DEPARTMENT OF

MECHANICAL ENGINEERING

ENERGY LAB

2019-20

(*18MEL58*)

As per VTU Syllabus CBCS scheme for V Semester

Pradeep N R

Faculty Incharge

Jagadesh A S

Instructor

BAPUJI INSTITUTE OF ENGINEERING AND TECHNOLOGY

DAVANGERE- 577 004

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Name : ....

USN : ....

Semester: .... Batch No......................

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BAPUJI INSTITUTE OF ENGINEERING AND TECHNOLOGY

DAVANGERE- 577 004

VISION OF THE INSTITUTE

To be center of excellence recognized nationally and internationally, in distinctive areas of engineering education and research, based on a culture of innovation and invention.

MISSION OF THE INSTITUTE

BIET contributes to the growth and development of its students by imparting a broad based engineering education and empowering them to be successful in their chosen field by inculcating in them positive approach, leadership qualities and ethical values.

VISION OF THE DEPARTMENT

The department endeavors to be a center of excellence, to provide quality education leading the students to become professional mechanical engineers with ethics, contributing to the society through research, innovation, entrepreneurial and leadership qualities.

MISSION OF THE DEPARTMENT

1. To impart quality technical education through effective teaching- learning process leading to development of professional skills and attitude to excel in Mechanical Engineering.
2. To interact with institutes of repute, to enhance academic and research activities.
3. To inculcate creative thinking abilities among students and develop entrepreneurial skills.
4. To imbibe ethical, environmental friendly and moral values amongst students through broad based education

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

1. Enable to understand mechanical engineering systems those are technically viable, economically feasible and socially acceptable to enhance quality of life.
2. Apply modern tools and techniques to solve problems in mechanical and allied engineering streams.
3. Communicate effectively using innovative tools, to demonstrate leadership and entrepreneurial skills.
4. Be a professional having ethical attitude with multidisciplinary approach to achieve self and organizational goals.
5. Utilize the best academic environment to create opportunity to cultivate lifelong learning skills needed to succeed in profession.

PROGRAM SPECIFIC OUTCOMES (PSO'S)

PS01:-Apply the acquired knowledge in design, thermal, manufacturing and interdisciplinary areas for solving industry and socially relevant problems.

PS02:-To enhance the abilities of students by imparting knowledge in emerging technologies to make them confident mechanical engineers.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – V

ENERGY LAB

Course Code	**18MEL58**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- This course will provide a basic understanding of fuel properties and its measurements using various types of measuring devices
- Energy conversion principles, analysis and understanding of I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.
- Exhaust emissions of I C Engines will be measured and compared with the standards.

Sl. No.	Experiments

PART A

1. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten's (closed) / Cleavland's (Open Cup) Apparatus
2. Determination of Calorific value of solid, liquid and gaseous fuels.
3. Determination of Viscosity of a lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
4. Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).
5. Use of planimeter

PART B

6. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal
   Efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A:F, Ratio heat balance sheet for
   (a) Four stroke Diesel Engine
   (b) Four stroke Petrol Engine
   (c) Multi Cylinder Diesel/Petrol Engine, (Morse test)
   (d) Two stroke Petrol Engine
   (e) Variable Compression Ratio I.C. Engine.

PART – C (Optional)

1. Visit to Automobile Industry/service stations.
2. Analysis of design, development, performance evaluation and process optimization in I C Engines.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Perform experiments to determine the properties of fuels and oils. Conduct experiments on engines and draw characteristics.
CO2: Test basic performance parameters of I.C. Engine and implement the knowledge in industry and determine the energy flow pattern through the I C Engine
CO3: Identify exhaust emission, factors affecting them and report the remedies.
CO4: Exhibit his competency towards preventive maintenance of IC engines.

DO's

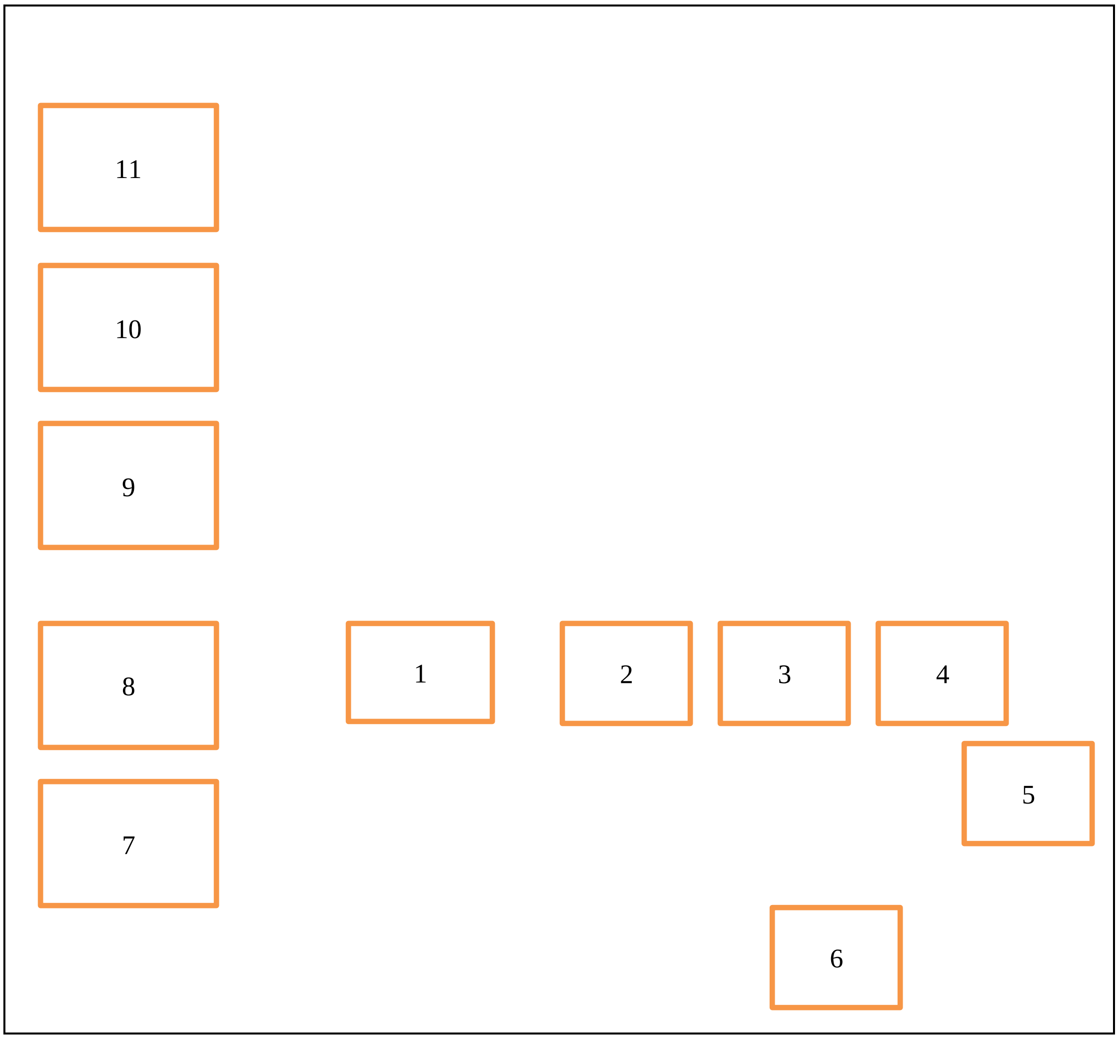
1. Students must always wear uniform and shoes before entering the lab.
2. Proper code of conduct and ethics must be followed in the lab.
3. Windows and doors to be kept open for proper ventilation and air circulation.
4. Note down the specifications of the experimental setup before performing the experiment.
5. Check for the electrical connections and inform if any discrepancy found to the attention of lecturer/lab instructor.
6. Perform the experiment under the supervision/guidance of a lecturer/lab instructor only.
7. After the observations are noted down switch off the electrical connections.
8. In case of fire use fire extinguisher/throw the sand provided in the lab.
9. In case of any physical injuries or emergencies use first aid box provided.
10. Any unsafe conditions prevailing in the lab can be brought to the notice of the lab in charge.

DONT's

1. Do not operate any experimental setup to its maximum value.
2. Do not touch/ handle the experimental setups/Test Rigs without their prior knowledge,
3. Never overcrowd the experimental setup/Test Rig, Leave sufficient space for the person to operate the equipment's.
4. Never rest your hands on the equipment or on the display board, because it has fragile measurement devices like thermometers, manometers, etc.

CONTENTS

LAYOUT OF ENERGY LABORATORY



INDEX

1) Red wood Viscometer No. –1
2) Say bolt Viscometer
3) Open cup Flash and fire point Apparatus
4) Closed cup Flash and fire point Apparatus
5) Junkers gas colorimeter with accessories
6) Bomb Calorimeter with all Accessories
7) 4-Stroke Diesel Engine with Accessories
8) 4-Stroke Diesel Engine Computerized Test set up with Eddy current Dynamometer.
9) Electronic Diesel injector control unit for Single Cylinder with Microcontroller & integrated power supply and Data Acquisition system with software for cylinder diesel engine, Cylinder Head for 2.5 Kw
10) Multi Cylinder Petrol Engine Test set up
11) Engine Test Up Four Stroke Petrol/Kerosene Engine
12) Computerized 4 stroke 4cylinder Diesel engine CRDI Maruthi Swift Engine Eddy current Dynamometer with Load cell

Layout

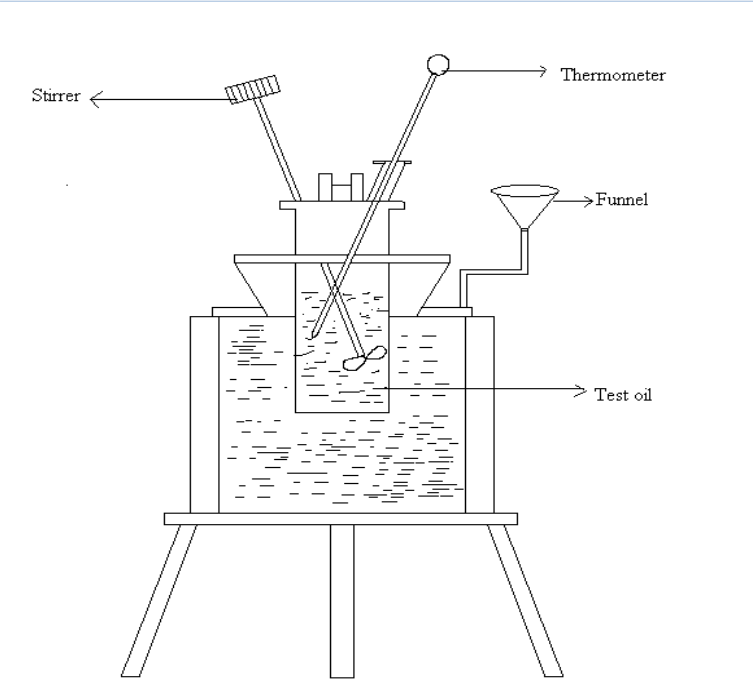
EXPERIMENT No. : 01

FLASH AND FIRE POINT OPEN CUP TYPE

Aim : To determine the flash & fire point of petroleum products Using Cleveland's open cup tester.

