

## **EXPERIMENT NO: 1**

### **FLASH AND FIRE POINT**

#### **(PENSKY MARTENS CLOSED CUP APPARATUS)**

**Conduct an experiment to determine the Flash point and Fire point of a given oil using Pensky Martens closed cup apparatus**

**AIM:** To determine the flash and fire point temperatures of the given sample of oil (Kerosene) using Pensky Martens closed Cup Apparatus.

#### **APPARATUS REQUIRED:**

1. Pensky Martens closed Cup Apparatus.
2. Thermometers
3. Electric heating arrangement.
4. Sample of oil.

#### **THEORY:**

**The flash point of any oil is defined as the lowest temperature at which it forms vapors and produces combustible mixture with air.** The higher flash point temperature is always desirable for any lubricating oil and lower flash point for any fuel. If the oil has the lower value of the flash point temperature, it will burn easily and forms the carbon deposits on the moving parts. The minimum flash temperature of the oil used in I.C engines varies from 200<sup>0</sup>C to 250<sup>0</sup>C .When the oil is tested by using the open cup apparatus, the temperature is slightly more than the above temperatures.

**The fire point of any oil is the lowest temperature at which oil just begins to burn continuously.** Flash and fire point temperature differs by 3<sup>0</sup>C to 5<sup>0</sup>C when it is tested. However a greater difference may be obtained if some additives are mixed with oil .The flash and the fire point temperatures depends upon the volatility of the oil

Fire and flash points are good indication of relative flammability of the oil and also limits the operating temperature of oil. Except for the safety from fire hazards, they do not have any significance for engine operation.

However, fire and flash points of lube oil are very good indication of the crankcase dilution. The fuel, which leak into the crankcase, readily evaporate and burn at considerably lower temperature than the temperature at which the oil would have burned, clearly indicates the degree of dilution.

Flash and fire point of the given light oil (Kerosene/Diesel) is determined by heating the oil in Pensky Martens closed Cup apparatus and measuring the temperature at regular interval till it reaches the temperature of flash and then the fire points is obtained and similarly by cooling the Flash and fire points are observed.

### **DESCRIPTION:**

The main components of the **Pensky Martens Closed cup Apparatus** is as follows

1. Oil Cup
2. Air Bath
3. Electric Heating Arrangement
4. Energy Regulating Box
5. Top Plate
6. Cover Assembly Having
  - Cover
  - Shutter
  - Stirring Device
  - Flame Exposure Device
  - Thermometer Socket

The brass oil cup is meant for heating the petroleum products to the Flash Point. It carries a mark all round in the inside to show the required level of liquid.

The cup has a flange which rests on the brass top and the lower parts of the cup is within the Air Bath or heating vessel. The top plate is screwed to the air Bath through brass Spacers, so that an air gap is produced between the cup and the air bath by which the transmission to the cup is almost entirely by heated air. The cup flange has an indicator to fit correctly on the Top Plate. The heat is supplied from 220V A.C. Mains, by an electric heater kept below the air bath and regulation of the heat is done by the energy regulator. The function of the Air Bath and the Top Plate is to prevent external air draughts from interfering with the heating.

The top Cover of the lid is made of brass plate and has tubular fitment which enables it to sit on the top cup. The cover has three holes, A, B and C in the peripheral region and also one circular hole which carries a split tube for taking brass collar of a thermometer and one central hole admits stirrer rod.

### **PROCEDURE:**

1. Clean the cup and fill it with given sample of oil up to the filling mark.
2. Cover the cup with lid.
3. Thermometer is now inserted and should not touch the metallic cup.
4. Heat the oil by means of electric heater so that the sample of oil gives out vapour at the rate of  $5^{\circ}\text{C}$ -  $6^{\circ}\text{C}$  per minute.
5. Stir the sample at one or two revolution per seconds.
6. When the oil gives out vapour, introduce the test flame above the lid, wait for flash with flickering sound.
7. Introducing test flame should be continued at regular intervals until the first flash is observed with peak flickering sound .The temperature corresponding to this flickering sound is noticed and it is flash point temperature of the given sample of oil.
8. Do not stir the sample while applying the test flame.

9. Continue the process of heating and introducing the test flame until the oil will begins to burn continuously ( for 5 seconds at least)and observe the temperature. This is the fire point temperature of the given sample of oil.
10. Repeat the test twice or thrice with fresh same sample of oil and observe the results.

**EXPERIMENTAL SETUP:**

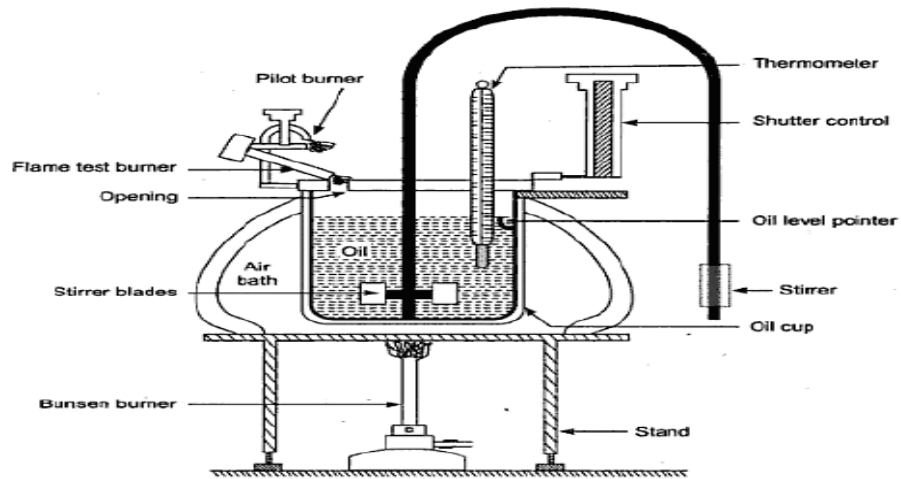


Figure : Pensky Marten's Flash Point Apparatus

**OBSERVATIONS:**

Given Sample of oil is -----

**TABULAR COLUMN:**

Sl. No	Temperature of oil in <sup>0</sup> C	Observation-No Flash/Flash/Fire
1.		
2.		
3.		

**RESULT:**

The flash point temperature of the given sample of oil is \_\_\_\_\_<sup>0</sup>C

The fire point temperature is of the given sample of oil is \_\_\_\_\_<sup>0</sup>C

## **EXPERIMENT NO: 2**

### **FLASH AND FIRE POINT (ABLE'S CLOSED CUP APPARATUS)**

**Conduct an experiment to determine the Flash point and Fire point of a given oil using Able's closed cup apparatus**

**AIM:** To determine the flash and fire point temperatures of the given sample of oil using Able's closed Cup apparatus.

#### **APPARATUS REQUIRED:**

1. Able's closed cup apparatus
2. Thermometer
3. Splinter sticks.
4. Sample of oil.

#### **THEORY:**

**Flash point** of the oil is the lowest temperature at which the oil gives sufficient amount of vapors resulting in a flash when a flame is brought near to it.

**Fire point** is the lowest temperature at which the oil gives sufficient amount of vapors resulting in a continuous burning of the oil when the flame is brought near to it.

#### **PROCEDURE:**

1. Clean the cup and fill it with given sample of oil up to the filling mark.
2. Insert the thermometer in the holder. Make sure that the thermometer should not touch the metallic cup.
3. Heat the oil by means of electric heater so that the sample of oil gives out vapour at the rate of  $10^{\circ}\text{C}$  per minute.
4. When the oil gives out vapour, introduce the test flame above the oil, without touching the surface of the oil and watch for flash with flickering sound.
5. Introducing test flame should be continued at regular intervals until the first flash is observed with peak flickering sound. The temperature corresponding to this flickering sound is noticed and it is flash point temperature of the given sample of oil.
6. Continue the process of heating and introducing the test flame until the oil will begins to burn continuously and observe the temperature. This is the fire point temperature of the given sample of oil.
7. Repeat the test twice or thrice with fresh same sample of oil and observe the results.
8. The observation is tabulated.

**EXPERIMENTAL SETUP:**

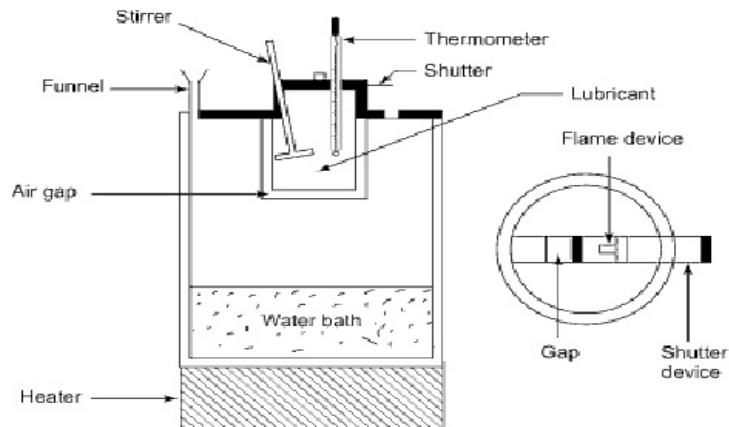


Figure: Abel's Flash Point Apparatus

**OBSERVATION:**

Type of Oil used: -----

**TABULAR COLUMN:**

Sl. No.	HEATING	
	Temperature in $^{\circ}\text{C}$	Observation
1		
2		
3		
4		

**RESULT:**

The flash point of the given oil is ..... $^{\circ}\text{C}$

The fire point of the given oil is ..... $^{\circ}\text{C}$

### **EXPERIMENT NO. 3**

## **FLASH POINT AND FIRE POINT BY CLEVELAND (OPEN CUP) APPARATUS**

**AIM:** To determine the flash point and fire point of petroleum products by Cleveland (Open cup) apparatus.

**APPARATUS:** Cleveland apparatus, thermometer.

### **THEORY:**

**Flash point** of the oil is the lowest temperature at which the oil gives sufficient amount of vapors resulting in a flash when a flame is brought near to it.

**Fire point** is the lowest temperature at which the oil gives sufficient amount of vapors resulting in a continuous burning of the oil when the flame is brought near to it.

### **PROCEDURE:**

1. Keep the apparatus on a table near a 230V, 50Hz, 5 amps power source.
2. Clean the oil cup with a soft cloth and fill the oil to be tested into the cup up to the mark.
3. Place the oil filled cup on heater; insert the thermometer into the clip, until the thermometer sensor bulb just dip into the oil surface.
4. Switch on the heater and heat the oil at a faster rate for first few min (2- 3 min) and control the heating rate at very slow rate ( $10^{\circ}\text{C}$  rise in 60 seconds) as the oil approaches the flash point.
5. Apply a test flame at every  $1.5^{\circ}\text{C}$  rise in temperature.
6. Record the temperature at which first flash occurs and report as flash point of the sample oil.
7. To obtain the fire point, continue heating at the same rate and keep applying the test flame to the surface of oil.
8. At approximately  $10^{\circ}\text{C}$  to  $15^{\circ}\text{C}$  rise in oil temperature above the flash point, applying the test flame the oil surface continue to burn for 5 to 6 seconds. Record the temperature at this point which is the fire point of the oil under test.
9. Tabulate the readings and declare the temperature as flash point and fire point of the oil under test.

### **OBSERVATION:**

Type of Oil: -----

**TABULAR COLUMN:**

Sl. No	Oil Temperature in $^{\circ}\text{C}$	Observations (Yes or No)	
		Flash point	Fire point
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10			

**RESULT:**

1) Flash Point of given oil = ----- $^{\circ}\text{C}$

2) Fire Point of given oil = -----  $^{\circ}\text{C}$

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**EXPERIMENT NO. 4****BOMB CALORIMETER**

**AIM:** To determine the calorific value of solid fuels.

**APPARATUS:** The Bomb Calorimeter mainly consists of the following:

1. Stainless steel Bomb
2. Calorimeter Vessel with Bomb support and insulating base
3. Water Jacket with outer body
4. Lid for water Jacket
5. Stirrer assembly with F.H.P. motor
6. Bomb firing unit with Electronic Digital Temperature Indicator
7. Pellet Press
8. Stand and dial pressure gauge
9. Connecting tubes(copper tubes O<sub>2</sub> Cylinder to pressure gauge & pressure gauge to bomb)
10. Connecting electrical leads(Firing unit to water jacket & water jacket to bomb)
11. Crucible Stainless steel
12. Gas release valve
13. Oxygen cylinder valve

**THEORY:**

A Bomb Calorimeter will measure the amount of heat generated when matter is burnt in a sealed chamber (Bomb) in an atmosphere of pure oxygen gas.

