राज्य अभियांत्रिकी एवं प्रौद्योगिकी संस्थान, नीलोखेड़ी

State Institute of Engineering & Technology, Nilokheri

(Formerly Govt. Engineering College)

# LABORATORYMANUAL

# INTERNAL COMBUSTION ENGINES

# MEC-306LA

**Departmentof Mechanical Engineering**

**STATE INSTITUTEOFENGINEERING AND TECHNOLOGY**

**(Affiliated to K.U. University)**

**NILOKHERI– 132117, KARNAL**

# ICE Lab

## List of Experiments

1. To make a trial on single cylinder four-stroke diesel engine to calculate BHP (brake horse power), SFC (specific fuel consumption) and draw its characteristics curves.
2. To make a trial on four-stroke high-speed diesel engine and to draw its heat balance sheet.
3. To perform morsetest to calculate IHP (indicated horse power) of a multi cylinder petrol engine and determine its mechanical efficiency.
4. To calculate the isothermal efficiency and volumetric efficiency of a two stage reciprocating air compressor.
5. To find the efficiency of an air blower.
6. To study;
   (i) Gas turbine and (ii) Wankle engine.
7. To study ;
   (i) Lubrication and cooling systems of an IC (internal Combustion) Engines
   (ii) The braking system of automobile.
8. To study the construction and working of simple carburattor.
9. To study the construction and working of cooling tower.

# Experiment- 1

1. **AIM**: TO MAKE A TRIAL ON SINGLE CYLINDER FOUR-STROKE DIESEL ENGINE TO CALCULATE BHP (BRAKE HORSE POWER), SFC (SPECIFIC FUEL CONSUMPTION) AND DRAW ITS CHARACTERISTICS CURVES.

**2. REQUIREMENTS:**

1. Digital temperature indicator to measure different temperatures sensed by respective thermocouples.
2. Digital RPM indicator to measure the speed of the engine.
3. Manometer to measure the quantity of air drawn into the engine cylinder.
4. Burette to measure the rate of fuel consumed.

**3. THEORY:**

The Mechanical brake drum is fixed to the engine flywheel and the engine is mounted on a MS Channel frame and further mounted on anti vibration-mounts. Panel board is used to fire burette with 3 way cock, digital temperature indicator with selector switch, digital RPM indication and U tube manometer.

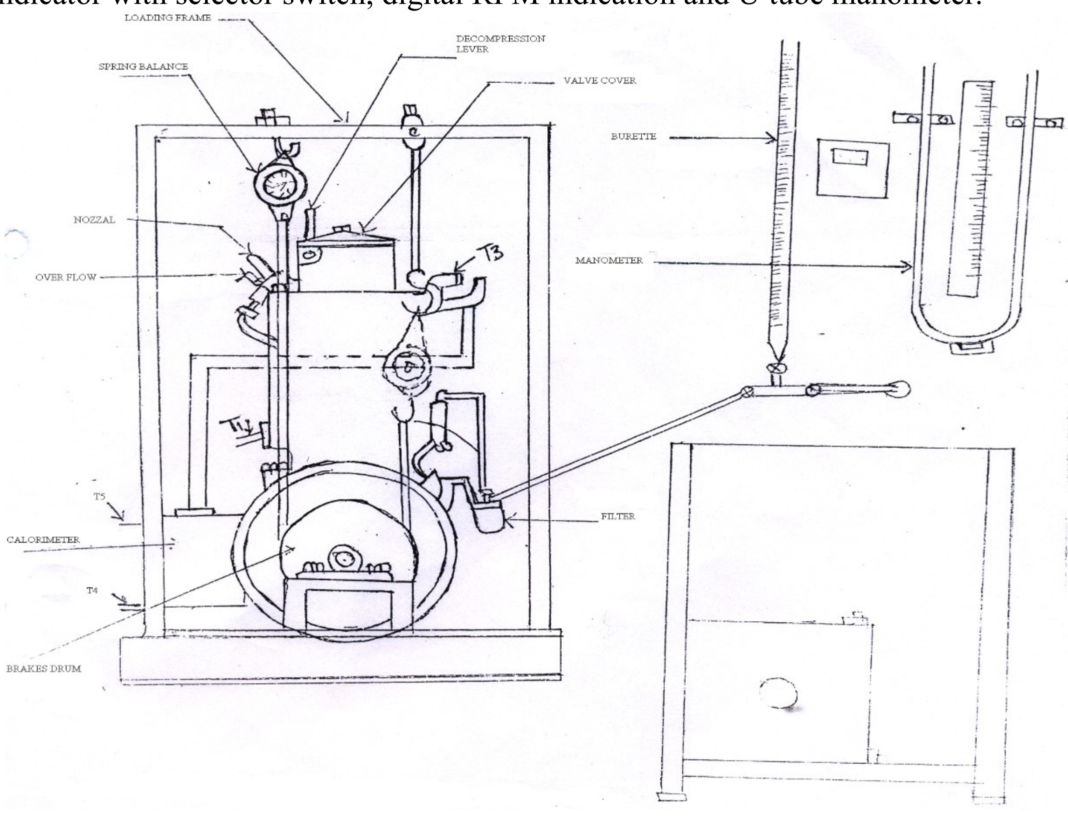



**Fig. Single cylinder four stroke diesel engine test rig**

**4. PROCEDURE:**

1. Fill fuel into the fuel tank mounted on the Panel frame.
2. Check the lubricating oil in the engine sump with the help of dip stick provided.

3. Open the fuel cock provided under the fuel tank and ensures that no air is trapped in the fuel line connected fuel tank and engine.
4. De-compress the engine by decompression lever provided on top of the engine head. (Lift the lever for decompression).
5. Crank the engine slowly, with the help of handle provided and ascertain proper flow of fuel into the pump and in turn through the nozzle into the engine cylinder. When maximum cranking speed is attained, pull the decompression lever down now the engine starts. Allow the engine to run and stabilize.
6. Now load the engine by turning the spring balance wheel in clock wise direction, the spring balance will read in Kg.
7. Record the following parameters indicated on the panel instrument on each load step.

(i) Speed of the engine from RPM indicator.

(ii) Rate of fuel from burette.

(iii) Quantity of air sucked into the engine cylinder from manometer.

(iv) Temperature $T_1$ to $T_4$ from temperature indictor by turning the selector switch to respective portion.

(v) Quantity of water flowing through engine head and calorimeter from respective rotameter.

8. To step the engine after the experiment is over push/pull the governor lever towards the engine cranking side.

**4.1 <u>FORMULAS</u>:**

**1.** Brake Horse Power (BHP)

$$BHP = \frac{2\pi N \times W \times \frac{(D+d)}{2}}{4500} \quad \text{or} \quad BP\,(KW) = \frac{2\pi N \times W \times \frac{(D+d)}{2}}{60 \times 1000}$$

Where:

W = Weight (load in Kg)

D = Diameter of Brake drum in mtrs. = 250mm

d = Diameter of rope in mtrs = 25mm

N = Speed of Engine (rpm)

**2**. Mass of fuel consumed in Kg/hr = $m_f$

$$m_f = \frac{X_{cc} \times s_{fuel} \times 60 \times 60 \times 1000}{T \sec} = Kg/hr$$

s = specific gravity of fuel

Where $X_{cc}$ is volume of fuel consumed in T sec.

Density of (Diesel) is 0.838 gms/cc.

**3**. Specific fuel consumption (SFC) in Kg/KW. h

$$SFC = \frac{m_f}{BHP}$$

**4.** Brake thermal Efficiency

$$\eta_{bth} = \frac{BP(KW)}{m_f / \sec. \times CV(kJ/kg)} = \frac{BHP \times 0.746 \times 3600}{4.186 \times C_V \times m_f}$$

Where Calorific value of fuel (Diesel) $C_V$ = 11000 Kcal/Kg

**5.** Indicated horse Power (IHP)

IHP can be calculated by Williams line Graph Method.

IHP = BHP + FHP

**6.** Mechanical Efficiency:

$$\eta_m = \frac{BHP}{IHP} \times 100 \ \%$$

**7.** Actual Volume ($V_a$) of air drawn into the cylinder of at RTP in cu.mtr/hr is calculated

Where $C_d$ of orifice = 0.62

Dia of orifice = 20 mm

$V_a = C_d \times A_o \sqrt{2gh_a}$ $m^3$/ min Also, $h_a \times \rho_a = h_w \times \rho_w$

$h_w$ = Head of water in cm.= $h_1$-$h_2$ = Manometer difference of water

$A_o$ = Area of Orifice in $m^2 = \frac{\pi}{4} d_o^2$

$h_a$ = Head, meter of air causing flow or height of air column

$\rho_a$ = Density of air in kg/$m^3$ = app. 1.22521

**8.** Swept Volume (Vs) in m/hr.

$$Vs = \text{Area of cylinder} * \text{stroke length} \times \frac{\text{Speed of Engine}}{2}$$

$$Vs = \frac{\pi}{4} D^2 \times L \times \frac{N}{2} \ m^3 / \min$$

Where : D = Dia of piston = 80 mm , N = rpm

L = Stroke length = 110 mm

**9.** Volumetric Efficiency

$$\eta_{vol.} = \frac{V_a}{V_s} \times 100$$

**Heat balance sheet**

**1.** Heat input =H= $m_f \times C_V$ in kJ/min.

Where $m_f$ = mass of fuel consumed per minute

$C_v$ = Calorific Value of fuel in KJ/kg

**2**. Heat Equivalent to BP = $H_1$ = B.P (kw) × 60 kJ/min.

**3**. Heat Carried away by engine Jacket Cooling water = $H_2$

$H_2$ = Mass of water flowing through engine jacket (Kg/min.) × Specific heat × difference in temp. at inlet to outlet

$H_2 = m_w \times C_{pw} \times \{T_2 - T_1)$ kJ/min.

Where specific heat of water = $C_{pw}$ = 4.18 kJ/kg-K

$T_1$ = Initial temp. of cooling water ($^o$c)

$T_2$ = Final temperature of cooling water ($^o$c)

**4.** Heat Carried away by exhaust gas = $H_3$

$H_3$ = Mass of exhaust gases (kg/min.)× mean Specific heat at constant pressure *difference in Exhaust gas inlet to calorimeter to exhaust gas outlet of calorimeter

$H_3 = m_e \times C_{pg} \times (T_4 - T_3)$ kJ/min.