Apparatus:

1. Test cup
2. Heating plate
3. Test flame applicator
4. Heater
5. Thermometer(0 ^{0}C to 400^{0}C)
6. Thermometer support



Theory:

"**Flash Point**" of the oil is the lowest temperatures at which oil gives sufficient amount of vapour resulting in flash when a flame is brought near to it.

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

Description:

Abel's Apparatus is open brass cup and is used to find out the flash and fire point of the given oil. Which is heated by the electric heater provided below. Cover of the cup has four holes, circular hole is provided to insert the thermometer to measure the temperature of the oil and remaining thee are rectangle in shape, which are covered with shutter. Central hole is provided to introduce the test flame remaining two for air admission. Stirrer is provided to stir the oil, and get the uniform temperature. A sliding shutter mechanism is used to dip the test flame for ignition.

Procedure :

1. Support the tester on a level steady table. If the room is not draft free provide the tester with shields on all the three sides to prevent under air currents.
2. Samples containing water may be dehydrated with calcium chloride or by loose plug of dry absorbent cotton.
3. Wash the cup with an appropriate solvent to remove any oil or traces of gum or residue remained from a previous test. If any deposits of carbon are present they should be removed with steel wool. Flush the cup with water and dry it.
4. Support the thermometer in a vertical position with the cup and locate at a point half way between center and the side of the cup.
5. Fill the cup so that the top of the meniscus is exactly up to the filling line. If too much sample has been added to the cup, remove the excess using a pipette. Destroy any air bubbles on the surface of the samples. If there is any sample sticking on the outside of the apparatus, clean it.
6. Light the test flame and adjust its size to that of the pilot flame.
7. Apply heat to the oil such that the temperature rise is from 5^0C to 6^0C per minute.
8. When the temperature rise is about 30 ^{0}C below the expected flash point start testing of the emanating vapour for combustibility for every

rise of 2 degree centigrade. Apply the test flame across its sweep for about one second at each time.

9. Record the flash point as the temperature is read on the thermometer when a flash appears at any point on the surface of oil.
10. Record the fire point when vapour ignites and continuously burns.

Observation :

SL. No.	Temp of oil ^0C	Observation
1	Room Temp.	No flash
2		No flash
3		No flash
4		No flash
5		No flash
6		Flash point
7		Flash point
8		Flash point
9		Flash point
10		Fire point

Result :

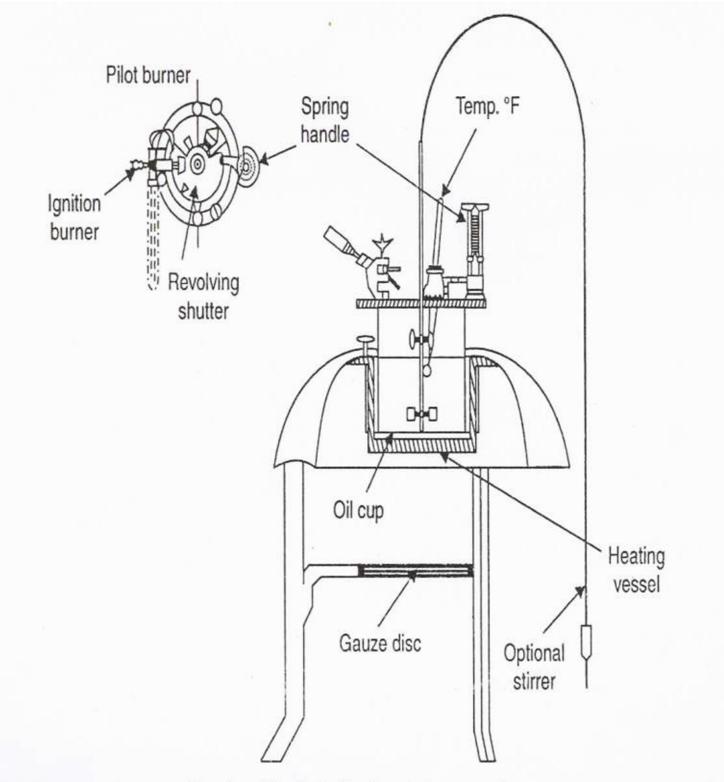
1. Flash point of the given oil= .... ^0C
2. Fire point of the given oil= .... ^0C

EXPERIMENT No. : 02

FLASH AND FIRE POINT CLOSED CUP TESTER

Aim : To determine the flash & fire point of petroleum products using pensky martin's closed cup tester.

Apparatus
1. Pensky martin's closed cup tester.
2. Heating plate.
3. Test flame applicator
4. Heater.
5. Thermometer (-5 ^{0}C to 100 ^{0}C & -5^{0}C to 370^{0}C)



Penskey-Marten's flash point apparatus.

Theory:

"**Flash Point**" of the oil is the lowest temperatures at which oil gives sufficient amount of vapours resulting in flash when a flame is brought near to it.

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

Description:

Test cup is generally made by brass material. Inside of the cup circular mark is made. The flange is equipped with devices for locating position by means of guide screws so as to fit always in same position. Cover is also made of brass, it has a stirrer mechanism passes though the center of the cover. It consists of two propellers mounted on the shaft one of the propellers is located in the oil, while the second one is placed in the vapour space. The stirrer shaft is rotated by means of a flexible shaft, which is turned by hand, and it has four openings, one is for thermometer while the other three are trapezoidal in shape. The middle one is for admitting the test flame and the other two are for admitting air. These thee openings are covered by means of a slide, which can be operated by means of a single screw the same screw operates the mechanism of the test and dips it in the vapour space of the cup. Burner is maintained near test flame for automatically lighting it when the slide is closed.

Procedure :

1. Support the tester on a level steady table. If the room is not draft free provide the tester with shields on all the three sides to prevent under air currents.
2. Samples containing water may be dehydrated with calcium chloride or by loose plug of dry absorbent cotton.
3. Wash the cup with an appropriate solvent to remove any oil or traces of gum or residue remained from a previous test. If any deposits of carbon are present they should be removed with steel wool. Flush the cup with water and dry it.
4. Insert the thermometer. Light the test flame. Apply heat to the oil such that the temperature rise is from 5 to 6 ^{0} C per minute. Turn the stirrer at about 90 to 120 rpm , stirring in a downward direction.
5. When the temp is about 20^{0}C below the expected value of the flash point start testing of the emanating vapour for combustibility at every rise of 1 degree centigrade. Apply the test flame by operating the mechanism on the cover. Retain the flame into the vapour for one second

and immediately close the cover by returning the mechanism to its original position. Do not stir the sample while applying the test flame.

6. Record the flash point as the temp read on the thermometer at the same time, when the test flame applicator causes a distinct flash in the interior of the cup.

Observation :

SL. No.	Temp of oil ^0C	Observation
1	Room Temp.	No flash
2		No flash
3		No flash
4		No flash
5		No flash
6		Flash point
7		Flash point
8		Flash point
9		Flash point
10		Fire point

Result :

1. Flash point of the given oil= ……………… ^0C
2. Fire point of the given oil= ……………… ^0C

WORK SHEET

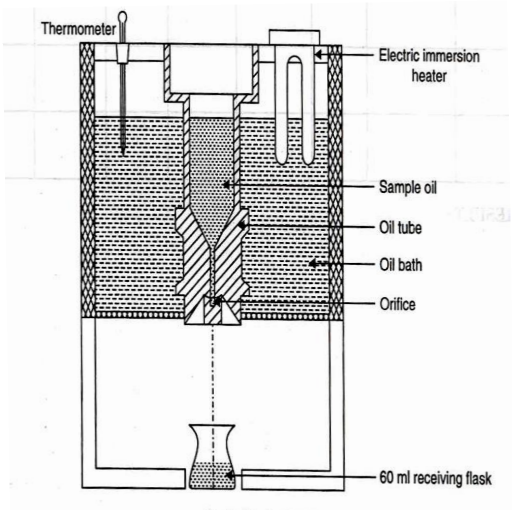
EXPERIMENT No. : 03

SAYBOLT VISCOMETER

Aim : To find the viscosity of the given lubricating oil, using saybolt viscometer.

Apparatus :

1. Saybolt viscometer.
2. Thermometer.
3. Stop watch.
4. 60 ml standard flask.
5. Digital Weighing balance.



Saybolt viscometer.

Theory:

Newton's Law governs Viscosity. It states shear stress is proportional to rate of shear strain.

Thus, $\tau \ \alpha \ \left(\frac{du}{dy}\right)$

Fluids, which obey Newton's law of viscosity, are known as Newtonian fluids and fluids, which do not obey this law, are Non-Newtonian fluids. The following graph shows the variation of shear stress with velocity gradient. Kinematic viscosity is expressed in centistokes in CGS units.

1 centistokes ICS = $\frac{1}{100}$ stokes = 10^{-2} cm^2/s

In SI units, ICS = $10^{-2} \times (10^{-2})^2 = 10^{-6}$ m^2/s

Description:

Figure shows the Saybolt viscosity test apparatus. It consists and oil tube and an orifice of standard dimensions. An electric immersion heater is used to heat the oil bath and a thermometer provided is used to measure the temperature of the oil bath. Oil whose viscosity is to be tested is taken in the oil test tube and a 60ml receiving flask kept exactly below the orifice receives the quantity of fluid (oil) passing though the orifice under the force of gravity during a given time interval.

Procedure:

1. Clean the viscometer using petrol oil.
2. Fix the cork at the orifice and fill the tube with oil whose viscosity is to be determined.
3. Insert one thermometer in oil cup and the other in the water bath.
4. Place the 60 ml flask in position under the orifice. When the oil temperature is steady at the desired value remove the cork from the orifice and at the same time start the stop watch.
5. Locate the receiving flask so that oil strikes the flared mouth and does not drop directly into the opening, which would cause foaming.
6. When the oil level reaches the 60 ml mark, stop the watch and at the same time fix the cork at the orifice and remove the flask.
7. Weigh the flask with oil and find the weight of oil.
8. Repeat the experiment at different temperature higher than room temperature oil should be cooled down to atmospheric temperature before taking it for weighing.

Tabulation :

1. Weight of the empty flask = …………………. g (Measure at every time)

SL No	Temp of oil ^0C	Time for collecting 60 ml oil 'T' in s	Mass of flask with oil 'm_1' in g	Mass of 60 ml oil 'm_2'in g	Density kg/m^3	Kinematic viscosity m^2/s	Dynamic Viscosity Ns/m^2
1							
2							
3							
4							

Specimen calculation

Note : i. The below formulae used is valid for heavy oils i.e. SAE 30 and above grade.

ii. Conversion of volume of oil from ml to m^3 .

1 lit=10^{-3} m^3

1 ml=10^{-3} x 10^{-3} m^3

1 ml=10^{-6} m^3

60ml=60X10^{-6} m^3

1. Kinematic viscosity (γ) = $(0.00226\,T - 1.95/T) \times 10^{-4}$, m^2/s When T < 100 s

   = $(0.00220\,T - 1.35/T)) \times 10^{-4}$, m^2/s When T > 100 s

2. Dynamic Viscosity (μ) = K.V x density of oil at that temperature, Pa-s

Dynamic viscosity $\mu = (\gamma \times \rho)$

μ =………….

