Laboratory Manual

# FLUID MACHINERY LAB

for

## B. Tech.
## Mechanical Engineering

Department of Mechanical Engineering

Rukmani & Sons

Brij Bhooshan Education Web Portal
Web: www.brijrbedu.org

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**B. Tech.**
**Mechanical Engineering**

Prepared by

A team of
Rukmani & Sons

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# LABORATORY OBJECTIVE

This lab has following objectives:

- To compare the results of analytical models introduced in lecture to the actual behavior of real fluid flows;
- To discuss and practice standard measurement techniques of fluid mechanics and their applications;
- To learn and practice writing technical reports.
- To work on small design projects;
- To understand the theory through experiment in lab;
- To understand how hydraulic energy convert into mechanical energy and mechanical energy into hydraulic energy.

# ABOUT THE LABORATORY

The main activities of the Laboratory for Hydraulic Machines are teaching, research and service in the field of hydrodynamics of rotating machines such as hydraulic turbines, pumps, pump-turbines, ship propellers etc... Both theoretical and experimental aspects are investigated with a particular emphasis on the industrial applications such as the design, the installation and the operation of hydraulic machines.

The following main topics of research activity are addressed:

1. Fundamental Research in Cavitation
2. Cavitation Erosion
3. Cavitation Detection and Monitoring
4. Flow Analysis in Turbines and Pumps
5. Rotor-Stator Interaction
6. Flow Investigation in Draft Tube
7. Stability in Francis Turbines
8. Active Control for Turbomachines Stability
9. Free Surface Flows in Pelton Turbines
10. Specific Instrumentation for Turbomachinery
11. Design Tools and Model Manufacturing

## GUIDELINES FOR TEACHERS/TECHNICAL ASSISTANTS

1. Know the laboratory: The teacher is expected to understand the layout of laboratory, specifications of equipments/instruments/materials, procedure of experiments, method of working in groups, planning time etc.
2. Ensure that required equipments are in working condition before start of experiment and also keep the operating or instruction/user manuals of equipments/instruments and this laboratory manual available.
3. On the first day of the lab, inform the students about the importance of subject/laboratory, various equipments/instruments that will be used in the lab etc. Also instruct them how to make the practical record file for this lab.
4. Explain the theoretical concepts, relevant to the experiment, to the students before start of each practical.
5. Demonstrate the experiment(s) clearly to the students group-wise.
6. Instruct the students to perform the practical. While taking reading/observation, each student must get a chance to perform or observe the experiment.
7. If the experimental setup has variations in the specifications of the equipment, the teachers are advised to make the necessary changes.
8. Teacher shall assess the performance of students by observation or by asking viva related questions to the students to tap their achievements regarding related knowledge/skills so that students can prepare accordingly.
9. The teacher must check carefully and sign the practical record file of the students periodically.
10. Teacher shall ensure that the industrial/site/plant visits recommended as per the syllabus of laboratory are covered.
11. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
12. Teacher may provide additional knowledge and skills to the students albeit not covered in the manual but are expected from students by the industries.
13. Teacher may suggest the students to refer additional related literature of the technical papers, reference books, seminar proceedings etc.
14. Teacher can organize group discussions/brain storming sessions/seminars to facilitate the exchange of practical knowledge amongst the students.

# GENERAL PRECAUTIONS AND SAFETY PROCEDURES

1. Teacher/technical assistant must ensure that all the electrical equipments/ instruments are used and periodically performance tested as per manufacturer's recommendations (permissible electrical and ambient temperature ratings).
2. Before use, the electrical equipment, extension cords, power tools etc. must be inspected for any damage (worn insulation, bent/missing pins, etc.). Any equipment found to be damaged or otherwise unsafe must be removed from service.
3. The mains plug of equipments must only be inserted in a socket outlet provided with a protective earth contact.
4. **WARNING**: The protective earth connection inside or outside the equipments/instruments must NEVER be interrupted or tampered. **IT CAN MAKE THE EQUIPMENT DANGEROUS**.
5. If an instrument shows visible damage or fails to perform the intended measurements, it is likely that the protection has been impaired. In such case the instrument must be made inoperative and the necessary repairs should be carried out.
6. Extension cords or power strips must not be plugged into one another so as to increase the overall reach.
7. Report all problems with building electrical systems to the teacher/technical assistant/maintenance for corrective action.
8. In case of any electrical hazard/fire reach out for the nearest fire-extinguisher or sand and use it for putting out the fire. Report immediately to the teacher/ technical assistant nearby.
9. For reasons of safety, every student must come to the laboratory in shoes (covering the whole feet).
10. Avoid wearing garments with loose hanging parts. The students should also ensure that floor around the equipment/machine is clear and dry (not oily) to avoid slipping. Please report immediately to the lab staff on seeing any coolant/oil spillage.
11. The student should take the permission and guidance of the lab staff/teacher before operating any equipment/machine. Unauthorized usage of any machine without prior guidance may lead to fatal accidents and injury.
12. The student will not lean on the equipment/machine or take any kind of support of the machine at any point of time.

# INSTRUCTIONS FOR STUDENTS

1. Listen carefully to the lecture and instructions given by the teacher about importance of subject/laboratory, curriculum structure, skills to be developed, information about equipment and instruments, procedure, method of continuous assessment, tentative plan of work in laboratory and total amount of work to be done in the semester/session.
2. Read and understand the theory of each experiment to be performed, before coming to the laboratory.
3. Understand the purpose of experiment and its practical implications. Observe carefully the demonstration of the experiment. When you perform it, organize the work in your group and make a record of all observations.
4. In case of absence, the student must perform the experiment(s) on the next turn or in his/her spare time with permission from the teacher/lab assistant.
5. Student should not hesitate to ask any difficulty faced during conduct of practical/exercise.
6. The student shall study all the questions given in the laboratory manual or asked by the teacher and know the answers to these questions properly.
7. The required instruments/tools will be issued from the laboratory store. They must be returned to the store on the same day at the end of lab hours.
8. Laboratory reports (practical file) should be submitted in a bound file or on A4 size sheets, properly filed, on the next turn completed in all respects i.e. with experiment(s) written, graphs attached (if applicable) and entries made in the list of contents of the file and get them checked from your laboratory teacher. Laboratory reports have associated grades/marks.
9. Student should not bring any food or drink item to the laboratory.
10. Student should develop habit of group discussion related to the experiments/exercises enabling exchange of knowledge/skills.
11. Student shall gain knowledge and develop required practical skills and competencies as expected by the industries.
12. Student shall develop the habit of evolving more ideas, innovations, skills etc. than included in the scope of the manual.
13. Student shall refer technical magazines, proceedings of the seminars; refer websites related to the scope of the subjects and update their knowledge and practical skills.