Where $C_{pg}$ = specific heat of exhaust gas = 1

$m_a$ = mass of air (kg/min.)= volume of Air x density of Air = $\rho_a \times V_a$

$m_f$ = mass of fuel consumed (kg/min.)

$m_e$ = mass of exhaust gasses per minute = $m_f + m_a$

**5**. Heat Unaccounted: - $H_4 = H-(H_1+H_2+H_3)$

**4.2 <u>OBSERVATION TABLE</u>**:

| **S. No.** | **Fuel consumed Xcc** | **Time in t (Sec)** | **rpm of engine. (N)** | **Mano meter Reading in cm** | **Load in kg** | **Calorimeter Reading** | **$T_1$** | **$T_2$** | **$T_3$** | **$T_4$** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

$T_1$ = Inlet temp. of water in engine
$T_2$ = Outlet temp. of water from engine
$T_3$ = Inlet temp. of water in calorimeter
$T_4$ = Outlet temp. of water from calorimeter

**4.3 <u>PRECAUTIONS</u>:**
**4.4**

1) Before starting the engine, oil level in sump and jacket cooling water supply must be checked.
2) Never stop the engine on load and never use decompression lever for stopping.
3) Do not tamper with any of engine settings, like governor, fuel injector etc.

**5. RESULT**: A Graph between BHP and SFC has been plotted.

# Experiment- 2

1. **AIM:** TO MAKE A TRIAL ON FOUR-STROKE HIGH-SPEED DIESEL ENGINE AND TO DRAW ITS HEAT BALANCE SHEET.

2. **REQUIREMENTS:** 4- cylinder 4-stroke Diesel engine test rig equipped with hydraulic dynamometer.

3. **THEORY:**

The performance of IC engine is generally given by heat balance sheet. To draw a heat balance sheet for IC engine, it is run at constant load. Indicated diagram is obtained with the help of an indicator. The quantity of fuel used in a given time and its calorific value, the amount, inlet and outlet temperature of cooling water and the weight of exhaust gasses are measured.

4. **PROCEDURE:**

1. Note down the reading of dial of hydraulic Dynamometer before starting(for zero error)
2. Load the engine at rated speed or apply the load for a particular speed and run for the 5 minutes.
3. After applying the load measure speed with tachometer and final reading of dial of hydraulic dynamometer. Difference in reading (final-initial) of dial of hydraulic dynamometer will be utilized for measurement of power of the engine (B) working with four cylinders.
4. Note down the time taken for the consumption of $10_{cc}$ of fuel
5. Also note down the manometer Readings.
6. Now Increase the load on the engine and note the speed of the engine with the help of the Tachometer.
7. Note down the time taken for the consumption of $10_{cc}$ of fuel
8. Also note down the manometer Readings.
9. Repeat the above procedure for the different reading by increasing the load on the engine

**4.1 FORMULE:**

1. Speed of engine(N) = constant
   Throttle = constant
   Total brake power (B.P.) = Total indicated power (I.P.) – Frictional power (F.P.)

2. B.P. = $2\pi NT/60000$ KW

   T= S ×L
   Where, S= Reading of dial of hydraulic dynamometer (final-initial, before starting the engine), kg
   L= 0.40m= Distance from centre of dynamometer shaft to centre of spring balance (dial) in m.

3. $$\text{TFC (kg/sec)} = \frac{\text{Volume of fuel consumed (cm}^3\text{)} \times \text{specific gravity of fuel} \times 10^3}{10^6 \times t\text{ (sec)}}$$

   Convert TFC (Total fuel consumption) in kg/hr.

   $$\text{TFC (kg/hr)} = \frac{\text{Volume of fuel consumed (cm}^3\text{) in t sec.} \times \text{specific gravity of fuel} \times 10^3}{10^6 \times t\text{ (sec)}} \times 3600$$

   Specific gravity of petrol = 0.72, and for diesel = 0.8
   Specific gravity of fuel = $(\rho g)_{fuel} / (\rho g)_{water}$
   Specific gravity of fuel = $\rho_{fuel}/\rho_{water = 1000\ Kg/m^3}$

Heat supplied (kJ/sec) = CV × $10^3$ × TFC (kg/sec), convert in KW as,
CV= Higher calorific value of fuel (for petrol = 43.963 MJ/kg and for diesel = 44MJ/kg)

1. **Heat input**
Heat supplied (kJ/sec) = CV × TFC (kg/sec), KW
Where, CV in KJ

**(i) Heat equivalent to B.P.**

$$BHP = \frac{2\pi NT}{4500} \text{ horse power}$$

T = load x L and L=0.32m

$$\text{So, B.P in KW} = \frac{2\pi NT}{60000}$$

**(ii) Frictional power** By Wilan's line method drawing the graph between TFC and B.P. and calculate FP.

**(iii) Heat carried away by the cooling water**

Where, $H_c = m_w C_{pw}(T_{c2}-T_{c1})$

$m_w$= flow rate of cooling water in kg/sec,
$C_{pw}$= const. heat of water at const. Temp. (4.18 kJ/kg-k)
$T_{c2}$ , $T_{c1}$ = cooling water temperature at exit and inlet respectively in k

**(iv) Heat carried out by the exhaust gases**

$H_g = C_{pg}(T_{g2} - T_{g1}) \times (m_f + m_a)$

Where; $C_{pg}$= specific heat of exhaust gases = 1
$m_f$ ,$m_a$ = mass flow rate of fuel and air
$T_{g2}$ , $T_{g1}$ = Exhaust gas temperature
Mass flow rate of air may be calculated as

$$\text{Volume flow rate} = C_d \times \frac{\pi}{4} \times d^2 \sqrt{2gh}$$

Where, $C_d$ = 0.62, d = diameter of orifice (10), h= height of air column
$h \times \rho_a = h_w \times \rho_w$

Where, $\rho_w$ = density of water 1000 kg/m$^3$
$\rho_a$ = density of air = 1.2 kg/m$^3$

$$m_a = C_d \times \frac{\pi}{4} \times d^2 \sqrt{2gh_w} \times \rho_a \times \rho_w = C_d A_o \sqrt{2\rho_a \Delta\rho}_a$$

Where, $h_w$ = manometer difference of water = $(h_1 - h_2)$

**(v) Heat carried out by calorimeter water:**

$H_{cal} = m_{wc} * C_{pw} (T_{cal2} - T_{cal1})$

Where, $m_{wc}$ = flow rate of cooling water through calorimeter in kg/s
$C_{pw}$ = specific heat of water at constant temp.(4.18 kj/kg-k)
$T_{cal2}$, $T_{cal1}$ = calorimeter cooling water temperature at exit and inlet respectively in k

**(vi) Uncounted Heat:** $\boxed{H_{in} - (B+F+H_c+H_g+H_{cal})}$

**4.2 OBESERVATION & CALCULATIONS TABLE:**

| Sr. No. | Fuel Consumed Xcc | Time in Sec (t) | RPM of Engine (N) | Load in kg |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

**5. RESULT**

**HEAT BALANCE SHEET**

| S.No. | Energy | (KW) | % of Heat |
|---|---|---|---|
| 1. | Heat input | | |
| i | Heat equivalent to brake power | | |
| ii | Heat equivalent to Friction power | | |
| iii | Heat carried out by cooling water | | |
| iv | Heat carried out by exhaust gases | | |
| v | Heat carried out by cooling water of calorimeter | | |
| vi | Uncounted Heat | | |
| | Total | | |

:

# Experiment 3

1. **AIM:** TO PERFORM MORSE TEST TO CALCULATE IHP (INDICATED HORSE POWER) OF A MULTI CYLINDER PETROL ENGINE AND DETERMINE ITS MECHANICAL EFFICIENCY.
2. **REQUIREMENTS:** 4- cylinder 4-stroke petrol engine test rig equipped with hydraulic dynamometer.
3. **THEORY:**

This test is applicable to multi cylinder engines. The engine is run at required speed and torque is measured. One cylinder is cut out, by shorting the plug if an SI engine is under test, or disconnecting an injector if a CI engine is under test. The speed falls because of the loss of power with one cylinder cut out, but is restored by reducing the load. The torque is measured again when the speed is reached its original value. If the value of IP of cylinder is denoted by $I_1$, $I_2$, $I_3$ and $I_4$ (for a four cylinder engine) and the power losses in each cylinder are denoted by $L_1$, $L_2$, $L_3$and $L_4$, then the value of BP, B at the test speed with all cylinder firing is given by

$$B = (I_1 – L_1) + (I_2 – L_2) + (I_3 – L_3) + (I_4 – L_4) \quad \ldots\ldots \quad \text{(i)}$$

If cylinder 1 is cut out then $I_1 = 0$

$$B_1 = (0 – L_1) + (I_2 – L_2) + (I_3 – L_3) + (I_4 – L_4) \quad \ldots\ldots \quad \text{(ii)}$$

Subtracting equation (ii) from (i), we get

$B – B_1 = I_1$ similarly

$B – B_2 = I_2$

$B – B_3 = I_3$

$B – B_4 = I_4$

4. **PROCEDURE:**

1. Note down the reading of dial of hydraulic Dynamometer before starting(for zero error)
2. Load the engine at full load at rated speed or apply the load for a particular speed and run for the 5 minutes.
3. After applying the load measure speed with tachometer and final reading of dial of hydraulic dynamometer. Difference in reading (final-initial) of dial of hydraulic dynamometer will be utilized for measurement of power of the engine (B) working with four cylinders.
4. Now cut off power to first cylinder (shorting of spark plug) by pulling the knife switch provided on engine panel. Adjust the load to maintain almost constant load with initial throttle and repeat the 3 and obtain the power of the engine ($B_1$) working with three cylinders.
5. Cut off power to second cylinder, and calculate power of the engine ($B_2$) working with three cylinders.
6. Cut off power to third cylinder, and calculate power of the engine (B) working with three cylinders.
7. Cut off power to fourth cylinder, and calculate power of the engine ($B_4$) working with three cylinders.
8. Indicated power of each cylinder may be calculated as:-
9. I.H.P. of cylinder 1= $B-B_1$
10. I.H.P. of cylinder 2= $B-B_2$
11. I.H.P. of cylinder 3= $B-B_3$
12. I.H.P. of cylinder 4= $B-B_4$
13. Total I.H.P.= 1+2+3+4
14. Or I.H.P. = $4B-B_1-B_2-B_3-B_4$
15. Calculate the TFC, bsfc and various efficiencies in formof mechanical, indicated thermal, brake thermal etc.