= ………….N s/m^2

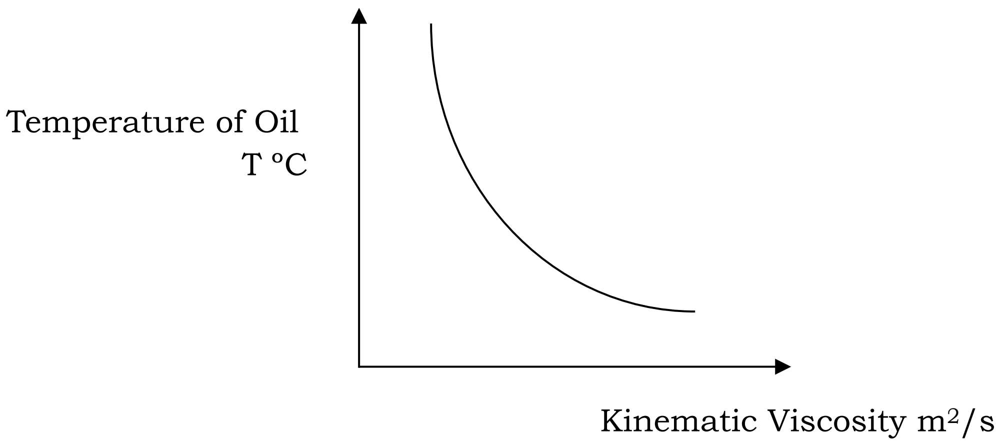
Where, ρ = Density of given oil in kg/m^3,

$$= \frac{\text{mass of oil}}{\text{volume of oil in } m^3}$$

$$= \left(\frac{m_2 - m_1}{60 \times 10^{-6}}\right) kg/m^3$$

=…………………… kg/m^3

NATURE OF GRAPH:



RESULT:

The viscosity of ………………………………(given sample of oil) is found out for different temperature and it is observed that viscosity decreases with increase in temperature.

WORK SHEET

WORK SHEET

WORK SHEET

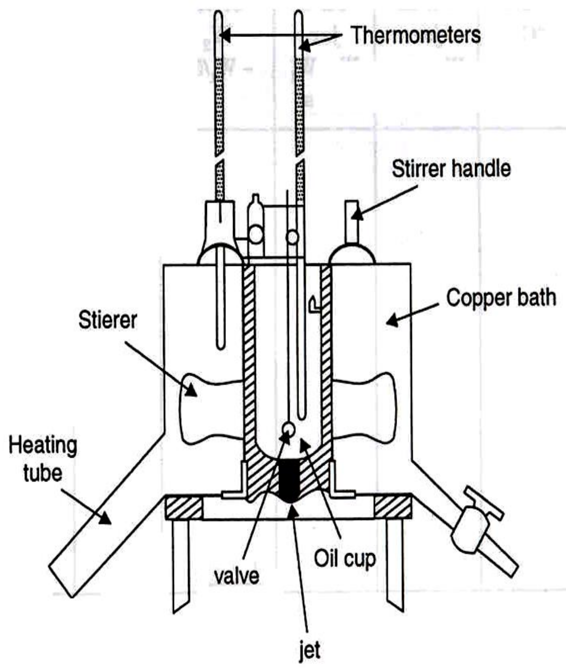
EXPERIMENT No. : 04

REDWOOD VISCOMETER

: To find the viscosity of the given lubricating oil, using redwood Viscometer

Apparatus

1. Redwood viscometer.
2. Thermometer
3. Receiving flask
4. Stop watch
5. Digital Weighing balance.



Theory:

Viscosity is one of the most important properties of the lubricant, which tells about its suitability for lubricating purpose. A lubricant reduces the friction between different moving parts by avoiding direct metal contact. The thin oil film formed between the moving surfaces keeps them apart.

Description:

Figure Shows a Redwood viscometer with thermometers. It consists of a standard cylindrical cup with a gauge wire to operate a plug or ball value. An agate jet of standard dimensions provided by the manufacturer is facilitated for the smooth and uninterrupted flow of oil though the orifice. The plug or ball value fits over the upper concave depression of the agate. The upward and downward movement of the plug regulates the oil flow from the cup. The oil cup is immersed in a water bath and the water bath is heated using an electric heater and a stirrer.

Procedure :

1. Clean the oil cup with petrol.
2. Level the viscometer using the leveling feet.
3. Fill the bath with water.
4. Fill the oil cup up to the index mark with oil whose viscosity is to be determined.
5. The water in the bath and the oil in the cup are constantly stirred to equalize their temp.
6. A 50 ml standard flask is kept below the jet,
7. When the temp of oil and water remain constant, lift the ball valve and collect 50 ml of oil in the flask and note down the time required to run down this 50 ml of oil from the oil cup into the receiver flask.
8. Do not stir the sample during the process of collection.
9. Weigh the standard flask with oil and find the weight of oil at that temp.
10. Repeat the experiment with different temp of the oil.

Observation :

Weight of the empty flask = ………….g (Measure empty flask every time)

SL No	Temp of oil ^0C	Time for collecting 50 ml oil 'T' in s	Mass of flask with oil 'm_1' in g	Mass of 50 ml oil 'm_2' in g	Density kg/m^3	Kinematic viscosity m^2/s	Dynamic Viscosity Ns/m^2
1							
2							
3							
4							

Specimen calculation :

Note: Conversion of volume of oil from ml to m^3 .

1 lit=10^{-3} m^3

1 ml=10^{-3} x 10^{-3} m^3

1 ml=10^{-6} m^3

50ml=50X10^{-6} m^3

1. Kinematic viscosity, **(γ)** = $(0.247\ T - 50/T) \times 10^{-6}$ m^2/s When T > 100 s

= $(0.260\ T - 179/T) \times 10^{-6}$ m^2/s When T < 100 s

2. . Dynamic viscosity (μ):

Dynamic viscosity $\mu = (\gamma \times \rho)$

= ……………N s/m^2

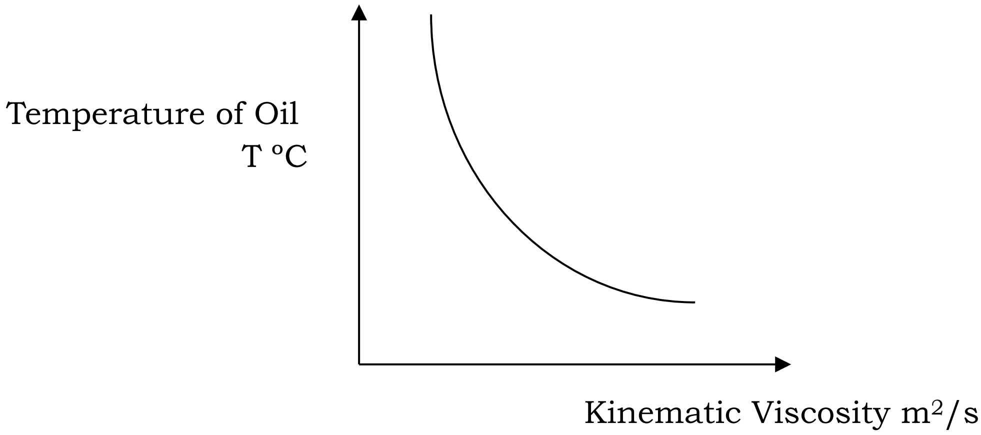
Where ρ = density of oil.

$$= \frac{\text{mass of oil}}{\text{volume of oil in } m^3}$$

$$= \frac{m_2 - m_1}{50x10^{-6}} \ kg/m^3$$

= ………………….kg/m^3

NATURE OF GRAPHS:



RESULT:

The viscosity of the ……………………………….(given sample of oil) is found out for different temperature and it is observed that viscosity decreases with increase in temperature.

WORK SHEET

WORK SHEET

WORK SHEET

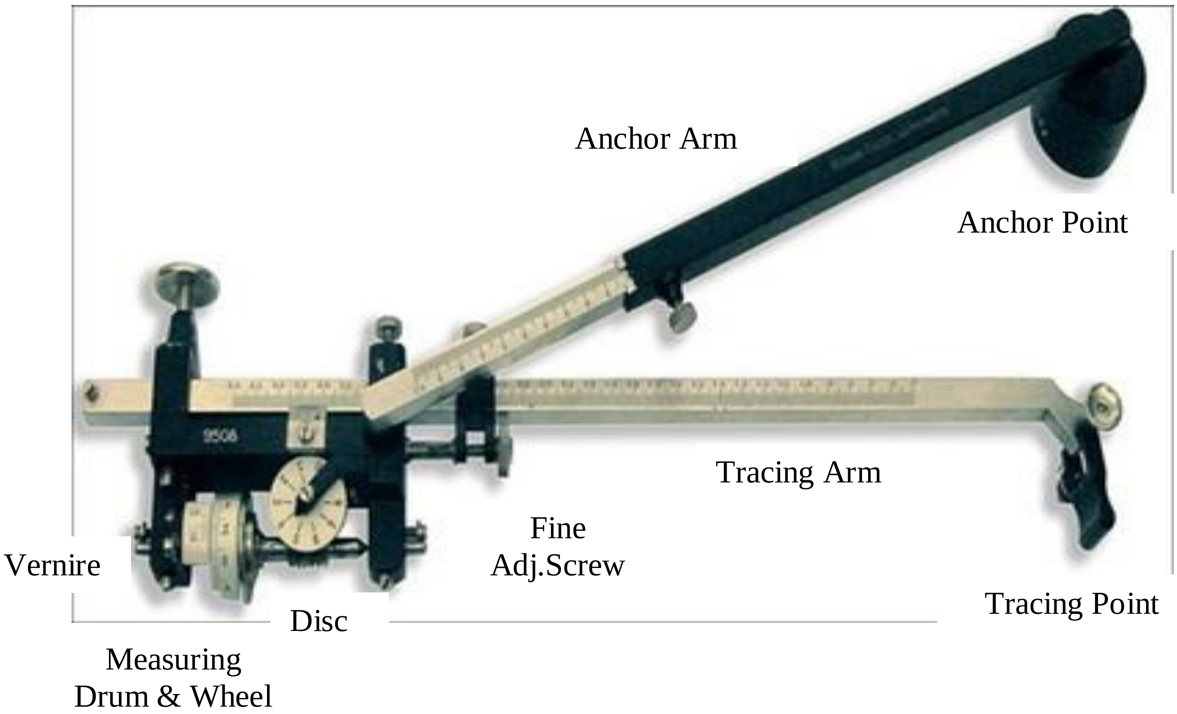
EXPERIMENT No. : 05

PLANIMETER

Aim : To determine the area of an regular and irregular figure.

Apparatus Planimeter

1. Drawing sheet



Theory :

Planimeter is an instrument for computation of area from the plotted map. It consists of two arms namely Tracing arm and anchor arm or Polar arm. The tracing arm is graduated its length can be adjusted at one end it has tracing point which is moved along the boundary line of the area. It has a carriage so which can be set at various points of the tracing arm with respect to the index of the vernier. The carriage consists of a measuring wheel divided into 100 divisions and vernier divided into 10 divisions. The wheel is geared to a counting disc which is graduated into 10 divisions.

The anchor arm carries needle point weight at one end which forms centre of rotation the ether end can pivoted by ball and socket arrangement the carriage on the tracing arm.

The planimeter rests on the tracing point, point and periphery of the wheel.

Procedure :

1. The index of the vernier is set to the exact graduation marked on the tracing arm corresponding to the scale as specified in the manufacturing, s guiding table that is 1:1 scale 13.68.
2. The anchor point is firmly fixed on the map area, outside or inside it. If anchor point is outside the measuring area C=0 and If anchor point is inside the measuring area C=23.89.
3. A starting point is marked on the area to be measured , And the tracing point is placed on the starting point. The initial reading (IR) is noted by observing disc. Wheel and vernier respectively.

