JSS MAHAVIDYAPEETHA
JSS SCIENCE & TECHNOLOGY UNIVERSITY
(JSSS&TU)
FORMERLY SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING
MYSURU-570006

DEPARTMENT OF MECHANICAL ENGINEERING

Energy Conversion Engineering Laboratory Manual

VI Semester B.E. Mechanical Engineering

USN :___________________________________
Name:___________________________________
Roll No: __________ **Sem** __________ **Sec** ________
Course Name _____________________________
Course Code _____________________________

DEPARTMENT OF MECHANICAL ENGINEERING

VISION OF THE DEPARTMENT

Department of mechanical engineering is committed to prepare graduates, post graduates and research scholars by providing them the best outcome based teaching-learning experience and scholarship enriched with professional ethics.

MISSION OF THE DEPARTMENT

M-1: Prepare globally acceptable graduates, post graduates and research scholars for their lifelong learning in Mechanical Engineering, Maintenance Engineering and Engineering Management.

M-2: Develop futuristic perspective in Research towards Science, Mechanical Engineering Maintenance Engineering and Engineering Management.

M-3: Establish collaborations with Industrial and Research organizations to form strategic and meaningful partnerships.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 Apply modern tools and skills in design and manufacturing to solve real world problems.

PSO2 Apply managerial concepts and principles of management and drive global economic growth.

PSO3 Apply thermal, fluid and materials fundamental knowledge and solve problem concerning environmental issues.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO1: To apply industrial manufacturing design system tools and necessary skills in the field of mechanical engineering in solving problems of the society.

PEO2: To apply principles of management and managerial concepts to enhance global economic growth.

PEO3: To apply thermal, fluid and materials engineering concepts in solving problems concerning environmental pollution and fossil fuel depletion and work towards alternatives.

PROGRAM OUTCOMES (POS)

PO1 **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

ENERGY CONVERSION ENGINEERING LABORATORY

Subject Code	**: ME58L**	**No. of Credits**	**: 0- 0 – 1.5**
No. of Lecture Hours / Week	**: 03**	**Exam Hours**	**: -**
Total No. of Contact Hours	**:**	**CIE Marks**	**: 50**

COURSE CONTENT

PART – A

Introduction

1. Lab layout, Location of instruments and Panels for carrying out experiments
2. List of Instruments with specifications
3. Calibration of instruments and standards to be discussed.

Experiments

4. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Pensky Martin (closed) Apparatus.

5. Determination of Calorific value of solid, liquid and gaseous fuels.

6. Determination of Viscosity of a lubricating oil using Redwood and Saybolt Viscometers.

7. Valve Timing diagram of an I.C. Engine.

6. Use of Planimeter – Computation of area of irregular shapes.

21 Hours

PART – B

1. 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.

21 Hours

COURSE OUTCOMES

After completion of this course, students will be able to:

CO1 Conduct tests and determine the properties of fuels and oils.
CO2 Conduct performance tests on IC engines and draw characteristics plots

Contents

EXPERIMENT NO. 1

FLASH AND FIRE POINT OF LIGHT OIL USING ABEL PENSKY APPARATUS

AIM: To determine the Flash and Fire point of the given light oil.

APPARATUS USED:

Abel Pensky Apparatus, Thermometer.

THEORY:

Flash point: The flash point is the lowest temperature, to which a lubricant must be heated before its vapor, when mixed with air, will ignite but not continue to burn.

Fire point: The fire point is the temperature at which lubricant combustion will be sustained. The flash and fire points are useful in determining a lubricant's volatility and fire resistance.

The flash point can be used to determine the transportation and storage temperature requirements for lubricants. Lubricant producers can also use the flash point to detect potential product contamination. A lubricant exhibiting a flash point significantly lower than normal will be suspected of contamination with a volatile product. Products with a flash point less than 38^{o} C will usually require special precautions for safe handling. The fire point for a lubricant is usually 8 to 10 percent above the flash point. The flash point and fire point should not be confused with the auto-ignition temperature of a lubricant, which is the temperature at which a lubricant will ignite spontaneously without an external ignition source.

Outline of the methods: The sample is placed in the cup of the Abel apparatus and heated at a prescribed rate. A small test flame is directed into the cup at regular intervals and the flash point is taken as the lowest temperature at which application of the test flame will cause the vapor above the sample to ignite with a distinct flash inside the cup.

