THERMAL

AND

HYDRAULIC MACHINES LAB

STUDENT REFERENCE MANUAL

DRONACHARYA
Group of Institutions

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PREFACE

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The objective of this manual is to familiarize the students with practical skills, measurement techniques and interpretation of results. It is intended to make this manual self contained in all respects, so that it can be used as a laboratory manual. In all the experiments, the relevant theory and general guidelines for the procedure to be followed have been given. Tabular sheets for entering the observations have also been provided in each experiment while graph sheets have been included wherever necessary.

It is suggested that the students should complete the computations, is the laboratory itself. However the students are advised to refer to the relevant text before interpreting the results and writing a permanent discussion. The questions provided at the end of each experiment will reinforce the students understanding of the subject and also help them to prepare for viva-voce exams.

GENERAL INSTRUCTIONS TO STUDENTS

- The purpose of this laboratory is to reinforce and enhance your understanding of the fundamentals of Thermal and Hydraulic machines. The experiments here are designed to demonstrate the applications of the basic fluid mechanics principles and to provide a more intuitive and physical understanding of the theory. The main objective is to introduce a variety of classical experimental and diagnostic techniques, and the principles behind these techniques..

- Read the lab manual and any background material needed before you come to the lab. You must be prepared for your experiments before coming to the lab. In many cases you may have to go back to your fluid mechanics textbooks to review the principles dealt with in the experiment.

- Actively participate in class and don't hesitate to ask questions. Utilize the teaching assistants. You should be well prepared before coming to the laboratory, unannounced questions may be asked at any time during the lab.

- Carelessness in personal conduct or in handling equipment may result in serious injury to the individual or the equipment. Do not run near moving machinery. Always be on the alert for strange sounds. Guard against entangling clothes in moving parts of machinery.

- Students must follow the proper dress code inside the laboratory. To protect clothing from dirt, wear a lab apron. Long hair should be tied back.

- Calculator, graph sheets and drawing accessories are mandatory.

- In performing the experiments, proceed carefully to minimize any water spills, especially on the electric circuits and wire.

- Make your workplace clean before leaving the laboratory. Maintain silence, order and discipline inside the lab.

- cell phones are not allowed inside the laboratory.

- Any injury no matter how small must be reported to the instructor immediately.

- Wish you a nice experience in this lab!

NAME OF EXPERIMENTS

1. . TO STUDY AND SKETCH ABOUT THE PRINCIPLE AND WORKING OF TWO STROKE DIESEL ENGINE

2. TO STUDY AND SKETCH ABOUT THE PRINCIPLE AND WORKING OF TWO STROKE I.C. ENGINE OR PETROL ENGINE

3. TO STUDY AND SKETCH ABOUT THE PRINCIPLE OF WORKING OF FOUR STROKE I.C. ENGINE OR PETROL ENGINE AND DIESEL ENGINE

4. EXPERIMENT ON CENTRIFUGUAL PUMP

5. EXPERIMENT ON REXIPROCATING PUMP

6. TURBINE EXPERIMENT *ON PELTON* TURBINE

7. TURBINE EXPERIMENT ON FRANCIS TURBINE

8. TURBINE EXPERIMENT ON KAPLAN TURBINE

9. IMPACT OF JET EXPERIMENT

EXPERIMENT-1

AIM-To Study and sketch about the principle and working of two stroke Diesel Engine

INTRODUCTION:

The fuel is supplied with the help of fuel injection pump and the injection to the cylinder. The working of diesel engine is similar to two stroke S.I Engine except that only air is induced into the crank case in case of C.I Engine in place of mixture of fuel and air.

MAIN PARTS OF THE C.I ENGINE:

1) **Cylinder-**
   It is hollow cylinder, one side of which is closed by cylinder head and is made of cast iron. Cylinder head usually contains both the valves and fuel injector or Spark Plug. The internal diameter of cylinder is called Bore.

2) **Piston-**
   The Piston is made of cylindrical casting of iron or aluminium alloy. The main function of the piston is to transmit the force created by combustion products to the connecting rod.

3) **Piston Rings-**
   It is made of grey cast iron.

4) **Connecting Rod-**
   The function of connecting rod is to convert the reciprocating motion of the piston into rotary motion of crankshaft. It is made of forged steel.

5) **Crank shaft-**
   It controls the motion of piston and is made of forged alloy steel or carbon's steel.

WORKING OF THE C.I ENGINE:

The fuel is supplied with the help of fuel injection pump and the injector to the cylinder. The working of diesel engine is similar to two stroke S.I Engine except that only air is induced into the crank case in case of C.I Engine in place of mixture of fuel and air. Consider the piston at T.D.C when piston moves down, the hot gases expand. During its downward motion, the piston firstly uncovers the exhaust port and a little later it uncovers the transfer port.

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Combustion Chamber

Spark Plug

Piston

Exhaust Outlet

Reed Valve

Crank Case

Fuel Intake

Fuel
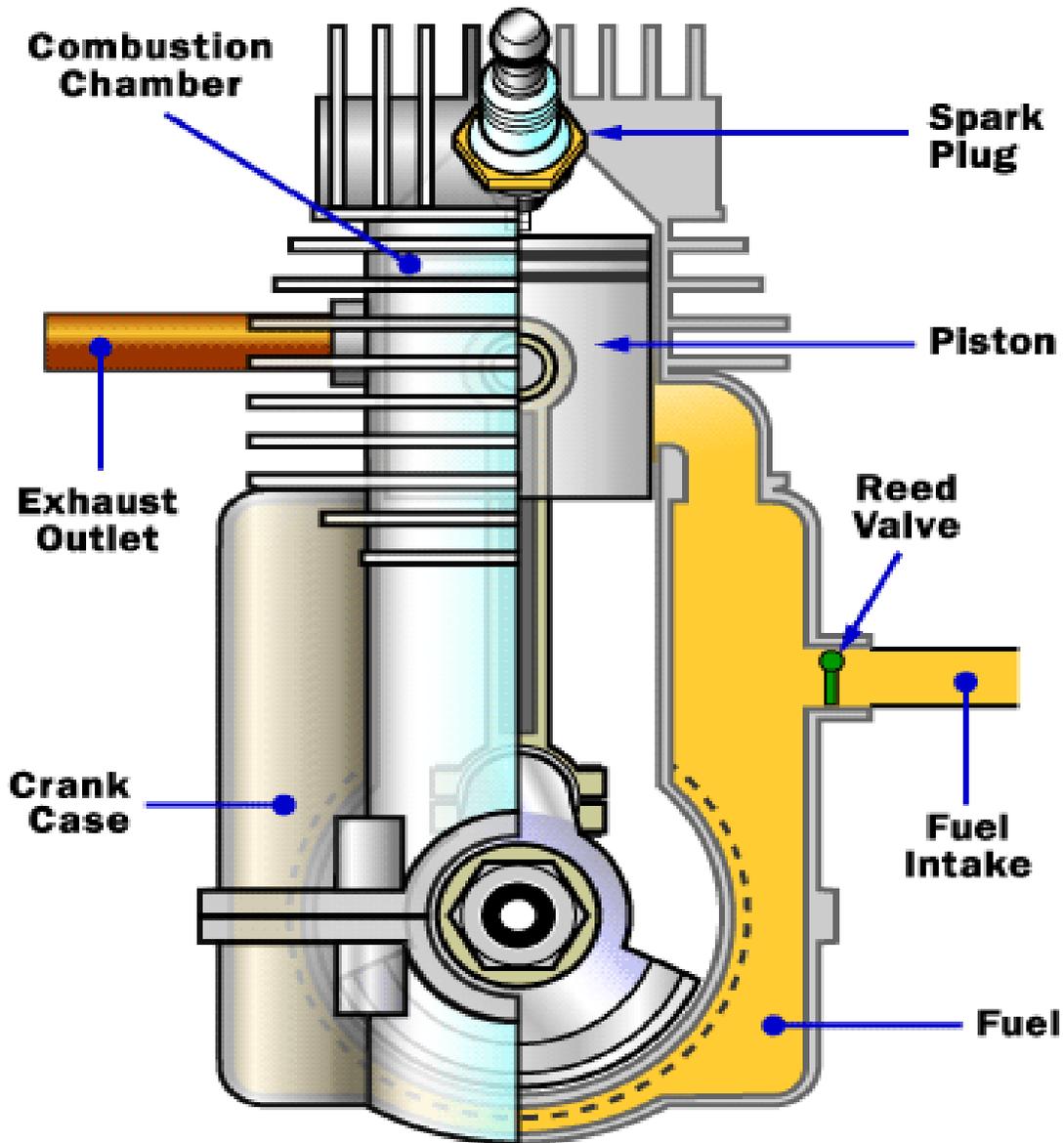
The basic components of a two-stroke engine