   Disc shows-units

   Wheel shows – tenth & hundredth

   Vernier shows-thousandth.
4. The tracing point is moved gently in a clockwise direction along the boundary of the area.
5. The number of times the **zero mark of the disc** passes the index mark in a clockwise or anticlockwise direction is observed.
6. Finally when the tracing point is moved to the starting point the final reading (FR)is noted.
7. Select known area of regular figures, ex: triangle, rectangle, circle any other figures, whose area's can be calculated. Using the planimeter determines the areas and determines percentage error in each case.
8. First calibrate planimeter using known areas of regular figures, determines the areas and determines percentage error in positive or negative. Now measure the irregular area using planimeter (add or subtract the error)finally you will get the area in cm^2.

Note:

Regular area :Rectangle, Square, Quarter Circle ,semi Circle thee fourth Circle, Full Circle Hexagon, Pentagon, Octagon, Rambo's etc.

Irregular area**:** Carnot cycle, Diesel cycle, Constant pressure cycle, Constant volume cycle, Rankine cycle, Otto cycle , Duel cycle any other irregular area

Tabulation :

Sl. No.	Figure	True area 'A' mm^2	Measured area 'a' mm^2	Error E = a - A	% Error =(E/A) x 100
1					
2					
3					

Specimen calculation :

Area A = M (FR-IR ± 10 N + C)

Where

M = Area for one revaluation of measuring wheel = $100cm^2$

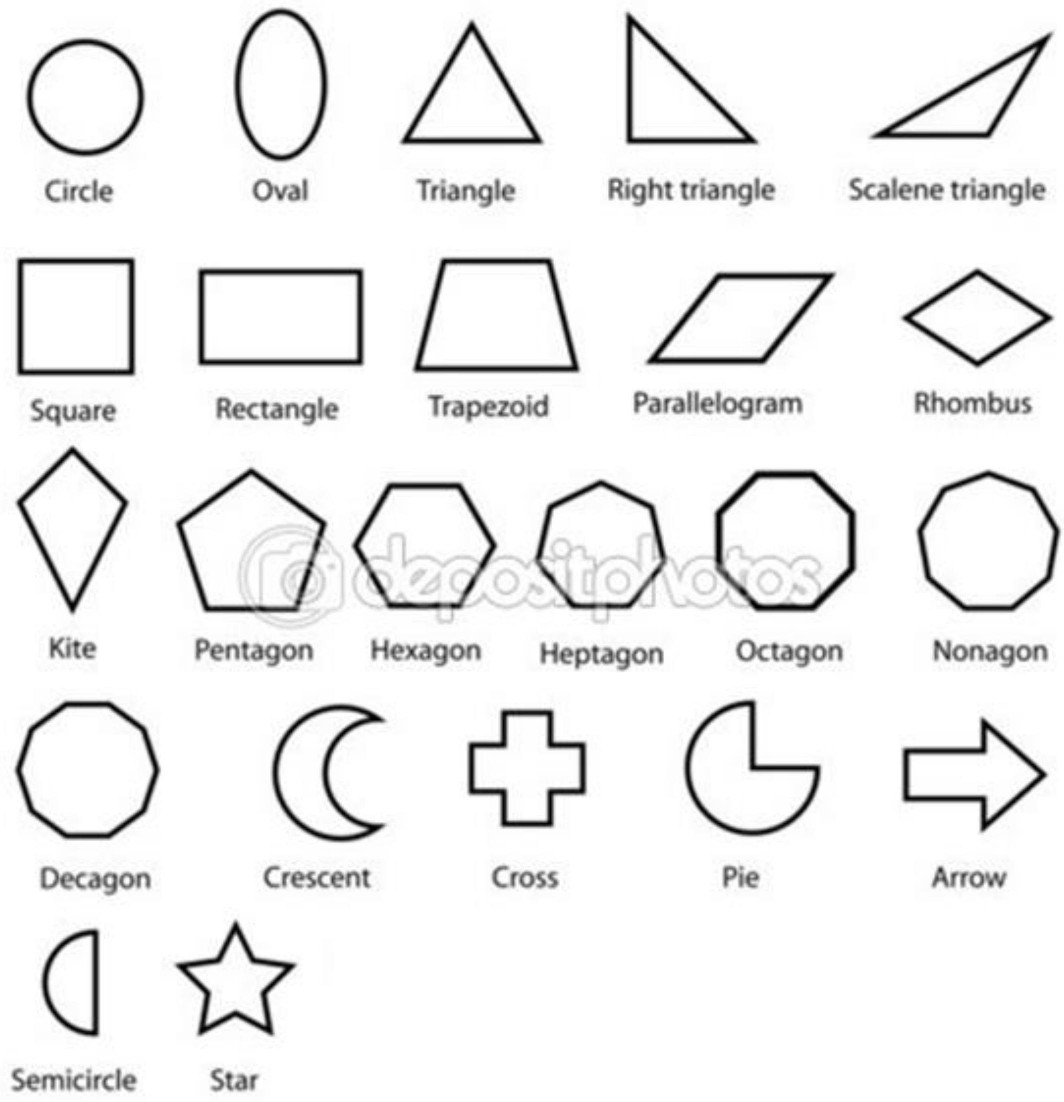
N = Number of times the zero mark of the disc passes index mark. (when N is positive when tracing arm moves clockwise and when N is negative when tracing arm moves in anticlockwise)

C = Constant Given in the table (C=0 and If anchor point is inside the measuring area C=23.89)

IR = Initial Reading

FR = Final Reading

Result : Percentage of error shown in the tabular column.



Measure the area of the followings

1. Diesel Cycle
2. Otto Cycle
3. Dual cycle
4. Carnot Cycle

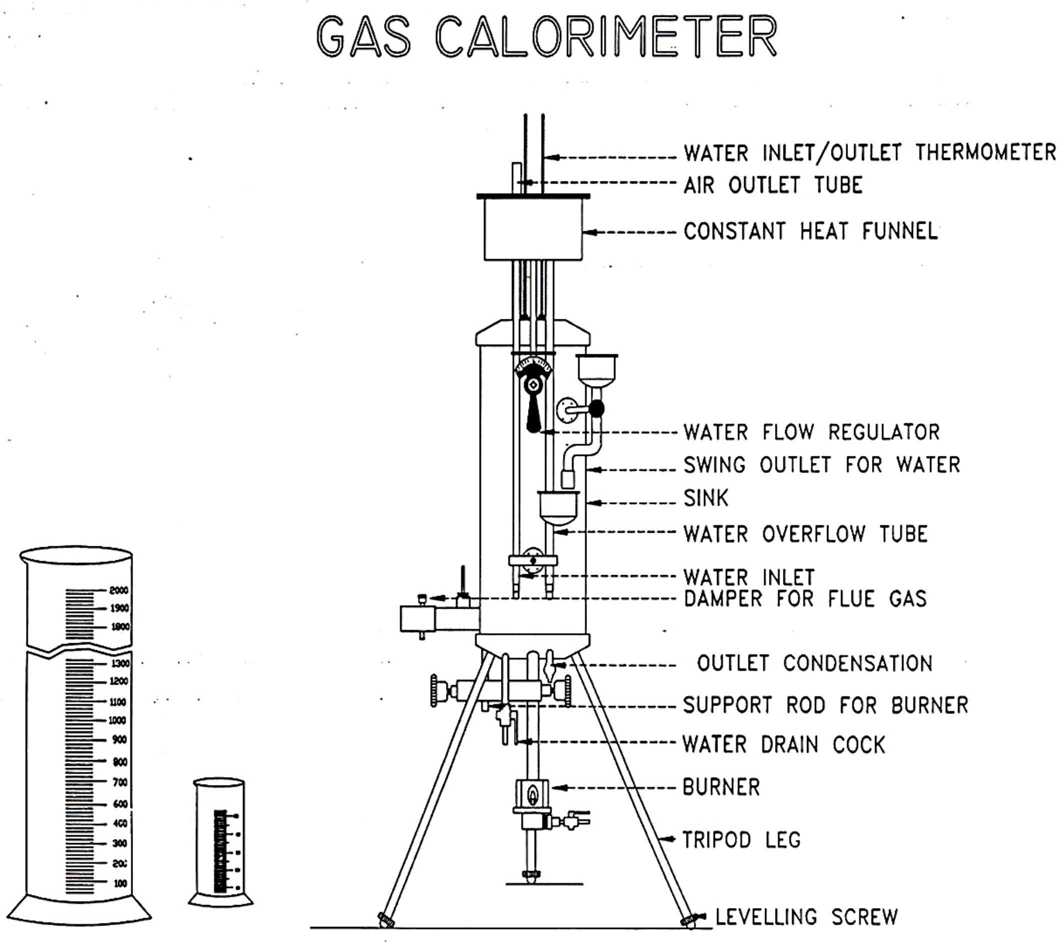
Note:
Draw the sketches of the given figure in A4 size sheet and staple /paste it here.

EXPERIMENT No. : 06

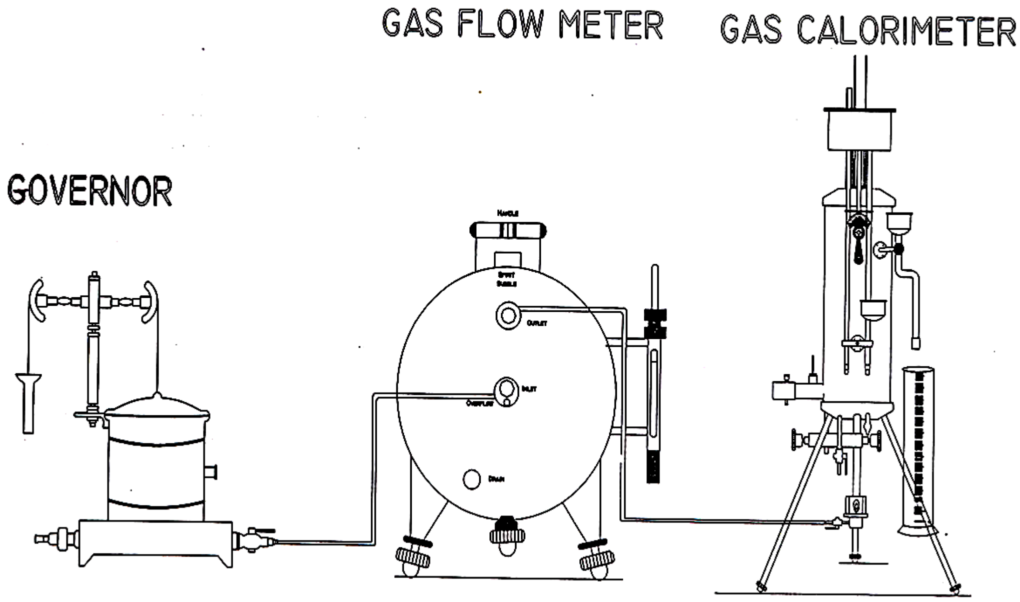
JUNKERS CALORIMETER

Aim : To determine the calorific value of the gaseous fuel.

Apparatus
1. Junkers gas calorimeter
2. Gas flow meter
3. LPG Cylinder
4. Governor
5. Measuring flask
6. Stop watch



Introduction: 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 which is built in. the heat transfer takes place essentially by counter flow heat exchange between the burning gas and the circulating water so that the nearly complete heat exchange taken place. Therefore, with the above assumption heat absorbed by the circulating water is equal to the heat released from the gaseous fuel is accurate enough for calculation of calorific value.