Note down the readings of temperature of cooling water, exhaust gas etc.

**4.1 FORMULA:**

1. Speed of engine(N) = constant
   Throttle = constant
   Total brake horse power (B.H.P.) = Total indicated horse power (I.H.P.) – Frictional horse power (F.H.P.)

2. $B.H.P. = \frac{2\pi NT}{4500}$ horse power
   $T = S \times L$
   Where, S= Reading of dial of hydraulic dynamometer (final-initial, before starting the engine)in kg and L= 0.40m= Distance from centre of dynamometer shaft to centre of spring balance (dial) in m.

3. $TFC\ (kg/sec) = \frac{\text{Volume of fuel consumed } (cm^3) \times \text{specific gravity of fuel} \times 10^3}{10^6 \times t\ (sec)}$
   Convert TFC (Total fuel consumption) in kg/hr.

   $TFC\ (kg/hr) = \frac{\text{Volume of fuel consumed } (cm^3) \times \text{specific gravity of fuel} \times 10^3 \text{ X } 3600}{10^6 \times t\ (sec)}$
   Specific gravity of petrol = 0.72, and for diesel = 0.8
   Specific gravity of fuel = $(\rho g)_{fuel} / (\rho g)_{water}$
   Specific gravity of fuel = $\rho_{fuel}/\rho_{water}$
   Heat supplied (kJ/sec) = $CV \times 10^3 \times TFC$ (kg/sec), convert in KW as,
   CV= Higher calorific value of fuel (for petrol = 43.963 MJ/kg and for diesel = 44MJ/kg)

***HEAT BALANCE SHEET***

**1. Heat input**

Heat supplied (kJ/sec) = CV × TFC (kg/sec), Where, CV in KJ/kg

$H_{in}$= CV × 3600 TFC (kg/hr), KWh

**(i) Heat equivalent to B.H.P.**

$B = \frac{2\pi NT}{4500}$ horse power

T = load × L and L=0.32m

So, B.P in KW = $\frac{2\pi NT}{60 \times 1000}$ KW

**(ii) Frictional horse power** = I.H.P. – B.H.P. from morse test

FP = IP– BP in KW

**(iii) Heat carried away by the cooling water**

Where, $H_c = m_w C_{pw}(T_{c2} - T_{c1})$

$m_w$= flow rate of cooling water in kg/sec,

$C_{pw}$= const. heat of water at const. Temp. (4.18 kJ/kg-k)

$T_{c2}$ , $T_{c1}$ = cooling water temperature at exit and inlet respectively in k

**(iv) Heat carried out by the exhaust gases**

$H_g = (m_a + m_f) Cpg(T_{g2} - T_{g1})$

Where; $C_{pg}$= specific heat of exhaust gases = 1

$m_f$ ,$m_a$ = mass flow rate of fuel and air

$T_{g2}$ , $T_{g1}$ = Exhaust gas temperature

Mass flow rate of air may be calculated as

Volume flow rate = $C_d \times \underline{\pi} \times d^2 \sqrt{2gh}$
4

Where, $C_d = 0.62$, d = diameter of orifice (10), h= height of air column

$$h = \frac{h_W}{\rho_A} \times \rho_w$$

Where, $\rho_w$ = density of water 1000 kg/m$^3$
$\rho_a$ = density of air = 1.2 kg/m$^3$

$$m_a = \rho_a \times C_d \times \frac{\pi}{4} \times d^2 \sqrt{} \times \sqrt{2gh \times \frac{h_W}{\rho_A} \times \rho_W}$$

Where, $h_w$ = manometer difference of water = $(h_1 - h_2)$

**(v) Heat carried out by calorimeter water:**
$H_{cal} = m_{wc} \times C_{pw} (T_{cal2} - T_{cal1})$
Where,$m_{wc}$ = flow rate of cooling water through calorimeter in kg/s
$C_{pw}$ = specific heat of water at constant temp.(4.18 kJ/kg-k)
$T_{cal2}$, $T_{cal1}$ = calorimeter cooling water temperature at exit and inlet respectively in k

**(vi) Uncounted Heat:** $H_{in} - (B+F+H_c+H_g+H_{cal})$

**4.2 <u>OBESERVATION TABLE</u>: (F.H.P)**

Speed of engine (N) = constant
Trottle = Constant

| **S.No.** | **Working** | **Dial reading(kg)** | **Speed N(rpm)** | **Fuel consumed(cc)** | **Time, t(sec)** | **TFC (kg/hr)** | **B.P= $\frac{2\pi NT}{60x1000}$** | **I.P.** | **Mean F.H.P.= I.P.-B.P.** |
|---|---|---|---|---|---|---|---|---|---|
| 1. | All cylinder working | | | | | | B = | | |
| 2. | Cut off first cylinder | | | | | | $B_1$= | | |
| 3. | Cut off second cylinder | | | | | | $B_2$= | | |
| 4. | Cut off third cylinder | | | | | | $B_3$= | | |
| 5. | Cut off fourth cylinder | | | | | | $B_4$= | | |

**HEAT BALANCE SHEET**

| S.No. | Energy | (KW) | % of Heat |
|---|---|---|---|
| 2. | Heat input | | |
| i | Heat equivalent to brake power | | |
| ii | Heat equivalent to Friction power | | |
| iii | Heat carried out by cooling water | | |
| iv | Heat carried out by exhaust gases | | |
| v | Heat carried out by cooling water of calorimeter | | |
| vi | Uncounted Heat | | |
| | Total | | |

**5. RESULT:** Mechanical efficiency ($\eta_{mech.}$)= ...........

# Experiment-4

1. **AIM:** TO CALCULATE THE ISOTHERMAL EFFICIENCY AND VOLUMETRICEFFICIENCY OF A TWO STAGE RECIPROCATING AIR COMPRESSOR.

**2. REQUIREMENTS:**

**3. THEORY:-**

The function of a compressor is to take a definite quantity of fluid (usually a gas and most often air) and deliver it at a required pressure. The most efficient machine is one, which will accomplish with the minimum input of mechanical work. Both reciprocating and rotary positivie displacement machines are used for a variety of purpose. However, here we are concerned only with reciprocating machines.

**Terminology:**

1. Single acting compressors are those compressors in which suction, compression and delivery of a gas take place on one side of the piston and we have one cycle per revolution of the crank-shaft.
2. Double acting compressors are those compressors in which suction, compression and delivery of air take place on both the sides of the piston and we have tow cycles per revolution of the crank-shaft.
3. Single stage compressors are those compressors in which the compression of air from the initial pressure to the final delivery pressure is carried out in one cylinder only.
4. Multi stage compressors are those in which the compression of air from the initial pressure to the final pressure is carried out in more than one cylinder. The air after compression in one cylinder is further compressed in the second cylinder and so on.

   Multistage, reciprocating air compressors are used for compressing air for very high pressures up to 1000 bar. But they have low rate of flow, limited up to $5m^3/s$. In a multistage air compressor, air compressed in low-pressure cylinder is further compressed in high-pressure cylinder. For minimum power, isothermal compressor is aimed at, in which case compressed air of low-pressure stage is cooled in the intercooler to initial temperature (in perfect cooling) before it goes to high-pressure stage.
   The advantages of multistage compression are
   - Better volumetric efficiency.
   - Working temperature is much lower therefore, lubrication is better and wear and tear is less.
   - Cooling is more efficient with intercoolers and cylinder wall cooling.

   - The cylinders are higher, only the high-pressure cylinder need be robust.
   - They have better mechanical balance requiring smaller fly wheel due to uniform torque.
5. Ratio of compression is defined as the ratio of absolute discharge pressure to absolute intake pressure.
6. Free Air is the volume delivered by the compressor measured at the pressure and temperature of the atmosphere in which the machine is situated.

7. Displacement of compressor is the volume swept through by the first stage piston. In double acting compressor it is the volume swept through by the both sides of the pistons.
8. Actual capacity of a compressor is the quantity of gas actually delivered. It is expressed is cubic meter of free gas per minute. The actual capacity of a compressor is always less than its displacement.
9. The volumetric efficiency is defined as the ration of mass of air delivered to the mass of air, which would fill the swept volume at the free air conditions of pressure and temperature. Or it may also be defined as the volume of air delivered measured at the free air pressure and temperature divided by the swept volume of the cylinder.

Following are the specifications of the compressor:

| | | |
|---|---|---|
| Compression Stage | : | Double stage |
| Cylinders | : | Two |
| Power | : | 3 H.P. |
| Compressor Speed | : | 950 |
| Free air delivery | : | 14.54 $m^3$/hr |
| Working pressure | : | 12.0 $Kg/cm^2$ |
| Lubrication | : | Splash Lubrication |
| Diameter of LP cylinder | : | 70 (mm) |
| Diameter of H.P. cylinder | : | 50 (mm) |
| Stroke length | : | 85 (mm) |
| Displacement Volume | : | 18.65 $m^2$/hr (or 311 lpm) |
| Motor Speed, N | : | 1440 (rpm) |

**4. <u>PROCEDURE</u>:**

To find free air delivered by the compressor:

Free air delivered is measured with the help of a venturimeter.

Let

$M$ = Mass flow rate, kg/Sec

$C_d$ = Coefficient of discharge of Venturimeter

$d_o$ = the diameter of smallest cross section of the flow meter, m

$A_o$ = the area of smallest cross section of the flow meter, $m^2$

G = acceleration due to gravity

$\nabla H$ = difference in the fluid level in the manometer limb

ρwater =density of manometric fluid

ρair = density of air at the entrance to the flow meter

$$M = C_d A_o \sqrt{2g \ Ah \ \rho_{water} \ \rho_{air}}$$

ρair corresponds to the pressure and temperature of air in the tank.