A known amount of the sample is burnt in a sealed chamber. The air is replaced by pure oxygen. The sample is ignited electrically. As the sample burns, heat is produced. The rise in temperature is determined. Since, barring heat loss the heat absorbed by calorimeter assembly and the rise in temperature enables to calculate the heat of combustion of the sample.

**W**=Water equivalent of the calorimeter assembly in calories per degree centigrade(2330 cal / °C)

**T**=Rise in temperature (registered by a sensitive thermometer) in degree centigrade

**H**=Heat of combustion of material in calories per gram

**M**=Mass of sample burnt in grams

Then  $W T = H M$

“H” is calculated easily since W, T and M are known,

$$\therefore H = \frac{WT}{M}$$



**PROCEDURE:**

1. Install the equipment on a plain flat table near a 230V, 50Hz, 5amps electrical power source and 15mm tap size water source.
2. Weigh the empty S.S. crucible and record.
3. Weigh exactly 1 gm of powdered dry fuel sample, pour it into the pellet press and press it to form a briquette (tablet / pellet), put it into the crucible and weigh it again to get the exact weight of the solid fuel sample.  
i.e. weight of (crucible + sample) – (empty crucible)
4. Open the bomb lid, keep it on the stand; insert the S.S. crucible into the metallic ring provided on one of the electrode stud.
5. Take a piece of ignition wire of about 100 mm length, weigh it and tie it on the electrode studs, in such a way that the wire touches the fuel pellet, but not the sides of the S.S. crucible.
6. Insert a piece of cotton thread of known weight on to the ignition wire without disturbing it.
7. Lift the Bomb lid assembly from the stand, insert it into the S.S. Bomb body and secure it with the cap.
8. Fill water into the outer shell to its full capacity, insert a glass thermometer with rubber cork. Keep the insulating base in position inside the shell.
9. Fill oxygen gas to about 20 atmospheres into the Bomb with the help of copper tubes with end connectors through pressure gauge from an oxygen cylinder (Oxygen cylinder is not in the scope of supply).
10. Fill water into the calorimeter vessel up to half its capacity and place the assembled Bomb unit, charged with oxygen into it in position. Top up with more water to bring the water level in the calorimeter vessel up to the Bomb lid level.
11. Keep the entire vessel assembly on the insulated base already placed in the outer shell. This should be carried out without disturbing the vessel assembly.
12. Connect the bomb unit to the Bomb firing unit with the electrical leads (connecting wires) and close the shell lid.
13. Insert the stirrer unit into the calorimeter vessel in proper position through the shell lid and secure it; connect the stirrer unit with the firing unit, also insert the thermocouple sensor into the calorimeter vessel through the shell lid and connect it to the firing unit.
14. Connect the Bomb firing unit to an electrical source of 230v, 50Hz, 5 amps keeping all the switches on the firing unit in “OFF” position.
15. Switch “ON” the main switch of the firing unit. Now the temperature indicator indicates the temperature sensed by the thermocouple.
16. Switch “ON” the stirrer unit.
17. Press the “green” button on the firing unit to check the continuity in the Bomb unit, observe the indicator glow.
18. Wait till the temperature in the calorimeter vessel, stabilize and record it as initial temperature. Press the “red” button on the firing unit to fire the sample inside the Bomb.
19. Now the temperature of the water in the calorimeter vessel starts rising, note and record the rise in temperature at every one-min. interval until the rise in temperature stabilizes or starts dropping.
20. Tabulate all the readings and calculate the calorific value of the solid fuel under test.
21. To close the experiment switch “OFF” the stirrer and main switch, open the shell lid and take out the Bomb assembly from the calorimeter vessel. Release all the flue gases from the Bomb

with the help of release valve, unscrew the cap open the lid and observe all the fuel sample is burnt completely.

22. Clean the Bomb and crucible with clean fresh water and keep it dry.

### **OBSERVATIONS:**

Calorific value of Standard Benzoic Acid (H) = 6319 Cal /gm

Water equivalent of Calorimeter (W) 2330 Cal/ °C

### **CALCULATIONS:**

$$WT = HM$$

$$\therefore H = \frac{W \times T}{M}$$

Where, W = Water equivalent of Calorimeter Cal/°C

H = Calorific Value of solid fuel sample in Cal/gm to be determined

T = Rise in temperature due to combustion of solid fuel inside the Bomb °C.

M = Mass of solid fuel sample Burnt inside the Bomb gms

### **RESULTS:**

Calorific value of given gaseous fuel is = -----

## **EXPERIMENT NO. 5**

### **BOY'S GAS CALORIMETER**

**AIM:** To determine the calorific value of gaseous fuel by Boy's Gas Calorimeter.

**APPARATUS:** Gas calorimeter, gas cylinder (small), digital weighing balance, Rotameter, control valves, pipe connections and Temperature indicator with Thermocouples (RTD).

#### **THEORY:**

This calorimeter is intended for the purpose of determining, the "Calorific Value of Gaseous Fuel", experimentally. The method is based on heat transfer from burning the known quantity of gaseous fuel for heating the known quantity of water that circulates in a copper coil heat exchanger. With the assumption that the heat absorbed by the circulating water is equal to the heat released from the gaseous fuel, is accurate enough for calculation of calorific value.

The gaseous fuel from the cylinder, which is kept on a weighing scale passes through the pipe connected to the burner of the calorimeter with a control valve. Water connection from a water source of 15-mm tap size is connected to the calorimeter through a Rotameter to circulate through the calorimeter. Temperature measurement is made on a digital temperature Indicator with RTD sensors located at inlet and outlet water connections.

Weight of gas burnt is directly indicated by the digital weighing scale in Kg. Amount of water flowing through the calorimeter is indicated by the Rotameter in LPM. The Digital temperature indicator indicates the inlet and outlet water temperature.

#### **PROCEDURE:**

1. Install the equipment near a 230V, 50Hz, 5amps, Single-phase power source (power socket) and an un interrupted water source of 15 mm tap size.
2. Keep the gas cylinder on the weighing scale, connect the rubber tube with regulator to gas cylinder and calorimeter. Keep the regulator closed.
3. Connect the un interrupted water source to the inlet of the Rotameter through control valve with a suitable flexible hose and the out let to drain.
4. Switch "on" the electrical main switch as well as the digital balance switch. Now the digital balance indicates some reading. Tare the cylinder weight to "zero".
5. Open the gas control valve, allow water into the calorimeter by opening Rotameter control valve, as the water starts flowing into the calorimeter ignition takes place automatically and starts burning. Adjust the water flow rate to any desired value by operating the Rotameter control valve and allow the calorimeter to stabilize.
6. Note down the readings indicated by the digital balance, Rotameter and temperature indicator (inlet & outlet).
7. Repeat the experiment by changing the flow rate of water.
8. Tabulate the readings and calculate the calorific value of the gaseous fuel.

**TABULAR COLUMN:**

Sl. No	Water flow rate			Weight of gas Initial - Final X1 - X2 Kg Kg	Difference X Kg	Time for X Kg in sec	Gas flow Kg/s	Water Temperature			Calorific Value Cv Kcal/ kg
	LPM	LPS	Kg/s					Tin °C	Tou t°C	Δt °C Tout-Tin	
1.											
2.											
3.											
4.											
5.											
6.											

**CALCULATION:**

The calorific value of gaseous fuel

$$C_v = \frac{W_w \times C_{p_w} \times \Delta t}{W_f} = \text{Kcal/ kg}$$

Where,

$W_w$  = weight of water flowing through Calorimeter in Kg/s (1 Kg=1 liter water)

$C_{p_w}$  = specific heat of water is 4.187 J/grams °C, 1 Kcal / Kg °C

$\Delta t$  = difference between water inlet and outlet temperature

$W_f$  = weight of Gaseous fuel burnt in Kg/s

**RESULT:**

Calorific value of given gaseous fuel is = -----K Cal/Kg

**EXPERIMENT NO. 6****VISCOSITY OF OIL USING SAYBOLT VISCOMETER**

**Conduct an experiment to determine the Absolute and Kinematic viscosity of a given lubricating oil at different temperatures using Saybolt Viscometer**

**AIM:** To determine the Absolute and Kinematic viscosity of a given sample of oil (SAE grade) at different temperature using Saybolt Viscometer.

**APPARATUS REQUIRED:**

Say bolt Viscometer, 60cc jar, thermometer, stopwatch, weighing box and Heating source.

**THEORY:**

Viscosity is the property of a liquid to resist shearing or sliding of its layers. It arises from cohesion and interaction between the fluid molecules and is manifested only when the fluid is in motion, either by a body moving through a fluid or a fluid moving around a body. When the liquid layers move with different velocities, internal friction forces appear which depend upon the time rate of shear deformation. In this respect, the liquid differ from solid in which shear stress is a function of the shear deformation itself. Newton postulated that the shear stress within a fluid is proportional to the spatial rate of change of velocity normal to the flow. The spatial rate of change of velocity is called the velocity gradient ( $dV/dy$ ). Then by **Newton's Hypothesis**

$$\tau = \mu (dV/dy).$$

Where  $\tau$  is the internal friction shear stress, ( $dV/dy$ ) is velocity gradient i.e. the change in the velocity per unit of distance between the adjacent layers of the fluid layers of the liquid (in a direction at right angles to the direction of motion); and  $\mu$  is the proportionality constant depending upon nature of the liquid and called the viscosity coefficient, absolute viscosity or dynamic viscosity.

For the homogeneous fluids, for liquids viscosity decreases with temperature whereas for a gas it increases with temperature growth.

**Absolute viscosity (Dynamic viscosity)** is defined as the force which the surface of one square cm exerts on a parallel plate at a distance of 1cm moving with a velocity of 1cm/sec, the space between being filled with liquid.

$$\text{Units: } 1 \text{ poise (P)} = 1 \text{ Dyne-s/cm}^2 = 10^{-1} \text{ N-s/m}^2$$

$$1 \text{ centipoises} = 10^{-2} \text{ poise} = 10^{-3} \text{ N-s/m}^2$$

**Kinematic viscosity** is defined as the ration of absolute viscosity to its density at the temperature.

$$\text{Units: } 1 \text{ stokes (st)} = 1 \text{ cm}^2/\text{s} = 10^{-4} \text{ m}^2/\text{s}$$

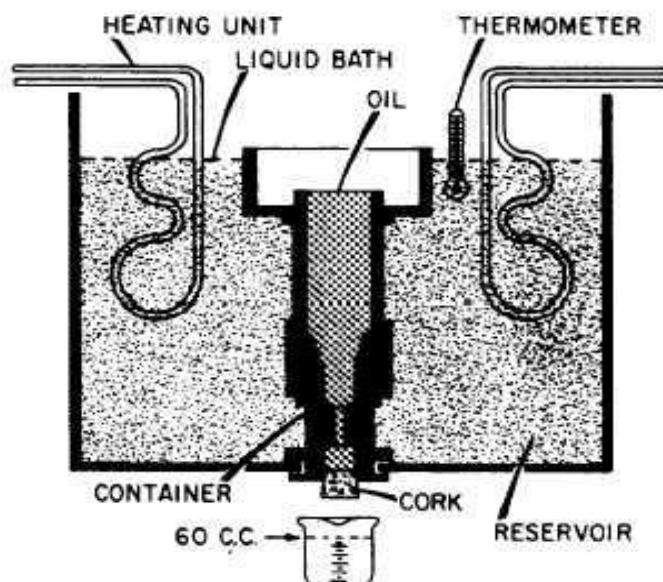
$$1 \text{ centistokes (c.st)} = 10^{-2} \text{ stokes} = 10^{-6} \text{ m}^2/\text{s}$$

Viscosity is usually measured with aid of viscometers (Saybolt or Redwood) in terms of Saybolt or Redwood Universal Seconds which is time required in seconds for a given quantity of oil to flow through a capillary tube under the specified test conditions.

Viscosity index: the viscosity of oil is substantially affected by its temperature, higher the temperature lower is the viscosity. This variation of viscosity of oil with changes in temperature is measured by its viscosity index. The oil is compared with two reference oils having same viscosity at 99<sup>0</sup>c. One, paraffinic base oil (considerable change in viscosity with temperature), is assigned an index of zero, Naphthenic base oil (little change in viscosity with temperature,), is assigned as index of 100.

High viscosity index number indicates relatively smaller changes in viscosity of the oil with temperature. Viscosity index of an oil is very important where extreme temperature are encountered. The lubricating oil must maintain a sufficient viscosity at high temperatures and still should not be too viscous for starting the engine at low temperatures.