Procedure :

1. Turn on water mains by opening the control knob of gas calorimeter to setting full.
2. Adjust the water supply in such a way that there will be only a small amount of overflow of excess water to the sink. This will let out the air bubbles present inside.
3. Remove the burner from the calorimeter open the outlet tap of the governor.
4. Allow the gas to pass for two or three revolutions as indicated by the flow meter.
5. Then light the burner and adjust the air regulating sleeve and the gas tap to get a non-luminous flame.
6. Clamp the burner keeping it to the top most position. Then adjust the flow of water to get a temp difference of 12^0C to 15^0C between the

water inlet and outlet temperature. This is important if the flow of water is less than required there will be a high temp difference and the water flow is to be adjusted in such a way that there will not be formation of steam

7. Allow the water outlet to indicate a steady temp. which may take about 20 to 30 minutes.
8. Keep the measuring jar beneath the swing water outlet tube, and simultaneously count the number of revolutions made by the gas flow meter pointer i.e. to find the volume of gas consumed during the test period
9. When the pointer has made 2 or 3 revolutions, swing the water outlet back to the sink. Also note the temp of water inlet and outlet as well as gas flow meter pointer i.e. to find the volume of gas consumed during the test period.
10. When the water flow and gas flows are same. Repeat the experiment thice and take the average of the reading and calculate calorific value of the gas.

Observation Column:

SL. No.	Gas Flow meter Reading	Water Collected ml	Time Sec.	T_1 ^0C	T_2 ^0C	T_2-T_1 ^0C (Min 14^0C)
1	One Revolution					
2	Two Revolution					
3	Three Revolution					

1. Gas consumed for 1revolution of flow meter = ---------------------- m^3
2. Water collected for one revolution, =------------------------m^3
3. Time taken for one revolution of flow meter = ----------------------Sec.

$$\text{Gas flow rate} = \frac{\text{Gas consumed for one revolution}}{\text{Time taken for one revolution of flow meter}} \ m^3/Sec.$$

$$\text{Water flow rate} = \frac{\text{Water collected for one revolution}}{\text{Time taken for one revolution of flow meter}} \ m^3/Sec.$$

Tabular Column

SL. No.	Gas Flow meter Reading	Volume of gas V_g, liters	Time Sec.	Calorific value kJ/kg
1	One Revolution			
2	Two Revolution			
3	Three Revolution			

Specimen Calculation :

Calorific value of the fuel * Mass of the fuel consumed = Heat absorbed by the water

$$\text{CV of the fuel} = \frac{\text{Mass of the water collected} * \text{Specific heat of water} * \text{Temp diff. of water}}{\text{Density of the gas} * \text{Volume of the fuel consumed}}$$

$V = m/\rho$

$m = V * \rho$

$m_g = V_g * \rho_g$ kg/m^3

- Density of water ρ_w = 1 Kg/lt at N.T.P
- Density of the gas ρ_g = 1.859 kg/m^3
- Atmospheric pressure P_a = 1.01325 bar
- Specific heat of water C_{pw} = 4.2 kJ/kg K

Calorific value of the gas By Volume method

1. Heat released by gas = Heat absorbed by water

$$CV * V_g * \rho_g = V_w * \rho_w * C_{pw} (T_2 - T_1)$$

$$CV_g = \frac{(V_w * \rho_w * C_{pw} (T_2 - T_1))}{V_g * \rho_g}$$

Calorific value of the gas By Mass method

$$m_g (CV_g) = m_w \times C_{pw} (T_2 - T_1)$$

$$CV_g = \frac{(m_w \times C_{pw} (T_2 - T_1))}{m_g}$$

Where

m_g = Mass of the gas m

V_g = Volume of Gas in m^3

V_w = Volume of Water in m^3

CV_g =………………… kJ/kg.

RESULT:

Calorific value of the given gaseous fuel =…………….. kJ/kg.

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EXPERIMENT No. : 07

BOMB CALORIMETER

Aim : To determine the calorific value of the liquid fuel with Bomb calorimeter

Apparatus
1. Bomb calorimeter
2. Electric wire
3. Thermometer

Procedure :

1. Weigh the empty crucible.
2. Now take approximately less than 1 gm of the liquid fuel into the crucible and reweigh, the weight of the fuel being obtained by difference.
3. Place the crucible in its supports and coil a small loop of the Nichome wire between the two conductors and a piece of thread is dipped into

the fuel. Screw the cap firmly on to the body of the bomb and charge with oxygen until a pressure of 25 bar is obtained.

4. Lower the bomb into the calorimeter and connect the firing wires.
5. Now pour about 2.25 liter of water into the calorimeter so as to completely cover the bomb. Fit the agitator and thermometer into position and start the agitator.
6. The observations may be divided into three periods.
7. The initial period of five minutes duration during which the temperature is read every minute. This period ends and the main period begins with the firing of the bomb, the temperature now being read at intervals of 10 seconds until transfer of heat from the bomb has ceased, as indicated by a fall in the thermometer readings.
8. The first reading of the final period is that immediately following the maximum reading, this period again being of 5 minutes duration with temperature read at interval of 2 minutes.
9. At the end of the experiment, the weight of crucible with the remaining unused length of Nichrome wire is determined.

Observation :

Time interval 't' in seconds	Differential temperature reading DDT ,or Rise in temperature 'T' in ˚C	PERIOD
		Preliminary
		Chief
		After

Specimen Calculation :

Heat balance equation

$$HM = WT$$

Where

W = Mean effective heat capacity of standard calibrated calorimeter = 2688 Cal/^{o}C

T = Rise in temperature in ^{o}C

M = Mass of fuel = ……….kg

H = Calorific valve of given fuel = W T / M

Gross Calorific Value, G.C.V = …………….. kJ/kg

Result : Calorific value of the fuel is _______________ kJ/kg

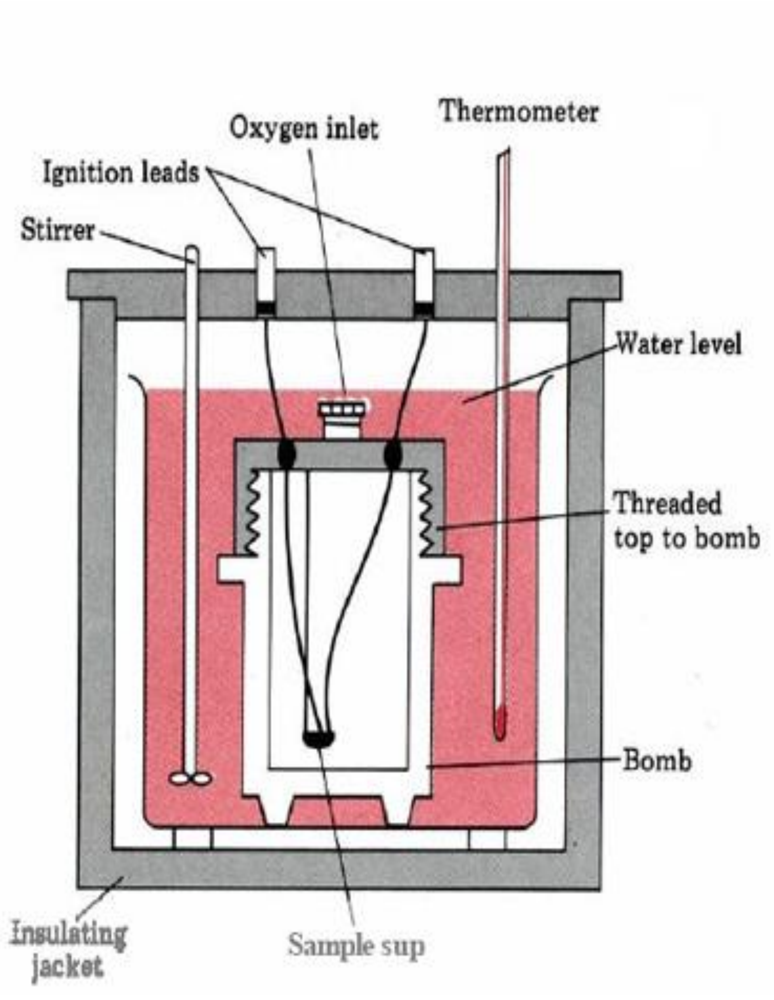

Fig. Bomb Calorimeter

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EXPERIMENT NO. : 08

VALVE TIMING DIAGRAM FOR 4-STROKE SINGLE CYLINDER DIESEL ENGINE

Aim: To draw the valve timing diagram for 4-stroke Single Cylinder Diesel engine .

Apparatus:

1. 4-stroke single cylinder engine .
2. Spirit level.
3. Dial indicator.
4. Inelastic thead to measure the circumferential distance on flywheel.
5. Chalk pieces or pencil for marking on flywheel.

Procedure:

a. Horizontal Engine :

1. Circumference of the fly wheel drum is measured. The flywheel is slowly rotated in the direction of rotation and the piston is moved towards the inner dead center **IDC**. When the piston is perfectly horizontal, as indicated by a spirit level placed on the flat surface of the crank web, a mark is made on the fly wheel with reference to a fixed point. This mark is recorded as the **IDC** mark.

2. The flywheel is rotated in the same direction till the cam just comes in contact with the roller follower of the intake valve. A slight resistance to the rotation of the roller indicates this. This position corresponds to the inlet valve opening and is marked on the brake drum as **IVO** with reference to the same fixed point. The flywheel is further rotated till the roller just comes out contact of cam. A slight resistance for manual rotation of the roller again indicates this. This position corresponds to the inlet valve closing and is marked on the fly wheel as **IVC**.

3. The same procedure is repeated for the exhaust valve and the exhaust valve opening **EVO** and closing **EVC** points are marked on the fly wheel.

4. The distance along the circumference of the fly wheel from the exhaust **IDC** to **IVO, IVC, EVO** & **EVC** are measured on the corresponding angles are calculated with reference to the **IDC** or **ODC**.

b. Vertical Engine:

1. The top dead center **TDC** is already available on the flywheel of this engine. The rocker arms are easily accessible when the end cover on the cylinder head is removed and hence a dial indicator is used to indicate the valve opening and closing positions from the movement of the rocker arm.

2. The magnetic base of the gauge is used to fix the gauge on the same flat surface on the cylinder head and the tIP of the stylus is made to rest on the rocker arm nut of inlet valve. The flywheel is slowly rotated in the direction of rotation and the point at which the dial is just start indicating upward movement. The rocker arm is marked on the flywheel with reference to the pointer on the engine at the flywheel. This corresponds to the inlet valve opening **IVO**.

3. The flywheel is further rotated in the same direction till the indicator shows downward movement of the rocker nut indicating the closing movement of the inlet valve. The rotation is continued till finally the dial pointer just stops moving. This indicates that the movements of the cam have just left contact with the rocker nut, which means that the valve is just closed. The corresponding position is marked on the flywheel as **IVC**.

4. The dial indicator is now positioned for other rocker arm and the procedure is repeated to obtain the exhaust valve opening and closing marks on the flywheel.

5. The circumferential distances of the various marks are now measured from the **TDC** and the valve opening and closing angles are calculated with respect to **TDC** or **BDC**.