EXPERIMENTAL SETUP:

The apparatus consists of a brass cup of standard dimensions. The cup is provided with a cover containing 3 ports. A stirrer is provided in the cover to stir oil sample during heating. There is a provision to insert thermometer to measure the temperature of oil.

The cup is surrounded by water bath which is heated by an electric heater.

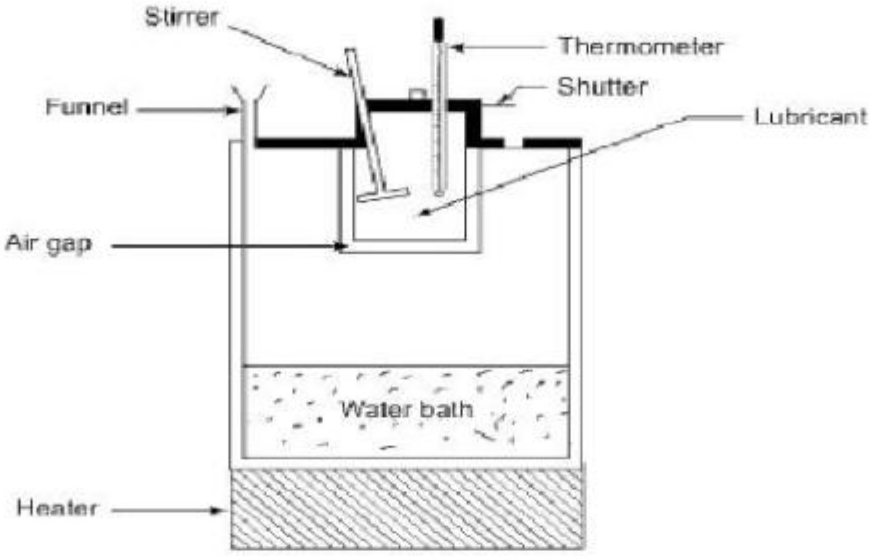


Fig.1: Experimental Setup of Abel Pensky Apparatus

PROCEDURE:

1. Clean the oil cup and wipe it dry.
2. Fill water into the water jacket to its full level and insert into the cylindrical stand.
3. Pour fuel oil to be tested into the oil cup up to the mark and place the oil cup into the air chamber of the water bath.
4. Close it with the lid having sliding ports.
5. Insert the thermometer in their respective holder.
6. The heater is switched on.
7. For every 2^0C rise in temperature of oil under test, the port in the cover is opened and burning stick/ flame is brought near the port.
8. This procedure is repeated till that temperature at which, the introduction of the burning splinter results in a momentary FLASH. At the moment temperature is recorded which is known as FLASH POINT.
9. Oil is heater further and the burning splinter is continued to be introduced neat the port till it results in a continuous flame. At this moment the temperature is recorded which gives the FIRE POINT.
10. This procedure is repeated which cooling the oil after removing the cup from the apparatus.

OBSERVATION:

Type of oil used:

TABULAR COLUMN:

SL. NO	Heating		Cooling	
	Oil temperature (^0C)	Remarks	Oil temperature (^0C)	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

CONCLUSIONS/INFERENCE:

(To be written by the student)

EXPERIMENT NO. 2

FLASH AND FIRE POINT OF HEAVY OIL USING PENSKY MARTIN APPARATUS

AIM: To determine the flash and fire point of given sample of heavy oil.

APPARATUS:

Pensky-Martin apparatus, thermometer, spirit lamp, splinters and oil.

THEORY:

In the Pensky-Marten‟s closed cup flash point test, a brass test cup is filled with a test sample and fitted with a cover. The sample is heated and stirred at specified rates depending on what it is that's being tested. An ignition source is directed into the cup at regular intervals with simultaneous interruption of stirring until a flash that spreads throughout the inside of the cup is seen. The corresponding temperature is its flash point.

Pensky-Martens closed cup is sealed with a lid through which the ignition source can be introduced periodically. The vapor above the liquid is assumed to be in reasonable equilibrium with the liquid. Closed cup testers give lower values for the flash point (typically 5-10K) and are a better approximation to the temperature at which the vapor pressure reaches the Lower Flammable Limit (LFL).