Variation of viscosity with temperature: temperature affects the viscosity. The viscosity of liquids decreases with the increase of temperature, while the viscosity of gases increases with the increase in temperature. This is due to reason that the viscous forces in a fluid are due to cohesive forces and molecular momentum transfer. In liquids the cohesive forces pre-dominates the molecular momentum transfer, due to closed packed molecules and with the increase in temperature, the cohesive forces decreases with the result of decrease in viscosity, but in case of gases the cohesive forces are small and molecular momentum transfer pre-dominates. With the increases in temperature, molecular momentum transfer increases and hence viscosity increases.



**Figure: Saybolt Viscometer**

**PROCEDURE:**

1. Clean the oil cup, the jet hole by a fine thread.
2. Set up the viscometer to ensure its level using a circular spirit level.
3. Fix the cork at the orifice.
4. Fill the test oil, up to the mark.
5. Insert a thermometer in oil bath.
6. Fill the water bath little above the mark.
7. Clean the 60 ml jar and weigh it.
8. Heat the water bath using an electric heater and stir it continuously.
9. Place the jar in the position under the orifice, when the oil temperature becomes steady at the desired level of temperature, remove the cork from the orifice and at the same time, start the stop watch.
10. Weigh the jar when it collects 60cc of oil in the bottle, stop the watch and tabulate the values of time taken and fix the cork in its position.
11. This is repeated for different temperatures preferable with an increment of 10<sup>0</sup>c.

**OBSERVATION :**

1. Oil used : \_\_\_\_\_
2. Volume of oil taken (V): \_\_\_\_\_

**TABULAR COLUMN:**

Sl. No	Oil Temp in °C	Jar Wt W <sub>1</sub> in gms	jar Wt+60 cc of oil W <sub>2</sub> gms	Wt. Of oil W=W <sub>2</sub> -W <sub>1</sub>	Time for 50ml flow 't'sec	Density W/V in gms/cm <sup>3</sup>	Kinematic Viscosity in m <sup>2</sup> /s	Absolute Viscosity Ns/m <sup>2</sup>
1								
2								
3								
4								

**CALCULATIONS:**

1. The Kinematic Viscosity is determined using empirical relation

$$KV = \left[ 0.22t - \frac{180}{t} \right] \times 10^{-6} \text{ in m}^2/\text{s}$$

2. The Absolute Viscosity is determined using empirical relation

$$AV = KV \times \text{density of oil at the temperature of experiment}$$

$$AV = KV \times \rho \times 10^3 \text{ Ns/m}^2$$

**RESULTS:**

1. Kinematics viscosity (K.V) = \_\_\_\_\_  $\text{m}^2/\text{s}$
2. Absolute viscosity (AV) = \_\_\_\_\_  $\text{N-s/m}^2$

**GRAPH:**

- Kinematics viscosity v/s Temperature in  $^{\circ}\text{C}$ .
- Absolute viscosity v/s Temperature in  $^{\circ}\text{C}$



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**EXPERIMENT NO. 7****VISCOSITY OF OIL USING REDWOOD VISCOMETER**

**Conduct an experiment to determine the Absolute and Kinematic viscosity of a given lubricating oil at different temperatures using Redwood Viscometer**

**AIM:** To determine the Absolute and Kinematics viscosity of a given sample of oil (SAE grade) at different temperature using Redwood Viscometer.

**APPARATUS:** Redwood Viscometer, 50 cc jar, thermometer, stopwatch, weighing box and Heating source.

**PROCEDURE:**

1. The oil cup is cleaned by using petrol and given oil is taken up to mark. Care is taken such that the ball is kept in position.
2. The cleaned specific gravity bottle is weighed accurately.
3. The room temperature is noted.
4. The ball is lifted and oil is collected in specific gravity bottle. The time taken for the flow of oil (50 cc) is noted.
5. The specific gravity bottle with oil is weighed accurately.
6. Repeat the experiment with different temperature of the oil.

**THEORY:**

**Absolute viscosity (Dynamic viscosity)** is defined as the force which the surface of one square cm exerts on a parallel plate at a distance of 1cm moving with a velocity of 1cm/sec, the space between being filled with liquid.

$$\text{Units: } 1 \text{ poise (P)} = 1 \text{ Dyne-s/cm}^2 = 10^{-1} \text{ N-s/m}^2$$

$$1 \text{ centipoises} = 10^{-2} \text{ poise} = 10^{-3} \text{ N-s/m}^2$$

**Kinematic viscosity** is defined as the ration of absolute viscosity to its density at the temperature.

$$\text{Units: } 1 \text{ stokes (st)} = 1 \text{ cm}^2/\text{s} = 10^{-4} \text{ m}^2/\text{s}$$

$$1 \text{ centistokes (c.st)} = 10^{-2} \text{ stokes} = 10^{-6} \text{ m}^2/\text{s}$$

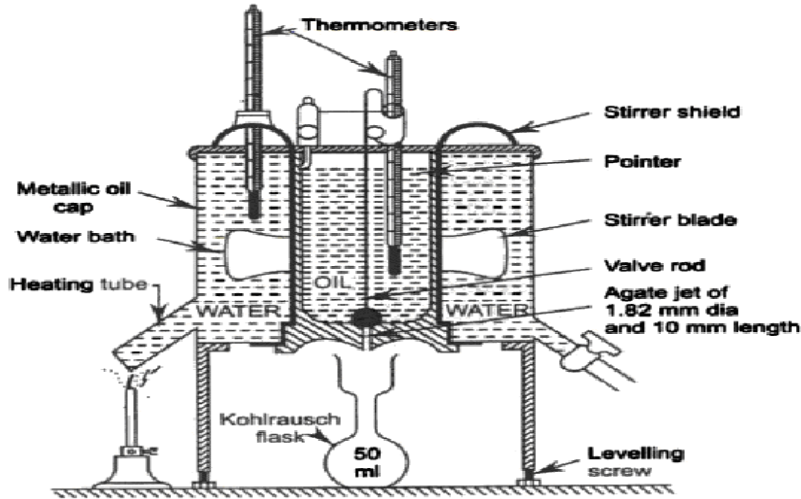


Figure: Redwood Viscometer

**OBSERVATION:**

1. Oil used: \_\_\_\_\_
2. Volume of oil taken (V): \_\_\_\_\_

**TABULAR COLUMN:**

Sl. No	Oil Temp in °C	Jar Wt W <sub>1</sub> in gms	jar Wt+60 cc of oil W <sub>2</sub> gms	Wt. Of oil W=W <sub>2</sub> -W <sub>1</sub>	Time for 50ml flow 't'sec	Density W/V in gms/cm <sup>3</sup>	Kinematic Viscosity in m <sup>2</sup> /s	Absolute Viscosity Ns/m <sup>2</sup>
1								
2								
3								
4								

**CALCULATIONS:**

1. The Kinematic Viscosity is determined using empirical relation

$$KV = \left[ 0.247t - \frac{65}{t} \right] \times 10^{-6} \text{ in m}^2/\text{s}$$

2. The Absolute Viscosity is determined using empirical relation

$$AV = KV \times \text{density of oil at the temperature of experiment}$$

$$AV = KV \times \rho \times 10^3 \text{ Ns/m}^2$$

**RESULTS:**

1. Kinematics viscosity ( K.V) = \_\_\_\_\_  $\text{m}^2/\text{s}$

2. Absolute viscosity (AV) = \_\_\_\_\_  $\text{N-s/m}^2$

**GRAPH:**

1. Kinematics viscosity V/s Temperature in  $^{\circ}\text{C}$

2. Absolute viscosity V/s Temperature in  $^{\circ}\text{C}$

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**EXPERIMENT NO. 8****TORSION VISCOMETER**

**AIM:** To determine the viscosity of given oil using torsion viscometer

**APPARATUS:** Torsion Viscometer, sample oil & thermometer.

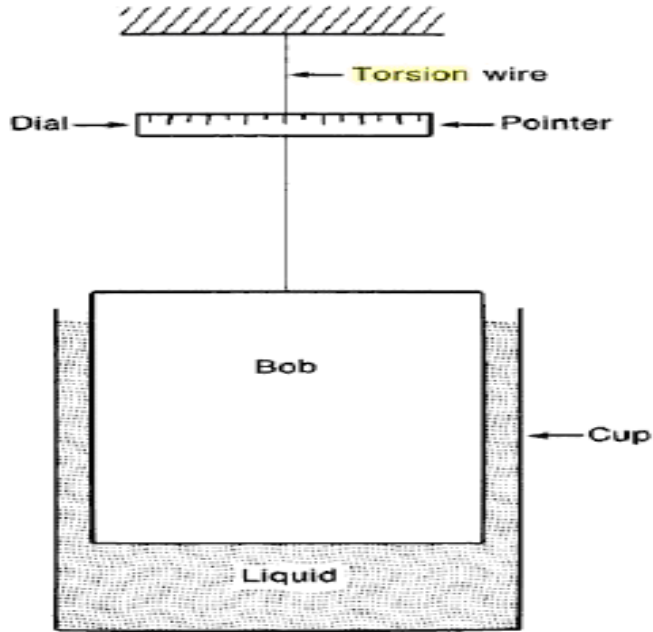
**THEORY:**

Torsional Viscometer type Gallenkamp. Torsional instrument for the viscosity determination of ceramic fluids and other types. The torsional viscometer Gallenkamp type makes viscosity measurements following the principle that a rotating cylinder immersed in a fluid is subject to a viscous drag. The apparatus consists of a device to hold a solid cylinder and a flywheel by means of a Torsion wire with end connectors. A release pin is provided to hold the flywheel in horizontal position. The flywheel is, surrounded by a graduated scale in degrees ( $0^0$  to  $360^0$ ). A pointer is attached to the flywheel to indicate the angular movement of the flywheel. Oil cup to hold the oil under test

**PROCEDURE:**

1. Install the apparatus on a plain flat table and level it with leveling screws.
2. Insert the torsion wire with end connectors into the tube vertically downwards with the top end connector of the wire fixed to a stationary head
3. Insert the bottom end connector of the wire into the top portion of the flywheel and secure it.
4. Fix the solid cylinder to the bottom portion of the flywheel.
5. Pour clean filtered oil to be tested into the oil cup up to about 5mm to 10mm below the top of the oil cup and place it on the platform provided and properly position it.
6. Slightly lift the top stationary head so that the flywheel along with torsion wire is free to rotate horizontally and position the pointer of the flywheel exactly in front of the release pin.
7. Adjust the pointer of the flywheel to zero degree by turning the stationary head either way with absolutely no torsion in the wire and tighten the stationary head.
8. Lift the oil cup along with the platform in such a way that, the solid cylinder under the flywheel completely immersed in the oil under test.
9. Manually give one full rotation to the flywheel ( $0^0$  to  $0^0$ ) and secure it in the release pin.
10. Now the apparatus is ready for the test
11. Slowly pull the release pin back without disturbing the set up.
12. The flywheel starts rotating and completes one full rotation ( $0^0$  to  $0^0$ ) and moves beyond zero purely by virtue of its momentum. This angular movement beyond zero

(over swing) is recorded and the viscosity of the oil under test in Redwood seconds is obtained from the graph provided.



**Figure: Torsion Viscometer**

**OBSERVATION:**

Type of oil used.....

**TABULAR COLUMN:**

Sl.no	Temperature of oil in °C	Angular rotation on the disk in degrees	Corresponding redwood seconds from graph
1			
2			
3			

**RESULTS:**

1. Kinematics viscosity ( K.V) = \_\_\_\_\_ m<sup>2</sup>/s

## **EXPERIMENT NO. 9**

### **VALVE TIMING DIAGRAM**

**AIM:** To draw the valve timing diagram of a given diesel engine.

**APPARATUS:** Four Stroke Diesel Engine - cut section.

#### **THEORY:**

The valve timing is the regulation of the position in the cycle at which the valves are set to open and close. Since the valve require a finite period of time to open or close without abruptness, a slight lead time is necessary for proper operation. The design of valve operating cam provides for smooth transition from one position from other, while cam time determines the valve timing.

#### **INLET VALVE**

The inlet valve opens little degree prior to the arrival of the piston at TDC during exhaust stroke. This ensures inlet valve fully opens so that fresh charge starts to flow into the cylinder as soon as piston starts moving downwards for suction stroke. If the inlet valve is allowed close at BDC the cylinder receive less charge than its capacity and pressure of the charge at the end of suction stroke will be below atmosphere. To avoid this , the inlet valve is made to open for 40 to 50<sup>0</sup> of crank rotation after the suction stroke for high speed engine and for high speed engine it is around 20 to 25<sup>0</sup> crank rotation.