Figure 4
The two-stroke diesel engine
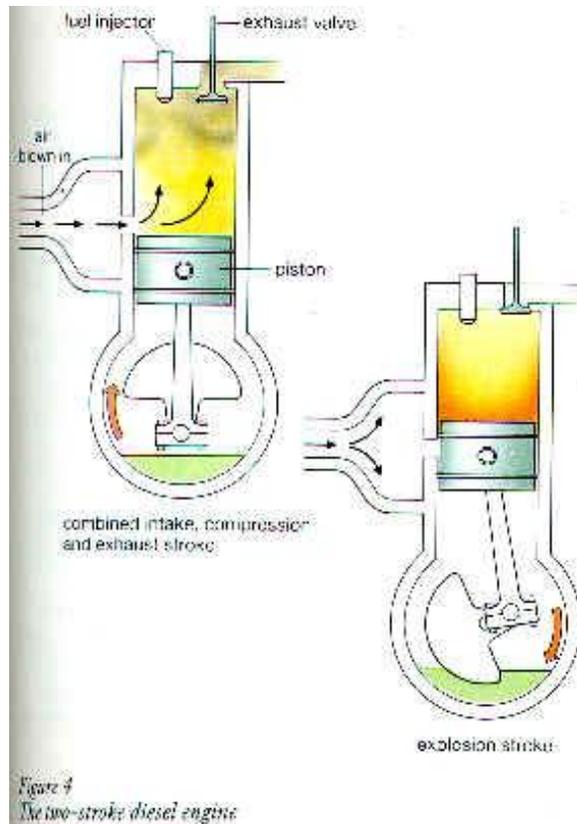
> ➢ The air compressed during the previous stroke in the crankcase is transferred into the cylinder via the transfer port. This incoming air pushes out the burnt gases while passing over the deflection. This process of sweeping out the burnt gases is called Scavenging
> ➢ The piston moves upwards i.e. from B.D.C to T.D.C. It first closes the transfer port and a little later the exhaust port.
> ➢ The air transfer earlier into the cylinder is now compressed with further movement of piston upwards.
> ➢ Before the end of compression stroke, the fuel is injected and the atomized fuel burns due to high temperature of air called Auto-ignition.
> ➢ The resultant hot gases will again expand, thus completing a cycle.

APPLICATIONS:

1. I.C Engines are used in all road vehicles
2. I.C Engines are widely used in rail road, aviation, marine etc.
3. I.C Engines are extensively used in lawn movers, motor boats, concrete mixing equipment etc.

AIM-To Study and sketch about the principle and working of two stroke I.C. Engine or Petrol Engine

INTRODUCTION:

The internal combustion engine is a heat engine in which the energy of fuel air mixture is released by combustion in the engine cylinder itself. The heat energy increases the pressure and temperature of the cylinder gas and subsequent expansion of the gas converts the heat energy into mechanical work.

MAIN PARTS OF THE I.C ENGINE OR PETROL ENGINE

1) **Cylinder:**
   It is hollow cylinder, one side of which is closed by cylinder head and is made of cast iron. The fuel is burnt inside of the cylinder and power is developed due to reciprocating motion of the piston.
2) **Piston:**
   The piston is made of cylindrical casting of iron or aluminium alloy. The piston is accurately machined to running fit in the cylinder bore and is provided with several grooves into which piston rings are fitted.
3) **Piston Rings:**
   The piston is made of cylindrical casting of iron or aluminium alloy. The function of the piston rings is to prevent any leakage of gas past the piston and to prevent the wear of the piston.
4) **Connecting Rod:**
   The Connecting Rod connects the piston and crank pin. The function of connecting rod is to convert the reciprocating motion off the piston into rotary motion of crankshaft.
5) **Crank Shaft:**
   The crankshaft is the principle rotating part of the engine. It serves to convert the forces applied by the connecting rod into rotational force.

   ### WORKING OF TWO STROKE PETROL ENGINE:
   In this type of engine the valves of the four stroke engine are replaced by ports which are three in number namely, transfer port, inlet or induction port and exhaust port.
   When the piston moves from TDC to BDC, the burnt gases expand and develop the motive power. When the piston moves downwards during its expansion stroke, the piston first covers the inlet port and compresses the fresh charge held in the crank case. After the completion of about 80% expansion stroke, the piston uncovers the exhaust port and some of the products of combustion escape to atmosphere.

On further motion of the piston, the piston uncovers the transfer port and allows the slightly compressed charge from the crank case to be admitted into the cylinder via the transfer port.

The top of the piston usually has a deflector. The fresh charge sweeps out the remainder of the burnt gases while passing over the deflector. During the upward motion of the piston from BDC to TDC, the piston first uncovers the inlet port allowing the fresh charge to be admitted into the crank case due to the partial vacuum created in the crank case & then it uncovers the transfer and exhaust ports. The cycle is now again repeated.

I.   **IGNITION OR INDUCTION:**
The piston is almost at the T.D.C position when the air or mixture of air and fuel is in compressed form. In Petrol Engine Spark occurs and ignition takes place. But in case of Diesel Engine, the fuel is injected and combustion takes place automatically.
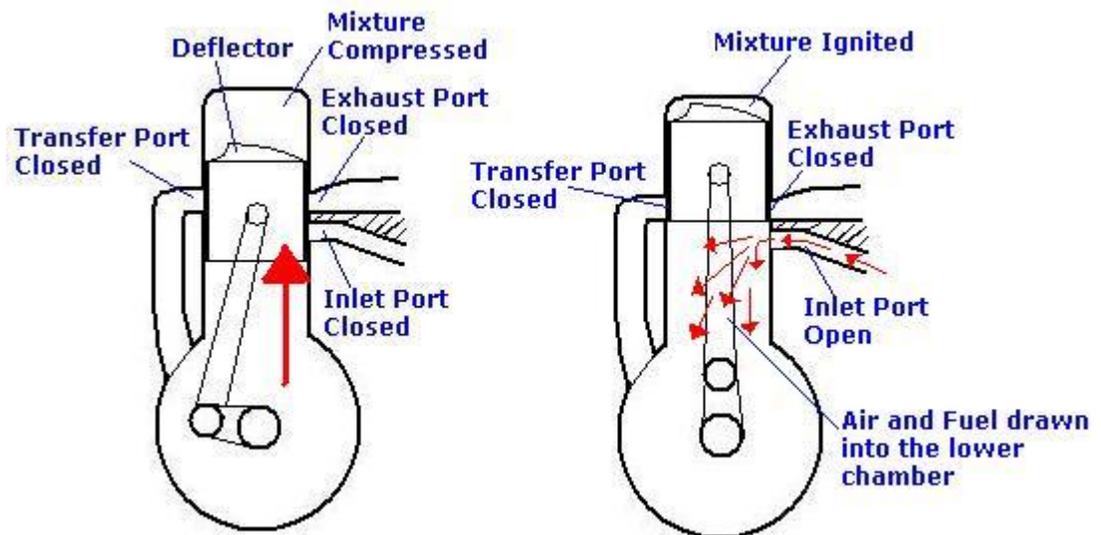
II.   **EXPANSION AND PARTIAL COMPRESSION:**
Due to combustion of the charge, the pressure increases which pushes the piston down, the expansion of gas takes place and work is done.