# EXPERIMENT – 1

**OBJECTIVE**:

Impact of Jet Experiment on stationary Flat plate.

## APPARATUS USED:

It consists of Flat plate with adjustable device. A water tank is provided with head measuring instrument and stopwatch to find out discharge quantity of water.

## PROCEDURE:

1. Open the Delivery valve and Jet its suitable position so as to attain head.
2. To measure the water head in the tank.
3. To measure the time for various heads.
4. To measure the diameter of jet.
5. Repeat the procedure for various heads and angle from horizontal axis.

## OBSERVATIONS:

| S. No. | Discharge | Velocity | F (Theoretical) | Weight | % Error |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |

## CALCULATION:

Discharge

$$= Q = A.\ h/t$$

where

$A$ = cross- section al area of tank (25 × 25 cm$^2$)

Velocity of water Jet

$$V = Q/a$$

where

a = cross-sectional area of nozzle (Dia. of Nozzle = 8mm)

Rate of change of momentum = $\rho\ Q\ V$

## RESULT:

Force exerted on the plate is ……………………………………………………
Percentage Error = Actual Value - Calculated value Actual value

## PRECAUTIONS:

1. Set the gate opening carefully & reading should be taken carefully.
2. Ensure that before starting the starter gate valve of discharge water is closed.
3. Ensure that after complete the practical all the valve are closed before switch off.

# EXPERIMENT – 2

## OBJECTIVE:

To obtain the overall efficiency of Kaplan turbine

## APPARATUS USED:

Kaplan turbine test rig Weight for different size rope for brake drum, large quantity of water etc.

## THEORY:

It is used for greater flow, when a Francis turbine is fail to meet this requirement. Main point about the runner blades is the variation of the blade angles all along there radial length. This Kaplan turbine blades are capable of rotation so as to change the blade angle when ever, required to meet the varied load demands When adjusting the angle of the runner blades of Kaplan turbine water can be blade to enter the blade tangentially and the velocity of whirl at out let become zero and thus restoring efficiency to maximum.

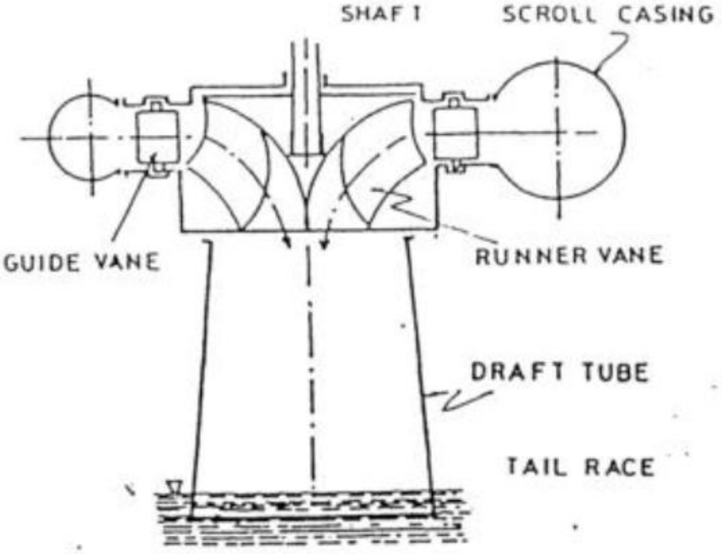
### Description of Apparatus:

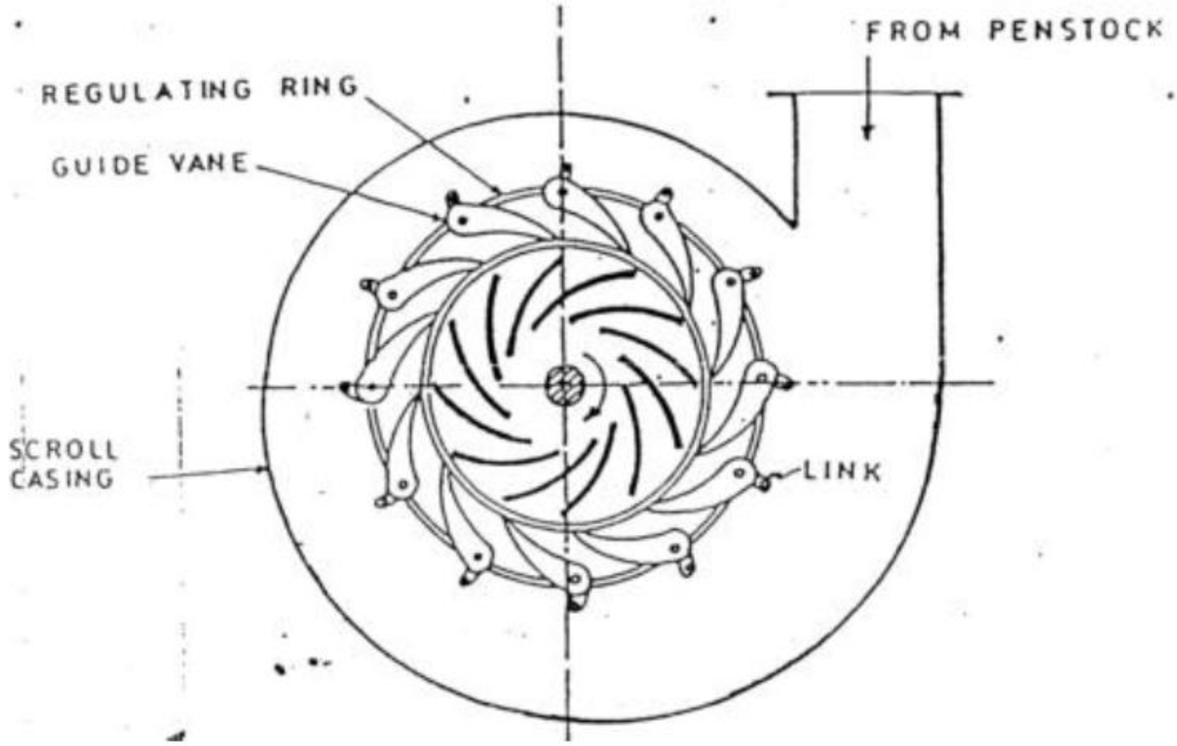
It consists of a spiral casing a rotor assembly with runner shaft and brake drum all mounted on suitable support. A straight conical draught tube is provided vertically below the runner for purpose of regaining the Kinetic energy from the exit water and also facilitating easy accessibility of turbine due to its location at a higher level then the tail raise. A transparent hollow Perspex cylinder is provided in between the casing and the draft tube for the purpose of observation of flow at exist of runner. rope brake arrangement is provided to load the turbine. Adjusting the guide vanes and four runner blades by means of hand wheel and a suitable like mechanism provided control the input in to the turbine. The net supply head on the turbine is measured by a pressure gauge .A suitable size circular sump with a vertical column is provided to store sufficient water for independent circulation through the unit. An optimum size of sump is provided to store sufficient water.