The kinetic energy of the charge produces a ram effect which packs more charge into the cylinder during this additional valve opening. Therefore inlet valve closing is delayed. Higher the speed of the engine, the inlet valve closing is delayed longer to take a advantage of ram effect.

#### **EXHAUST VALVE**

Complete clearance of the exhaust gas from the cylinder is necessary to take in more charge. Earlier opening of the exhaust valve before reaching to TDC facilitates the removal of the burnt gases by virtue of the pressure at this point. The kinetic energy of the fresh charge may also assist the removal of the burnt gases. Due to these reasons there is always overlap of valve opening

#### **IDENTIFICATION OF THE VALVES:**

The valves can be identified as follows. The valve that is situated in the intake manifold is the inlet valve and the other is the exhaust valve.

#### **CORRECT DIRECTION OF ROTATION:**

The flywheel is rotated in an arbitrary direction. If the exhaust valve opens after nearly one revolution of the flywheel after the closure of the inlet valve, it is correct direction of rotation.

Inlet valve begins to open when the piston starts moving downward direction and both valves begin to close during upward movement of the piston. As piston descends again, both valves remain closed and only exhaust valve should start opening during upward motion of piston during two revolution of the fly wheel for the correct direction to be ensured.

### **TIMING OF VALVE OPENING AND CLOSING:**

The flywheel is rotated in the correct direction of rotation. A feeler gauge is introduced in the taper clearance, when the feeler gauge is just gripped; it is the point at which the valve begins to open. The rotation is continued until the gauge just released. A mark is made on the flywheel against the fixed mark. This is closing point for the valve. The same procedure is repeated for the other valve.

### **FUEL INJECTION TIMING:**

The pressure tube from the pump is removed. The flywheel is rotated. When the oil just rises in the fuel pump, it is the point at which the fuel is going to be injected. A mark is made on the flywheel with respect to the fixed mark. The flywheel is rotated slowly and the oil is removed by cotton waste simultaneously. When the fuel level in the pump outlet cases to rise, it is the point at which the fuel injection ends. A corresponding mark is made on the flywheel.

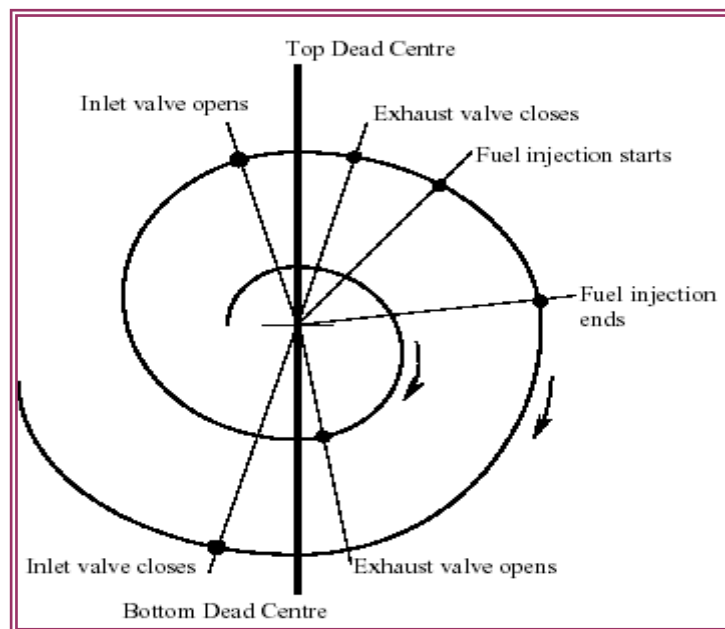
### **PROCEDURE:**

1. Identify BDC and TDC-visible as engine is a cut section.
2. Identify the Inlet and Outlet Valves
3. Ensure the correct direction of rotation
4. Find the reading in degree on the flywheel at TDC and BDC. Some play of the flywheel should be carefully adjusted for.
5. Keep the piston just before TDC and start moving fly wheel in correct direction.
6. Watch the movement of the Inlet Valve carefully and note the reading on flywheel against a pointer on the engine frame for this.
7. This difference of value from TDC corresponds to Inlet Valve opening either before TDC (bTDC) or After TDC (aTDC), depending upon valve movement after or before TDC.
8. Keep moving the flywheel, Inlet valve fully opens and ready to get closed as piston reaches BDC. This corresponds to **Suction Stroke**.
9. Note the reading on the flywheel, watching the beginning of the close of Inlet Valve with respect to BDC.
10. The difference in value between value at BDC and that at beginning of the close of inlet should be recorded as Inlet Valve closing after (aBDC) or before BDC (bBDC).
11. Move the flywheel further in the same direction till piston reaches TDC.
12. **Compression Stroke**
13. Till now Exhaust Valve is unmoved (closed only) and Inlet Valve starts to close as piston reaches TDC.
14. Note the crank angle net value when Inlet Valve closes with respect to TDC as after TDC (aTDC) or before TDC (bTDC).
15. This completes one revolution of the crank i.e  $360^0$  of crank angles.

16. Further rotation of flywheel moves piston again downwards and observe both valve in closed position. This corresponds to **Power Stroke**.
17. As piston rises from the BDC towards TDC, performing **Exhaust Stroke**, Exhaust Valve begins to move (open) and this value in net crank angles with respect to BDC as BDC or TDC is noted.
18. Finally as piston reaches TDC, Exhaust Valve starts closing and Inlet Valve begins to open for the next cycle.
19. Note down the reading for the exhaust Valve closing in terms of after or before TDC.
20. For some period, near TDC both valves may be opened which is termed as *valve overlap*.

**Typical valve timings for four stroke CI engine are as follows:**

Position	Theoretical	Actual
Inlet valve opens (IVO)	TDC	Up to 30 <sup>0</sup> before TDC
Inlet valve closes (IVC)	BDC	Up to 50 <sup>0</sup> after BDC
Exhaust valve opens (EVO)	BDC	UP to 45 <sup>0</sup> before BDC
Exhaust valve closes (EVC)	TDC	Up to 30 <sup>0</sup> after TDC



**Figure: Valve timing diagram of IC engine**



**TABULATION:**

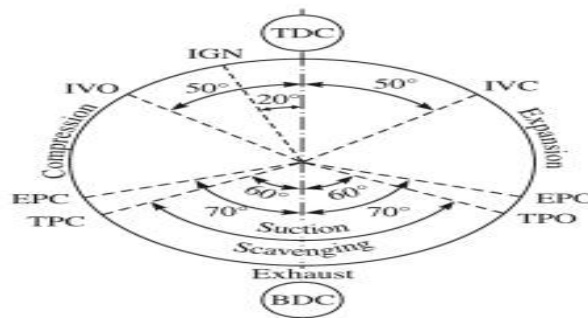
Sl.No	Particulars	Angle of rotation from top dead center
1	Inlet valve opens (IVO)	
2	Inlet valve closes (IVC)	
3	Exhaust valve opens (EVO)	
4	Exhaust valve closes (EVC)	

**RESULT:**

1. Inlet valve opens (IVO) = ..... *Before TDC*
2. Inlet valve closes (IVC) = ..... *After BDC*
3. Exhaust valve opens (EVO) = ..... *Before BDC*
4. Exhaust valve closes (EVC) = ..... *After TDC*

**EXPERIMENT NO .10****PORT TIMING DIAGRM****(Cut section petrol engine)****AIM:** To draw port timing diagram for a given petrol engine.**THEORY:** Hear in this type of engines ports which takes charge of air and fuel mixture and removes exhaust from the cylinder it self, by virtue of position of piston. When piston moves inside the cylinder it closes & opens ports. In two stroke engines one revolution of crank shaft completes one cycle .**INLET PORT:** Through which mixture of fuel and air enters the crank casing.**EXHAUST PORT:** Through which the burnet (exhaust) gas exits**TRANFER PORT:** Through which air and fuel mixture enters the cylinder head**PROCEDURE:**

1. Fix a reference pointer on the body of the engine near the flywheel
2. Identify the ports.
3. Find out the direction of rotation of the crank – shaft.
4. Mark the TDC position and BDC position on the flywheel.
5. Mark the opening and closings of the inlet, Exhaust and Transfer ports.
6. Using the protractor fixed on the flywheel, find out the angular position of the piston
7. Name the events IPO , IPC, EPO, EPC , TPO, and TPC.

**Figure: Port Timing Diagram**

**TABULAR COLOUMN:**

SL.NO	EVENT	POSITION OF CRANK	ANGULAR POSITION FROM THE NEAREST DEAD CENTRE
1	IPO	BTDC	
2	IPC	ATDC	
3	TPO	BBDC	
4	TPC	ABDC	
5	EPO	BBDC	
6	EPC	ABDC	

Where,

I P O – Inlet port opens

I P C – Inlet port closes

T P O – Transfer port opens

T P C – Transfer port closes

E P O – Exhaust port opens

E P C – Exhaust port closes

BTDC – Before top dead centre,

ABDC – After bottom dead centre

BBDC – Before bottom dead centre

ATDC – After top dead centre

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**EXPERIMENT NO: 11****PERFORMANCE TEST ON A TWO STROKE, SINGLE CYLINDER PETROL ENGINE**

Conduct the Performance test on a two stroke petrol engine and calculate the brake power, thermal efficiency, specific fuel consumption, volumetric efficiency and air-fuel ratio.

**AIM:** To conduct the performance test on a two stroke petrol engine.

**APPARATUS:** Single cylinder 2-S petrol engine set up – With provision for necessary measurements.

**SPECIFICATIONS:**

**ENGINE:** Bajaj Classic / Chetek, Two stroke, Vertical, Single cylinder, Air cooled, Spark ignition, Petrol driven.

Compression Ratio:	7.4: 1
Ignition Timing:	Spark advance of 33 degree Before TDC
Bore:	57 mm.
Stroke Length:	57 mm.
Displacement:	145.45 cc
Brake power:	2.5 HP
Speed:	3000 rpm

**DYNAMOMETER:** **Alternator AC.**

Speed:	3000 rpm
Capacity:	2 kw.
Current:	Max 10 A
Voltage:	220 V AC

**TEMPERATURE MEASUREMENTS:**

Channel No 1:	T <sub>1</sub> - Room Temperature.
Channel No 2:	T <sub>2</sub> - Air inlet Temperature.
Channel No 3:	T <sub>3</sub> - Exhaust gas Temperature.

## **THEORY:**

### **MEASUREMENTS:**

**Air Intake by Engine:** The engine is connected to volumetric tank of air tight; one end of the tank is fitted with an orifice 15 mm diameter, the tank is connected to U-tube manometer through ¼ inch, hose nipple fitting by polythene transparent tube. The deflection of manometer caused due to velocity difference between the tank and atmospheric air velocity measures the air by which we can calculate quantity of air flowing into the engine cylinder.

**Fuel Flow Measurement:** The control panel is fitted with a fuel tank which is connected to a 3-way manifold where one end of the manifold is connected to measuring burette of 100 CC capacities and the other end is connected to the engine. The fuel flow to the engine can be measured by closing the stop cock provided at the top of 3-way manifold.

**Speed:** Speed of the engine can be measured with a digital rpm indicator which is connected by sensor. The sensor is fitted near the rotating shaft of the prime mover where according to the speed the pulse signals are sent to the indicator.

**Description of Equipment:** The engine is two stroke single cylinder petrol engine, the engine flywheel is connected to rope brake drum for loading the engine.

The brake power from the engine can be calculated by torque weighing the dead weights applied on the rope brake drum. The air intake tank, fuel measuring system, speed indicator and manometer has been provided for completeness of the test rig. All measurements instrumentations are provided on an independent panel separated from the engine and loading rope brake drum unit.

### **HEAT BALANCE SHEET:**

Mainly reveals the performance of the engine. The main components of the heat balance are: 1) heat equivalent to the effective work (Break power) of the engine, 2) Heat rejected to the cooling medium, 3) Heat carried away from the engine with the exhaust gases, 3) Unaccounted losses including the radiation losses from the various parts of the engine and heat loss due to incomplete combustion. The friction loss is not shown as a separate icon item the heat balance sheet as the friction loss ultimately reappears as heat in cooling water, exhaust and radiation.

### **WORKING PRINCIPLE:**

Compressed fuel and air in the cylinder is ignited using the spark discharged by a spark-plug. The resulting explosion drives the piston to the bottom. As the piston moves to the bottom, it is compressing the air/fuel mixture in the crankcase. As the piston approaches the bottom of its stroke, the exhaust port is uncovered. The pressure in the cylinder drives most of the exhaust gases out of cylinder.