Indicator diagram for 2-stroke engine
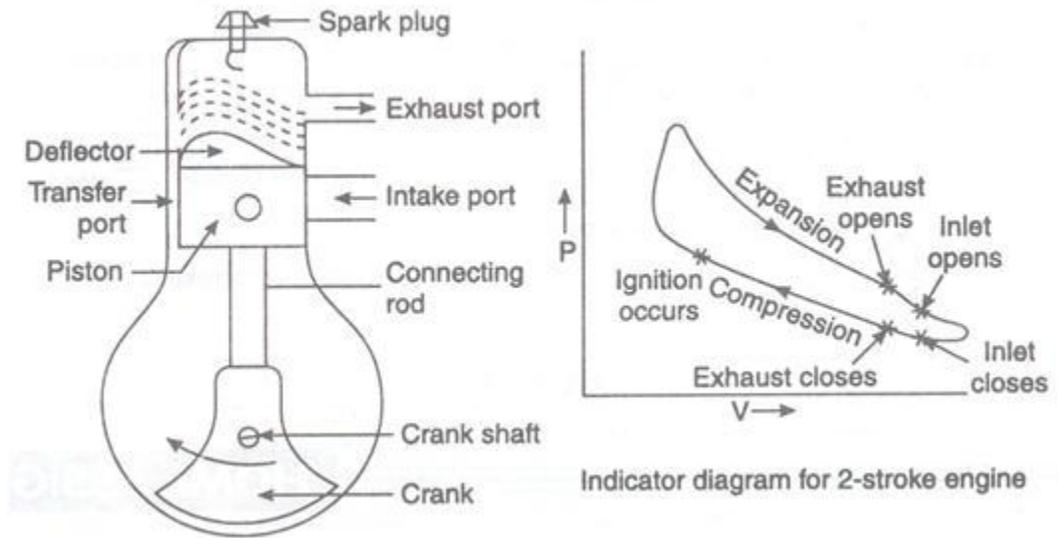
III. EXHAUST AND TRANSFERENCE:

After completing of about 4/5th of the power, the exhaust port is uncovered by the piston and the products of combustion starts leaving the cylinder through the exhaust port. When the piston is approaching at the B.D.C position, the exhaust port is still open and transfer port is uncovered by the piston. As soon as the piston reaches B.D.C, it moves upward. In this position both inlet port and exhaust port are closed and the compression of the charge begins in the cylinder till the piston reaches at T.D.C. Thus during the two stroke of the piston, there is one power stroke.

> **APPLICATIONS:**
>   4. I.C Engines are used in all road vehicles
>   5. I.C Engines are widely used in rail road, aviation, marine etc.
>   6. I.C Engines are extensively used in lawn movers, motor boats, concrete mixing equipment etc.

EXPERIMENT-3

AIM-To Study and sketch about the principle of working of four stroke I.C. Engine or Petrol Engine and Diesel Engine

INTRODUCTION:

The internal combustion engine is a heat engine in which the energy of fuel air mixture is released by combustion in the engine cylinder itself. The heat energy increases the pressure and temperature of the cylinder gas and subsequent expansion of the gas converts the heat en de c ergy into mechanical work.

MAIN PARTS OF THE I.C ENGINE OR PETROL ENGINE

1) **Cylinder:**

   It is hollow cylinder, one side of which is closed by cylinder head and is made of cast iron. The fuel is burnt inside of the cylinder and power is developed due to reciprocating motion of the piston. Cylinder head usually contains both the valves and fuel injector or spark plug. The internal diameter of cylinder is called Bore.

2) **Piston:**

   The piston is made of cylindrical casting of iron or aluminium alloy. The piston is accurately machined to running fit in the cylinder bore and is provided with several grooves into which piston rings are fitted. The main function of piston is to transmit the force created by combustion products to the connecting rod.

3) **Piston Rings:**

   The piston is made of cylindrical casting of iron or aluminium alloy. The function of the piston rings is to prevent any leakage of gas past the piston and to prevent the wear of the piston.

4) **Connecting Rod:**

   The Connecting Rod connects the piston and crank pin. The function of connecting rod is to convert the reciprocating motion of the piston into rotary motion of crankshaft. It is made up of forged steel.

5) **Crank Shaft:**

The crankshaft is the principle rotating part of the engine. It serves to convert the forces applied by the connecting rod into rotational force. It controls the motion of piston and is made of forged alloy steel or carbon steel.

6) **Valves:**

There are two valves for every cylinder. One is the inlet valve which admits air or mixture of air and fuel in the suction stroke. The other is the exhaust valve through which the product of combustion after doing work on the piston escapes to the atmosphere.

7) **Cams and Camshaft:**

Each valve requires a cam to open and close it, at the proper point in engine cycle. The cams are mounted on a shaft known as camshaft, which is driven by crank shaft through gears.

8) **Crankcase:**

The crankcase holds together the cylinder, piston and crankshaft.

9) **Carburetor:**

It is used in petrol engines to atomize, vaporize and mixing the fuel with air in required proportion at all loads and speed before entering to the engine cylinder.

10) **Fuel Pump and Injector Unit:**

It is used in diesel engine to supply the fuel under high pressure to atomizer or injector which consists of one or more orifices through which the fuel is sprayed into cylinder.

11) **Spark Plug:**

It petrol engine a spark plug is located at the top of cylinder and initiates combustion.

12) **Flywheel:**

It is heavy wheel mounted on the crankshaft to minimize the cyclic variations in speed the turning moment becomes uniform at the crankshaft.

WORKING OF FOUR STROKE PETROL ENGINE:

Petrol Engine operates on a four stroke cycle.
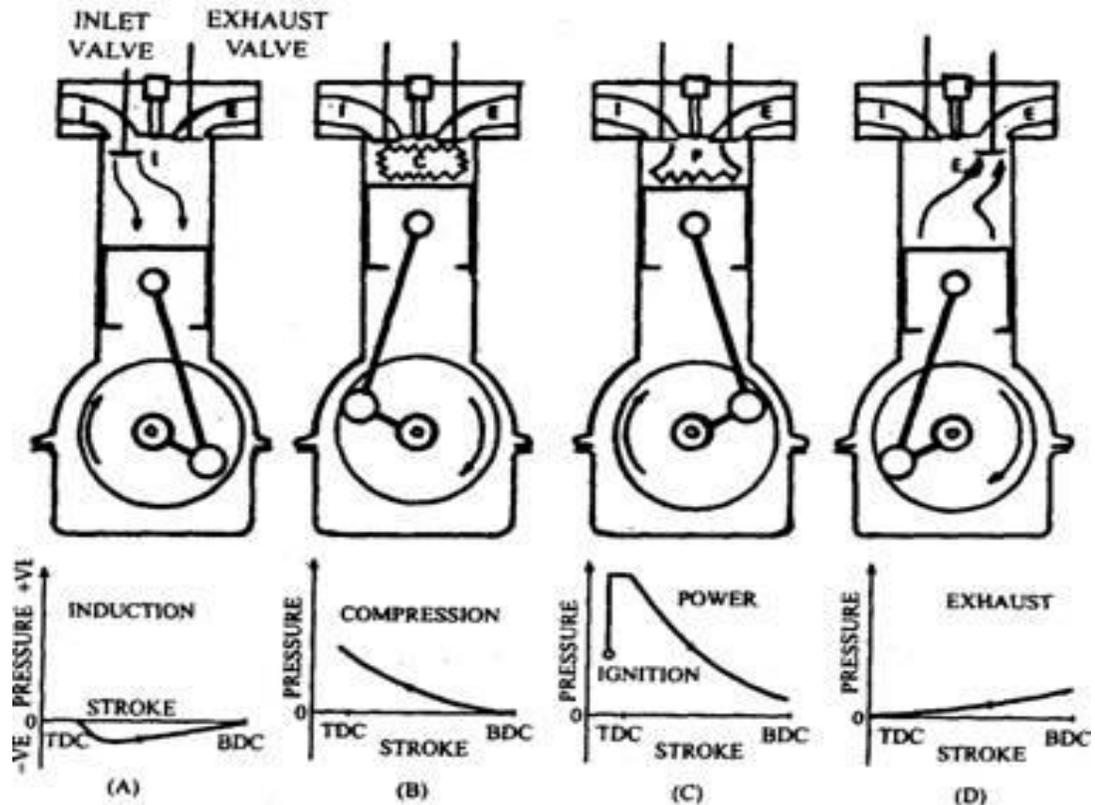
I. INTAKE OR SUCTION STROKE:

During suction stroke intake valve is opened and the exhaust valve is closed and the piston moves down, due to rotation of crankshaft either getting energy from the flywheel or from a motor starter. As the piston moves the pressure in the cylinder drops below atmospheric pressure. The high pressure on carburetor or air filter side thrust the air to rush towards cylinder. The suction process continues till the piston moves from the top dead centre position to the bottom dead centre.