## SPECIFICATIONS:

| | | |
|---|---|---|
| Rated supply head | = | 10 meters |

| | | |
|---|---|---|
| Power output | = | 1Kw |
| No. of runner blades | = | 4 |
| Brake drum diameter | = | 300 m |
| Rope diameter | = | 15 mm |




## PROCEDURE:

1. Allow the water to pass through turbine and to attain speed at without load.
2. Increase the load on the turbine pan gradually.
3. Note the supply heads.

4. Note the discharge through pressure gauge reading.
5. Brake weight (Dead weight plus hanger and rope weight).
6. Repeat all the reading five & six time.

## OBSERVATION:

Inlet diameter of Orifice $d_1$ = 150 mm
Coefficient of Discharge = 0.67

| S. No. | Speed of shaft 'N' in R.P.M. | Manometer reading | | | Pressure gauge reading (H) | Discharge Q | Spring balance $W_1$ | Spring balance $W_2$ | Net weight $W = W_1 - W_2$ (Kg) | Output | Input | Efficiency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $h_1$ | $h_2$ | $h_3$ | | | | | | | | |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |

## CALCULATION:

$$\text{Output Power (Brake Power)} = \frac{2\pi N W R_e \times 9.81}{60 \times 1000}$$

Guide vane opening = 0.5
where
N = Turbine speed in r.p.m.
T = Torque in Kg.m (effective radius drum in meter × net brake load in kg)
or

$$T = w \times Re \text{ kgm.}$$

Re = 0.165m
Runway speed = 1900rpm
h in meter = $(h_1 - h_2) \times 13.6$
Maximum net load = 6 Kg

$$Q = C_d\sqrt{2gh} \times A$$

$$A = (\pi/4) \times d^2$$

Dia. Of orifice (d) = 0.10062m

$$\text{Input power} = v\, Q \times H \text{ Kw( H in meter of water)}$$

v = 981 Kg/ $m^3$ = Specific weight of water

where

Q = discharge of water in $m^3$/sec.

H = Supply head in meters

There for

$$\eta = \frac{\text{Output Power}}{\text{Input Power}} \times 100$$

## RESULT:

The overall efficiency of Kaplan turbine is………..

## PRECAUTIONS:

1. Ensure that the end of experiment close the delivery valve before removing the loads.
2. Ensure that all the valve close and remove load before switch off.
3. Never switch off the supply of pump when the 5urbine is working under load .Reading start after few second of turbine running.
4. Never run the pump without water in it.

# EXPERIMENT – 3

## OBJECTIVE:

To obtain the overall efficiency of Francis turbine.

## APPARATUS USED:

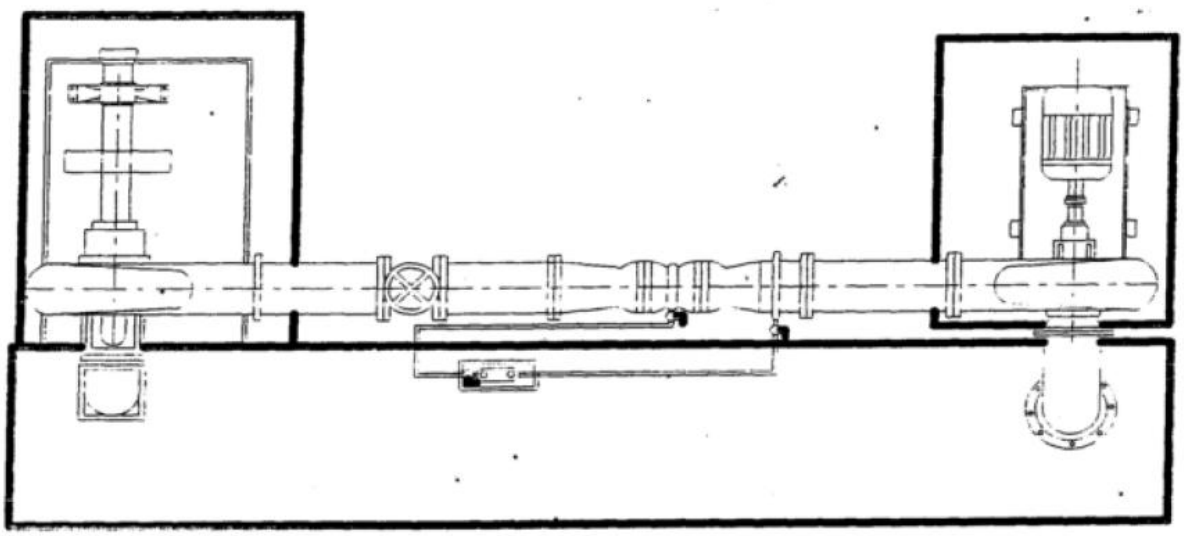
Francis Turbine test rig. Digital tachometer, load etc

**Description of Apparatus:**

A Francis turbine to which water under requisite head is supplied by means of Centrifugal pump. It consists of spiral casing an outer, bearing pedestal and rotor assembly with runner shaft and brake drum all mounted on a base plate. A straight conical draft tube is provided with for the purpose of kinetic energy from the exit water and facilitating easy accessibility of the turbine due to locating at a higher level. A rope brake arrangement is provided to load the turbine. The output of the can be controlled by the guide's vanes.

## THEORY:

A Francis turbine is an inward flow reaction turbine in which water enters at high pressure it discharge water into the tailrace through draft tube. The energy of the flowing water is taken up by the turbine to develop power. Normally a turbine is required to work under one set of running conditions. Develop power speed, head etc. for which it is designed.



## PROCEDURE:

1. Prime the pump and start the electric motor to run the pump.
2. Open the delivery valves and allows the water to start stand up to crest.
3. Set the full gate open the delivery valve.
4. Apply different sets of loads $w_1$ and $w_2$ on the turbine shaft.
5. Note the speed, N, (r. p.m.) on shaft.
6. Change the gate opening and repeat the procedure four times.
7. Note the spring balance reading every time.