As the piston finally reaches bottom, the intake port is uncovered by the piston. The piston's movement has pressurized the mixture in the crankcase, so it rushes into the cylinder trough

transfer port, displacing the remaining exhaust gases and filling the cylinder with a fresh charge of fuel.

In many two-stroke engines, the piston is shaped so that the incoming fuel mixture doesn't flow right over the top of the piston and go out the exhaust port.

Now the momentum in the crankshaft starts driving the piston back toward the spark plug for the compression stroke. As the air/fuel mixture in the piston is compressed, a vacuum is created in the crankcase. This vacuum opens the reed valve and sucks air/fuel/oil in from the carburetor.

Once the piston reaches the end of the compression stroke, spark-plug fires again to repeat the cycle. It's called a two-stroke engine because there is a compression stroke and then a combustion stroke. In a four-stroke engine there are separate intake, compression, combustion and exhaust strokes.

### **OPERATIONS:**

1. Confirm the presence of the fuel (petrol and lubricating oil mixture) in the petrol tank and ensure that there is no load on the engine.
2. Start the engine by kicking of the pedal and choose a proper gear ratio by shifting the gear lever.
3. Allow the fuel to flow through the burette by operating the three-way cock suitably. By switching on the heater, load the engine through the alternator dynamometer.
4. Note the following readings:
  - a. Time taken for the consumption of known quantity of fuel oil in seconds.
  - b. The load on the engine in terms of voltage and current.
  - c. Speed of the engine by using a speed sensor.
  - d. Manometer reading.
  - e. Room, inlet air and exhaust gas temperatures.
5. Repeat the experiment for different loads by keeping speed constant.
6. Stop the engine at no load condition by cutting of electrical power supply to the spark plug of the engine.

### **OBSERVATION:**

- |   |                                |
|---|--------------------------------|
| 1. Cylinder Bore                              | $D = 57 \text{ mm}$            |
| 2. Stroke length                              | $L = 57 \text{ mm}$            |
| 3. Orifice Diameter                           | $D_o = 0.15 \text{ m}$         |
| 4. Orifice Co-efficient of discharge          | $C_d = 0.6$                    |
| 5. Acceleration due to gravity                | $g = 9.81 \text{ m/s}^2$       |
| 6. Calorific value of fuel                    | $CV = 47500 \text{ kJ/kg}$     |
| 7. Fuel density                               | $\rho_f = 750 \text{ kg/m}^3$  |
| 8. Water density                              | $\rho_w = 1000 \text{ kg/m}^3$ |
| 9. Particular gas constant of air             | $R = 0.287 \text{ kJ/kg-K}$    |
| 10. Specific heat of air at constant pressure | $c_p = 1.005 \text{ kJ/kg.K}$  |
| 11. Normal Atmospheric pressure               | $P_a = 1.013 \text{ bar}$      |

12. Density of air

$\rho_a$  : (obtained from  $pV=mRT$ )  
 $R= 287$ ,  $p$  in  $N/m^2$ ,  $T$  in  $^0k$

**OBSERVATION TABLE:**

Load in KW	Speed N in rpm	Energy meter reading for 3 rev in secs	Air consumption in mtrs of water read manometer $h_m$	Fuel consumption		Temperature				
				Volume in ml	Time in sec	Air Inlet Temp in $^0C$ $T_1$	Exhaust gas (inlet to calorimeter) temperature in $^0C$ $T_2$	Calorimeter Water Inlet Temp in $^0C$ $T_3$	Calorimeter Water outlet temperature in $^0C$ $T_4$	Exhaust gas (outlet from calorimeter) temp in $^0C$ $T_5$
1.										
2.										
3.										
4.										
5.										

NOTE: TEMPERATURE POINTS,

$T_1$  = AIR INLET TEMPERATURE

$T_2$  = EXHAUST GAS TEMPERATURE BEFORE CALORIE METER

$T_3$  = CALORIE METER WATER INLET TEMPERATURE

$T_4$  = CALORIMETER WATER OUTLET TEMPERATURE

$T_5$  = EXHAUST GAS TEMPERATURE AFTER CALORIE METER

**LIST OF FORMULAE:**

**1. Electrical Power as indicated by Energy Meter:**

$$BP_{SHAFT} = \frac{n \times 60 \times 60}{1200 \times t} \text{ in KW}$$

Where,

$n$  = Number of revolutions of energy meter disc.

$t$  = time taken by the Energy meter for  $n$  revolutions, in seconds.

**2. Mass Of Fuel Consumed Per Minute (  $m_f$  ) :**

$$m_f = \frac{\text{Pipette Reading} \times \rho_P \times 60}{T \times 1000} \quad \text{Kg / min.}$$

Where,

$\rho_P$  = density of petrol = 0.72 gm/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

Volume of pipette = pipette reading

**3. Total Fuel Consumption (TFC):**

$$\text{TFC} = m_f \times 60 \text{ in Kg / h.}$$

Where,

$m_f$  = kg/min

60 = Conversion from min to hr.

**4. Specific Fuel Consumption (SFC):**

$$\text{S.F.C.} = \frac{\text{T.F.C}}{\text{B.P}} \quad \text{Kg / KW - hr}$$

**5. Heat Input (HI):**

$$\text{HI} = \frac{\text{T.F.C}}{60 \times 60} \times C_V \quad \text{KW}$$

where,

TFC in Kg/h.

$C_V$  = Calorific Value of petrol = 48,000 KJ/Kg (approx.)



**6. Air - Fuel Ratio: (A/F)**

$$AF = \frac{m_a}{m_f}$$

Where,  $m_f$  in kg/min

$$m_a = 60 \times C_d \times A \times V_a \times \rho_a \quad \text{Kg / min}$$

$$\text{i.e. } V_a = \sqrt{(2g (h_m / 1000) \times [(\rho_w / \rho_a) - 1])} \quad \text{m/s.}$$

$$\text{where, } C_d = 0.62,$$

$$A = \frac{\pi d^2}{4} \quad \text{in m}^2, \quad \text{Orifice diameter, } d = 0.014 \text{ m}$$

$h_m$  in mm of Water from manometer reading

$$g = 9.81 \text{ m/s}^2$$

$$\rho_a = \text{Density of Air} = 1.10 \text{ Kg/m}^3$$

$$\rho_w = \text{Density of water} = 1000 \text{ Kg/m}^3$$

**7. Indicated Power ( Ip ) :**

$$IP = (BP + FP) \text{ KW}$$

Where,  $FP = (1/3) BP$  (1/3 of maximum BP by Willans Curve)

**8. Mechanical Efficiency: ( $\eta_m$ )**

$$\eta_m = \frac{BP}{IP} \times 100\%$$

**RESULTS:**

Thus the performance test on single cylinder 4-stroke petrol engine is conducted and characteristic curves are drawn.

**RESULTS TABLE:**

Sl No	Brake Power	Total Mass of fuel Consumed $M_f$	A/F ratio	Brake Specific Fuel Consumption <i>BSFC</i>	Brake Thermal Efficiency $\eta_{bth}$	Volumetric Efficiency $\eta_v$
1						
2						

**CHARACTERISTIC CURVES:**

- i. Brake power V/s Brake Thermal efficiency
- ii. Brake Power V/s Brake specification fuel consumption

**EXPERIMENT NO: 12****PERFORMANCE TEST ON FOUR STROKE, SINGLE CYLINDER, DIESEL ENGINE**

Conduct the Performance test on a Four stroke diesel engine and calculate the brake power, thermal efficiency, specific fuel consumption, volumetric efficiency and air-fuel ratio.

**AIM:** To conduct the performance test on single cylinder 4stroke, water cooled Diesel Engine.

**APPARATUS:** Vertical single cylinder diesel engine with water cooling set up, cranking lever.

**SPECIFICATIONS:**

- Make : Kirloskar AV-1
- Loading : Mechanical-Dead Weights
- Rated Power : 3.7 kW, 1500 rpm (5 hp)
- Bore and Stroke : 80mmX110mm
- Compression Ratio : 16.5:1
- Cylinder Capacity : 624.19cc
- Dynamometer : Rope Brake Dynamometer
- Starting : Hand Cranking
- Orifice Diameter (air flow) : 15mm
- Engine Cooling : Water Cooled
- Fuel tank capacity : 7.5 lts.

**WORKING PRINCIPLE:**

High-speed diesel engine operates on the four-stroke cycle principle. The cycle is completed in two revolutions of the flywheel. Diesel engine work on the principle of diesel cycle (known as constant pressure heat addition cycle). The four strokes of the cycle are Suction, Compression, Expansion or Working and Exhaust Stroke.

Internal combustion engines are the important prime movers used in various applications including transportation and power generation. Compression Ignition Engines use high compression ratio and fuel is burnt in the cylinder using high temperature obtained as a result of high compression. These engines are popular in applications requiring higher power out puts such as in bus, truck etc.

The working of the engine depends upon various factors such as type of fuel, speed, load, air to fuel ratio etc. Study of performance is made by measuring power output, specific fuel consumption and various efficiencies at different conditions.

**ROPE BRAKE DYNAMOMETER:**

Brake drum is fixed to engine flywheel through extended shaft with two support bearings. A rope is wound on drum circumference and two spring balances are provided for slack and tight sides. A hand wheel is provided to increase or decrease load. Brake drum is cooled inside by water flow and a scoop removes hot water from brake drum. A spring balance indicated load on the engine.

**OPERATIONS:**

1. Check properly the lubrication, fuel supply, cooling water supply and no load on the engine.
2. Start the engine by operating the decompression lever and cranking the crankshaft. When the engine gradually picks up speed the decompression lever automatically disengages.
3. Apply the load on the engine by rotating the hand wheel through the rope brake dynamometer. Allow the fuel to flow through the burette by operating the three-way cock suitably.
4. Note the following readings:
  - a. Time taken for the consumption of 10 cc of fuel oil in seconds.
  - b. The load on the engine in kg.
  - c. Speed of the engine in rpm.
  - d. Rate of flow of engine cooling water and inlet and outlet temperatures of cooling water.
  - e. Room, inlet air and exhaust gas temperatures.
  - f. Manometer reading.
5. Repeat the experiment by applying the different loads and note the corresponding readings.
6. Remove the load on the engine. Stop engine by cutting off the fuel supply, cooling water supplies.

**OBSERVATIONS:**

1. Cylinder bore	$D = 80\text{mm}$
2. Stroke length	$L = 110\text{mm}$
3. Brake drum radius	$r_b = 139\text{mm}$
4. Orifice diameter	$D_o = 16\text{mm}$
5. Orifice co-efficient of discharge	$C_d = 0.62$
6. Acceleration due to gravity	$g = 9.81\text{m/sec}^2$
7. Calorific value of fuel	$CV = 42,500 \text{ kJ/kg}$
8. Water density	$\rho_w = 1000 \text{ kg/ m}^3$
9. Fuel density	$\rho_f = 850 \text{ kg/ m}^3$
10. Air density	$\rho_a = 1.29 \text{ kg/m}^3$ ; (obtained from $pV=mRT$ )
	$R = 287, p \text{ in N/m}^2, T \text{ in } ^\circ\text{k}$
11. Specific heat of water at constant pressure	$c_{pw} = 4.182 \text{ kJ/kg-K}$

12. Specific heat of air at constant pressure  $c_{pa} = 1.005 \text{ kJ/kg-K}$

13. Atmospheric pressure  $P_a = 1.013 \text{ bar}$

**TABULAR COLUMN:**

Engine speed in rpm	Spring balance reading		Fuel burette readings		Air flow manometer reading in mm of water	Air inlet temperature in °C	Water temperature for engine in °C			Exhaust gas temp before calorimeter in °C	Water inlet temp for calorimeter in °C	Water outlet temp for calorimeter in °C	Exhaust gas temperature after calorimeter in °C
	N	F <sub>1</sub>	F <sub>2</sub>	Volume in ml			Time in Sec	T <sub>1</sub>	T <sub>2</sub>				

**CALCULATIONS:**

**1. Full load Calculation:**

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

Where: N=Speed of the engine in rpm,

$$T = \text{torque in N-m; } T = [W_{max} \times g] \times r_b.$$

The value of  $W_{max}$  can be identified and the applied load should be within this limit, and experiments are conducted for exact load intervals.