II. COMPRESSION STROKE:

During this stroke both the valve are closed and piston moves from B.D.C to T.D.C. The air is compressed upto a compression ratio. There is reduction of volume of air or charge which results in an increase of pressure and the temperature of the cylinder contents. In petrol engines the compression ratio varies from 5 to 10.5 and pressure and temperature at the end of compression are 7 to 14 bars and 250°C to 500°C respectively. For Diesel engines the compression ratio is 12 to 20

and the pressure and temperature at the end of compression are 28 to 59 bars and 600°C to 700°C respectively.

III. EXPANSION OR POWER STROKE:

During this stroke both valves are closed. The power stroke includes combustion of fuel and expansion of the products of the combustion. The combustion starts at the end of the compression stroke when piston is approaching to T.D.C. In petrol engine, a spark plug initiates the combustion. During combustion temperature and pressure of the gas is increased. The volume of gas however remains constant during combustion.

In Diesel Engines, one or more jets of fuel, compressed to a pressure of 105 to 210 bar by an injector pump are injected into the combustion chamber by a fuel nozzle at the end of compression stroke. The injected fuel is vaporized and is raised to self ignition temperature. The combustion then starts automatically and there is sudden rise of temperature at constant pressure. The high pressure and the high temperature of the product of combustion, thus obtained push the piston outward from T.D.C TO B.D.C position. This reciprocating motion of the piston is converted into the rotary motion by crankshaft, connecting rod and crank mechanism.

IV. EXHAUST STROKE

When about $7/8^{th}$ of the power stroke has been completed, the exhaust valve begins to open and the inlet valve remains closed. The products of combustion are exhausted into atmosphere when the piston moves from B.D.C to T.D.C position. During this process the pressure is slightly more than atmospheric pressure when the piston is approaching T.D.C, the exhaust valve closes and some of the rest burnt gases are left in clearance space. At the end of exhaust stroke, the inlet valve opens and the cylinder is ready to receive the fresh charge to begin a new cycle.
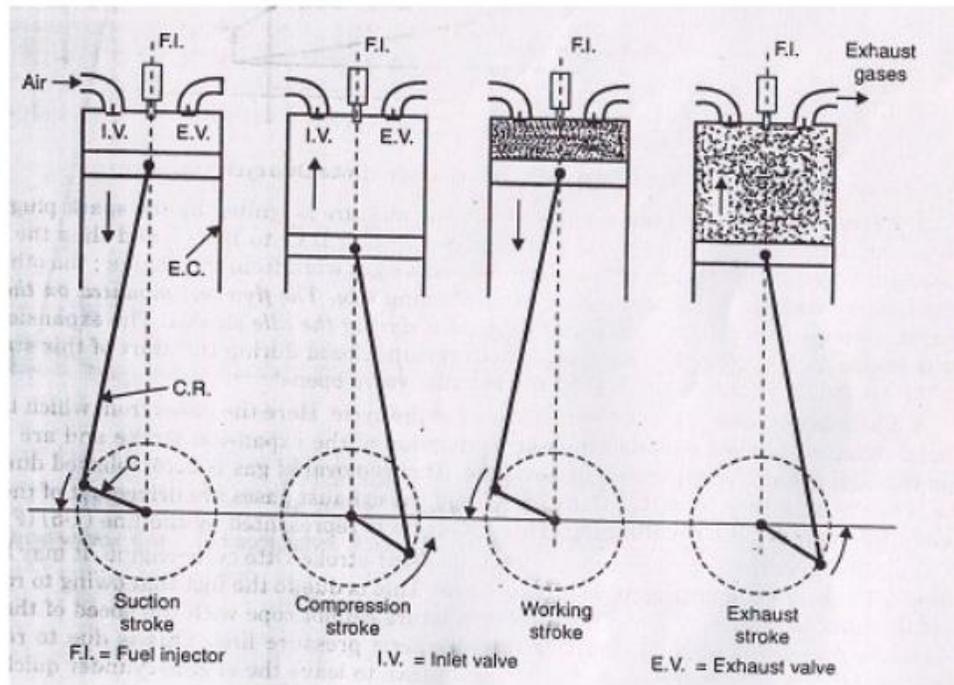
Fig. Four-stroke Diesel cycle engine

APPLICATIONS:

7. I.C Engines are used in all road vehicles
8. I.C Engines are widely used in rail road, aviation, marine etc.
9. I.C Engines are extensively used in lawn movers, motor boats, concrete mixing equipment etc.

EXPERIMENT-4

EXPERIMENT ON CENTRIFUGAL PUMP

Learning Objectives:

At the end of this experiment, the student will be able to:
- Know the operation of centrifugal pump.
- Draw the characteristic curves of centrifugal pump at constant speed.

**Aim:** To conduct performance test on a centrifugal pump at rated speed.

Model:

1.FOOT VALVE &STRAINER
2.SUMP
3.DELIVERY VALVE
4.DELIVERY PIPE
5.CASING
6.IMPELLER
7.SUCTION PIPE
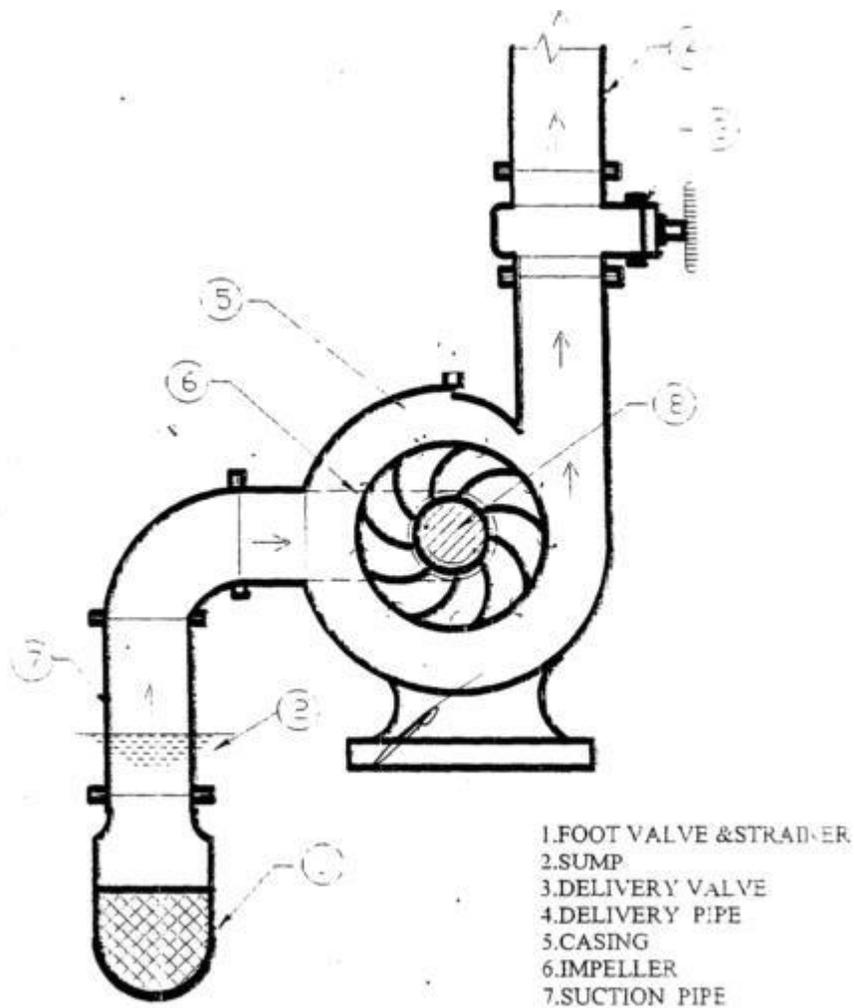
Fig. Component parts of Centrifugal Pump

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Theory: A centrifugal pump consists of an impeller rotating inside a casing .The impeller has a number of curved vanes. Due to the centrifugal head impressed by the rotation of the impeller, the water enter at the Centre and flows outwards to the periphery.Then it is collected in a gradually increasing passage in the casing known as volute chamber which serves to convert a part of the velocity head into pressured head.