## SPECIFICATIONS:

| | |
|---|---|
| Power output | = 1Kw |
| No. of guided Vanes | = 10 |
| Rated supply Head | = 19 meter |
| Brake drum diameter $d_1$ | = 300 mm |
| Rope brake diameter $d_2$ | =15 mm |
| Dia. Of orifice | = 67.8 mm |
| Runway speed | = 2000 rpm |
| Guide vane position | = 6 |

## OBSERVATION:

Initial reading of spring balance =

| S. No. | Pressure Head reading in Kg/cms$^2$ | | | | Manometer head h × 13.6 | Q | Speed N | Applied load w1in Kg. | Spring load $w_2$ in Kg. | $W_1 - W_2$ | Output | Input | Efficiency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H | $H_1$ | $H_2$ | $h = H_1 - H_2$ | | | | | | | | | |
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |

We know

One Kg /cms$^2$ = 10 meter

H = Pressure gauge reading in Kg/cm$^2$

h = orifice head in meter of water $(h_1 - h_2) \times 13.6$ m of water

Re = 0.165 m(brake drum)

Dia. Of orifice = 67.8mm

$\eta_0$ = Overall efficiency of turbine
Weight of rope and hanger = 1 Kg
Brake drum dia. = 0.3 m
Rope dia. = 0.015m
Guide vane opening = 0.5
$C_d$ =0.67

## CALCULATIONS:

Efficiency

$$\eta_0 = \frac{\text{Output Power}}{\text{Input Power}} \times 100$$

If

$$\text{Output Power (Brake Power)} = \frac{2\pi N W R_e \times 9.81}{60 \times 1000}$$

H = Pressure gauge reading × 10 in meter

where

N = Turbine speed in r.p.m.
Re = drum radius (0.165m)

or

$$W = (w_1 - w_2)$$

$$\text{Input of power} = H \times Q \times \nu \text{ Kw (H in meter of water)}$$

Q = Discharge of in $m^3$/sec.
H = Pressure head in meter
ν = Sp. weight off water is 981 Kg/$m^2$

$$A = (\pi/4) \times d^2$$

d =0.067m

or

$$Q = C_d\sqrt{2gh} \times A$$

## RESULT:

The overall efficiency of Francis turbine is………….

## PRECAUTIONS:

1. Prime the pump before starting the motor.
2. Set the gate opening carefully.
3. Reading should be taken very carefully.
4. After complete the practical ensure that unload weight on weight pan.

# EXPERIMENT – 4

## OBJECTIVE:

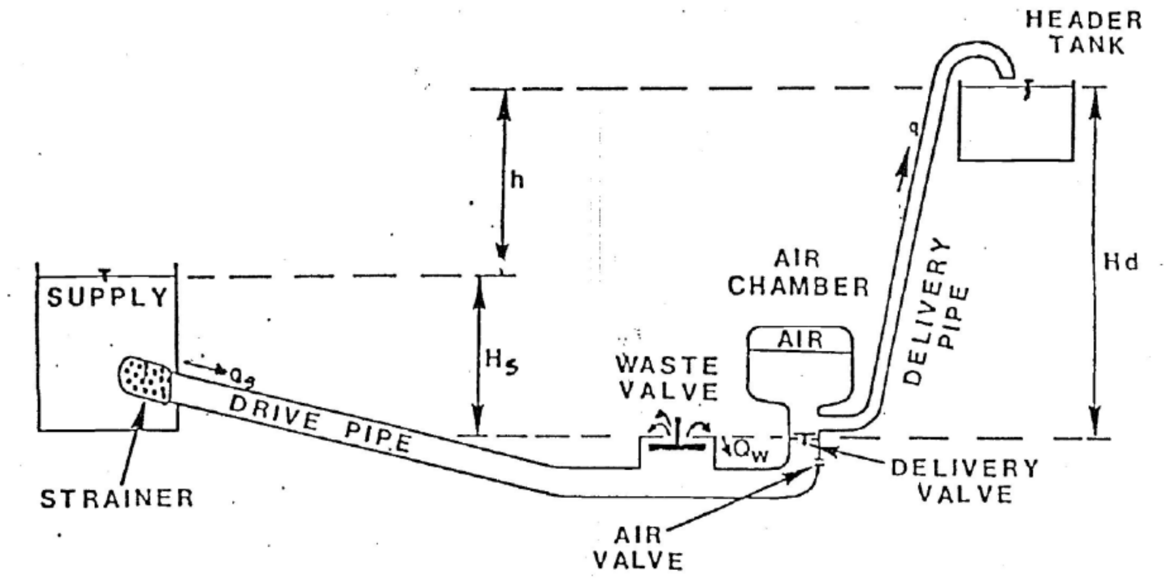
To study the performance of hydraulic ram under varying condition of head and beats.

## APPARATUS USED:

Stop watch, hook gauge, hydraulic ram and continuous water supply.

## THEORY:

The pump drive their energy from external sources in the form of mechanical energy but hydraulic ram is hydraulically driven pump which utilize the dynamic pressure of water pouring under a flow head to lift a portion of water to a higher head if large quantity of water is available at low pressure . A part can be converted into water at high pressure, rest quantity of water going wastage. It consists of supply end to a valve. Box has two automotive valves. An air vessel is fixed above the valve. The delivery valve is fixed at the front of air vessel.




## PROCEDURE:

1. Allow the water to enter the ram chamber and regular flow by opening and regulate the flow by opening the valve which in turn makes the no of beats.

2. Keep the no of beats constant and very the delivery head.
3. Collect the useful water in measuring tank.
4. Repeat the experiment and take the reading.
5. Repeat the experiment for various beats, keeping the head constant.
6. Measure the discharge of delivery pipe.
7. Convert the no. of beats of the water in t – sec.

## OBSERVATION:

Initial pressure gauge reading =
Different of level b / w pressure gauge =
Waste valve delivery head =

## CALCULATION:

$$\text{Rankine Efficiency } (\eta_r) = \frac{Q(H-h)}{(Q-q)h}$$

$$\text{D' Aubuisson Efficiency}(\eta) = \frac{q \times H}{Q \times h}$$

## RESULT:

The efficiency of ram…………………………………

## PRECAUTIONS:

1. The Ambustion efficiency is greater than Rankin efficiency.
2. Before starting the hydraulic ram make sure that supply overflow pipe is running.

# EXPERIMENT – 5

## OBJECTIVE:

To Determine the overall Efficiency of Reciprocating Pump.