EXPERIMENTAL SETUP:

It consists of a barrel cup of standard dimension; the cup is provided with a cover containing three ports. A stirrer is provided in the cover to stir oil sample during heating, and there is a provision to insert a thermometer to measure the temperature of oil. The cup is provided by water both which is heated by an electric heater.

Outline of the Method: the sample is heated in a test cup at a slow and constant rate with continuous stirring. A small test flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is taken as the lowest temperature at which the application of the test flame causes the vapour above the sample to ignite momentarily.

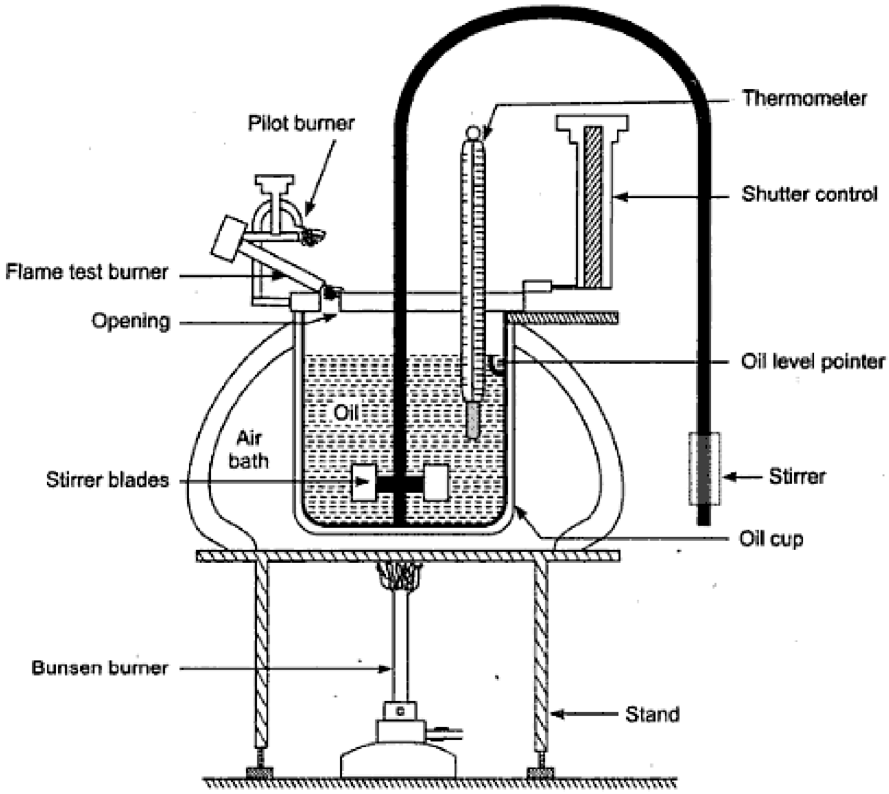


Fig.2: Experimental Setup of Pensky Martin Apparatus

PROCEDURE:

1. The cup is filled with given sample of oil up to the mark.
2. The cup is closed with cover and thermometer is inserted and an initial temperature is recorded.
3. The heater is switched on for every five degree rise in temperature, the port cover is opened and burning stick brought near the port.
4. The procedure is repeated for all the temperature till the introduction of burning splinters result in a momentary flash.
5. At that moment the temperature is recorded which is known as flash point.
6. Oil is further heated and burning splinter is continued to introduce near the port till it results in a continuous flame. The temperature is recorded which gives the fire point.
7. This procedure is repeated while cooling the oil after removing the cup from the apparatus.

OBSERVATION:

Type of oil Used:

TABULAR COLUMN:

SL NO	Heating		Cooling	
	Oil temperature (^0C)	Remarks	Oil temperature (^0C)	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT NO 3

SAYBOLT VISCOMETER

AIM: To determine the viscosity of the given sample of oil.

APPARATUS USED:

Say Bolt Viscometer, 60ml flask, thermometer & stopwatch.

EXPERIMENTAL SETUP:

The viscometer consists of oil cup of 30mm diameter and 90 mm height. The cup is provided by water bath which is heated electrically. The oil cup has an orifice at its bottom which can be opened or closed using a cork plug. The plug is opened while collecting the oil sample in the 60CC flask. There is a provision for inserting the thermometer to note down the temperature of the oil.