Observations:

a. Horizontal engine :

1. Horizontal engine circumference of the brake drum = …………………….mm.

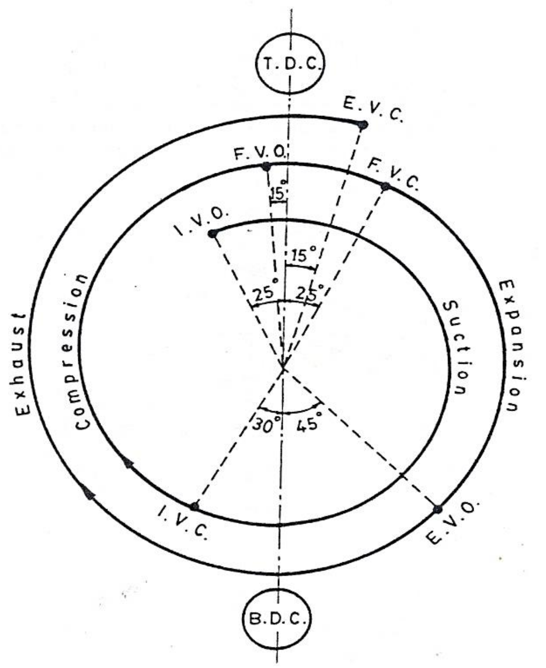
Position of the crank web	Arc length (mm)	Angles (deg.)
IVO w.r.t. IDC		
IVC w.r.t. IDC		
EVO w.r.t. IDC		
EVC w.r.t. IDC		
Angle of over lap = ………………………….. ^{o}		

calculations:

1. Arc length between the IVO and IDC X = …………………………….mm.
2. Circumference of brake -drum Y =…………………………….. mm
3. Angle between IVO & IDC =X/Y x 360 ^{o}= ………………………………. ^{o}

Results :

The valve timing diagram for the given 4 - stroke horizontal and vertical engine is as shown in the valve timing diagram.



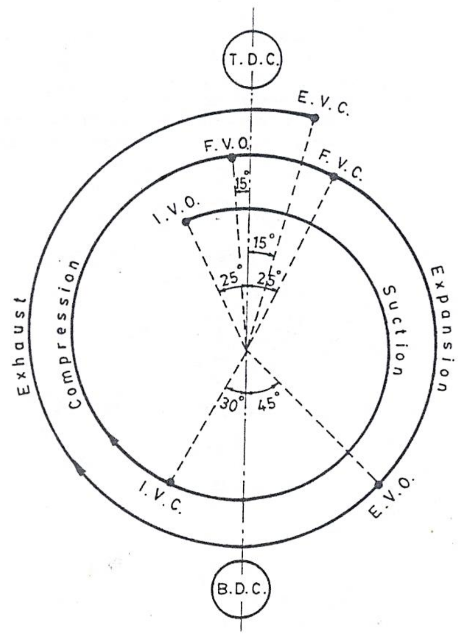
b. Vertical engine :

1. Vertical engine circumference of the flywheel = ……………………………mm.

Position of the valve w.r.t to TDC	Arc length (in mm)	Angle (in deg.)
IVO w.r.t. TDC		
IVC w.r.t. TDC		
EVO w.r.t. TDC		
EVC w.r.t. TDC		
Angle of over lap = ……………………….^{o}		

calculations:

1. Arc length between the IVO and TDC. X = ………………… mm.
2. Circumference of brake –drum Y = ………………... mm
3. Angle between IVO & TDC = (X/Y) x 360^0 =………………………^{0}



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EXPERIMENT NO. : 09

PORT TIMING DIAGRAM FOR 2-STROKE ENGINE

Aim : To draw the port timing diagram for a 2- stroke engine model

Apparatus :

1. sectioned model,
2. Inelastic thead to measure the circumferential distance on flywheel.
3. Chalk pieces or pencil for marking on flywheel.

Procedure :

1. A sectioned model is considered for the determination of the port timing. The section of the crank is in the form of semi circle. The bottom dead center position is first marked on this semi circle. When the crank is in this position, both suction and exhaust ports are open.

2. The crank is slowly rotated until the position just covers the suction port and this position is marked. The angle of the crank in this position with respect to the **BDC** position can now be determined by knowing the arc lengths on the semi circle.

3. The crank is further rotated until the position just covers the exhaust port and this position is again marked. Once again the angle of crank is in this position with respect to the **BDC** position can be determined by knowing the corresponding arc length.

4. The opening and closing of ports are symmetrical with respect to the **BDC** Hence the port opening angles are identical with the closing angles, but they are before the **BDC**.

Observation:

1. Circumference of the flywheel = ……..……………………mm.

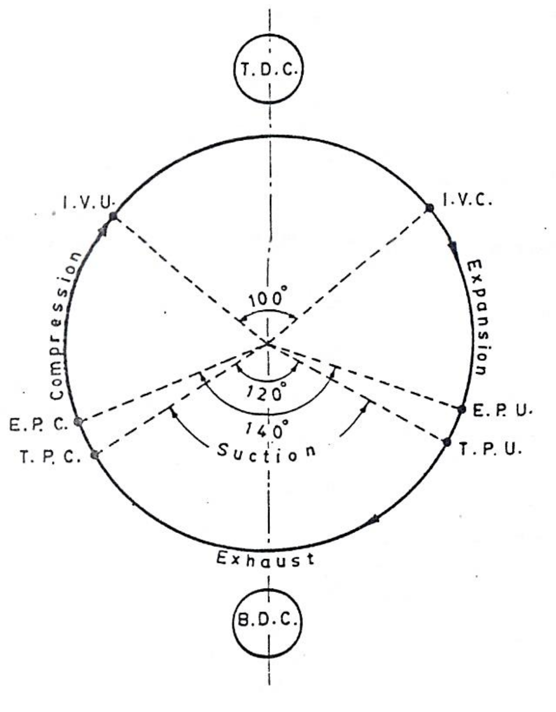
Position of the crank	Arc length (in mm)	Angle (in deg.)
PO w.r.t. BDC		
IPC w.r.t. BDC		
EPO w.r.t. BDC		
EPC w.r.t. BDC		

Calculations:

1. Arc length between the IPO and BDC X = …………………….. mm
2. Circumference of flywheel Y= …………………….. mm
3. Angle between IPO & BDC =X/Y x 360^0 =…………………………^{0}

Results :

The port timing diagram for the given sectioned 2 - stroke engine model is as shown in the port timing diagram.



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EXPERIMENT NO. : 10

ENGINE TEST SET UP

Aim : To study the performance of 4-stroke, single cylinder diesel engine

Apparatus :

1. Single cylinder 4- stroke diesel engine
2. Stop watch

Description :

The setup consists of single cylinder, four strokes, diesel engine connected to rope brake type dynamometer. It is provided with necessary equipment and instrument for combustion pressure and crank angle measurements. These signals are interfaced with computer though engine indicator for Pθ, PV plots and engine indicator power, provision is also made for air, fuel, exhaust temperature and load measurements. Digital indication is provided for exhaust temperature. The setup enables study of for indicator power, brake power, thermal efficiency, volumetric efficiency, fuel consumption, air fuel ratio etc. The software package is fully configurable. The Pθ diagram, PV plot and performance curves are obtained at various operating points

Theory : Following are the formulae used in calculation of various results.

Nomenclature :

T1	Jacket water inlet temperature	K
T2	Jacket water outlet temperature	K
T3	Exhaust gas temperature	K
T_{amb}	Ambient temperature	K
mf	Fuel flow	kg/h
ma	Air flow	kg/h
Mw	Jacket water flow	kg/h
W	Net dynamometer load	N
N	Speed of engine	r/min

System constants:

D	Engine cylinder diameter	m
L	Engine stroke length	m,
No. Cyl	Number of cylinder	K
N	No. of cycle	1 for two stroke
		2 for four stroke
R	Dynamometer drum radius	M
Cal.val	Calorific value of fuel	kJ/kg
D	Orifice diameter	M
C_d	Coefficient of discharge	
ρ_a	Air density	kg/m^3
ρ_w	Water density	kg/ m^3
H	Manometer reading across orificemeter	Meters of water
C_{pw}	Specific heat of water at constant pressure	kJ/kg K
C_{pex}	Specific heat of exhaust at constant pressure	kJ/kg K

Specification :

Engine	Single cylinder,4stroke,water cooled, diesel, make- Kirloskar, Model -TV!, Rated Power -5.2kW, Speed –1500 r/min, bore-87.5mm, stroke-10mm, Compression ratio-17.5.

Observations:

SL. No.	Load, 'W' in N	Speed, N In r/min	Air flow, m_a in kg/h	Fuel flow m_f in kg/h	Water flow m_w in kg/h	Inlet water temp. T_1 °C	Outlet water temp. T_2 °C	Exhaust gas temp. T_3 °C
1								
2								
3								
4								

Results :

Brake power BP In kW	Brake mean effective pressure, bmep in bar	Brake specific fuel consumption bsfc in kg/kW-h	Brake thermal efficiency η_{bth}	Indicated thermal efficiency η_{ith}	Volumetric efficiency, η_{vol}	Mechanical efficiency, η_{mech}	Air fuel ratio, A/F

Specimen Calculations:

1. Brake Power, BP = 2 x π x N x (W x R) / (60 x 1000), kW

2. Brake Mean Effective Pressure, bar

$$b_{mep} = \frac{BP \times 60}{\pi/4 \times D^2 \times L \times (N/n) \times \text{No. of cylinder} \times 100}$$

3. Indicated Power: From PV diagram work done per cycle per cylinder

= Area of PV diagram x (X scale factor) x (Y scale factor), Nm.

Where P_m = as / l ,
a= Area of indicator diagram, m^2,
s= spring constant in $N/m^2/m$
l= length of indicator, m

Area of PV diagram in m^2
X scale factor in m
Y scale factor in $N/m^2/m$

$$IP = \frac{\text{Work done per cycle per cylinder} \times (N/n) \times \text{No. of cylinder}}{60 \times 1000} \text{ kW}$$

4. Indicated Mean Effective Pressure, bar

$$i_{mep} = \frac{IP \times 60}{\pi/4 \times D^2 \times L \times (N/n) \times \text{No. of cylinder} \times 100} \text{ Bar}$$

5. Frictional Power: FP = IP –BP, kW

Note : Frictional power, IP can be calculated from William's line method (i.e by plotting the graph total fuel consumption v/s brake power)

6. Brake specific fuel consumption in kg/kW-h

$$bsfc = \frac{m_f}{BP} \text{ kg/kW-h}$$

7. Brake thermal efficiency :

$$\eta_{bth} = \frac{BP \times 3600}{m_f \times C.V} \times 100 \text{ , \%}$$

8. Indicated Thermal Efficiency :

$$\eta_{ith} = \frac{IP \times 3600}{m_f \times C.V} \times 100 \text{ , \%}$$

9. Mechanical Efficiency :

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

10. Air flow, m_a

$m_a = C_d (\pi/4)d^2\{ 2gh \times (\rho_w/\rho_a)\}^{1/2} \times 3600 \times \rho_a$, kg/h

Volumetric efficiency = Actual air flow / Theoretical air flow

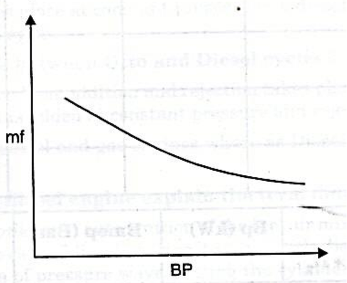
$$\eta_{vol} = \frac{m_a}{(\pi/4) \times D^2 \times L \times (N/n) \times 60 \times \text{No. of cylinder} \times \rho_a} \times 100$$