Free air delivered is given by $M = \frac{PV}{RT}$

Where P&T are the atmospheric pressure and temperature

**To find volumetric efficiency of the compressor:**

$$Volumetiric\ efficiency = \frac{Free\ air\ delivered}{Swept\ Volume}$$

**4.1 GIVEN:**

| | |
|---|---|
| Length of the torque arm, L, m | = 0.0175 |
| $C_d$ of venture meter | = 0.98 |
| Diameter of throat, $d_0$, m | = 0.015 |
| Throat area, $A_O$ $m^2$ | = 1.767 x $10^{-4}$ |
| $^{g,}$ m /Sec | = 9.81 |
| Density of manometeric fluid, $\rho_w$, kg/m3 | = 995 - 1000 |
| Density of air entering the compressor at 27°C, kg/$m^3$ | = 1.20 |

**4.1 OBSERVATION TABLE:**

| S. No. | Intake Air Temp. $T_1$ | Air Temp. after inter cooler $T_2$ | Air Temp after inter cooler $T_3$ | Pressure $P_2$ after LP cylinder | Spring Balance Reading $S_1$ | Torque T=9.81 x $S_1$xL | Power | Mass flow rate M | Free air delivered |
|---|---|---|---|---|---|---|---|---|---|
| 01 | | | | | | | | | |
| 02 | | | | | | | | | |
| 03 | | | | | | | | | |

**5. RESULTS:**

(i) Volumetric efficiency of two stage reciprocating compressor is ……………….

(ii) Isothermal Efficiency of two stage reciprocating compressor is ……………….

# Experiment- 5

1. **AIM:** TO FIND THE EFFICIENCY OF AN AIR BLOWER.

**2. REQUIREMENTS:**

Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15 amp socket with earth connection.

Bench Area Required: 2.5 m * 0 .5 m

**3. THEORY:**

Blowers are used in furnaces, cupolas, mine and air-conditioning plants etc. There can be three different types of impellers namely radial curved vane, forward curve vane, and backward curve vane. Blowers are used to discharge higher volume of air at low pressure. They consist of impeller and spiral casing. They are used in furnaces, cupolas, mine and air conditioning plants etc. There can be three different types of impellers namely radial curved vane, forward curve vane, and backward curve vane. Impellers may be made of sheets and can be casted. Motor rotates the impeller and impeller sucks the air through the center and delivers the air through its periphery. Velocity, discharge and head depend upon the outlet, inlet angles and peripheral speed.

Blower consists of a motor, impeller and its body. Three impellers i.e. forward curved, backward curved and radial curved vane is provided with the set-up. These are interchangeable and any one of then can be fixed on the motor shaft. To find out the outlet velocity, the pitot tube is provided. Differential manometer is fixed to find out the difference of pressure of pitot tube at Blower outlet. Energy meter is provided to find out the input power to blower. For changing the discharge and head, valve is provided at outlet of the air.

**IDENTIFICATION OF IMPELLERS**

1. Backward curved impellers are identified by Black color.
2. Radial curved impellers are identified by Red color.
3. Forward curved impellers are identified by Yellow color.

**4. PROCEDURE:**

**Starting Procedure:**

1.Clean the apparatus and make it free from Dust.

2.Fill manometer fluid in manometer Tube i.e. water.

3.Fix the Impeller on the blower desired one (Radial, Backward or Forward Curve Vane).

4.Ensure that all On/Off Switches given on the Panel are at OFF position. Now switch ON the Main Power Supply.

5.Switch ON the Blower.

6.Fix the RPM of motor with the help of DC Drive and read the RPM of motor with the help of RPM Indicator provided on the Panel

7.Control the flow of air with the help of control valve provided in the discharge pipe.

8.Measure the pressure difference, static head & dynamic head with the help of manometer.

9.Record the power consumption by means of energy meter, provided in panel using Stop Watch.

10.Repeat the same experiment for constant RPM but change the flow of air with the help of control valve and then for different RPM.

11.When experiment on first particular Impeller is over, fix other desired Impeller on Blower and start experiment.

**Closing Procedure:**

1.When experiment is over, adjust DC Drive knob at ZERO.

2.Switch OFF the Blower.

3.Switch OFF Power Supply to Panel.

**4.1 GIVEN:**:

| | | |
|---|---|---|
| $g$ | = | 9.81 $m/s^2$ |
| $\rho_a$ | = | 1.19 $kg/m^3$ |
| $\rho_w$ | = | 1000 $kg/m^3$ |
| $C_v$ | = | 0.98 |
| $\eta_{motor}$ | = | 0.8 |
| D | = | 0.069 m |

**4.2 OBSERVATION & CALCULATION:**

| N, RPM | Opening cm | $h_{11}$, cm | $h_{12}$, cm | $h_{21}$, cm | $h_{22}$, cm | $R_1$, cm | $R_2$, cm | $t_P$, cm | p |
|---|---|---|---|---|---|---|---|---|---|
| | Full open | | | | | | | | |
| | ¾ Open | | | | | | | | |
| | ½ Open | | | | | | | | |
| | ¼ Open | | | | | | | | |

$$E_i = \frac{p}{t_P} \times \frac{3600}{EMC}, \text{ kW} = \text{---------------- kW}$$

$$E_S = E_i \times \eta_m, \text{ kW} = \text{-------------- kW}$$

$$h_1 = \frac{h_{11} - h_{12}}{100}, \text{ m} = \text{------------------ m}$$

$$h_2 = \frac{h_{21} - h_{22}}{100}, \text{ m} = \text{------------------ m}$$

$$R = \frac{R_1 - R_2}{100}, \text{ m} = \text{-------------------- m}$$

$$H = (h_1 + h_2)\left(\frac{\rho_w}{\rho_a} - 1\right), \text{ m of air} = \text{---------------- m of air}$$

$$V = C_v \sqrt{2gh}, \text{ m/sec} = \text{---------------- m/sec}$$

$$h = R\left(\frac{\rho_w}{\rho_a} - 1\right), \text{ m of air} = \text{------------- m}$$

$$Q = V \times A, \text{ m}^3\text{/sec} = \text{----------- m}^3\text{/sec}$$

$$E_o = \frac{\rho_a \times g \times H \times Q}{1000}, \text{ kW} = \text{-------------- kW}$$

$$\eta_B = \frac{E_o}{E_S} \times 100\% = \text{------------- \%}$$

$$\eta_o = \frac{E_o}{E_i} \times 100\% = \text{---------------- \%}$$

**4.3 NOMENCLATURE**:

A= Area of cross section of pipe, $m^2$

$C_v$ = Co-efficient of Discharge for Pitot tube

D = Diameter of pipe, m

$E_i$ = Power input, kW

$E_o$ = Power output, kW

$E_S$ = Shaft power, kW

EMC = Energy Meter Constant, Pulses/kW hr

g = Acceleration due to gravity, $m/s^2$

H = Total Head, m of air

$h_1$ = Static Head, m

$h_2$ = Dynamic Head, m

N = Speed of Blower, RPM

P = Pulses of energy meter

Q = Discharge, $m^3/s$

R = Rise of water level in measuring tank, m

$R_1$ = Final level of water in measuring tank, cm

$R_2$ = Initial level of water in measuring tank, cm

$t_P$ = Time taken by P, sec

V = Velocity of Air, m/sec

$\rho_a$ = Density of Air, $kg/m^3$

$\rho_w$ = Density of Water, $kg/m^3$

$\eta_m$ = Efficiency of motor %

$\eta_B$ = Efficiency of blower %

$\eta_o$ = Overall efficiency %

$h_{11}$& $h_{12}$ = High Pressure side Manometer Reading, cm

$h_{21}$& $h_{22}$ = Low pressure side Manometer Reading, cm

**4.4 <u>PRECAUTIONS & MAINTENANCE INSTRUCTIONS</u>**:

1. Always keep apparatus free from dust.
2. Do not run the apparatus without the permission of your incharge
3. Switch off the main power supply after complete the experiment

**5. RESULT**:

Efficiency of an air blower is approximately ……………………..

# Experiment- 6

**1. AIM**: TO STUDY THE (I) GAS TURBINE AND (II) THE WANKLE ENGINE.

.

**2. REQUIREMENTS:** Models of wankle engine and gas turbine

**3. THEORY**:-

**GAS TURBINE:** A gas turbine is a rotary machine, similar in principle to a steam turbine. The characteristics features of a gas turbine as we think of the name today include a compression process and a heat addition process. The gas turbine represents perhaps the most satisfactory way of processing very large quantities of power in a self contained and compact unit. The thermal efficiency of the gas turbine along is steel quite modest 20 to 30 % compare with that of a modern steam turbine plant 38 to 40 %. It is possible to construct turbine plant whose efficiency is of order of 45 or more. Higher efficiency must be attained in future.

**The following are the major's fields of applications of gas turbine.**

- Air Crafts
- Industrial Power generation
- Oil & Gas industry
- Marine propulsion

The efficiency of a gas turbine is not the criterion for the choice of this plant.

**The gas turbines have the following limitations:**

- They are not self starting
- Low efficiency at part loads
- Non reversibility
- Higher rotor speed
- Over all efficiency of the plant is low

**CLASSIFICATION OF GAS TURBINES:** In the early stages of Gas Turbine development from 1905 onward "Constant volume combustion" or "explosion" type gas turbines were built and were known as Holzworth gas turbines. This type entailed the use of valves and consequent intermittent operation. It soon became obsolete and was replaced by "constant pressure gas turbines" working on Joule (or Brayton) cycle. The constant pressure gas turbines are further classified as:

1. Open Cycle Gas Turbine
2. Closed Cycle Gas Turbine.

**OPEN CYCLE GAS TURBINE:**

It is an internal combustion engine. As shown in the diagram the gas is taken from the atmosphere at 1, and is compressed in a centrifugal or axial flow type compressor to a pressor P2 and t

emperature T3. the compressed air enters the combustion chamber where fuel is added directly into it and burnet at constant pressure (neglecting the pressure drop in the combustion chamber) raising the temperature to a maximum cycle temperature T3. the high temperature and high pressure gas enter the turbine at 3 and expand upto atmospheric pressure produsing work. After expansion the products of combustion are exhausted in to the atmosphere. About 60% of the

turbine power is utilized for driving the compressor and remaining is the net output. The cycle may be assumed to be completed by cooling of the exhaust gasses at constant pressure to original temperature. A gas turbine is not a self starting machine. For starting, it is first motored to some minimum speed, called the coming in speed, before the fuel is in turned on. A motor of about 5% of the power output is provided for this purpose.