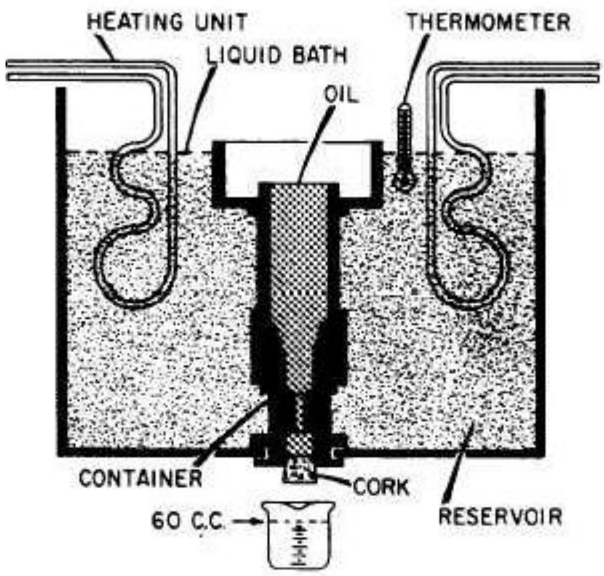


Fig.3: Experimental Setup of Saybolt Viscometer

PROCEDURE:

1. The Orifice is closed using cork plug.
2. The oil cup is filled with the given sample of oil and the lid is closed.
3. The initial oil temperature is recorded.
4. The flask is placed below the orifice and the plug is opened.
5. The time taken to collect 60 cc of oil is noted.
6. The orifice is closed and the oil collected is transferred back to the cup.
7. The oil is heated and for every 5^0C rise in temperature, the above procedure is repeated.

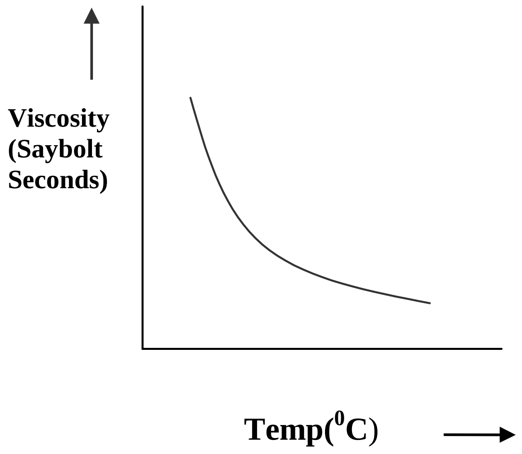
OBSERVATION:

Type of oil Used:

TABULAR COLUMN:

Trial no.	Temperature (^{0}C)	Time taken (seconds)	Viscosity (say bolt seconds)
1			
2			
3			
4			
5			
6			

Plot a graph of viscosity in say bolt seconds v/s temperature in ^{0}C



Viscosity in saybolt's second were determined and relevant graphs were drawn. Viscosity varies with temperature and has negative exponential trend.

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT NO 4

RED WOOD VISCOMETER

AIM: To determine the absolute viscosity and kinematic viscosity of the given sample of oil.

APPARATUS USED:

Red wood viscometer, 50 cc flask, weighing balance, stopwatch, thermometer.

Experimental Setup:

Redwood viscometer Consists of a cylindrical oil cup furnished with a gauge point, a gate / metallic Orifice jet at the bottom having a concave depression from inside to facilitate a ball with stiff wire to act as a valve to start or stop oil flow. The outer side of the orifice jet is convex, so that the oil under test does not creep over the lower face of the oil cup. The oil cup is surrounded by a water bath with a circular electrical immersion heater and a stirring device. Two thermometers are provided to measure water bath temp. & oil temperature under test. A round flat-bottomed flask of 50 ml marking is used to measure time for 50 ml of oil flow. The water bath with oil cup is supported on a tripod stand with leveling screws.

