hydraulic pumps.
- What is an air vessel?
- What do you understand by single acting & double acting pump?
- Define slip of a pump?
- Define a reciprocating pump?
- What are the main parts of the reciprocating pump?
- Define indicator diagram.

Estd: 2008

METHODIST

COLLEGE OF ENGINEERING & TECHNOLOGY

Approved by AICTE New Delhi | Affiliated to Osmania University, Hyderabad

Abids, Hyderabad, Telangana, 500001