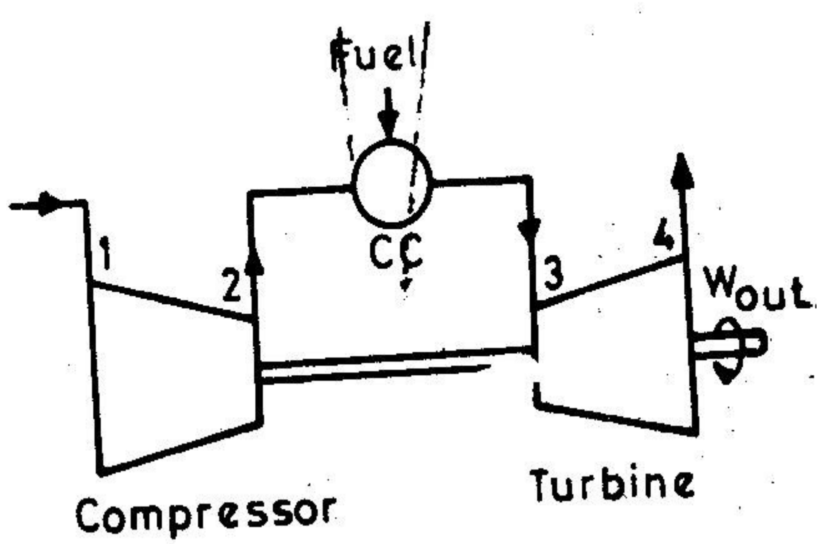



**Diagram of Open cycle Gas Turbine**

**CLOSED CYCLE GAS TURBINE:**

The closed cycle gas turbine is shown in Fig. in it the same working fluid, be it air or some other gas, is repeatedly circulated through the machines. The working fluid does not come in contact with the atmospheric air or fuel. The heat to the working substance is provided in the heater by burning the fuel externally. Hence it is an external combustion engine. The turbine exhaust rejects its heat in a cooler.

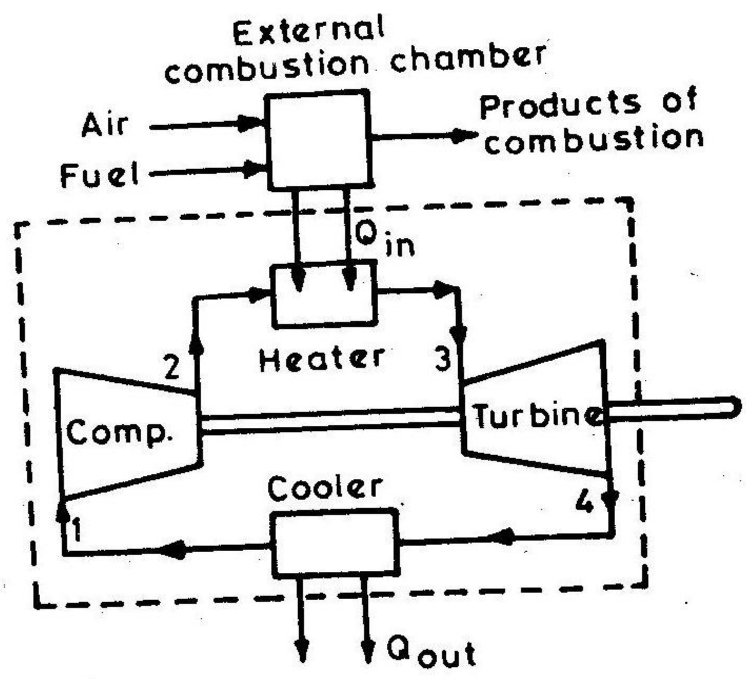
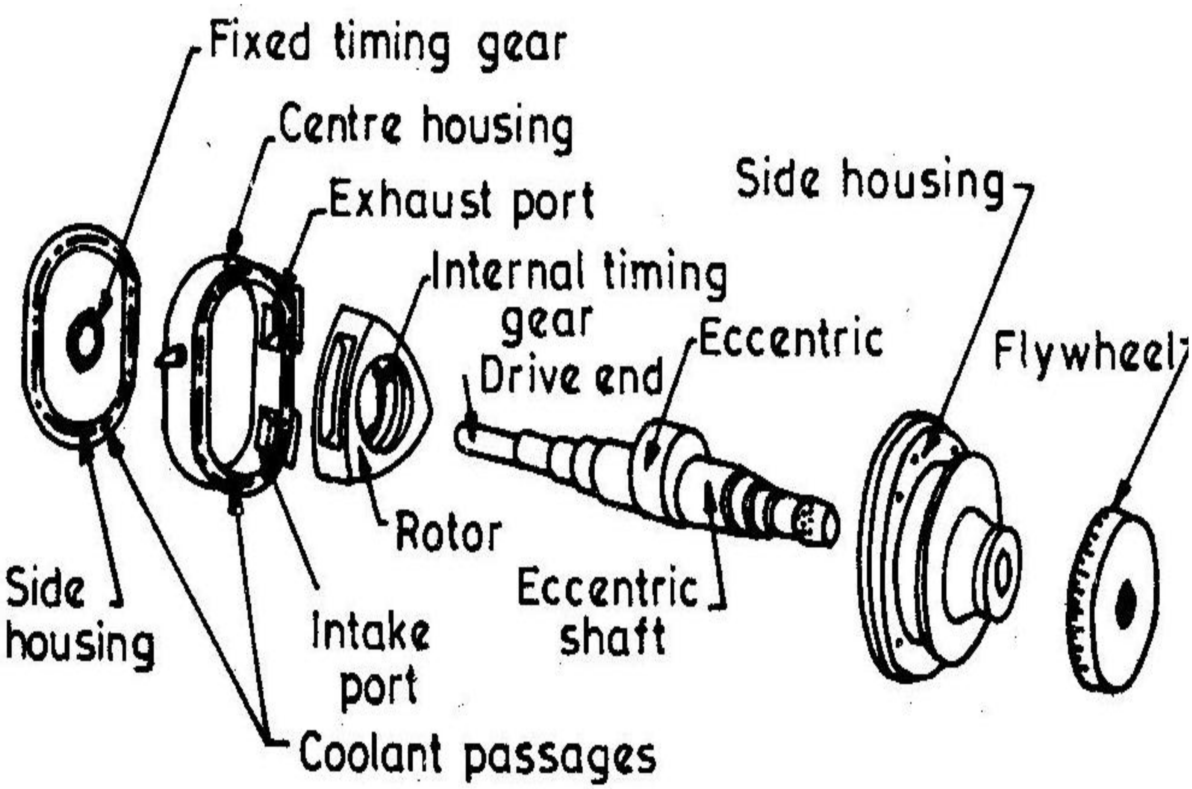



**Diagram of Closed cycle Gas Turbine**

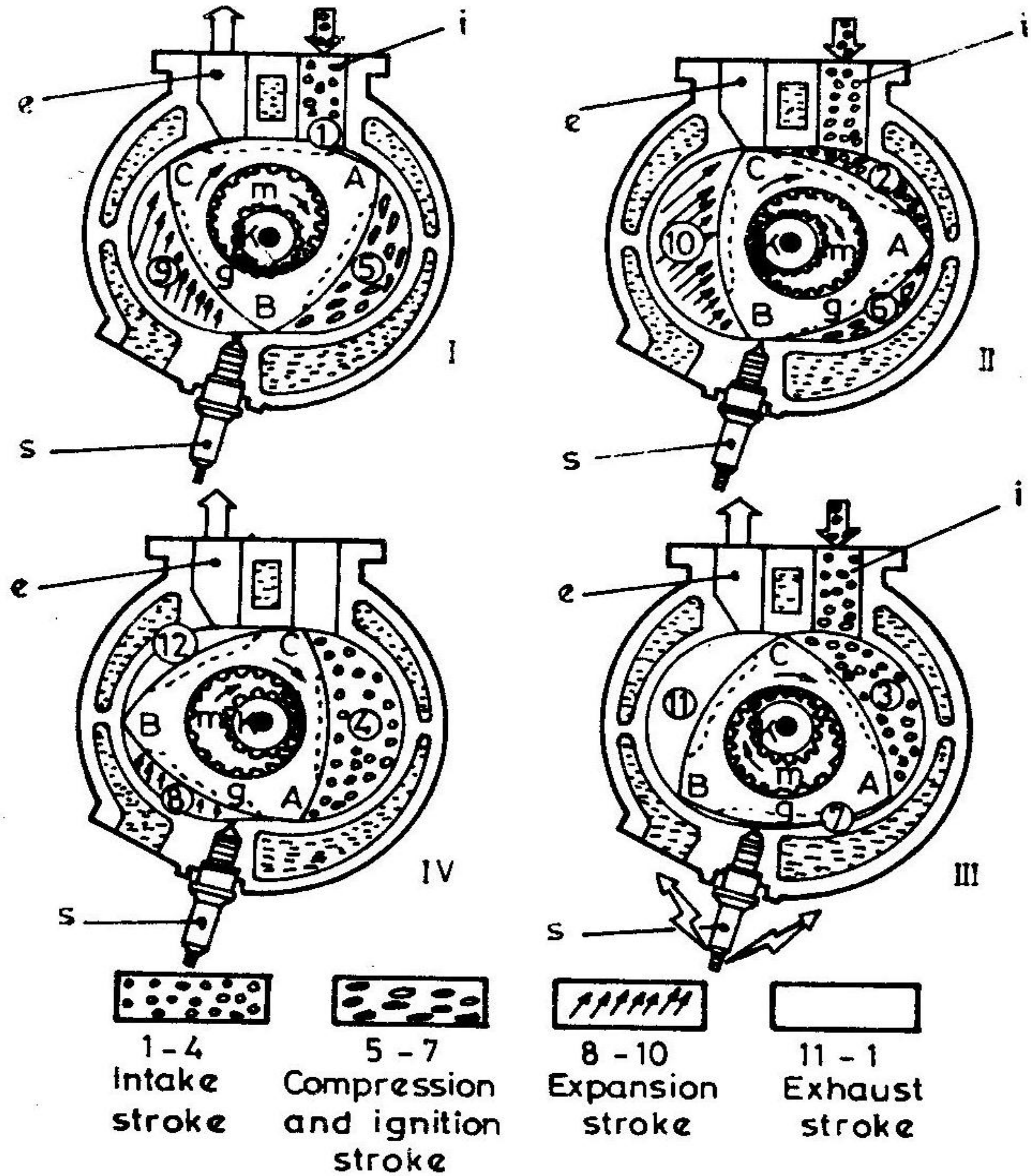
**WANKEL ENGINE:** Felix wankel introduced a rotary engine in 1924 it works on ordinary Otto cycle but differs from reciprocating IC engines .It is purely rotary engine having no reciprocating part or piston. It makes use of a rotor instead of a piston, which turns, inside a chamber. This design gives a new challenge to existing reciprocating engines.