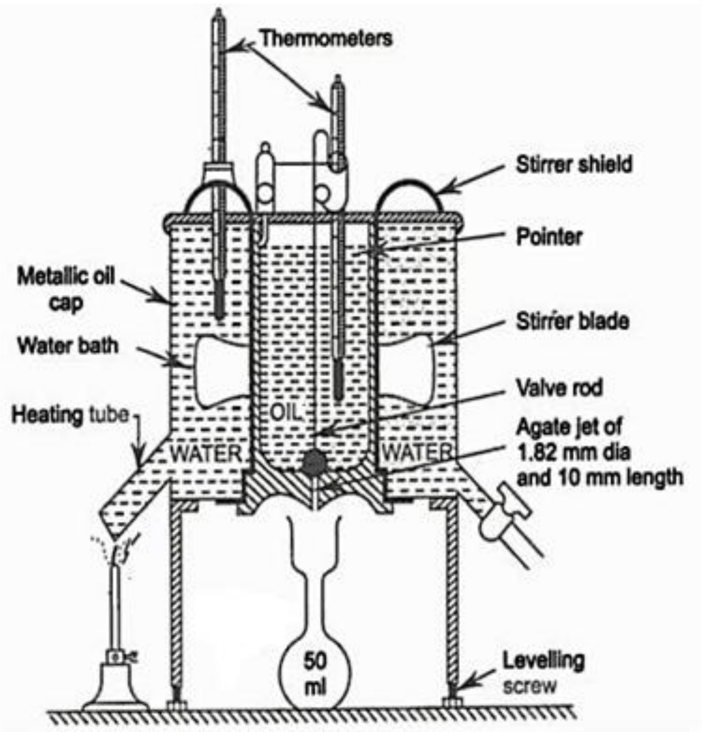


Fig.4: Experimental Setup of Redwood Viscometer

PROCEDURE: -

1. The orifice is closed using ball valve.
2. The oil cylinder is filled with a given sample of oil and the lid is closed.
3. The initial oil temperature is recorded.
4. Empty and dry flask is weighed and weight is recorded.
5. The flask is placed below the orifice and a valve is lifted and allow the oil to flow.
6. Time taken to collect 50 CC oil is noted down.
7. The orifice is closed with the help of ball valve and oil sample is transferred back to the oil cylinder.
8. The flask along with the collected oil is weighed again and weight is recorded.
9. The oil is heated for every 5^0 C rise in temperature, the above procedure is repeated and result is tabulated.

OBSERVATION: -

Type of oil.......................................

Weight of the empty flask (W_1) .... (grams)

TABULAR COLUMN:

Trial no.	Weight of the flask with oil (W_2-grams)	Weight of the oil (W-grams)	Oil tempt. (^{0}C)	Time taken to collect 50 cc of oil (t -sec)	Specific gravity of oil (SG)	Red wood viscosity / Red wood number	Kinematic viscosity (stoke)	Absolute viscosity	
								N-sec/m^2	poise
1									
2									
3									
4									
5									
6									

Plot a graph of absolute viscosity (poise) v/s Temperature (^{0}C) and Kinematic viscosity v/s Temperature

CALCULATIONS:

Weight of the oil W= W_2-W_1 in gram

Specific gravity= weight of the oil / weight of standard water (measured by 50cc flask)

Red wood number = $\frac{(\mathbf{t\ x\ 100\ x\ specific\ gravity})}{(\mathbf{535x0.915})}$

Where,
t= time taken for flow of 50 cc sample oil.
535= time in second for the flow of 50 cc of standard vaporized oil.
0.915=specific gravity of vaporized oil.
100=red wood number for standard vaporized oil.

Kinematic viscosity = $\left[(\mathbf{0.00246}\boldsymbol{xt}) - \frac{\mathbf{1.9}}{\boldsymbol{t}}\right]$ stokes

Where,
t- time in seconds; t=40 to 85 seconds.

Kinematic viscosity = $\left[(\mathbf{0.00246}\boldsymbol{xt}) - \frac{\mathbf{0.65}}{\boldsymbol{t}}\right]$stokes

Where,

t =85 to 2000 seconds.