For a higher heads multi stage centrifugal pumps having two or more impellers in series will have to be used. This single stage centrifugal pump of size (50mm x 50mm) is coupled to 3 HP capacity Squirrel cage induction motor. The suction side is 50mm dia and delivery side is 50mm dia.An energy meter is provided to measure the input to the motor and collecting tank to measure the discharge. A pressure gauge and vacuum gauge are fitted in delivery and suction sides to measure the head of water. The pump must be full of water upto delivery valve before starting. For this reason it should not be allowed water to drain and hence a foot valve is provided. But after the long run the leather valve in the

foot valve becomes useless and so the foot valve becomes leaky.In this case the pump should be primed by pouring water.

Tools required: Stop watch, measuring scale and Energy meter etc.

Procedure:

1. Check the pressure gauges. Make sure both of them show atmospheric pressure.
2. Observe the suction and delivery pipe diameters. Measure the dimensions of collecting tank. Measure the difference in elevation between the suction and delivery pressure tapings.
3. Prime the centrifugal pump. Keep the delivery valve fully closed.
4. Start the pump.
5. Open the delivery valve slightly. Observe the pressure gauge readings.
6. Measure the discharge using the collecting tank stopwatch setup.
7. Note the time for n revolutions of the energy meter disk.
8. Open the delivery valve gradually to maximum. Repeat the above observations for different discharges.
9. Tabulate the readings. Draw the performance characteristics; H Vs. Q, Pbhp
10. Vs. Q and h Vs. Q.

Observations:

1. Size of the collecting tank $= l \times b \times h$
2. Diameter of the suction pipe, $d_s = 50$ mm
3. Diameter of the delivery pipe, $d_d = 50$ mm
4. Energy meter constant, $N = 400$ rev / KWH

**

5. Difference in the levels of pressure and vacuum gauges,
   X = 43cm.

Model Calculations:

1. Actual discharge : $Q = AR/t \ (m^3/s)$

   Where

   A: Cross-sectional area of collecting tank $= l \times b$
   R: Rise of water column in collecting tank in meters
   t: Time taken for 'R' units rise of water column in seconds

   $Q = \qquad m^3/s$

2. Pressure gauge reading in metres of water column (H_g)

   $$H_g = [\ (P_g \times 10^4 \times 9.81)/\ 9810]\ m$$

   $P_g = $ Pressure gauge reading in kg/cm^2

   $H_g = $

3. Vacuum gauge reading in meters of water column (H_v)

   $$H_v = (h_v \times 10^{-3} \times x \ 13.6)\ m\ of\ water$$

   $H_v = $ Vacuum gauge reading

4. Velocity head in delivery pipe $(V_d^2 / 2g)$

   V_d : Velocity of flow in delivery pipe $= Q/(\pi/4 \ d_d^2)$

   $(V_d^2 / 2g) = $

5. Velocity head in suction pipe $(V_s^2 / 2g)$

   V_s : Velocity of flow in suction pipe $= Q/(\pi/4 d_s^2)$

   $(V_s^2 / 2g) = $

6. Total head in the pump (H)

   $H \quad : \ H_g + H_v + X$

7. Output of the pump (O/P)

   Out Put $= \qquad \gamma.Q.H$ Watts

8. Input to the pump (I/P)

   $I/P = (3600 \times n) / (N \times T)$

7

n : Number of revolutions of energy meter

N : Energy meter constant rev/ kWh

T : Time for 'n' revolutions of energy meter in sec.

9. Overall efficiency (η_0)

η_0 = Output/Input

Observation Table

Sl. No	Press.gauge readings		Vacuum gauge readings		Total head H (m)	Time for 0.2 m rise in collecting tank t (sec)	Time for 10 rev. in energy meter T (sec)	Actual disch- arge Q_a (m^3/s)	Output kw	Input kw	Efficiency
		m of water		m of wat							
1											
2											
3											

Graph: H Vs Q at constant speed
Q/p V_s Q at constant speed
I/p V_s Q at constant speed
η Vs Q at constant speed

Result:

Review Questions:

1. What is priming? What is use of foot valve?
2. What is manometric head?
3. What is the function of the casing used in centrifugal pump?
4. What is NPSH?
5. What is the minimum starting speed of a centrifugal pump?
6. Hydraulic efficiency of centrifugal pump is defined as.
7. The centrifugal pump should be so installed above the water level in the sump why?

EXPERIMENT-5

EXPERIMENT ON RECIPROCATING PUMP

Learning Objectives::
At the end of this experiment, the student will be able to:
- Know the operation of reciprocating pump.
- Draw the characteristic curves of reciprocating pump.

Aim: To determine the efficiency of reciprocating pump at a constant speed.

Model:
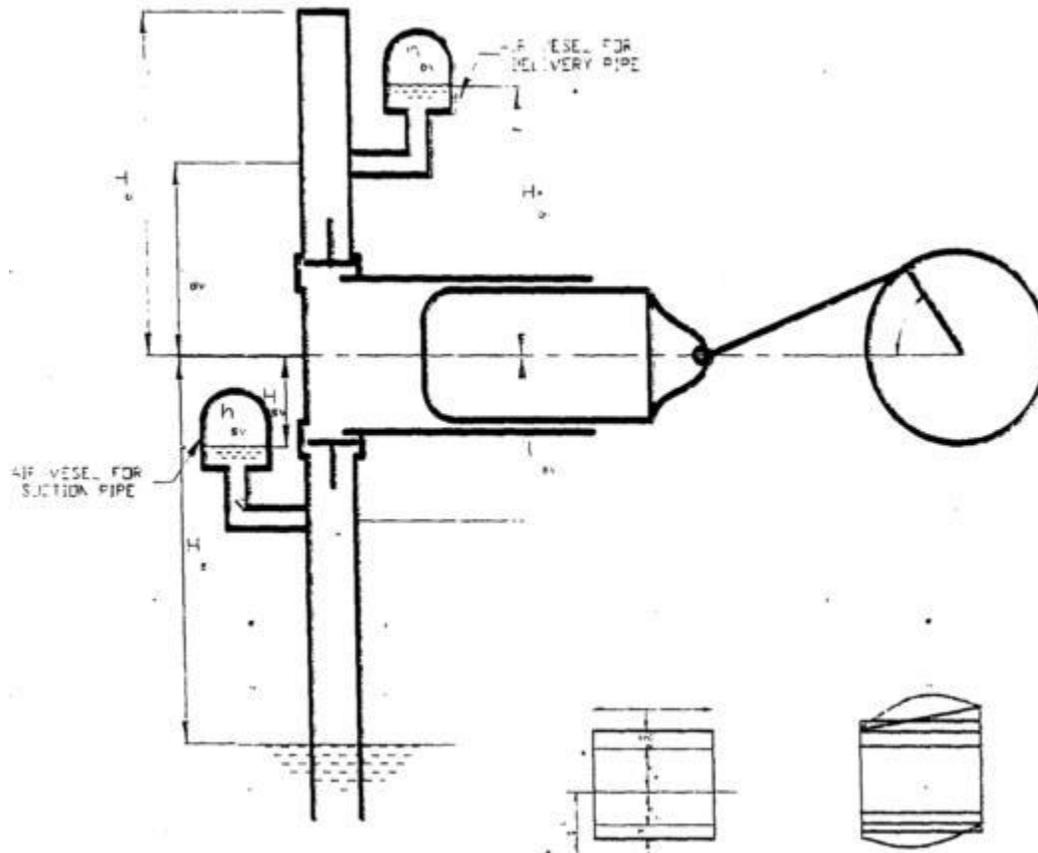
Fig. Reciprocating pump with air vessel