**CONSTRUCTION:** It consists of three lob rotors that rotate eccentrically in an oval chamber. The rotor is mounted on the crankshaft through external and internal gears. The rotor lobes A, B and C are sealed tightly against the sides of the oval chamber. The combustion of rotor and chamber spaces insures that they remain in connect with each other through out the rotation. The rotor has oval shaped depression on it three sides between the lobes and shown by dotted lines in fig.

**OPERATION:** Three lob rotors makes three space around it in the oval chamber. The cycle of intake, compression, power and exhaust are simultaneously in three spaces around rotor when engine is running. Figure represent the fuel intake, in which the rotor side AB creates suction. The mixture from the carburetor enters the suction chamber. As the rotor turns clockwise, the mixture compressed between the rotor and the chamber. Further it is ignited, burnt gases turning the rotor and finally the exhaust gases are pushed out the chamber as at rotor side AB is again in the initial position to take the fresh charge. Thus the cycle is completed. The cycle of operations goes on in all the three sides of the rotor simultaneously. It obvious that the three powers impulses in every revolution of the rotor which is three times compares to a two stroke engine and six times compare to a four stroke engine. The engine delivers power almost simultaneously. The eccentric motion of the rotor develops vibrations, which are eliminated by the use of symmetrically mounted flywheel.



**Main parts of Wankel engine**




**(Working diagram of Wankel engine)**

# Experiment -7

**1. AIM**: TO STUDY (I) LUBRICATION AND COOLING SYSTEMS OF AN IC (INTERNAL COMBUSTION). ENGINES AND (II) THE BRAKING SYSTEM OF AUTOMOBILE.

**2. REQUIREMENTS:** Models of lubrication and cooling system

**3. THEORY:**

The various systems adopted for the lubrication of automobile engine are:
1. Petroil System
2. Splash System
3. Pressure System
4. Dry Sump System

**1.Petroil System:** It is simplest of all types of engine lubrication systems used in two stroke engine e.g. scooter and motorcycle engines. Certain amount of the lubricating oil is mixed with the petrol itself, the usual ratio being 2% to 3% of oil. If it is less, there is danger of oil starvation or insufficient lubricating causing damage to the engine; if however it is more, there will be excessive carbon deposits in the cylinder head and the engine will also give dark smoke. It Shows in fig. 1
**2. Splash System:** It is one of cheapest methods of engine lubrication. A scoop is made in the lowest part of the connecting rod and the oil is stored in the oil trough, it being pumped there from the crankcase oil pump. When the engine runs, the scoop causes the oil to splash on the cylinder walls each time it passes through its BDC position. This affects the lubrication of engine walls, gudgeon pin, main crankshaft bearings big end bearings etc.It Shows in fig. 2
**3. Pressure System:** In the pressure system, an oil pump takes the oil from the wet sump through a strainer and delivers it through a filter to the main oil gallery at a pressure of 200 to 400 Kpa. The oil pressure is controlled by means of a pressure relief valve, situated in the filter unit or the pump housing. There is one main gallery in case of inline engines. From the main gallery, the oil goes through the drilled passages to the main back to the sump, some is splashed to lubricate cylinder walls while the rest goes to the hole to the crankpins from where a hole in the lubricating connecting rod web, lead it to the gudgeon pin. For the camshaft and timing gears lubricating oil is led through separate oil lines from the oil gallery to each camshaft bearing through a pressure-reducing valve. To lubricate the timing gears and the sprocket chain, sometimes a directed oil jet is employed. The valve tappets are lubricated by connecting the main oil gallery to the tappet guide surfaces through drilled holes. At the end of the main gallery, an oil pressure switch is provided. Which operates the warning light on the dashboard? When the oil pressure becomes lower than the specified value, say 0.3 bar, the warning light comes on to attract the driver's attentions. During the circulation the oil gains heat from various engine parts, which is given out to the sump walls.It Shows in fig. 3

**4. Dry Sump System:** This system is employed in some racing car engines and military jeep as the oil in the wet sump is subjected to large back and forth acceleration also where the vehicle has to be operated at very sleep angles. If ordinary pressure system of lubrication is used in such cases, the situations may arise when there is no oil at the place where oil sump is installed. To avoid such

instances, dry sump system is used, wherein two pumps, instead of one, are used. The scavenge pump is installed in the crankcase portion which is the lowest. It pumps oil to a separate reservoir, through the oil filter from where the oil pump pumps it to the cylinder bearings; a full pressure system of lubrication is employed. The oil pressure is maintained at 400-500 kPa for the main and big end bearings while about 500-100 kPa pressure is used for timing gears and cam shaft bearing etc.

## COOLING SYSTEMS:

Various methods used for cooling of automobile engines are:
1. Air cooling 2. Water Cooling

**1. Air-cooling:** The basic principle involved in this method is to have current of air flowing continuously over the heated metal surface from where the heat is to be removed. The heat dissipated depends upon following factors:

a) Surface area of metal into contact with air
b) Mass flow rate of air
c) Temperature difference between the heated surface and air
d) Conductivity of metal