11. Air fuel ratio: $A/F = m_a / m_f$

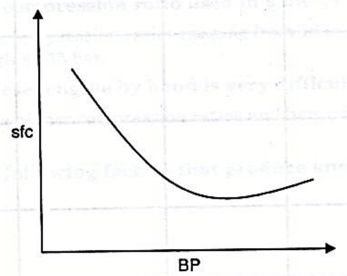
CHARACTERISTIC CURVES :

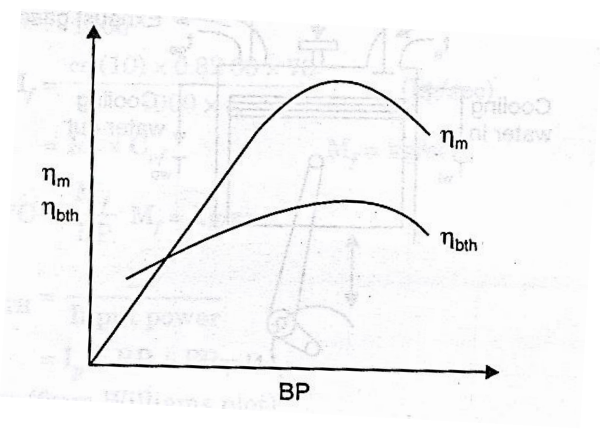
The following characteristic curves are drawn,

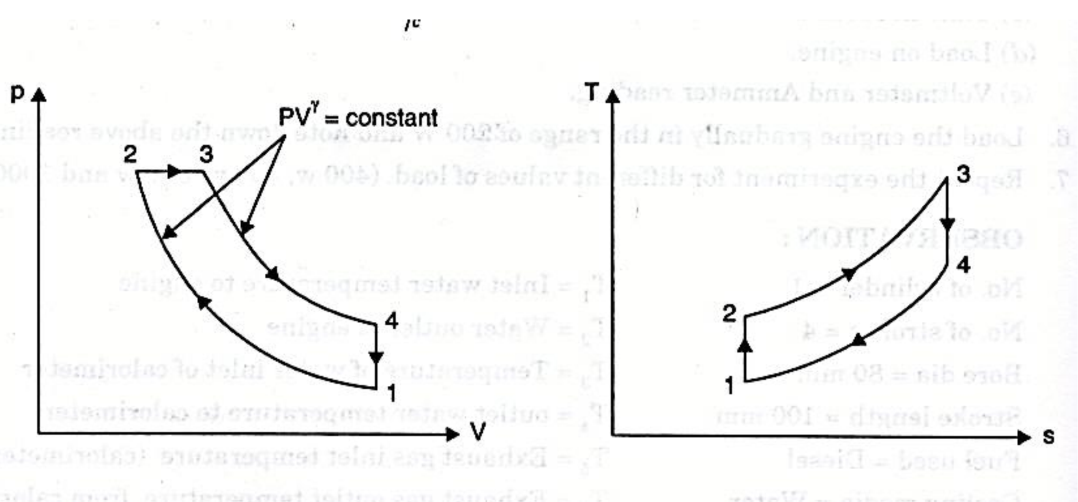
1. Total fuel consumption Mf v/s BP



2. Specific fuel consumption (sfc) v/s BP







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EXPERIMENT NO. : 11

MORSE TEST

AIM: To determine the frictional power of the given 4 stroke, 4 cylinder petrol engine.

APPARATUS:

Engine hydraulic dynamometer, water circulation system, sensors for measurement of speed and load, load varying mechanism.

THEORY:

Morse test is used to find a close estimate of indicated power (IP) of a multicylinder engine. In this test the engine is coupled to suitable brake dynamometer and the brake power is determined by running the engine at the required speed. The cylinder is first cut-off by shorting out the spark plug of the first cylinder.

As a result of cutting out the first cylinder, engine speed will drop. Load on the engine is now removed so that the original speed is attained .The brake power under this load is determined and recorded (BP_1) the first cylinder operation is restored normal and the second cylinder is cut-off. The engine speed will again vary .By adjusting the load on the engine, speed brought to original speed (BP2) same procedure is continued till the last cylinder is cut-off.

Other methods to determine frictional power are,

1. William's line method.
2. Motering test.
3. Difference between indicated and brake power.

PROCEDURE:

1. Remove all loads on the engine.
2. Start the engine.
3. Adjust the throttle valve to obtain the required speed of the engine.
4. Load the engine to its maximum value by using dynamometer adjusts the throttle position by any desire speed.
5. Cut-off the first cylinder current supply to the spark plug of first cylinder.
6. The speed of engine decreases .Attain the normal speed by adjusting the load without adjusting the throttle valve.
7. Repeat the experiment by cutting the other cylinders one at a time and note down all the readings

OBSERVATIONS AND TABULATIONS:

SL. No.	Cylinder condition.	Engine speed N (rpm)	Load W(kN)	Brake Power kW	Indicated Power kW
1	All cylinders are firing			(BP) =	(IP) =
2	First cylinder is cut off			$(BP)_1$=	$(IP)_1$ =
3	Second cylinder is cut off			$(BP)_2$ =	$(IP)_2$ =
4	Third cylinder is cut off			$(BP)_3$ =	$(IP)_3$ =
5	Fourth cylinder is cut off			$(BP)_4$ =	$(IP)_4$ =

FULL LOAD:

Brake power = $2\pi NT$ in kW,

N = Engine speed in rpm,

T = Torque in kN-m,

W = Net load acting on the brake drum in kN,

R = Radius of brake drum in m,

T = W x R in kN-m.

1. Total brake power when all cylinders firing (BP) = $\frac{2\pi NT}{60}$ kW

2. Brake power when first cylinder is cut off $(BP)_1 = \frac{2\pi\ (W1\ X\ R)}{60}$ kW

3 Brake power when second cylinder is cut off $(BP)_2 = \frac{2\pi\ (W2\ X\ R)}{60}$ kW

4 Brake power when third cylinder is cut off $(BP)_3 = \frac{2\pi\ (W3\ X\ R)}{60}$ kW

5. Brake power when third cylinder is cut off $(BP)_4 = \frac{2\pi\ (W4\ X\ R)}{60}$ kW

6 .Indicated power when first cylinder is not firing $(IP)_1 = (BP) — (BP)_1$

7. Indicated power when second cylinder is not firing $(IP)_2 = (BP) — (BP)_2$

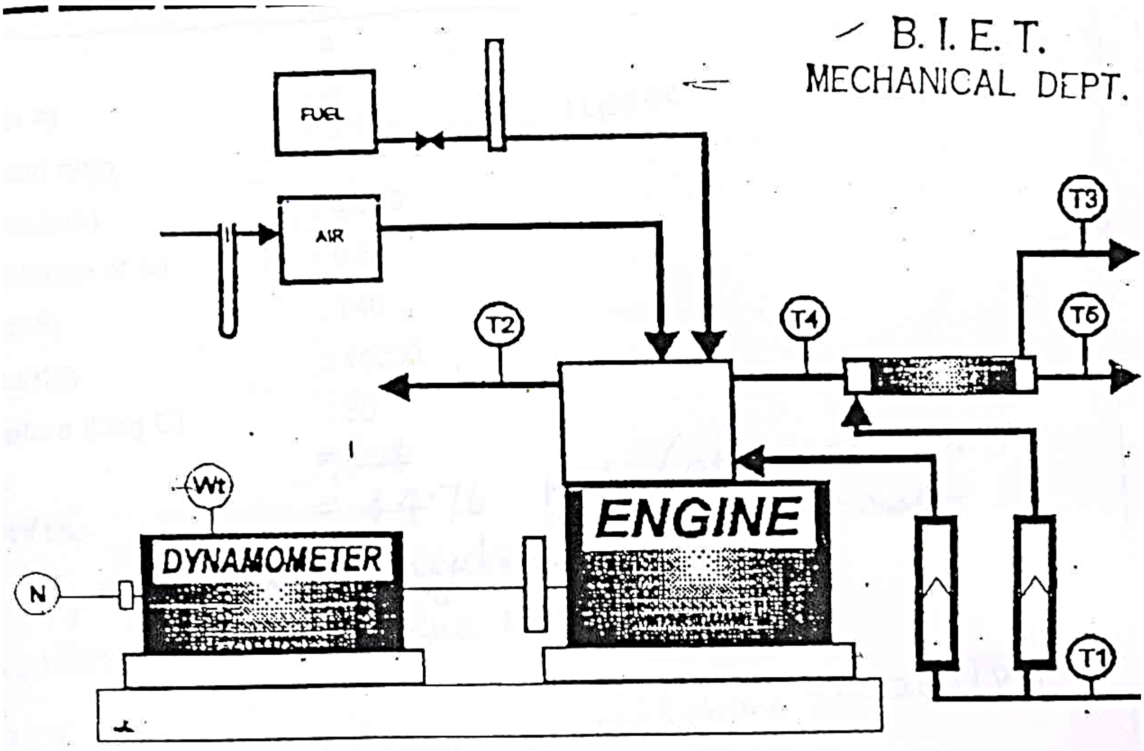
8. Indicated power when third cylinder is not firing $(IP)_3 = (BP) — (BP)_3$

9. Indicated power when fourth cylinder is not firing $(IP)_4 = (BP) — (BP)_4$

10. Total indicated power (IP) $= (IP)_1 + (IP)_2 + (IP)_3 + (IP)_4$

11. Total friction power (FP) =(IP)—(BP) kW

12. Mechanical efficiency $\eta_{mech} = \frac{\text{Brake power (BP)}}{\text{Indicated power (IP)}}$



T1	Jacket water inlet temperature	Deg.C
T2	Jacket water outlet temperature	Deg.C
T3	Calorimeter water inlet temperature	Deg.C
T4	Calorimeter water outlet temperature	Deg.C
T5	Exhaust gas to calorimeter inlet temp.	Deg.C
T6	Exhaust gas from calorimeter outlet temp.	Deg.C
F1	Fuel flow	Kg/hr
F2	Air flow	Kg/hr
F3	Jacket water flow	Kg/hr
F4	Calorimeter water flow	Kg/hr
W	Dynamometer load	Newton

Technical details of Indica Engine

Engine stroke length (m)	: 0.0795
Engine connecting rod length (m)	: 0.145
Engine cylinder dia (m)	: 0.075
Dynamometer arm length (m)	: 0.29
No of cylinders	: 4
No of strokes	: 4
Engine compression ratio	: 9:1
Cubic capacity	: 1405cc
Air orifice dia (m)	: 0.043
Coefficient of discharge of air	: 0.6
Fuel density (kg/ m^3)	: 740
Calorific value (kJ/kg	: 44,000.
Ambient temperature (°C)	: 30
Rated power	: 44.76 kW (@ 5000 rpm)
Type of dynamometer	: Hydraulic

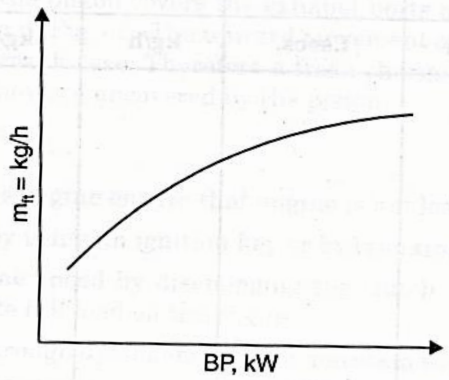
Rota meter : For water measurement 100 – 1000lph and 25 – 250 lph.