**2. Head of air:**

$$h_a = \frac{\rho_w \times h_w}{\rho_a} \dots \dots \dots m$$

Where:  $\rho_a$  = Density of the Air  $\text{kg/ m}^3$ ,

$\rho_w$  = Density of the Water  $\text{kg/ m}^3$ ,

$$h_w = (h_1 + h_2) \text{ Manometric head of water in m.}$$

**3. Mass flow rate of air (m<sub>a</sub>)**

$$m_a = [Q_{act}]_{air} \times \rho_a \times 3600 \text{ in kg/hr}$$

where:  $[Q_{act}]_{air} = C_d \times A_0 \sqrt{2gh_a}$  m<sup>3</sup>/sec,

$$A_0 = (\pi/4 d_0^2) \text{ Area of orifice m}^2,$$

**4. Brake Power (B.P.)**

$$BP = \frac{2 \times \pi \times N \times T}{1000 \times 60} \dots\dots\dots kW$$

$$B.P. = \frac{2\pi N(S_1 - S_2)g \langle r_b \rangle}{60 \times 1000} \dots\dots\dots kW$$

N = Engine Speed in rpm

T = Output Torque in N-m

**5. Total mass of Fuel Consumed (F<sub>c</sub> or TFC or M<sub>f</sub>):**

$$M_f = \frac{\rho_f \times V_f \times 3600}{t} \dots kg/hr$$

Where:  $\rho_f$  = Density of the fuel in 850 kg/m<sup>3</sup>

$V_f$  = volume of fuel consumed in m<sup>3</sup>; 10cc=10/(100)<sup>3</sup> m<sup>3</sup>,

t = time taken for 10c.c. fuel consumption in sec.

**6. Air Fuel ratio (A/F)**

$$\frac{A}{F} = \frac{M_a}{M_f}$$

**7. Heat supplied (Q<sub>s</sub>)**

$$Q_s = M_f \times C.V. \text{ in kW}$$

Where: C.V = Calorific Value of the Fuel in kJ / kg

**8. Indicated Power (I.P)**

$$I.P = B.P + F.P \text{ in kW}$$

Where: F.P = Frictional Power in kW. *From Willan's line method (graph)*

*from the graph of BP v/s FC(kg/sec) or from graph*

**9. Mechanical Efficiency ( $\eta_{Mech}$ )**

$$\eta_{mech} = \frac{BP}{I.P.} \times 100 \dots \%$$

**10. Brake Thermal Efficiency ( $\eta_{BTh}$ )**

$$\eta_{bth} = \frac{BP}{Q_s} \times 100 \dots \%$$

**11. Indicated Thermal Efficiency ( $\eta_{ITh}$ ).**

$$\eta_{ith} = \frac{IP}{Q_s} \times 100 \dots \%$$

**12. Swept volume ( $V_s$ ).**

$$V_s = (\pi/4) D^2 \times L \times (N/2) \times 60 \text{ m}^3/\text{hr.}$$

Where: D = Cylinder bore in m,

L = Stroke length in m,

N = Speed of the engine in rpm.

**13. Actual volume  $V_a$ .**

$$V_a = \text{volume flow rate of air} = (m_a / \rho_a) \text{ in m}^3/\text{hr}$$

**14. Volumetric efficiency ( $\eta_v$ )**

$$\eta_v = (V_a / V_s) \times 100 \%$$

**15. Specific fuel consumption:**

**BSFC** =  $M_f/BP$  in kg/KW-hr (Break Specific Fuel Consumption)

**ISFC** =  $M_f/IP$  in kg/KW-hr (Indicated Specific Fuel Consumption)

**RESULTS:**

Sl.No	B.P	M <sub>f</sub>	A/F	I.P	BSFC	ISFC	$\eta_{bth}$	$\eta_{ith}$	$\eta_{mech}$	$\eta_v$
1										
2										
3										
4										

**GRAPHS:**

1. Fuel consumption V/s Brake power (William's line method)
2. Brake thermal efficiency V/s Brake power
3. Indicated thermal efficiency V/s Brake power
4. Specific fuel consumption V/s Brake power
5. Mechanical efficiency V/s Brake power



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## HEAT BALANCE TEST ON A SINGLE CYLINDER, FOUR STROKE DIESEL ENGINE

**Conduct an experiment to draw the heat balance sheet for a given single cylinder four stroke diesel engine.**

**AIM:** To conduct the heat balance test for a single cylinder diesel engine and to prepare heat balance sheet.

**APPARATUS:** Vertical single cylinder diesel engine with water cooling set up, cranking lever.

### **SPECIFICATIONS:**

- Make : Kirloskar AV-1
- Loading : Mechanical-Dead Weights
- Rated Power : 3.7 kW, 1500 rpm (5 hp)
- Bore and Stroke : 80mmX110mm
- Compression Ratio : 16.5:1
- Cylinder Capacity : 624.19cc
- Dynamometer : Rope Brake Dynamometer
- Starting : Hand Cranking
- Orifice Diameter (air flow) : 15mm
- Engine Cooling : Water Cooled
- Fuel tank capacity : 7.5 lts.

### **THEORY:**

All the heat energy supplied by the combustion of fuel is not converted into useful work. A part of it will be carried away by cooling water, a part of it carried away by exhaust gas. A part of it is lost by convection and radiation as well as due to the leakage of gases and a part of power developed inside engine is also used to run the accessories as lubricating pump, cam shaft and water circulating pump. These cannot be measured precisely and treated as unaccounted loss.

A heat balance is an account of heat supplied and heat utilized in various ways in the system. The results of the above calculations are tabulated in a table and this table is known as *Heat Balance Sheet*, where the heat distribution is expressed as percentage of heat supplied.

### **PROCEDURE:**

1. Check properly the lubrication, fuel supply, cooling water supply and no load on the engine.
2. Start the engine by operating the decompression lever and cranking the crankshaft. When the engine gradually picks up speed the decompression lever automatically disengages.
3. Apply the load on the engine by rotating the hand wheel through the rope brake dynamometer. Allow the fuel to flow through the burette by operating the three-way cock suitably.

4. Note the following readings:
  - i. Time taken for the consumption of 10 cc of fuel oil in seconds.
  - ii. The load on the engine in kg.
  - iii. Speed of the engine in rpm.
  - iv. Rate of flow of engine cooling water and inlet and outlet temperatures of cooling water.
  - v. Room, inlet air and exhaust gas temperatures.
  - vi. Manometer reading.
5. Repeat the experiment by applying the different loads and note the corresponding readings.
6. Remove the load on the engine. Stop engine by cutting off the fuel supply, cooling water supplies.

## **OBSERVATIONS:**

- |   |   |
|---|---|
| 1. Cylinder bore                                | $D = 80\text{mm}$   |
| 2. Stroke length                                | $L = 110\text{mm}$  |
| 3. Brake drum radius                            | $r_b = 139\text{mm}$  |
| 4. Orifice diameter                             | $D_o = 16\text{mm}$   |
| 5. Orifice co-efficient of discharge            | $C_d = 0.6$   |
| 6. Acceleration due to gravity                  | $g = 9.81\text{m/sec}^2$                                    |
| 7. Calorific value of fuel                      | $CV = 42,500 \text{ kJ/kg}$                                 |
| 8. Water density                                | $\rho_w = 1000 \text{ kg/ m}^3$                             |
| 9. Fuel density                                 | $\rho_f = 850 \text{ kg/ m}^3$                              |
| 10. Air density                                 | $\rho_a = 1.29 \text{ kg/m}^3$ ; (obtained from $pV=mRT$ )  |
|   | $R = 287, p \text{ in N/m}^2, T \text{ in } ^\circ\text{k}$ |
| 11. Specific heat of water at constant pressure | $c_{pw} = 4.182 \text{ kJ/kg-K}$                            |
| 12. Specific heat of air at constant pressure   | $c_{pa} = 1.005 \text{ kJ/kg-K}$                            |
| 13. Atmospheric pressure                        | $P_a = 1.013 \text{ bar}$                                   |

**TABULAR COLUMN:**

Sl. No	Speed (rpm) N	Manometer Reading (mm)		Time 't' for 10cc of Fuel (sec)	Water Flow 'm <sub>w</sub> ' (lpm)	Temperature in °C				
		h <sub>1</sub>	h <sub>2</sub>			T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
1										
2										
3										
4										

**Temperatures are referred to as follows**

**T<sub>1</sub>**
**T<sub>2</sub>**
**T<sub>3</sub>**
**T<sub>4</sub>**
**T<sub>5</sub>**

**Atmospheric air    Air I/L    Cooling water O/L    Exhaust gas O/L    Cooling water I/L**

**CALCULATIONS:**

**1.Full load Calculation:**

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

where: N=Speed of the engine in rpm,

$$T = \text{Torque in N-m; } T = [W_{max} \times g] \times r_b.$$

The value of W<sub>max</sub> can be identified and the applied load should be within this limit, and experiments are conducted for exact load intervals.

**2. Head of air:**

$$h_a = \frac{\rho_w \times h_w}{\rho_a} \dots \dots \dots m$$

where: ρ<sub>a</sub> = Density of the air kg/ m<sup>3</sup>,

ρ<sub>w</sub> = Density of the water kg/ m<sup>3</sup>,

h<sub>w</sub> = (h<sub>1</sub>+h<sub>2</sub>) Monometric head of water in m.

**3. Mass flow rate of air (m<sub>a</sub>)**

$$m_a = [Q_{act}]_{air} \times \rho_a \times 3600 \text{ in kg/hr}$$

Where  $[Q_{act}]_{air} = C_d \times A_0 \sqrt{2gh_a}$  m<sup>3</sup>/sec,

$$A_0 = (\pi/4 d_0^2) \text{ Area of orifice m}^2,$$

**4. Brake Power (B.P.)**

$$BP = \frac{2 \times \pi \times N \times T}{1000 \times 60} \dots\dots\dots kW$$

$$B.P. = \frac{2 \times \pi \times N \times (S_1 - S_2) \times g \times r_b}{60 \times 1000} \dots\dots\dots kW$$

N = Engine Speed in rpm

T = Output Torque in N-m

**5. Total mass of Fuel Consumed (F<sub>c</sub> or TFC or M<sub>f</sub>):**

$$M_f = \frac{\rho_f \times V_f \times 3600}{t} \dots kg/hr$$

Where:  $\rho_f$  = Density of the fuel in 850 kg/m<sup>3</sup>

$V_f$  = volume of fuel consumed in m<sup>3</sup>; 10cc=10/(100)<sup>3</sup> m<sup>3</sup>,

t = time taken for 10c.c. fuel consumption in sec.

**6. Air Fuel ratio (A/F)**

$$\frac{A}{F} = \frac{M_a}{M_f}$$

**7. Heat supplied (Q<sub>s</sub>)**

$$Q_s = M_f \times C.V. \text{ in kW}$$

Where C.V = Calorific Value of the Fuel in kJ / kg

**8. Heat carried by Cooling water (Q<sub>w</sub>)**

$$Q_w = m_w \times C_{p_w} (T_3 - T_5) = - \dots\dots\dots kW$$

**9. Heat carried by exhaust gases ( $Q_g$ )**

$$Q_g = m_g \times C_{pg} (T_4 - T_2) = \text{----- kW}$$

$m_g$  = Mass Flow Rate of exhaust gas. =  $(M_f + M_a)$  and  $C_{pg} = 1.005 \text{ KJ/kg K}$

**10. Heat equivalent of Brake Power ( $Q_{BP}$ )**

$$Q_{BP} = BP / Q_s = \text{----- kW}$$

**10. Unaccounted heat loss ( $Q_{UA}$ )**

$$Q_{UA} = Q_s - (Q_w + Q_{cm} + Q_g + Q_{BP}) \text{----- kW}$$

**RESULTS:**

M <sub>f</sub> kg/Sec	M <sub>a</sub> kg/Sec	BP kW	Q <sub>s</sub>		Q <sub>w</sub>		Q <sub>eg</sub>		Q <sub>BP</sub>		Q <sub>UA</sub>	
			kW	%	kW	%	kW	%	kW	%	kW	%

**HEAT BALANCE SHEET:**

*(For one set of reading)*

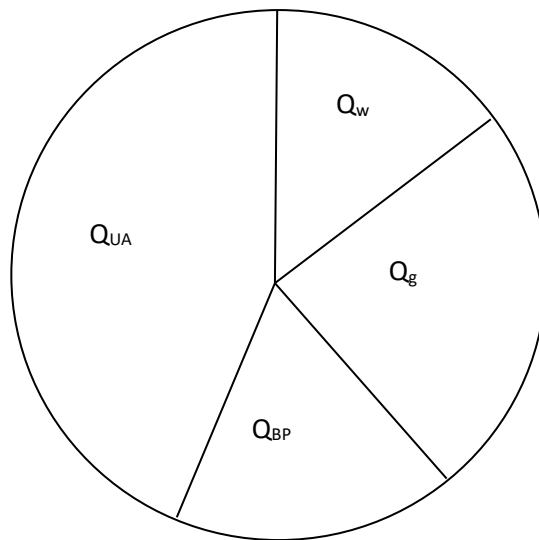
Heat Supplied Value In kW	%	Heat Distributed		Heat In kW	%
	100	1.Heat carried by Cooling water		(Q <sub>w</sub> )	
		2.Heat carried by exhaust gases		(Q <sub>g</sub> )	
		3.Heat equivalent of Brake Power		(Q <sub>BP</sub> )	
		4.Unaccounted heat loss		(Q <sub>UA</sub> )	
Total	100				

**The heat balance sheet is drawn as below**

Taking the Heat Input Value as  $360^0$  – other heat losses are calculated in terms of angles.