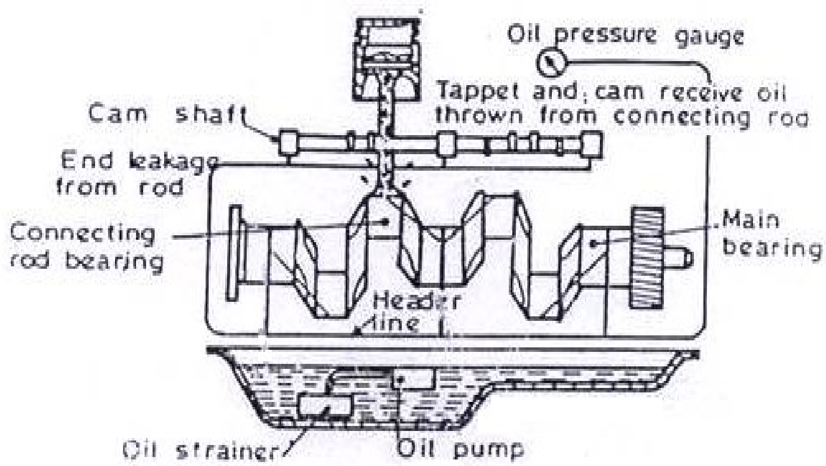



**Fig.1 Pressurized lubrication System**

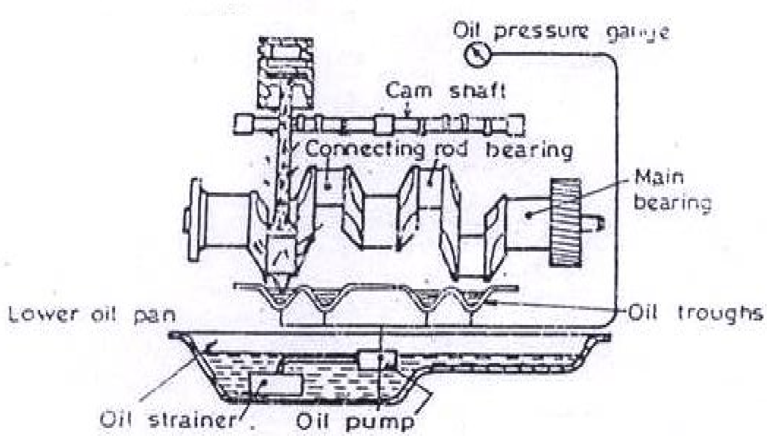



**Fig.2 Splash System**

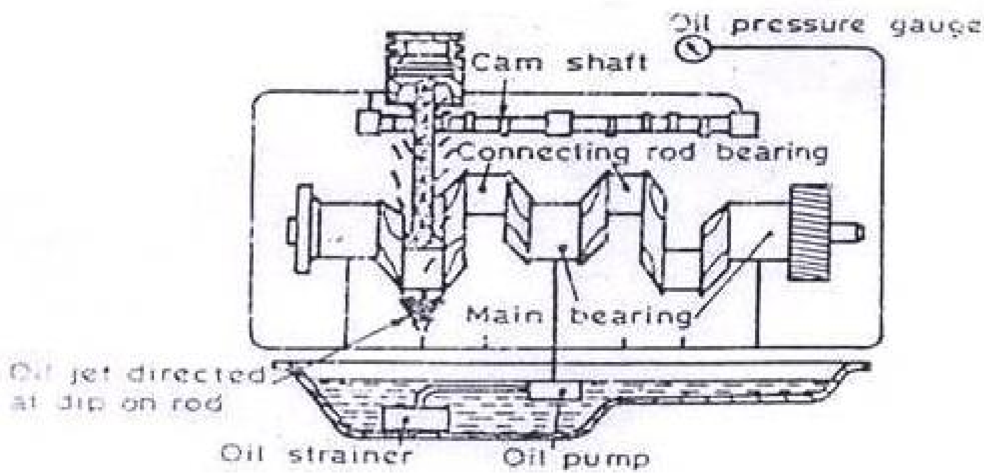



**Fig.3 Pressure System**

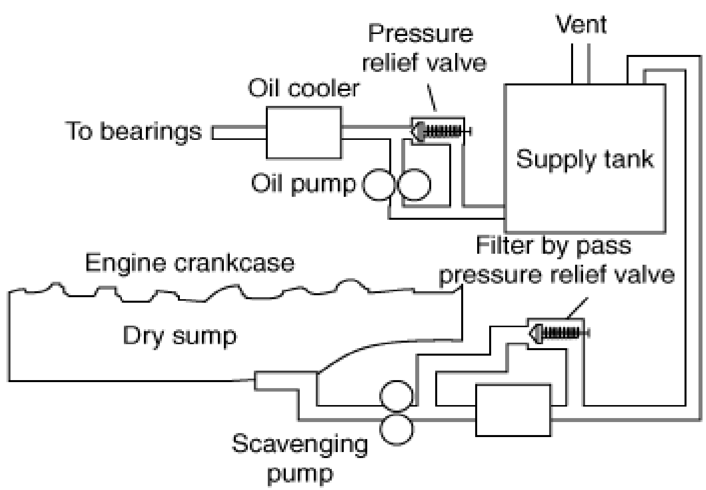
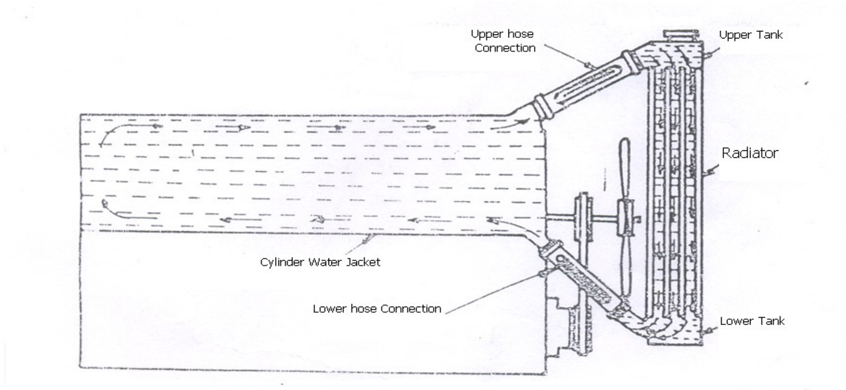



**Fig.4Dry Sump Lubrication System**

This for an effective cooling the surface area of the metal which is in contact with the air should be increased. This is done by using fins over the cylinder barrels. These fins are either cast as an integral part of the cylinder or separate finned barrels are inserted over the cylinder barrel. Use of copper and steel alloys have also been made to improve heat transfer because of their better thermal conductivity.

**2.Water Cooling:** In water-cooling systems, the engine cylinder is surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water, which goes to the radiator where it loses its heat to the air. Water cooling systems are of two types:

**(i) Thermosyphon System**: It consists of a radiator connected to the engine through flexible hoses. In this system, circulation of water is obtained from the difference in densities of the hot and the cold regions of cooling water. The circulating water gets heat from the engine cylinders, thereby cooling the same. The same heat in the water is then dissipated into the atmosphere, through the radiator, by mainly conduction and convection. Therefore, the circulating water becomes cold by the time it reaches the collector tank of the radiator. The same water is then circulated through the engine to collect heat from the cylinders. The rate at which water circulates in this system is proportional to the heat output or the load on the engine and not to the engine speed. Some of the therosyphon system also had fans mounted behind the radiator and driven by belt and pulleys from the crankshaft, to assist the flow of cooling air.




**ThermoSyphone System**

**(ii) Pump Circulation System**: A pump is used for the circulation of cooling water and a thermostat is employed to control the airflow. The pump is driven by means of a belt from the engine crankshaft. The drive for the fan is also obtained from the same belt that drives the pump and the generator.

**HYDRAULIC BRAKING SYSTEM OF AN AUTOMOBILE:**

**Layout and the components:**
Most of the cars today used hydraulically-operated foot brakes on all the four wheels with an addition hand break mechanically operated on car wheels. An outline of the braking system is shown in the figure. The main components in the braking system are master cylinder which contains the brake fluid. Master cylinder is operated by the brake paddle and is further connected to the wheel cylinder in which the fluid (Break fluid) flows through steel pipelines, Union and flexible hoses.

**Master cylinder:**
This can be named as the heart of the hydraulic braking system. There are two main chambers the fluid reservoir and the compression chamber in which the piston operates. The fluid in the reservoir compensates for any change in the fluid volume in the pipeline due to temperature variation and to some extent due to leakage. To prevent leakage there are rubber seals on both ends of the piston in the compression chamber. The fluid always surrounds the reduced diameter region of the piston. A rubber bush covers the push rod end of the master cylinder to prevent the dust from entering inside. Towards the break line side of the compression chamber, there is a fluid check valve with a rubber

cap inside. It serves to retain the residual pressure in the brake line even when the brakes are released. There are a number of holes in the piston head on the primary seal side. Two holes connect the fluid reservoir to the compression chamber. The smaller one out of these is about 0.7 mm diameter and is called the bypass or compensation port. The second hole is called the intake or the recuperation port. Beside there is a vent in the cap, to keep the brake fluid always at atmospheric pressure.

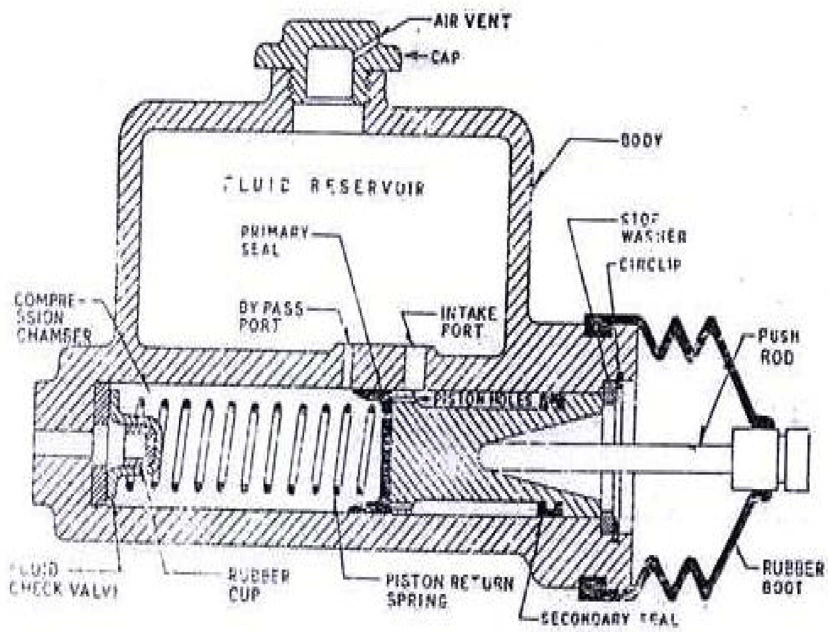



**Fig. 5 Master cylinder**

**Wheel cylinder:** Wheel cylinder is the brake systems are meant to force the brake shoes against the drum. The construction is very simple. Each Wheel cylinder is provided with piston, rubber seals (cups), Cup spreaders, spring and Dust covers (boots). The brake line from the master cylinder is attached to the inlet port and a bleeder screw with a cover is provided to beed air from the system whenever required. Wheel cylinders are mounted on the back plate. When brakes are applied the fluid under pressure from the master cylinder enters the inlet port and force the piston to move outwards to push the bush against the drum. Similarly when brakes are released, the brake shoe retractor springs force the brake fluid out of the wheel cylinder by pushing the piston inwards.

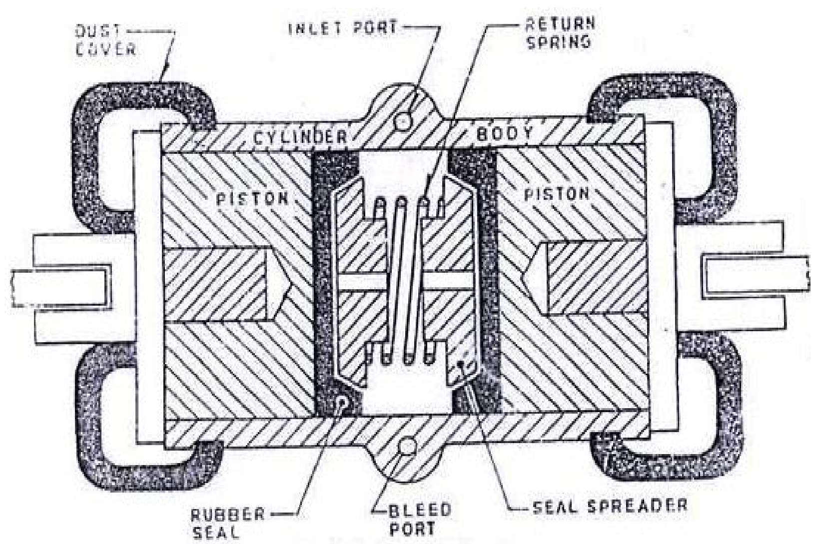



**Fig. 6 Wheel cylinder**

# Experiment- 8

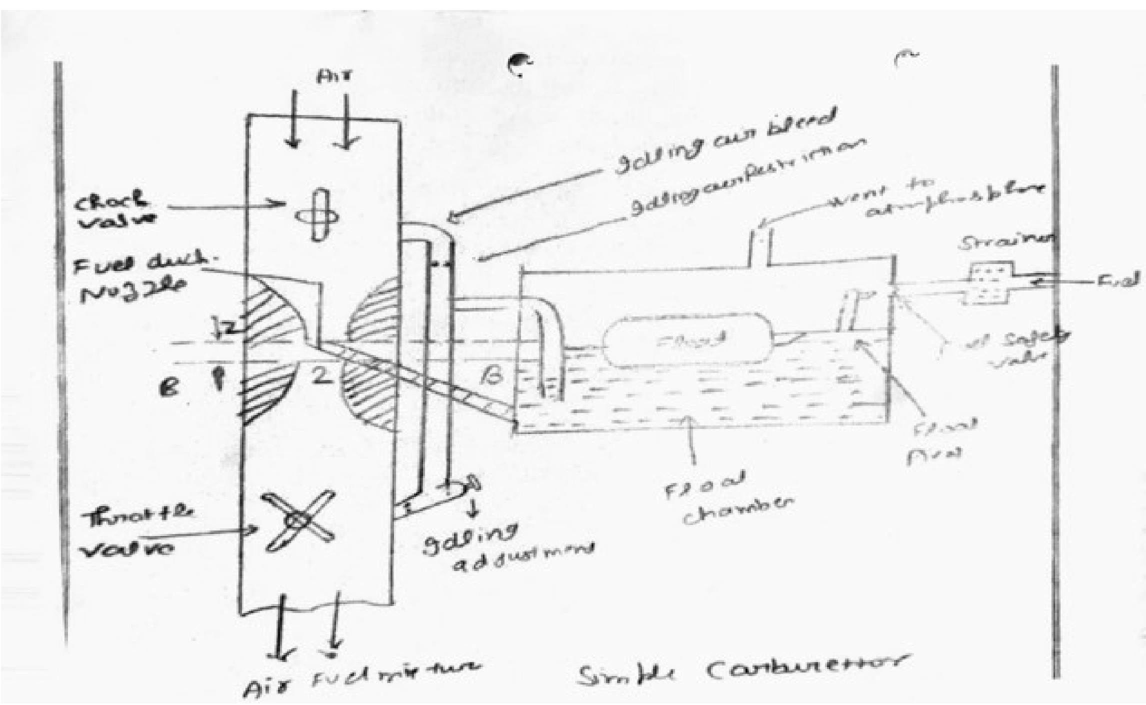
**AIM**: - TO STUDY THE CONSTRUCTION & WORKING OF A SIMPLE CARBURETOR.