## APPARATUS USED:

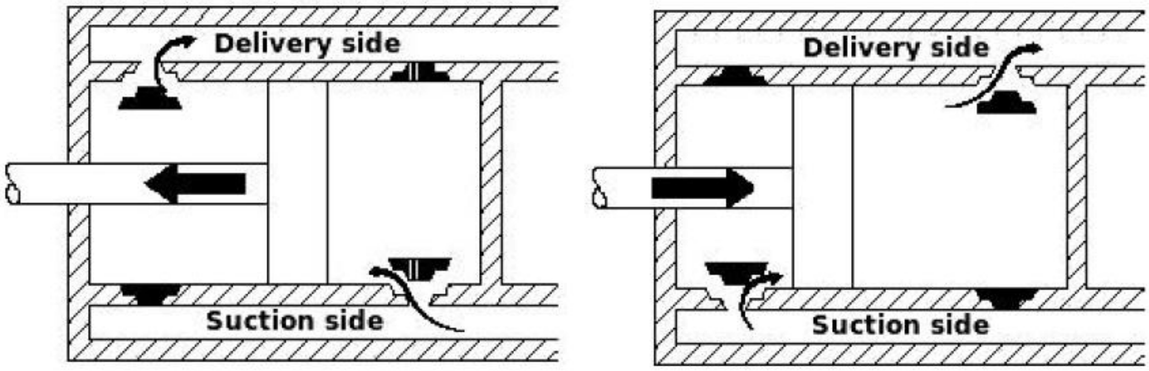
Stop watch, Reciprocating pump, and continuous supply of water.

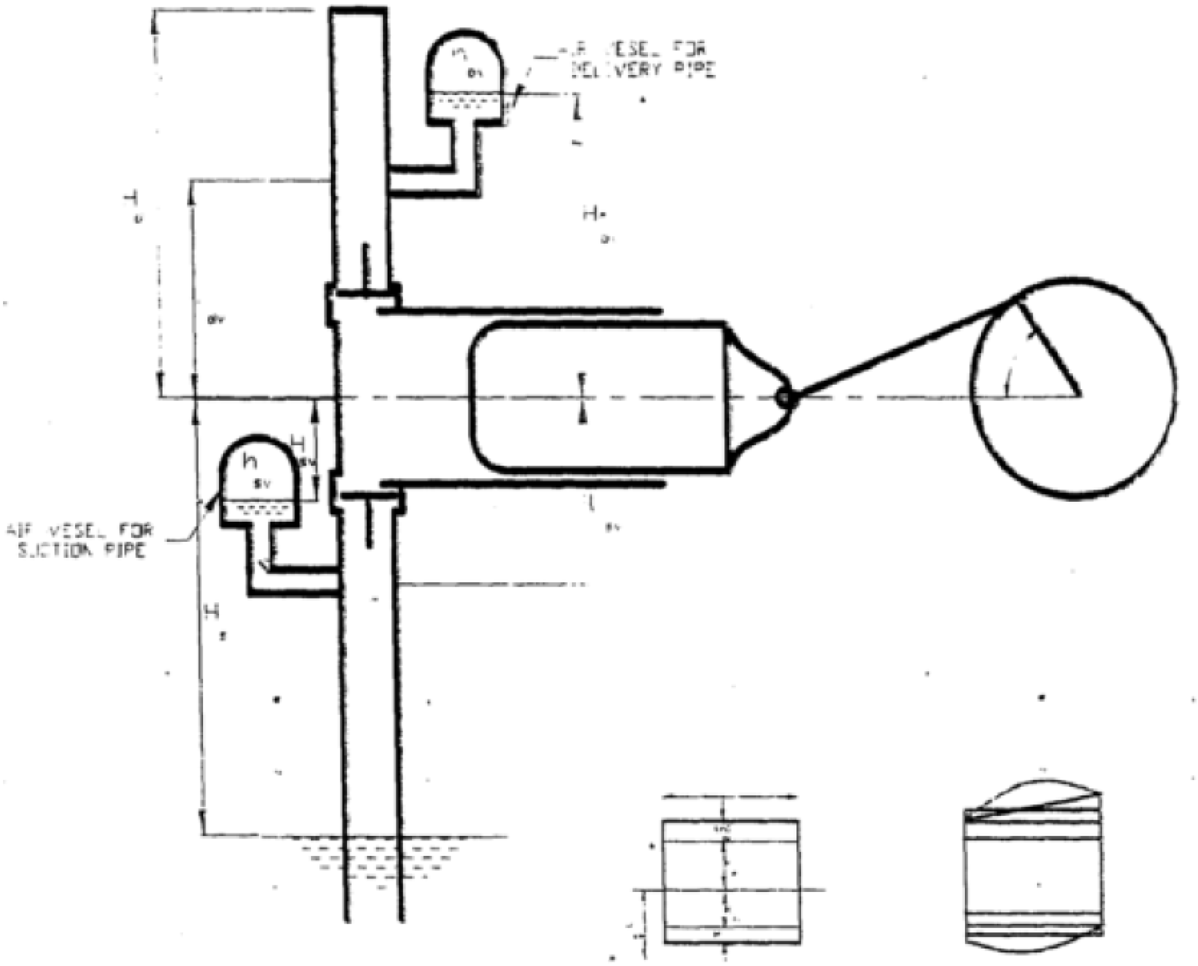
## DESCRIPTION OF THE APPARATUS:

The reciprocating pump is a position displacement piston pump .The cylinder has got two valves. One allows water into cylinder from the suction pipe and then allowing water into cylinder from the suction pipe and the other allowing from cylinder into delivery pipe. During the suction stroke a partial vacuum is created inside the cylinder. The suction valve opens and water enter into the cylinder during the return stroke the suction valve closed and the water inside the cylinder is displaced into the delivery pipe through the delivery valve. In case of double acting pump two set of valves are operated and there is continuous flow of water usually an air vessel is fitted on the delivery side. An energy meter along with starter is provided for the determination of input of water .The pump can run at four different speeds by use of V – belt and stopped pulley mechanism. The belt can be put in different grooves of the pulley for changing the speed the belt .Special arrangement is provided and required pipe lines are also provided.

**Specifications of the Pump:**

| | | |
|---|---|---|
| Suction pressure | = | 32 |
| Delivery pressure | = | 25 |
| Suction lift | = | 7 meter |
| Output | = | 2165 lit/hrs |
| Total head | = | 60 meter |
| Motor required | = | 75 H.P. |
| Pump bore | = | 38 mm |
| Stroke length | = | 44.5mm |



## PROCEDURE:

1. Fill the pump with ¼ liters of oil and check the oil level before it runs.
2. To get proper lubrication, please turn the pump pulley by hand both ways before starting.
3. Firstly start the motor of the pump.
4. Take different reading for the size of the pulley.