Load sensor : Load cell, strain gauge type, range 0 -50kg.

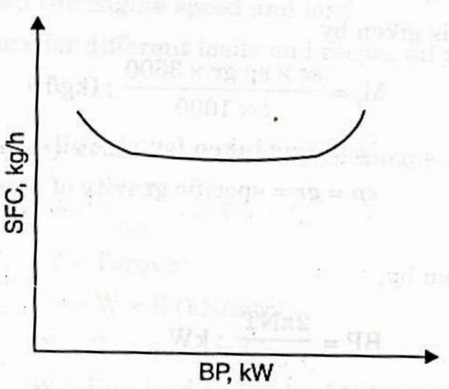
CHARACTERISTIC CURVES :

The following performance curves are down using the tabulated data.

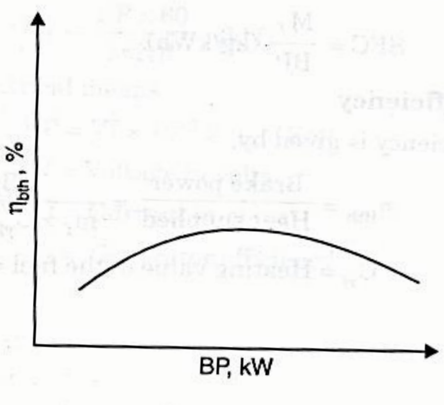
1. Total fuel consumption v/s BP.



2. Specific fuel consumption v/s BP.



3. Brake thermal efficiency v/s Brake power.



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EXPERIMENT NO. : 12

FOUR STROKE PETROL / KEROSENEENGINE

AIM:

To study the performance parameters of a four stroke petrol/kerosene engine and to determine total fuel consumption (TFC),specific fuel consumption (SFC), brake power (BP) and brake thermal efficiency

APPARATUS:

Four stroke petrol / kerosene engine test rig, tachometer and stop watch.

PROCEDURE:

1. Before starting the engine ensure that engine is not loaded.
2. Start the engine by using an ignition key or by cranking or kick starter.
3. Increase the engine speed by disengaging the clutch and run the engine at rated speed and calculate full load on the engine.
4. Load the engine though dynamometer and maintain the required speed by adjusting the thottle valve.
5. When the engine speed is steady note down the time taken to consume known volume of fuel ('x' cc). Record the engine speed and load.
6. Repeat the procedure for different loads and record all the readings.

FULL LOAD:

$$BP = \frac{2\pi NT}{60} \text{ (kW)}$$

T = Torque= W x R (kN-m)

N = Engine speed in rpm = N/2 for four stroke

W = Full load on the brake drum in kN.

R = Brake drum radius in m.

$$W = \frac{BP \times 60}{2\pi NR} = \qquad \text{kN}$$

OBSERVATIONS AND TABULATIONS:

Sl. No	Load w In kN	Engine speed N in rpm	Time taken for x_{cc} oil to consume t. secs.	Total fuel consumption in kg/h	Specific fuel consumption in kg/kWh	Brake power in kW	Brake thermal efficiency in %

1. Total fuel Consumption

Total consumption is given by

$$m_f = \frac{X_{cc} \times sp\ gr \times 3600}{t \times 1000} \quad (kg/h)$$

Sp.gr of petrol = 0.72

X_{cc} = fuel consumed in cc

t= time in sec

2. Brake power

Brake power is given by,

$$B\,P = \frac{2\Pi NT}{60} \quad kW.$$

3. Specific Fuel Consumption

Specific fuel consumption is given by,

$$SFC = \frac{m_f}{BP} \quad (kg/kWh)$$

4. Brake thermal efficiency

Brake thermal efficiency is given by,

$$\eta_{Bth} = \frac{\text{Brake power}}{\text{Heat supplied}} = \frac{BP}{m_f \times C_{vf}}$$

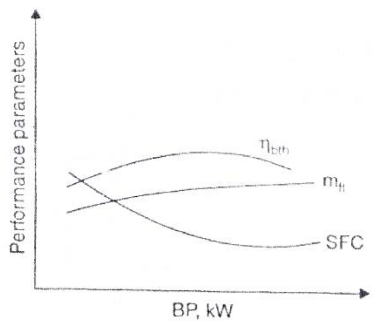
C_{vf} = Heating value of the fuel = 43500 kJ/kg.

The following characteristics curves are plotted on a graph with the tabulated results.

(*a*) m_{ft} v/s Brake power

(*b*) SFC v/s Brake power

(*c*) η_{bth} v/s Brake power



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EXPERIMENT NO: 13

ENGINE TEST SET-UP FOR HEAT BALANCE SHEET

AIM:

To study the performance of 4-stroke, single cylinder water cooled diesel engine and to draw the heat balance sheet.

Apparatus :

1. Single cylinder 4- stroke diesel engine
2. Stop watch

Description :

The setup consists of single cylinder, four strokes, diesel engine connected to rope brake type dynamometer. It is provided with necessary equipment and instrument for combustion pressure and crank angle measurements. These signals are interfaced with computer though engine indicator for Pθ, PV plots and engine indicator power, provision is also made for air, fuel, exhaust temperature and load measurements. Digital indication is provided for exhaust temperature. The setup enables study of for indicator power, brake power, thermal efficiency, volumetric efficiency, fuel consumption, air fuel ratio etc. The software package is fully configurable. The Pθ diagram, PV plot and performance curves are obtained at various operating points

Theory : Following are the formulae used in calculation of various results.

Nomenclature :

T_1	Jacket water inlet temperature	K
T_2	Jacket water outlet temperature	K
T_3	Exhaust gas temperature	K
T_{amb}	Ambient temperature	K
m_f	Fuel flow	kg/h
m_a	Air flow	kg/h
M_w	Jacket water flow	kg/h
W	Net dynamometer load	N
N	Speed of engine	r/min

System constants:

D	Engine cylinder diameter	m
L	Engine stroke length	m,
No. Cyl	Number of cylinder	K
N	No. of cycle	1 for two stroke
		2 for four stroke
R	Dynamometer drum radius	M
Cal.val	Calorific value of fuel	kJ/kg
D	Orifice diameter	M
C_d	Coefficient of discharge	
ρ_a	Air density	kg/m^3
ρ_w	Water density	kg/ m^3
H	Manometer reading across orificemeter	Meters of water
C_{pw}	Specific heat of water at constant pressure	kJ/kg K
C_{pex}	Specific heat of exhaust at constant pressure	kJ/kg K

Specification :

Engine	Single cylinder,4stroke,water cooled, diesel, make- Kirloskar, Model -TV!, Rated Power -5.2kW, Speed –1500 r/min, bore-87.5mm, stroke-10mm, Compression ratio-17.5.

TABULAR COLUMN

Load W in N.	Time taken for 10cc of fuel in ml	Air flow m_a in kg/h	Fuel flow m_f in kg/h	Water collected in ml	Inlet water temperature T_1°C	Outlet water temperature T_2°C	Exhaust gas temperature T_3°C	Brake power BP in kW	Indicated power IP in kW	Frictional power FP in kW

Heat balance sheet calculation

1. Heat supplied by the fuel $= m_f \times cv_f =$ $\times 3600$ kJ/h

2. Break power developed$= \frac{2\pi NT}{60\times1000}$ kW

3. (a) Heat equivalent to BP= $\times 3600$ kJ/h

$m_f = \frac{X_{cc} \text{ x sp gr x } 3600}{t \text{ x } 1000}$ (kg/h)

Sp.gr of diesel = 0.85

X_{cc} = fuel consumed in cc

t= time in sec

4. $m_a = \left\{c_d * \frac{\Pi}{4} * d^2 * \sqrt{2gh_w\left(\frac{\rho_w}{\rho_a}\right)}\right\}\rho_a * 3600$ kg/h

= kg/h

5. Frictional loss = Kw from graph1

= $\times 3600$ kJ/h

6. $m_a = m_a + m_f$ kg/h

7. (b) heat loss to cooling water= $m_w \times C_p \times T_2 - T_1 \times 3600$

= kJ/h

8. (c) heat loss to exhaust gas= $m_g \times C_p \times T_3 - T_4 \times 3600$

= kJ/h

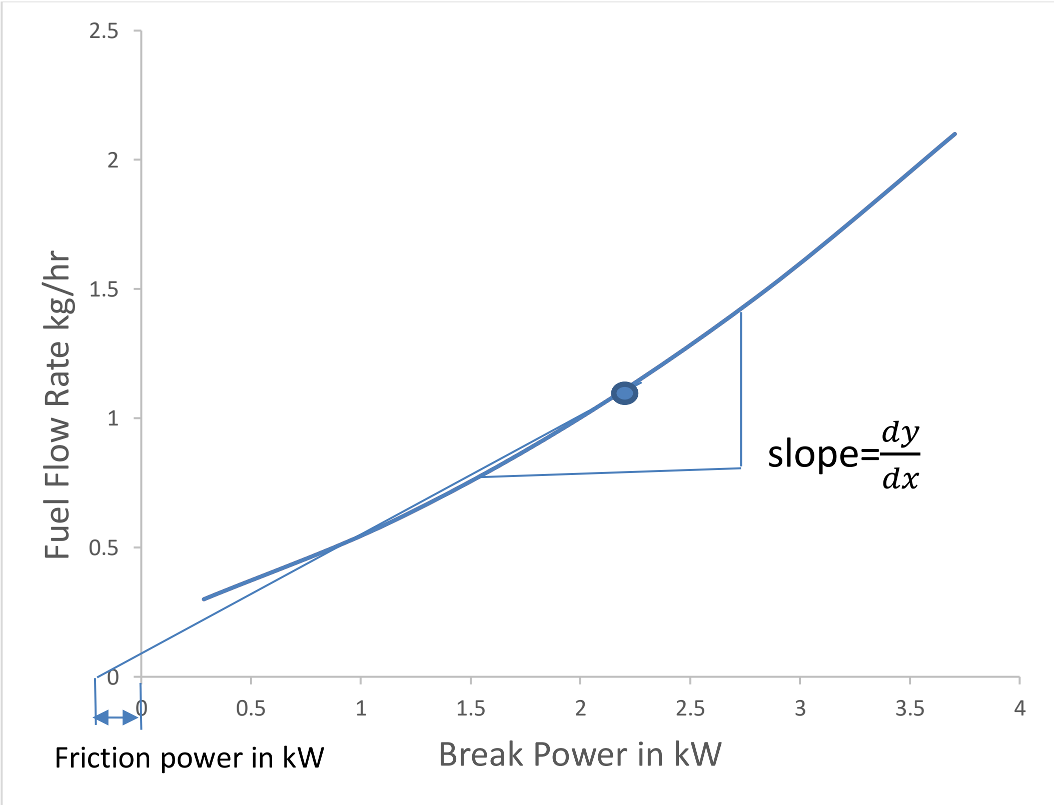
9. Un accounted heat loss= total heat supplied – [a + b + c]

= kJ/h

Heat balance sheet

Sl. NO	Energy input	kW or kJ/kg	%	Energy output	kW or kJ/kg	%
				a) Heat equivalent to BP b) Heat loss to cooling water c) Heat loss to exhaust gas d) Unaccounted heat loss		
	Total		100			%

From Graph: Williams line method



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