**THEORY:-**

(i) A simple or Elementary Carburettor :- A simple and elementary caburettor provides an air fuel mixture for crushing or normal range at a single speed & then add other mechanisms to perform other functions like starting, idling, variable, load & speed operation & acceleration.

**Construction & Working**:-

A simple Carburettor consists of float chamber, nozzle metering orifice, venture & throttle valve. The float & needle valve system maintain a constant height of fuel in float chamber. If the amount of fuel in float chamber falls below the designing level, the float lower, therefore opening the needle of fuel supply valve. When the designing level has reached the float closes the fuel supply valve thus stopping additional fuel flow from the supply system. Float chamber is vented to the atmosphere. During the suction stroke air is drawn through venturi. Venturi is a tube of decreasing cross section which reaches a minimum at the throat. It is also known as choke tube. As the air passes through the venturi, the velocity increases & reaches to maximum to the venturi throat corresponding & pressure in the venturi throat corresponding & pressure in the venturi throat decreases. From the float chamber the fuel is fed to discharging jet, the tip of which is located in throat of venturi. Because of differential pressure between the float chamber & the throat of the venturi is known as Carburettor depression, fuel of discharging jet and is chosen to give the required air fuel state. The pressure at the throat at fully open throttle conditions lies between 4-5 cm.




Hg below the atmosphere and selom exceeds 8cm Hg below atmospheric pressure. To avoid overflow of fuel through the jet, the level of liquid in float chamber is maintained at a level slightly below the tip of nozzle.

The difference in height between the top of nozzle & float chamber level is maintained. The gasoline engine quantity governed which means that power output is to be verified at a particular speed, the amount of charge delivered is varied. This is achieved by mean of throttle valve usually of butterfly type which is situated after the venturi tube. As the throttle valve is closed less air flow through the venturi tube less quantity of air fuel mixture delivered to the cylinder & hence power output is reduced. As throttle is opened more air flow through the choke tube resulting in increased quantity of mixture being delivered to engine. This increase in engine power output. A simple Carburettor of type described above suffer from a fundamental drawback is that it provide the required A/F only at one throttle position.

## Experiment -9

AIM:-TO STUDY THE CONSTRUCTION & WORKING OF A COOLING TOWER
THEORY:-
In power plant, hot water from the condenser is cooled is cooling tower so that it can be reused
In condenser or condensation of steam. In a cooling tower water is made to trickle down drop by drop so that it come in contact with the air moving in opposite direction. As a result of this some water is evaporated & it is taken with air. In evaporation the heat is taken away along the bulk of water, which is thus cooled
Factors Affecting Cooling Of Water In Cooling Tower Are:-
(1) Temperature of air
(2) Humidity of air
(3) Temperature of hot air
(4) Size & height of tower
(5) Velocity of air entering tower
(6) Accessibility of air to all plant tower
(8) Arrangement of plate in tower
(7) Degree of uniformity in descending water
(8) Arrangement of plate is tower

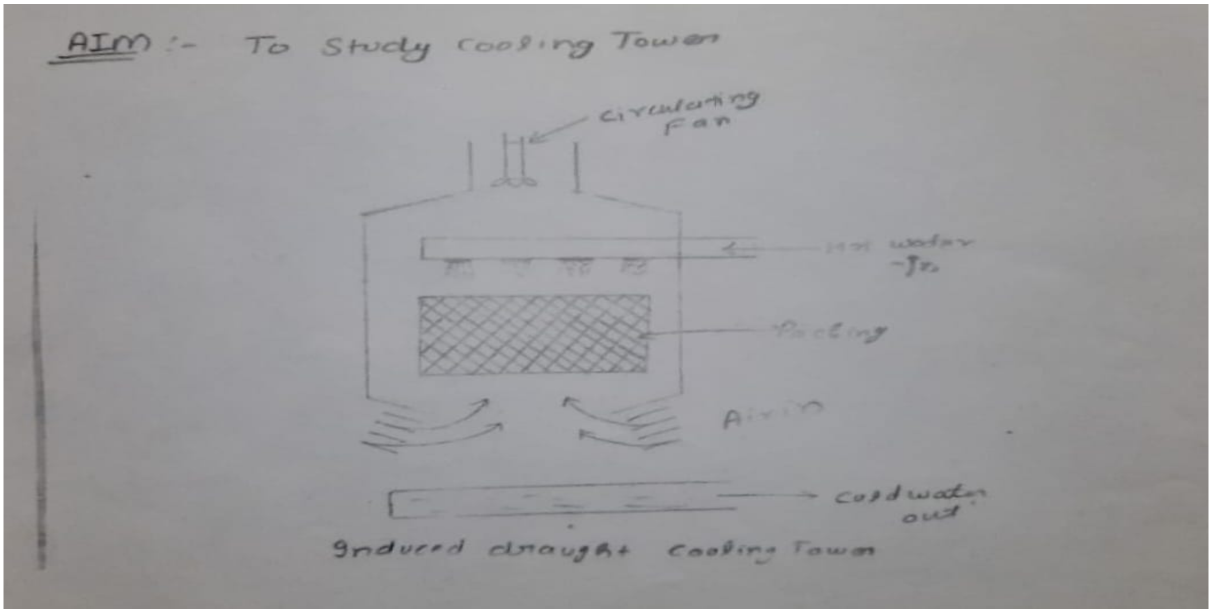
Cooling towers may be classified according to material, of which they are made i.e

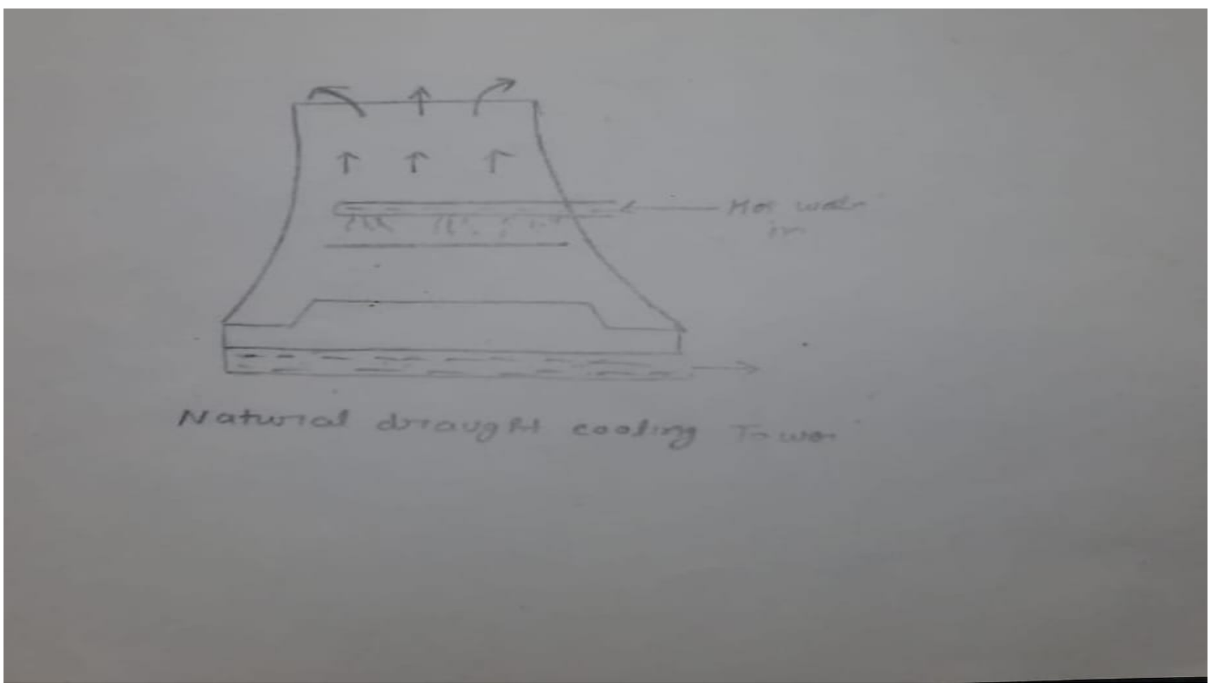
(a) Timber -Timber towers are rarely used due to following disadvantages
 i) Short Life
 ii)High maintenance charge
 iii)Limited cooling capacity

(b) Concrete:- Concrete tower possess the following disadvantages
 i) Increase in stability under air pressure
 ii) Low Maintenance
 iii) Improve rough & air circulation
 iv) Large capacity sometime in the order of 5 x 10^3 m^3/h

(c) Steel Duct type:-Duct type cooling tower are rarely used in case of modern power plant owing to small capacity

The cooling tower require a drought of air for evaporation of water sprayed. The drought may be created by chimney or available natural air velocity or by fans. The mechanical drought may be forced or induced depending on placement of fans.


AIM :- To Study cooling Tower
circulating Fan
Hot water in
Packing
Air in
Cold water out
Induced draught Cooling Tower


Hot water in
Natural draught cooling Tower