## OBSERVATION:

| S.No. | Input power (V) | Suction pressure ( vacume) $P_1$ mm of Hg | RPM of pump | Time for rise in water level (sec) | Rise in water level ( cm) | Discharge pressure $P_2$ ( $Kg/cm^2$ ) |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

## CALCULATION:

Theoretical volume swept by piston

$$Q_{th} = 2$$

where

t = Time for rise in seconds

d = bore dia.in mm

L = Stroke length in mm

Actual discharge ($Q_a$)

= Volume of water/ time

= (Area of tank × rise in level) / time = $m^3$ /min

$h_s$ = Vaccum gauge reading × (10/733) meter

$h_d$ = pressure gauge reading × 10 meter

Manometric head ($h_m$) = $h_d + h_s + x$ = meter

Shaft power = V × I Watt = output power

Water power = v × Q × $H_{static}$ = Input power

v = Sp weight of water = 981 $Kg/m^3$

$$\text{Overall Efficiency} = \frac{\text{Output of Pump}}{\text{Input of Pump}} \times 100$$

## RESULT:

## PRECAUTIONS:

1. Before starting the motor, get proper lubrication.
2. Do not run the pump with a closed delivery or dry suction line.
3. Reading should be taken very carefully.
4. Before starting the motor makes sure that all the connections are tight.

# EXPERIMENT – 6

## OBJECTIVE:

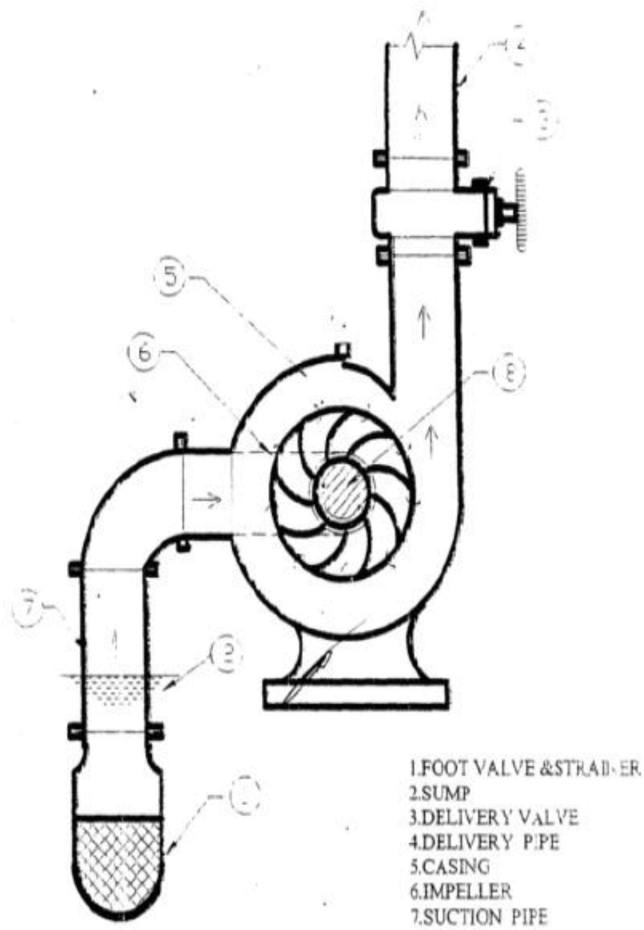
To Determine the overall Efficiency of Centrifugal Pump

## APPARATUS USED:

Stop watch, Centrifugal pump assemble, and continuous supply of water.

**THEORY:**

In centrifugal pump water enter the pump at the centre through a suction pipe, at the end of which is provided a screen and foot valve .Screen prevents any debris to enter the suction pipe. Foot valve establishes unidirectional flow into the pipe.



**Description of the Apparatus:**

The test rig consists of a motor centrifugal pump are coupled through the belt by variable speed pulley arrangement and further it is mounted on a sump tank. A collecting tank is provided to measure discharge of the pump. Further it is also provided with panel board consisting of energy meter to measure the power input of the motor. Digital rpm indicator is provided to measure the speed of the pump and a starter is used to start the pump. The test rig is complete with suction and discharge pressure gauges along with suitable pipeline.

## PROCEDURE:

1. Prime the pump if necessary.
2. Select the desired speed by rotating hand wheel provided at motor end.
3. Start the pump.
4. Note down the reading of different pressure and rpm.
5. Wait for few minute and then open the delivery valve.

**Specifications of the Pump:**

| | | |
|---|---|---|
| Level difference between suction and delivery pressure gauge (X) | = | 90mm |
| Delivery pipe dia. | = | 25 mm |
| Suction pipe dia. | = | 25 mm |
| Size of measuring tank | = | 40 × 50 cm |
| Total head | = | meter |
| Motor required | = | 1 H.P. |

## OBSERVATION:

| S.No. | Input power V | Speed of pump in rpm | Suction pressure (vacume) $P_1$ mm of Hg | Discharge pressure $P_2$ Kg/cm$^2$ | Rise of water level in measuring tank(cm) | Time for rise in level |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

## CALCULATION:

Discharge Q = (Area of tank × rise in level)/time = m$^3$/min

Velocity of discharge = $Q/A_d$ m/s ($A_d$ = area of discharge pipe)

Velocity of suction = $Q/A_s$ m/s ($A_s$ = area of suction pipe )

$h_s$ = vacuum gauge reading × ( 10/733) meter

$h_d$ = pressure gauge reading × 10 meter

Total head ($H$) = $h_d + h_s + V_d^2/2g + V_s^2/2g + X$ meter

Shaft power = V ×x I watt = output powers

Water Power = v × Q × H = input power

v = Sp weight of water = 9810 N/$m^3$ = 981 Kg/ $m^3$

Overall efficiency = (water power/Shaft power) × 100 %

## RESULT:

Overall Efficiency of the centrifugal pump is............

## PRECAUTIONS:

1. Before starting the motor, get proper lubrication.
2. Do not run the pump with a closed delivery or dry suction line.
3. Reading should be taken very carefully.
4. Before starting the motor makes sure that all the connections are tight.

# EXPERIMENT – 7

**OBJECTIVE**:

To obtain characteristic Curve of Pelton turbine.

## APPARATUS USED:

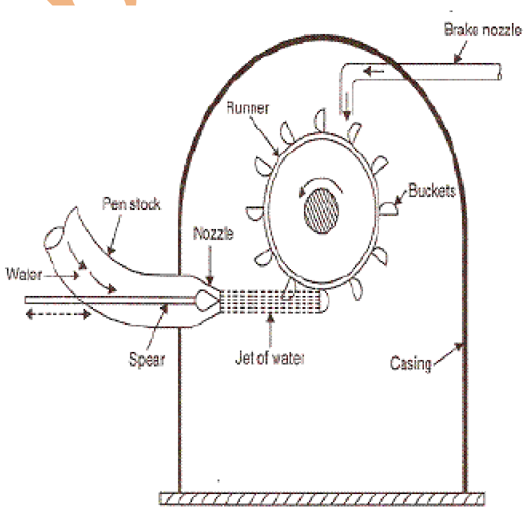
Pelton wheel turbine test rig, Tachometer, continuous flow of water etc

## THEORY:

Pelton wheel is a tangential impulse turbine, and water strikes its buckets as a free jet with velocity. Thus wheels start rotating and develop power. Quantity of water strikes the Buckets can be controlled by movement of a steam lined shaped spear working inside the supply pipe nozzle. Thus changing the area of flow of nozzle .Power developed by the turbine shaft is absorbed by the friction offered by the belt under tension wound by round the brake drum

**Description of Apparatus:**

It consists of casing with large circular transparent window kept at the front for the inspection of buckets. A rope brake arrangement is provided to load the turbine .Adjusting the spear position by means of a hand wheel filled with indicator arrangement can control the input to the turbine.