**All values in same units**

1.  $Q_w$  in angles =  $(360 \times Q_w) / Q_s$
2.  $Q_g$  in angles =  $(360 \times Q_g) / Q_s$
3.  $Q_{BP}$  in angles =  $(360 \times Q_{BP}) / Q_s$
4.  $Q_{UA}$  in angles =  $(360 \times Q_{UA}) / Q_s$



## **EXPERIMENT NO: 13**

# **PERFORMANCE TEST ON A THREE CYLINDER FOUR STROKE PETROL ENGINE**

**Conduct the Performance test on a Four stroke Petrol engine and calculate the brake power, thermal efficiency, specific fuel consumption, volumetric efficiency and air-fuel ratio.**

**AIM:** To conduct a performance analysis of four stroke three cylinders Petrol Engine.

### **SPECIFICATIONS OF ENGINE:**

- |                       |                                 |
|-----------------------|---------------------------------|
| 1. Bore:              | 70 mm                           |
| 2. Stroke:            | 66.7 mm                         |
| 3. Brake power:       | 3 HP                            |
| 4. Speed:             | 3000 rpm                        |
| 5. Compression ratio: | 16.5:1                          |
| 6. Clutch:            | Diaphragm type                  |
| 7. Engine oil:        | SAE 20 W/40 (4.5 ltrs capacity) |

### **HYDRAULIC DYNAMOMETER:**

It works on the principle of dissipating the power in fluid friction. It consists of a rotor coupled to the output shaft of the engine. This rotor rotates in a casing called a stator filled with fluid, which develops centrifugal force. Due to this force, the stator tends to revolve with the impeller or rotor, but it is resisted by a torque arm supporting a balance weight. The frictional forces between the rotor and the fluid are measured by the spring balance fitted on the stator. The heat developed due to dissipation of power is carried away by a continuous supply of water. The output can be controlled by regulating the flow of water between the stator and rotor.

### **PROCEDURE:**

1. The lubrication system is checked. The inlet valves of cooling water and the sluice gates in the dynamometer are opened.
2. The self-starter switch is switched on. The engine is allowed to pick up the speed gradually.
3. Load is applied on the engine by operating the sluice gate in the dynamometer. The speed of the engine is varied by operating the throttle valve provided on the fuel supply line.
4. Note the following readings:
  - a. Time taken for the consumption of 10 cc of fuel oil in seconds.
  - b. The load on the engine in kg.
  - c. Speed of the engine in rpm.
  - d. Rate of flow of engine cooling water and inlet and outlet temperatures of cooling water.

- e. Room, inlet air and exhaust gas temperatures.
  - f. Manometer reading.
5. Repeat the experiment by applying the different loads and note the corresponding readings.
  6. Remove the load on the engine by closing the sluice gates and cut off the fuel supply to the engine. This stops the engine.

**OBSERVATIONS:**

1. Cylinder bore  $D = 68\text{mm}$
2. Stroke length  $L = 72\text{mm}$
3. Orifice diameter  $D_o = 16\text{mm}$
4. Orifice co-efficient of discharge  $C_d = 0.6$
5. Acceleration due to gravity  $g = 9.81\text{m/sec}^2$
6. Calorific value of fuel  $CV = 48000 \text{ kJ/kg}$
7. Water density  $\rho_w = 1000 \text{ kg/ m}^3$
8. Fuel density  $\rho_f = 750 \text{ kg/ m}^3$
9. Specific heat of water at constant pressure  $c_{pw} = 4.182 \text{ kJ/kg-K}$
10. Specific heat of air at constant pressure  $c_{pa} = 1.005 \text{ kJ/kg-K}$
11. Atmospheric pressure  $P_a = 1.013 \text{ bar}$

**TABULAR COLUMN:**

Speed in rpm of engine	Spring balance readings in Kg	Air Consumption of water read on manometer in mm	Fuel Consumption Read on meter in kg/h	Temperature in °C				Water flow rate in lpm from engine head	Water flow rate in lpm from calorimeter
				T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>		



**CALCULATION:****1. Brake Power (Bp),**

$$BP = \frac{2 \times \pi \times N \times f \times r \times 9.81}{60 \times 1000} \text{ KW}$$

Where,

N = RPM of Engine

r = Torque arm distance in m

f = load applied on engine in kg

**2. Mass Of Fuel Consumed Per Minute (M<sub>f</sub>):**

$$\text{Pipette Reading} \times \rho_p \times 60$$

$$m_f = \frac{\text{Pipette Reading} \times \rho_p \times 60}{T \times 1000} \text{ Kg / min.}$$

Where,  $\rho_p$  = density of Petrol = 0.72 gm/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

**3. Total Fuel Consumption (TFC):**

TFC = Fuel flow meter reading in kg/h.

$$TFC = m_f \times 60 \text{ in Kg / hr} \quad \text{Where, } m_f = \text{kg/min}$$

60 = Conversion from min to hr

**4. Specific Fuel Consumption (SFC):**

$$S.F.C. = \frac{T.F.C.}{B.P} \text{ kg/kw - hr}$$

**5. Heat Input (Hi):**

$$HI = \frac{T.F.C.}{60 \times 60} \times CV \text{ KW}$$

Where,

TFC in Kg/h.

CV = Calorific Value of

Petrol = 48,000 KJ/kg (approx).

**6. Brake Thermal Efficiency ( $\eta_{B\text{therm}}$ ):**

$$\eta_{B\text{therm}} = \frac{B.P}{HI} \times 100$$

**7. Air - Fuel Ratio: (A/F)**

$$AF = \frac{m_a}{m_f}$$

Where,  $m_f$  is in kg/min (From formula – 2)

$$m_a = V_a \times \rho_a \text{ in Kg / min}$$

i.e.  $V_a = 60 \times C_d \times A \times \sqrt{(2g h_a)} \text{ m}^3/\text{s}$  ,  $C_d = 0.62$ ,

$$A = \frac{\pi d^2}{4} \text{ in m}^2 \text{ , } d = 0.016\text{m Orifice diameter}$$

$$h_a = \frac{\rho_w h_w}{\rho_a}$$

Where,  $h_w$  = Water manometer reading in m.

$$g = 9.81 \text{ m/s}^2$$

$$\rho_a = \text{Density of Air} = 1.10 \text{ Kg/m}^3$$

$$\rho_w = \text{Density of water} = 1000 \text{ Kg/m}^3$$

**8. Indicated Power (Ip) :**

$$IP = (BP+FP) \text{ KW} \quad \text{Where, FP is obtained from Morse test.}$$

**9. Mechanical Efficiency: ( $\eta_{\text{Mech}}$ )**

$$\eta_{\text{mech}} = \frac{BP}{IP} \times 100\%$$

**10. Volumetric Efficiency:**

$$\eta_{\text{Vol}} = \frac{V_s}{V_t} \times 100$$

Where,  $V_s$  = Swept Volume,  $V_t$  = Theoretical Volume at STP

**RESULTS COLOUMN:**

Sl.No	bp	mf	A/F	Bsfc	$\eta_{bp}$	$\eta_v$
1						
2						
3						
4						

**GRAPHS:**

1. Brake thermal efficiency V/s Brake power
2. Specific fuel consumption V/s Brake power
3. Volumetric efficiency V/s Brake power

## MORSE TEST

**Determine the friction power of a given 3 cylinder four stroke Petrol engine by Morse test**

**AIM:** To conduct the MORSE TEST to determine the Friction Power of a 3 cylinder 4-stroke, water cooled engine with swinging type hydraulic loading arrangement.

**APPARATUS:** Multi cylinder 4-S petrol engine set up – With provision for necessary measurements.

**THEORY:** Friction Power (FP) is the power dissipated as friction. This is obtained by various methods like Morse Test for multi-cylinder engine, Willan’s Line Method for a diesel engine, and Retardation Test and Motoring Test for all types of engines. Given in terms of IP and BP

by:  $FP = IP - BP$  in Watts

**This test is applicable only to multi cylinder engines.**

The ignition, in case of a petrol engine or injection in case of a diesel engine is cut on by one resulting in reduction in the engine speed. Speed falls because of reduced power with one cylinder cut off each time. This speed is made constant by reducing the load on the engine.

If the value of the Indicated Power of the cylinders are denoted as  $I_1, I_2, I_3$  and  $I_4$  and the Friction Power Losses in each cylinder are denoted by  $F_1, F_2, F_3$  and  $F_4$ , then the value of Brake Power when all the cylinders are firing at test speed is given by;

$$B.P. = (I_1 - F_1) + (I_2 - F_2) + (I_3 - F_3) + (I_4 - F_4) \text{-----1}$$

If number one cylinder is cut off, then the contribution  $I_1$  is lost; and if the losses due to that cylinder remain the same as when it is firing; then  $B.P._1$ , now obtained at same speed is

$$(B.P.)_1 = (0 - F_1) + (I_2 - F_2) + (I_3 - F_3) + (I_4 - F_4) \text{-----2}$$

Subtracting 2 from 1,

$$B.P. - (B.P.)_1 = I_1$$

Similarly

$$B.P. - (B.P.)_2 = I_2 ; \text{ when cylinder number 2 is cut off}$$

$$B.P. - (B.P.)_3 = I_3; \text{ when cylinder number 3 is cut off}$$

Then for the engine; Total Indicated power is,

$$I P = I_1 + I_2 + I_3$$

Then for the engine; Total Friction power is

$$FP = IP - BP$$

### **PROCEDURE:**

1. Check the petrol level in the tank
2. Check sufficient lubricating oil in the oil sump(crank case)
3. Check the cooling water flow to the engine – 100 lts/hr
4. Keep the engine in disengaged position
5. Keep the carburetor throttle in full open position
6. Start the engine by ignition key and battery
7. Adjust the engine speed to about 1000 to 2000 rpm (fixed value)
8. Load the engine by engaging the clutch lever and letting the water flow to the dynamometer
9. Keep the dynamometer water pressure about 1.5 kg.
10. Change the Load the engine about 15 kg reading on the spring balance dial while speed maintained at fixed value
11. Note the firing order of 3 cylinder and cut off the firing of first of 3 cylinders.
12. Now the total power developed drops and hence the speed.
13. Bring back the speed (fixed value) by reducing the load by operating the loading wheel in the anti clockwise direction.
14. Note the load at this constant speed value.
15. Similarly cut off the ignition of the next firing cylinder in the firing order and simultaneously engaging the ignition lever cutoff initially.
16. Maintain the speed again by reducing the load by operating the loading wheel in the anti clockwise direction.
17. Repeat this process for all three cylinders in the order and every time note all necessary readings.
18. At the end of experiment, remove the load, reduce the speed and disengage the clutch and then switch off the engine.

**TABULAR COLUMN:**

Sl No	Operating Condition	Load in kg	Speed 'N' rpm	Brake Power in KW	Indicated power of each cylinder
1.	All cylinders working	W=		BP=	
2.	Cylinder 1 <sup>st</sup> cut off	W <sub>1</sub> =		BP <sub>1</sub> =	IP <sub>1</sub> =BP-BP <sub>1</sub> =
3.	Cylinder 2 <sup>nd</sup> cut off	W <sub>2</sub> =		BP <sub>2</sub> =	IP <sub>2</sub> =BP-BP <sub>2</sub> =
4.	Cylinder 3 <sup>rd</sup> cut off	W <sub>3</sub> =		BP <sub>3</sub> =	IP <sub>3</sub> =BP-BP <sub>3</sub> =

**SPECIMAN CALCULATIONS:**

Brake power =  $\frac{WXN}{2720}$       Where 2720 = Dynamo meter constant

Total IP of the Engine:

$$IP = IP_1 + IP_2 + IP_3$$

$$IP =$$

Total Friction power of the Engine

$$FP = IP - BP$$

$$FP =$$

Mechanical efficiency of the Engine =  $\frac{BP}{IP} =$

- Result:
1. Total BP of the Engine = .....
  2. Total IP of the Engine = .....
  3. Total FP of the Engine = .....