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 into the discharge pipe. The fluid enters a pumping chamber via an inlet valve and is pushed out via a 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. Reciprocating
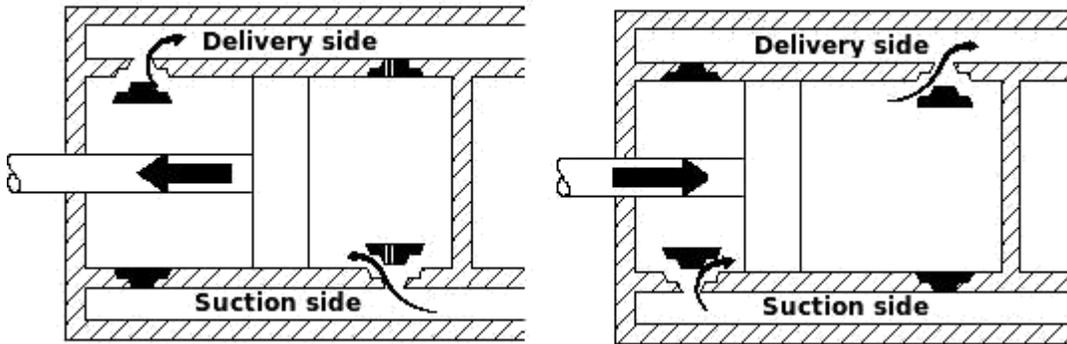
Reciprocating pumps are self priming and are suitable for very high heads at low flows. They deliver reliable discharge flows and is often used for metering duties because of constancy of flow rate. The flow rate is changed only by adjusting the rpm of the driver. These pumps deliver a highly pulsed 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. Check the pressure gauges. Make sure both of them show atmospheric pressure.
2. Observe the suction and delivery pipe diameters.
3. Measure the dimensions of collecting tank.
4. Measure the difference in elevation between the suction and delivery pressure tappings.
5. Open the delivery valve fully. Never close this valve below a critical level to reduce the flow rate. The fluid has no place to go and something will break.
6. Start the pump.
7. Throttle the gate valve to get the required head.
8.   Note
        a) Pressure gauge (G) and Vacuum gauge (V) readings
        b) Time taken for n (=10) revolutions of the energy meter (T) in sec.
        c) Time taken for R(=0.2m) rise of water in the collecting tank (t) in sec
        d). The position (X in meter) of pressure gauge above the vacuum gauge

9. Tabulate the readings. Draw the performance characteristics; H Vs. Q, Pbhp Vs. Q and h Vs. Q.

Tools required: Stop watch, measuring tape, Energy meter etc.

Observations:

    1.   Size of the collecting tank = l_c x b_c x h_c = 0.30 m × 0.30 m × 0.60 m
    2.   Difference in the levels of vacuum gauge and pressure gauge = X = 7.5 cm.

3.   Energy meter constant, N = 800 rev/kwh

Model Calculations:

1.   Actual discharge $Q = AR/t \ m^3/s$

   A: Cross-sectional area of collecting tank = $l_c \times b_c$ (0.30 m × 0.30 m) R: Rise of water column in collecting tank
   t: Time taken for 'R' units rise of water column

2.   Pressure gauge reading in water (H_g meters) $P_g = W. H_g$
   Therefore $H_g = P_g / W \ = \ \dfrac{P_g \times 10^4 \times 9.81}{9810}$ m

   Where P_G = Pressure gauge reading in Kg/cm^2

3.   Vacuum gauge reading in water (H_v meters)

   $$P_v = W. H_v$$

   Therefore $H_v = P_v / W = \dfrac{P_v \times 10^4 \times 9.81}{9810}$ m   Where

   P_v = Vacuum gauge reading in Kg/Cm^2

4.   Velocity head in the suction pipe ($Vs^2 / 2g$)
   Where V_s: Velocity of flow in suction pipe = $Q/A_s = Q / (\pi/4 d_s^2)$

5.   Velocity head in the delivery pipe ($V_d^2 / 2g$)
   Where V_d: Velocity of flow in delivery pipe = $Q/A_d = Q / (\pi/4 \ d_d^2)$

6.   Total head on the pump (H)
   $$H = H_g + H_v + (V_d^2 / 2g - V_s^2 / 2g) + X$$

7.   Output from the pump (O/P)
             O/P = W. Q. H Watts

   Where W: Specific weight of liquid being pumped = 9810
          N/m^3 Q: Actual Discharge
          H: Total Head on the pump
           Input to the pump (I/P)

             I/P = 3600 × n/NT

$$\frac{N\ T}{}$$

Where n: Number of revolutions of the energy meter

N: Energy meter constant (rev/kWh)

T: Time taken for 'n' revolutions of energy meter

9. Overall efficiency of the pump (η)
   =IP/OP *100

Observation Table

Sl No	Press.Gauge Readings	Vacuum Gauge Readings	Height of Pressure gauge above vacuum gauges (x .m.)	Total Head 'h' in m	Time for 0.2 m rise in collecting tank T seconds	Time for 10 rev. in energy meter T seconds	Actual Disch-arge Qa in m^3/S	Out put kw	Input kw	Effi-ciency
1										
2										
3										
4										

Graph: See page No.1122 of FM & HM by Modi & Seth for operating characteristics curves
Also for fig see page No.1094 of the above text book

Result:

**

EXPERIMENT 6

TURBINE EXPERIMEENT ON PELTON WHEEL

**Learning Objectives:**
At the end of this experiment, the student will be able to:
- Know the working of a Pelton wheel.
- Draw the characteristic curves of Pelton turbine under constant head and constant speed.

Aim: To determine the characteristic curves of Peloton wheel under constant head and constant speed.

Model: Stop watch and measured weights etc.
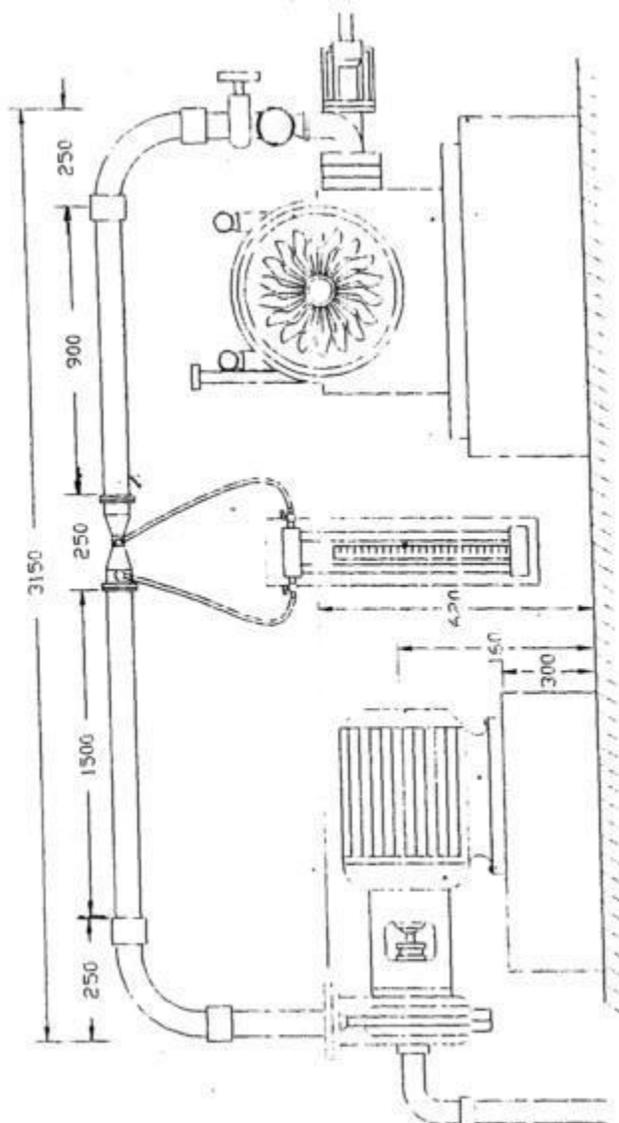
PELTON TURBINE

Tools required: Pelton Turbine, Pressure gauges, Tachometer and Manometer

Procedure for constant speed:

1. Keeps the nozzle opening at the required position i.e. full opening or $3/4^{th}$ opening?
2. Start the pump
3. Allow water to the turbine, then the turbine rotates
4. Adjust the gate valve such that the required head is achieved.
5. Note the speed of the turbine
6. Take readings in manometer
7. Note down the pressure of water in the pressure gauge
8. Load the turbine by putting weights.
9. Note down the dead weight T_1 and spring weight T_2
10. Note down the head.
11. Repeat the experiment for different loadings
12. Tabulate the readings

Procedure for variable speed:

1. Fix the guide vane opening as 4/8
2. Prime the pump
3. Allow water into turbine by starting the pump
4. Vent the cocks of manometer
5. Allow the water into the runner such that the speed of the turbine runner is at required constant speed using tachometer.
6. Note down the readings of left limb and right limb of differential manometer
7. Note down the pressure gauge reading
8. Note down the spring weight and dead weight on the hanger
9. Add weight to the hanger of brake drum and repeat the steps from 5 to 8.
10. Repeat the experiment steps from 5 to 10 for different guide vane openings.