## PROCEDURE:

1. Prime the centrifugal pump and start the electric motor to run the Pump .Set the full gate opening by means of spear wheel.

2. Open the delivery valve and set it to a suitable position so as attain head.
3. To measure the turbine shaft speed.
4. To measure the brake weight (dead weight + hanger and rope weight).
5. Spring balance reading.
6. Repeat the procedure for different.

**Specifications:**

| | | |
|---|---|---|
| Full load of motor | = | 22 Kg |
| Output of pump | = | 3.75 w (h. p.) |
| Diameter of brake drum | = | 275 mm |
| No. of buckets | = | 18 Nos. |
| Dia. Of orifice meter ($d_1$) | = | 36mm |
| Dia. Of rope (d) | = | 25mm |
| Area of orifice (a) | = | $\pi d_1^2/2$ |
| Q | = | $C_d \times a \times \sqrt{2gH}$ |
| $C_d$ | = | 0.62 |
| Velocity of discharge $V_d$ | = | $Q/A_d$ |
| hd | = | Pressure gauge reading × 10 meter |
| Head H | = | $h_d + V_d^2/2g$ meter |

## OBSERVATION:

Inlet diameter of Venturimeter throat = 65 mm
Outlet diameter of Venturimeter throat = 65mm

| S. No. | Pressure head reading in meter | | | | Applied Load $w_1$ in Kg. | Spring load $w_2$ in Kg. | Speed of turbine shaft 'N' |
|---|---|---|---|---|---|---|---|
| | $P_1$ | $P_2$ | $P_3$ | $P_4$ | | | |
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |

## CALCULATIONS:

$Q_u$ = Unit discharge of water
$P_u$ = Unit out power of turbine
$N_u$ = Unit speed of shaft turbine
$\eta_u$ = Unit overall efficiency of turbine
$H = (P_1 - P_2)/\rho g$

If Output power

$$= \frac{2\pi NT}{60 \times 1000} \text{ kW}$$

where

N = Turbine speed on shaft in r.p.m.

T = Torque in Kg.m.

If, T = $(w_1 - w_2)$ × radius of drum

Input of power

$$= \frac{\rho g Q H}{1000} \text{ kW}$$

where

ρ = Density of water

Q = Discharge of water in $m^3$/ sec.

H = Supply head in meter

Therefore, Overall efficiency

$$\eta_0 = \frac{\text{Output Power}}{\text{Input Power}} \times 100$$

where,

P = Output power

N = Speed of shaft

Q = discharge in cube meter per second.

$P_1$ & $P_2$ in $Kg/cm^2$

## RESULT:

The Efficiency of Pelton turbine is ................

## PRECAUTIONS:

1. Prime the centrifugal pump before starting the motor.
2. Set the gate opening carefully & reading should be taken carefully.
3. Ensure that before starting the starter gate valve of discharge water is closed.
4. Ensure that gate valve of drum should be closed before starting the starter.
5. Ensure that after complete the practical all the valve are closed before switch off.

# EXPERIMENT – 8

**OBJECTIVE**:

To study construction of hydraulic braking (disc/drum) systems and functioning of master & wheel cylinders and draw sketches.

## EQUIPMENT:

A working or a non working model of Braking system.

## THEORY:

**Functions of Brake:**

There are two distinct functions of the brake:

1. To stop or slow down the vehicle in the shortest possible distances in emergencies.
2. To control the vehicle to be retained when descending a hill.

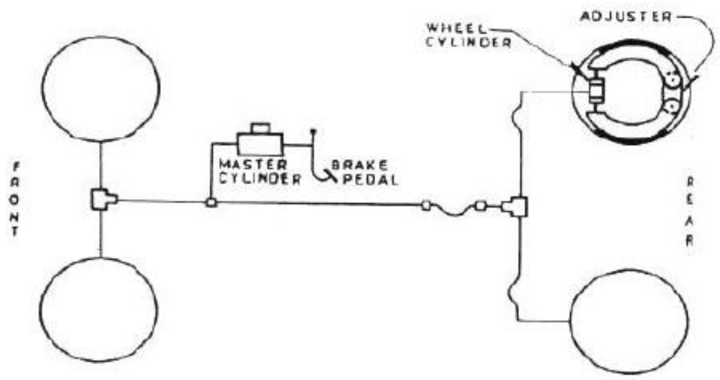
**Classification of Brakes:**

1. From construction point of view
   (a) Drum brakes
   (b) Disc brakes
2. By method of actuation
   (a) Mechanical brakes
   (b) Hydraulic brakes
   (c) Electric brakes
   (d) Vacuum brakes
   (e) Air brakes

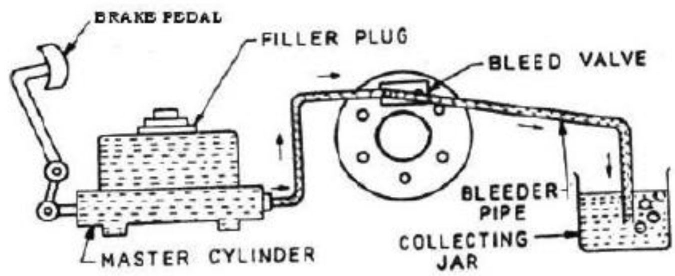


**HYDRAULIC BRAKE SYSTEM:**

These types of brakes consist of master cylinder, which contains hydraulic brake fluid. Master cylinder is operated by the brake pedal and is further connected to the wheel cylinder in each wheel through pipelines, unions and flexible lines. The system is so designed that even when the brakes are in the released position, a small pressure of about 50kpa is maintained in the pipelines to ensure that the cups of the wheel cylinder are kept expanded. This prevents the air entering the wheel cylinders when the brakes are released.




LAYOUT OF HYDRAULIC BRAKES




BLEEDING OF HYDRAULIC BRAKES

**Fig. 8.1 Hydraulic Break**

Besides this pressure also serves the following purposes:

1. It keeps the free travel of the pedal minimum by opposing the brake shoe retraction springs.
2. During bleeding, it does not allow the fluid pumped into the line to return, thus quickly purging air from the system.