**EXPERIMENT NO: 14****VARIBLE COMPRESSION RATIO PETROL ENGINE TEST RIG.  
(Electrical Loading)**

**AIM** : To Conduct performance test on Varible compression ratio petrol engine test rig

**DESCRIPTION**: The Test Rig consists of Four-Stroke Petrol Engine (Air Cooled) to be tested for performance is coupled to AC current generator. The arrangement is made for the following measurements of the set-up.

- 1) The Rate of Fuel Consumption is measured by using Volumetric Pipette.
- 2) Air Flow is measured by Manometer, connected to Air Box.
- 3) The different mechanical loading is achieved by loading the engine through rope – break drum assembly attached to weighing balance.
- 4) The engine speed is measured by electronic digital meter.
- 5) Temperature at air inlet, engine exhaust gas, engine water inlet and outlet and calorimeter inlet and outlet are measured by electronic digital temperature indicator with thermocouple.
- 6) Water flow is measured by water flow meter or rotameter.

The whole instrumentation is mounted on a self-contained unit ready for operation.

**SPECIFICATIONS:**

- |                         |   |   |
|-------------------------|---|---|
| 1. ENGINE TYPE          | : | 4-Stroke , Single Cylinder,Air cooled<br>Petrol Engine,spark ignition . |
| 2. MAKE                 | : | Greaves   |
| 3. MAXIMUM POWER, ‘ P ’ | : | 2.2 KW.   |
| 4. RATED SPEED, ‘ N ’   | : | 3000 RPM.   |
| 5. BORE, ‘ D ’          | : | 70mm.   |
| 6. STROKE, ‘ L ’        | : | 66.7 mm.  |

### **OPERATION:**

- 1) Check the Petrol in the tank.
- 2) Check the sufficient lubricating oil in the oil sump (crank case).
- 3) Check the water circulation to the engine head .
- 4) Put on the mains, and check 'mains on' in the indicator as it glows.
- 6) Loosen the locking bolt of the auxillary piston-screw rod assembly.
- 7) Rotate the hand wheel and bring the indicator to the required Compression ratio.
- 8) Lock the screw rod assembly before conducting the experiment for the Compression ratio selected.
- 9) Allow petrol and start the engine by using Rope.
- 10) Keep the Loading knob in OFF positions, initially.
- 11) Apply the Load to the AC Generators by Switching - ON the loading switches.
- 12) Allow some time so that the speed stabilizes.
- 13) Now take down readings of Air flow, temperature indicator, fuel flow, engine speed and power consumption.
- 14) Repeat the procedure (9) & (13) for different loads.
- 15) Tabulate the readings as shown in the enclosed sheet.
- 16) After the experiment is over, keep the petrol control valve at closed position.
- 17) Allow water to flow for some time through auxiliary piston head after completion of the experiment



**TABULAR COLOUMN:**

Load in KW	Speed in rpm (N)	Voltmeter reading in volts	Current in amps	Fuel Cosumption	Energy meter reading for 3 revs	Manometer reading in mm (h <sub>m</sub> )	Temp in °C		Compression ratio
							T <sub>1</sub>	T <sub>2</sub>	

**NOTE: TEMPERATURE POINTS,**

T<sub>1</sub> = AIR INLET TEMPERATURE

T<sub>2</sub> = ENGINE HEAD WATER INLET

T<sub>3</sub> = ENGINE HEAD WATER OTLET

T<sub>4</sub> = EXHAUST GAS OUTLET TEMPERATURE

T<sub>5</sub> = WATER INLET TEMPERATURE FOR CALORIEMETER

T<sub>6</sub> = WATER OUTLET TEMPERATURE FOR CALORIEMETE

T<sub>7</sub> = EXHAUST OUTLET TEMPERATURE AFTER CALORIEMETER

**CALCULATIONS:**

**1.Brake Power (Bp):**

$$Bp_{(elec)} = \frac{n \times 60 \times 60}{Em \times t} \quad \text{KW.}$$

$$Bp_{(Eng)} = \frac{Bp_{(elec)}}{D_{trans}} \quad \text{KW.}$$

Where,

$n$  = No. of revaluation of energy meter.

$E_m$  = Energy meter constant = 1200 revln/ KW-hr

$t$  = time for 'n' revln of energy meter in sec.

Transmission efficiency = 0.7

**2. Mass Of Fuel Consumed Per Minute ( $M_f$ ) :**

$$m_f = \frac{\text{Pipette Reading} \times \rho_p \times 60}{T \times 1000} \text{ Kg / min.}$$

Where,  $\rho_p$  = density of petrol = 0.72gm/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

$T$  = time taken 20cc of fuel consumption.

**3. Total Fuel Consumption (TFC):**

$$\text{TFC} = m_f \times 60 \text{ Kg / h.}$$

Where,  $m_f$  = kg/min

60 = Conversion from min to hr

**4. Specific Fuel Consumption(SFC):**

$$\text{S.F.C.} = \frac{\text{T.F.C}}{\text{B.P}} \text{ Kg / KW - hr}$$

**5. Heat Input( HI ) :**

$$\text{HI} = \frac{\text{T.F.C}}{60 \times 60} \times C_v \text{ KW}$$

Where, TFC in Kg/h.

$C_v$  = Calorific Value of Diesel = 48,000 KJ

**6. Brake Thermal Efficiency:**

$$\eta_{B\text{therm}} = \frac{\text{B.P}}{\text{HI}} \times 100$$

**7. Air - Fuel Ratio: (A/F)**

$$\text{AF} = \frac{m_a}{m_f}$$

Where,  $m_f$  is in kg/min

$$m_a = 60 \times C_d \times A \times V_a \times \rho_a \quad \text{in Kg / min}$$

i.e.  $V_a = \sqrt{\frac{2g(h_m / 1000) \times [(\rho_w / \rho_a) - 1]}{\rho_a}} \quad \text{m/s.}$

$$C_d = 0.62,$$

$$A = \frac{\pi d^2}{4} \quad \text{in m}^2, \quad \text{Orifice diameter } d = 0.016\text{m}$$

$h_m$  in mm of Water from manometer reading

$$g = 9.81 \text{ m/s}^2$$

$$\rho_a = \text{Density of Air} = 1.10 \text{ Kg/m}^3$$

$$\rho_w = \text{Density of water} = 1000 \text{ Kg/m}^3$$

**8. Indicated Power ( IP ) :**

$$\text{IP} = (\text{BP} + \text{FP}) \quad \text{KW}$$

$$\text{Where, FP} = (1/3) * \text{BP}$$

9. Mechanical Efficiency: ( $\eta_m$ )

$$\eta_m = \frac{\text{BP}}{\text{IP}} \times 100\%$$

10. Volumetric Efficiency: ( $\eta_{vol}$ )

$$\eta_v = \frac{V_s}{V_t} \times 100$$

Where,  $V_s$  = Swept Volume,  $V_t$  = Theoretical Volume at STP.

$$\text{a) } V_t = \text{Theoretical Volume} = \frac{\pi \times D^2 \times L \times N}{4 \times 2} \quad \text{in m}^3/\text{min}$$

Here,  $D$  = Bore Diameter = 0.07m,  $L$  = Stroke Length = 0.0667  $N$  = Speed in RPM.

$$\text{b) } V_s = \text{Swept volume at STP} = V_a \times (T_s/T_a)$$

Here,  $T_a$  = Ambient Temperature,  $^{\circ}\text{K} = T_1 + 273$

$T_s$  = Standard Temperature  $^{\circ}\text{k} = 288 \text{ }^{\circ}\text{K}$

{NOTE:  $[(P_a V_a)/ T_a] = (P_s V_s) / T_s$ ;  $P_a \sim P_s$  }

and, actual volume of air intake is given by,

$$\text{c) } V_a = 60 \times C_d \times A \times \sqrt{(2 * g * h_a)} \quad \text{m}^3/\text{min.}$$

$$C_d = 0.62,$$

$$A = \frac{\pi d^2}{4} \quad \text{in m}^2, \quad d = 0.016\text{m Orifice diameter}$$

$$h_a = \frac{\rho_w h_w}{\rho_a}$$

$h_w$  in m of Water from manometer reading

$$g = 9.81 \text{ m/s}^2$$

$$\rho_a = \text{Density of Air} = 1.10 \text{ Kg/m}^3$$

$$\rho_w = \text{Density of water} = 1000 \text{ Kg/m}^3$$

**RESULTS COLOUMN:**

Sl.No	bp	mf	A/F	Bsfc	$\eta_{bp}$	$\eta_v$
1						
2						

**VIVA QUESTIONS & ANSWERS**

1. Define Flash point?

Flash point of oil may be defined as the minimum temperature at which it gives off sufficient vapours when mixed with air and gives rise to a momentary flash of light on the application of a small pilot flame.

2. Define Fire point?

Fire point is defined as the lowest temperature to which oil should be heated to give sufficient vapours to form an inflammable mixture with air to burn for at least five or more seconds, when a pilot flame is introduced near of it.

3. Define Calorific value?

The Calorific value of a fuel is defined as the amount of heat obtained by the complete combustion of a unit mass of fuel

4. What is the use of bomb calorimeter?

Bomb calorimeter is used to determine Calorific value of solid and liquid fuel.

5. Define Higher Calorific value?

It is the quantity of heat obtained by the complete combustion of one kg of fuel, when the products of combustion are cooled down to the temperature of the surrounding air, usually 15<sup>0</sup> C it is also called as gross Calorific value.

6. Define Lower Calorific value?

It is the quantity of heat obtained by the combustion of one kg of fuel, when the product of combustion is not sufficiently cooled down to condense the steam formed during combustion. it is also called as net Calorific value.

7. What is the use of Boy's Gas Calorimeter?

Boy's Gas Calorimeter is used to determine the calorific value of gaseous fuel.

8. Define viscosity?

Viscosity is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid.

9. Define kinematic viscosity?

It is defined as the ratio between the dynamic viscosity and density of fluid. It is denoted by the Greek symbol ( $\nu$ ) called 'nu'.

10. What is the use of viscometer?

It is used to measure viscosity of oil.

11. Define heat engine and classify.

Heat engine is a device which transforms the chemical energy of a fuel into thermal energy and utilizes this thermal energy to perform useful work. Thus, thermal energy is converted to mechanical energy in heat engines. They are classified into two categories

- a. External combustion engine
- b. Internal combustion engine

12. What do you mean by internal combustion engine?

In internal combustion engine combustion takes place within the engine cylinder.

Eg: Petrol engines, Diesel engines, Gasoline engines etc.

13. What do you mean by External combustion engine?

In external combustion engine combustion takes place outside the engine cylinder.

Eg: Steam engine, Steam turbine, etc.

14. What do you mean by bore?

The inside diameter of the cylinder is called bore.

15. Define compression ratio.

It is defined as the ratio between total cylinder volumes to the clearance volume

16. Define indicated power?

It is the power developed by the engine within the cylinder.

17. Define Brake power?

It is the power available at the crank shaft.

18. What is the use dynamometer?

Dynamometer is used to measure brake power of the engines.

19. Name different types of dynamometer?

Rope brake Dynamometer  
Hydraulic Dynamometer  
Electric dynamometer

20. What do you mean by heat balance sheet?

Heat balance sheet gives an idea about the amount of heat input and amount of heat utilized in the system.

21. What do you mean swept volume?

The nominal volume swept by the piston when travelling from one dead centre to other is called as swept volume or displacement volume. it is expressed in terms of cubic centimeter (cc).

22. Define mechanical efficiency.

It is the ratio of brake power to indicated power.

23. Define brake thermal efficiency?

It is the ratio of brake power developed by the engine to heat supplied by the fuel.

24. Define indicated thermal efficiency?

It is the ratio of indicated power developed by the engine to heat supplied by the fuel.

25. What do you mean by volumetric efficiency?

It is defined as the volume flow rate of air into the intake system divided by the rate at which the volume is displaced by the system

26. Differentiate between petrol engine and diesel engine with regard to the suction stroke?

During suction stroke of petrol engine air fuel mixture will enter the engine cylinder. During suction stroke of diesel engine only air will enter the engine cylinder.

27. What is use of piston rings?

Piston rings, fitted into the slots around the piston, provide a tight seal between the piston and cylinder wall thus preventing leakage of combustion gases.

28. Why is Otto cycle called as constant volume Cycle?

The cycle is so called because heat is supplied at constant volume.

29. What do you mean by Scavenging?

Scavenging process is the replacement of combustion products in the cylinder from previous power stroke with fresh air charge to be burned in the next cycle.

30. What do you mean by octane number?

The octane number of the fuel is the percentage of octane in the reference mixture which knocks under the same conditions as the fuel.



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