Observations:

To find discharge the venturimeter and the manometer have been calibrated.
Venturimeter: $d/D = 0.6$, $D = 0.065$ m, $Q_a = 0.0055\sqrt{H_1}$ m^3/s
The height of mercury column in left arm $= h_1$ m
The height of mercury column in right arm $= h_2$ m
Difference of levels $= h_1 - h_2 = h$
Equivalent water column $= (S_m/S - 1)h = (13.6/1-1)h = 12.6h = H_1$

Model Calculations:

1. Calculation of IP:

        Discharge $= Q \, m^3/s$
        Head $= H \, m$
        IP $= \sqrt{QH}$

**

2.   Calculation of BP:

$$\begin{aligned}
\text{Dead weight } (T_1) &= & & \text{Kg} \\
\text{Spring weight } (T_2) &= & & \text{Kg} \\
\text{Weight of hanger (To)} &= & & \text{Kg} \\
\text{Resultant load (T)} = T_1 - T_2 + \text{To} &= & & \text{Kg} \\
\text{Speed (N)} &= & & \text{rpm} \\
\text{Dia. of brake drum} &= & 0.40 \text{ m} \\
\text{Thickness of rope} &= & 0.015 \text{ m.} \\
\text{Resultant dia., D} &= & 0.415 \text{ m}
\end{aligned}$$

$$BP = 2\pi NT/60$$

3.   Efficiency of the turbine, $\eta = \dfrac{BP}{IP}$

Observation Table

Sl.No.	Head (m)	Manometer (h) m	Discharge m³/s	Speed rpm	T_1	T_2	T	BP	IP	Efficiency

Result:

Review Questions:

1. What are main components of Pelton turbine?

2. Draw velocity diagrams (at inlet and outlet) for Pelton blade

3. Why is Pelton turbine suitable for high heads?

4. What is the function of spear mechanism?

5. What is the normal range of specific speed of a Pelton turbine

6. What are the characteristics of Pelton wheel? What are their uses?

7. After the nozzle water has atmospheric pressure through out, then why is a casing provided to the wheel?

8. Why not Pelton wheels are suitable for low heads?

9. What are the methods available to govern the turbine?

EXPERIMENT 7

TURBINE EXPERIMEENT ON FRANCIS TURBINE

Learning Objectives:
At the end of this experiment, the student will be able to:
- Know the working of a Francis turbine.
- Draw the characteristic curves of Francis turbine.

Aim: a) To study the constant head characteristics of Francis turbine

       b) To study the operating characteristics of Francis turbine.

       c) To determine the specific speed

Model:
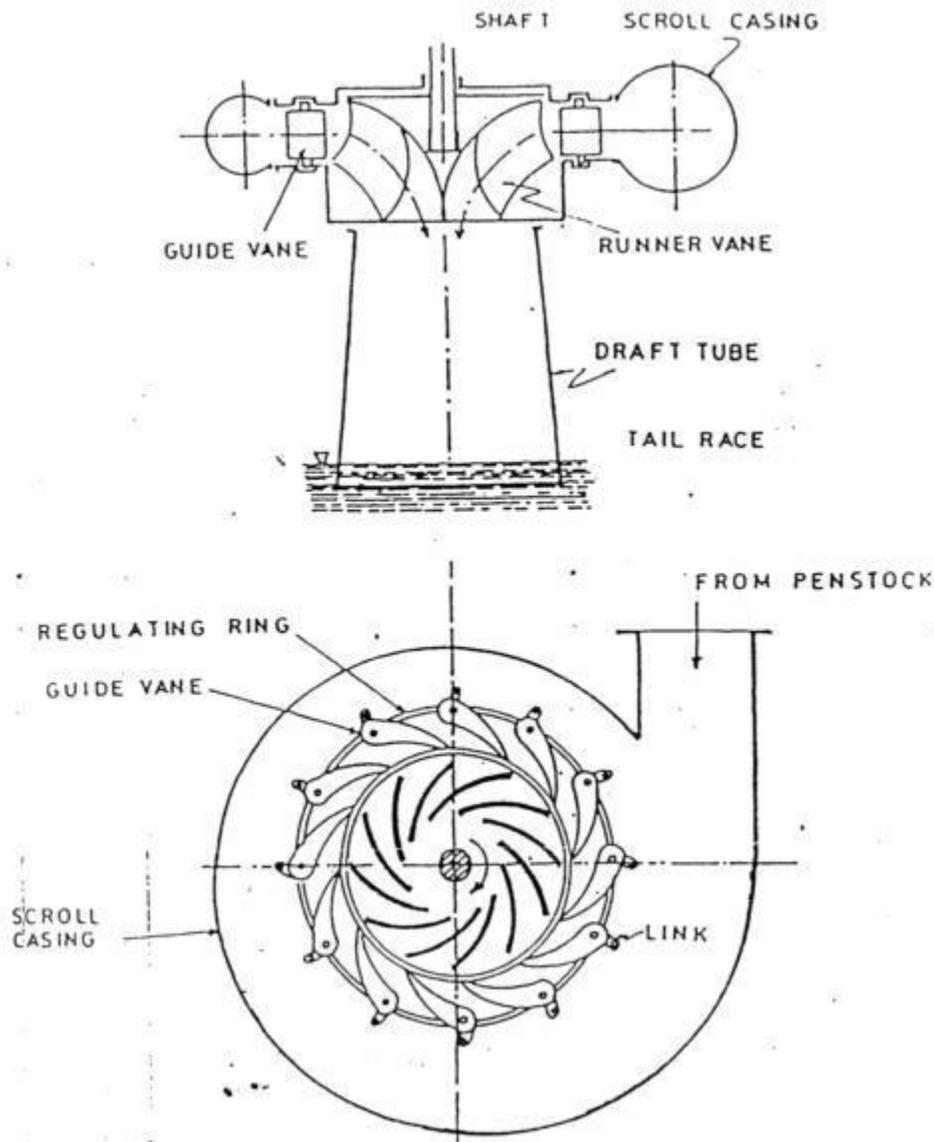
Fig. Francis Turbine

Tools required: Francis Turbine, Pressure gauges, Tachometer and

Manometer

Procedure for constant head operation of turbine:

1. Fix the guide vane opening as 4/8.
2. Prime the pump
3. Allow water in the turbine by starting the pump
4. Vent the cocks of manometer
5. Adjust the gate valve such that the sum of the pressure gauge and vacuum gauge is as required constant head.
6. Note down the pressure gauge and vacuum gauge readings.
7. Note down the left limb and right limb of the differential manometer.
8. Note down the spring weight and dead weight on hanger.
9. Measure the speed of the turbine using tachometer.
10. Repeat the experiment by adding loads on the brake drum
11. Repeat the steps from 1 to 10 for different guide vane opening.

Procedure for variable speed head operation of turbine:

1. Fix the guide vane opening as 4/8.
2. Prime the pump
3. Allow water into turbine by starting the pump
4. Vent the cocks of manometer.
5. Allow the water into the runner such that the speed of the turbine runner is at required constant speed using tachometer.
6. Note down the left limb and right limb of differential manometer.
7. Note down the pressure gauge and vacuum gauge readings.
8. Note down the spring weight and dead weight on the hanger.
9. Add weight to the hanger of brake drum repeat the steps from 5 to 8.
10. Repeat the experiment steps from 5 to 9 for different guide vane openings.