**Master Cylinder:**

It consists of fluid reservoir and compression chamber in which piston operates. The fluid in the reservoir compensates for any change in the fluid volume in the pipelines due to temperature variations and to some extent due to leakage. To prevent leakage there are rubber seals on both sides of the piston in the compression chamber. The fluid always surrounds the reduced diameter region of the piston. A rubber boot covers the push rod and of the master cylinder to prevent the dirt entering inside. Towards the brake lines side of the compression chamber, there is fluid check valve with a rubber cupinside. It serves to retain the residual pressure in the brake lines even when the brakes released.

There are a number of holes in the piston head on the primary (high pressure) seal side. Two holes connect at the reservoir to the compression chamber. The smaller one out of these is about 0.7 mm diameter and is called the bypass or compression port. The second hole is called the intake or recuperation port.

Besides, there is a vent in the cap, to keep the brake fluid always at atmospheric pressure.

The push rod is operated with the foot brake pedal through the linkage. As the pedal is pressed, push rod moves to left against the force of the spring, till it covers the bypass port. Further movement of the push rod causes building up of pressure in the compression chamber. Finally, when sufficient pressure has built up, the inner rubber cup of the fluid check valve is deflected, forcing the fluid under pressure in the lines. This fluid enters the wheel cylinder or the caliper and moves the pistons thereby applying the brakes. When the brakes are released, the spring pressure in the master cylinder moves the piston to the right extreme position. This same force of the spring keeps the fluid check valve pressed on its seat for sometime and thereby delays the return of fluid from the lines into the compression chamber again. Some delay is also caused by the inertia of the fluid in the lines. This produces a vacuum in the compression chamber and unless this is destroyed immediately, there are all chances of air leakage into the system. Even a very small amount of air will render the brakes unless, the air being compressible. Having intake port as shown in figure solves this problem. As soon as some vacuum is formed, the atmospheric pressure in the fluid reservoir forces the fluid through intake port and holes in the piston, which deflects the rubber, cup and enters the compression chamber, destroying the vacuum. But by the time, the vacuum is destroyed; the fluid from the lines comes back into the reservoir by lifting the fluid check valve off its seat. This extra fluid now has to be accommodated somehow, because compression chamber is already full. If this is not done, the pressure in the lines will not be relievedfully and there are chances of brake shoe rubbing with the drum. Once this happens, there will be more heat generated at the drum, which when transmitted to the wheel cylinders would cause the fluid to expand and exert still more pressure, causing the shoes to move still further towards the drum. In this way, a vicious circle will start, causing the brakes to jam ultimately.

This is avoided by means of bypass port. The extra fluid coming from the lines passes to the fluid reservoir, where pressure is maintained atmospheric by providing an air vent. Wheel Cylinder: The construction is very simple. The brake fluid under pressure forces the piston apart, thereby applying the brakes.

**Antilock Braking:**

The most efficient braking takes place when the wheels are still moving. If the brakes lock the wheels so that the tires skid, kinetic friction results, and braking is much less effective. To prevent skidding and provide maximum effective braking, several antilock devices have been developed. Some provide skid control at the rear wheels only. Others provide control at all four wheels.

Control means that as long as the wheels are rotating, the antilock device permits normal application of the brakes. But if the brakes are applied so hard that the wheels tend to stop turning and a skid starts to develop, the device comes into operation. It partly releases the brakes so that the wheels continue to rotate. However, braking continues, but it is held to just below the point where a skid would start. The result is maximum braking.

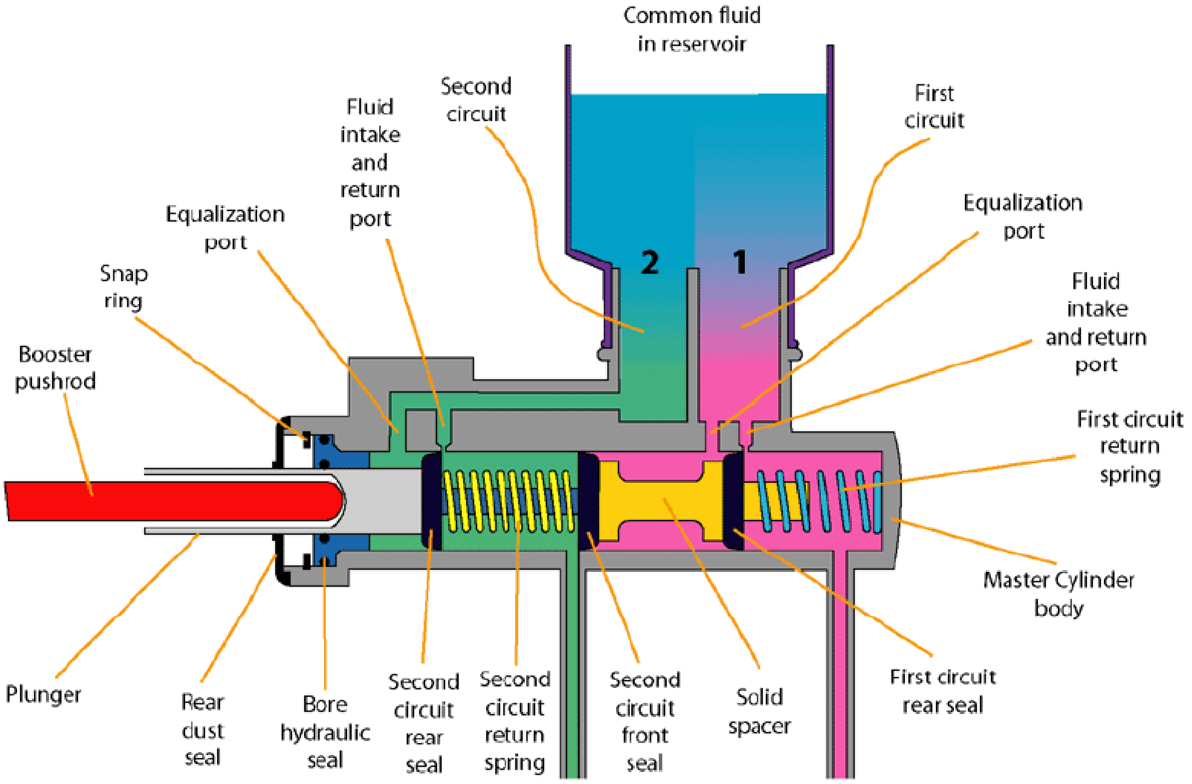



**Fig. 8.2 Antilock Braking**