Model Calculations:

a) Discharge formula for venturimeter $Q=0.031\sqrt{H_1}$

Where $H_1=12.6h$.

h = difference in the levels of manometer.

b) Total head $H = G+V$

Where G= pressure head

V=Vaccum head

c) Input to the turbine $IP = \gamma\,Q\,H$

d) Output

Brake drum diameter = 0.3 m
Pipe diameter = 0.015 m.
Equivalent drum diameter = 0.315 m
Hanger weight T_0= 1 kg.
Load weight = T_1 kg.
Spring weight = T_2 Kg.
Resultant load T= (T_1+T_0-T_2) kg.
Speed of turbine = N rpm.
BP   = 2π NT/60

e)   Efficiency (η_o) = $\dfrac{\text{Output}}{\text{Input}}$ = $\dfrac{\text{BHP}}{\text{IHP}}$

f)   Specific speed: It may be defined as the speed of geometrically similar

turbine which will develop one unit power under unit head.

$$N_S = \dfrac{N\sqrt{P}}{H^{5/4}}$$

Result:

Review Questions:

1. What is the function of draft tube?

2. What is the function of guide vanes?

3. Can you locate the portion in Francis turbine where cavitations likely to occur?

4. What is the advantage of draft tube divergent over a cylindrical of uniform diameter along its length?

5. What are fast, medium by slow runners?

EXPERIMENT 8

TURBINE EXPERIMEENT ONKAPLAN TURBINE

Learning Objectives:

At the end of this experiment, the student will be able to:
- Know the working of a Kaplan turbine.
- Draw the characteristic curves of Kaplan turbine.

**Aim:** To draw the performance characteristic curves and determine the overall efficiency.

Model:
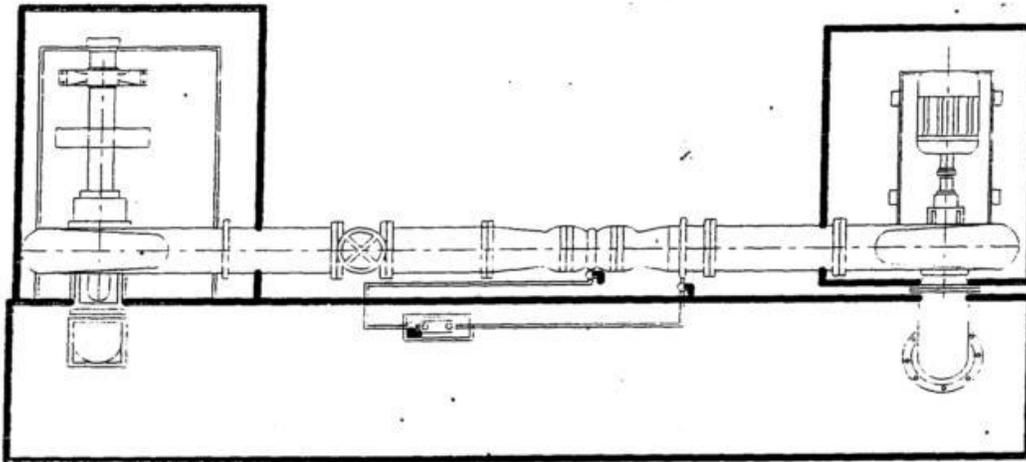
Fig. Kaplan Turbine

Tools required: Kaplan Turbine, Pressure gauges, Tachometer and
Manometer

Procedure:

1. Keep the guide vane at 2/8 opening
2. Keep the runner vane at 3/8 opening
3. Prime the pump and close the gate valve
4. Start the pump
5. Open the gate valve slowly
6. Note down the pressure gauge reading G.
7. Note down the vacuum gauge reading V.
8. Vent the gauges of venturimeter
9. Note down the readings of pressure gauge (G_1) and vacuum gauge (V_1)
10. Measure the speed of the turbine by tachometer.
11. Load the turbine by placing dead weight and take all readings.
12. Experiment can be repeated for different guide and runner vane openings.

**

Observations:

Hanger weight (T_0) =
Brake drum resultant dia. =

Model Calculations:

1. Discharge equation of venturimeter $Q = 0.082 \sqrt{H_1}$ m^3/sec.

   Where $H_1 = (G_1 + V_1)$ m

2. Head: $H = G + V$

   Where G = Pressure gauge reading in meters
   V = Vacuum gauge reading in meters.

3. Input to the turbine $IP = \sqrt{QH}$

4. Output:

   Brake drum diameter = 0.30 m.
   Rope diameter = 0.015 m   Equivalent drum diameter $D = 0.315$ m
   Dead weight T1=
   Hanger weight T_o =
   Spring weight T_2 =
   Resultant load $T = T_1 - T_2 + T_o$ =
   Speed of the turbine N =
   $BP = 2\prod NT/60$ =

5. Efficiency = Output /Input = BP/IP

Observation Table:

Sl. No	Guide and runner vane opening	Gauge reading of venturimeter		Gauge reading of kaplan turbine		Spring weight	Dead weight	Speed runner
		G_1 (Kg/m^2)	V_1 (Kg/m^2)	G_2 (Kg/m^2)	V_2 (Kg/m^2)	T_1	T_2	N (rpm)
1								
2								
3								
4								
5								

**

Sl. No	Guide and runner vane opening	Gauge reading of venturimeter		Gauge reading of kaplan turbine		Venturi head T_1	Total head T_2	Discharge	Resultant load	IP	BP	Efficiency	Specific speed N_s
		G_1 (m)	V_1 (m)	G (m)	V (m)	H_1 (m)	H_1 (m)	0.002 $\sqrt{H_1}$	$T=T_1-T_2+T_0$ Kg				
1													
2													
3													
4													
5													

Graphs:

1) % of full load Vs η_o

2) N_u Vs Q_u or P_u or η_o

Result:

Review Questions:

1. What are suitable conditions for erection of Kaplan turbine

2. Why is the number of blades of Kaplan turbine restricted to 4 to 6?

3. Is this turbine axial flow or mixed flow?

4. Port load efficiency of Kaplan turbine is high, why?

5. What is the minimum pressure that can be maintained at the exit of the reaction turbine?

IMPACT OF JET EXPERIMENT

Learning Objectives:

At the end of this experiment, the student will be able to:
- Derive the expression for impact of jet on flat and hemispherical plates.
- Calculate the co-efficient of impact.

Aim: To find the co-efficient of impact (C_i) for flat and hemi
spherical plates.

Tools required: Experimental setup of impact of jet with flat and
Hemispherical plates set of weights, stop watch and scale.

Procedure:

1. The lever is kept horizontal by adjusting counter weight on the left hand side weigh the plate is fixed opposite to the jet.
2. A weight of 100gm is placed on the right hand side pan.
3. Water is jet is allowed to strike plate and discharge is so adjusted
4. The lever retains equilibrium position.
5. The pressure gauge reading is noted and time taken for H cm rise in
6. The collecting tank is also noted.
7. The weight on the right hand side pan is increased and procedure
8. Repeated for five such different weights.
9. Then the plate is changed and another plate is fixed and the whole
10. Experiment is repeated.

Model Calculations:

$F_{act} = W\ Y/X$

$Y =$

$X =$

$F_{th} = PQV$

$Q = AH/t\ m^3/sec.$

$V =$ Velocity of jet

$\quad = \sqrt{2g} \times (p/\gamma - z)$

Where $\quad \gamma = 9.81 \times 10^3\ N/m^3$

$\quad\quad\quad \rho =$

$\quad\quad\quad Z =$

$C_i = F_{act}/F_{th}$

Observation Table:

Sl. No.	Plate	Weights Kgf	Gauge reading	Velocity m/s	Vertical Y cm	Horizontal X cm	Time taken for H cm rise	Q_a =AH/t	F_{act} Kgf	F_{th} Kgf	$C_i = F_{act}/F_{th}$
1	Flat plate										
2											
3											
4											
1	Hemis pheric al										
2											
3											
4											

Graph:

Q_a Vs. C_i for flat and hemi spherical plates

Result:

Co-efficient of impact for

Flat plate   =

Hemi spherical plate   =

Review Questions:

1. What is an expression for impact of jet on fixed flat plate?
2. What is an expression for impact of jet on moveable flat plate?
3. What is an expression for impact of jet on fixed inclined plate?
4. What is an expression for impact of jet on fixed curved plate?