Absolute viscosity= $\frac{(\mathbf{Kinematic\ viscosity\ (m2/sec)\ x\ specific\ weight\ of\ oil})}{\mathbf{g}}$ (N-S/m^2)

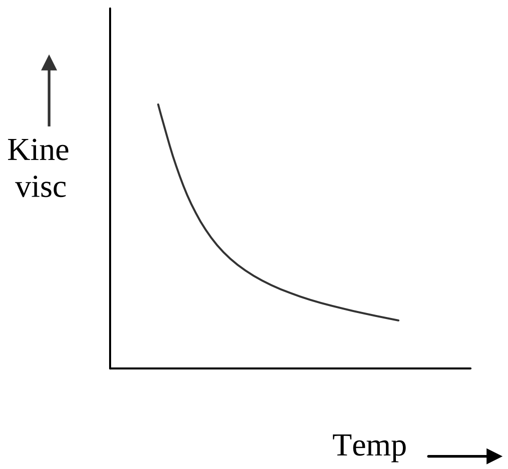
Where,
1 stokes=1cm^2/sec g=9.81m/s^2

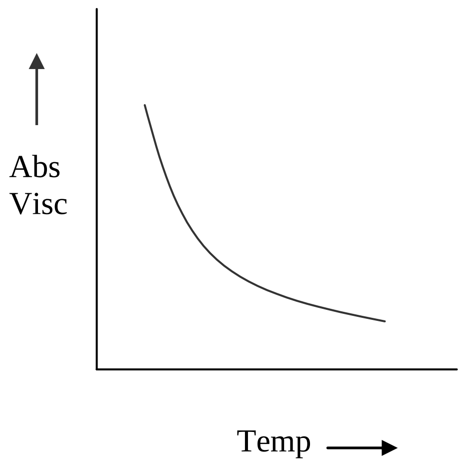
Specific weight of oil = specific gravity x specific weight of water(N/m^3)

Where,
Specific weight of water = 9810 N/m^3
1 poise = 0.1 N-sec/m^2

Plot a graph of absolute viscosity (poise) v/s Temperature (^{0}C) and Kinematic viscosity v/s Temperature

Specimen graphs





CONCLUSIONS/INFERENCE:

(to be written by the student)

<u>EXPERIMENT NO 5</u>

BOMB CALORIMETER

AIM: To determine calorific value of a given sample of solid fuel.

APPARATUS USED:

Bomb Calorimeter, Thermometer, weighing balance, Stopwatch, Oxygen cylinder and given fuel.

EXPERIMENTAL SETUP:

It consists of a small stainless-steel cylinder known as bomb, this cylinder is provided with two valves one for charging the oxygen and other for releasing the burnt gas. The bomb is filled with a solid fuel in a crucible with fusing element. The bomb is placed vertically in a container filled with water. A thermometer is used to record a temperature of water.

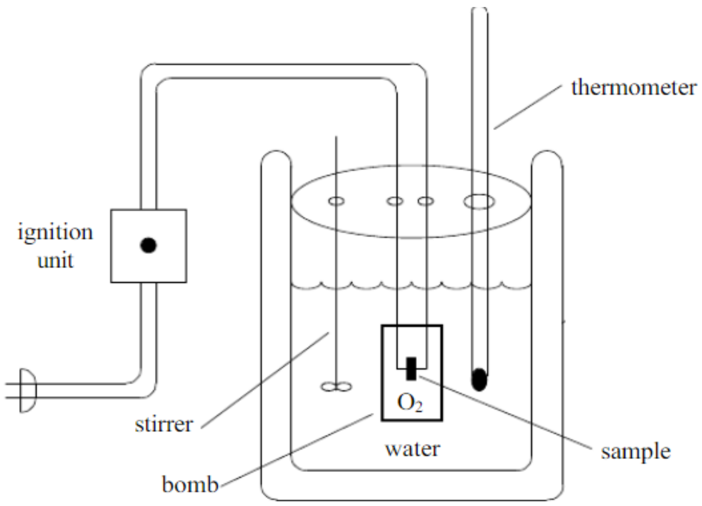


Fig.5: Experimental Setup of Bombs Calorimeter

THEORY: - The Calorific value of a fuel is defined as the heat released when one kg or one m^3 of fuel is burnt completely with air or oxygen. While the calorific values of solid and liquid fuels are expressed in kJ/kg, that of the gaseous fuel is expressed in kJ/m^3. While the heat released when the water formed during combustion, if any, is completely condensed is called the **Higher Calorific Value (HCV)**, the heat released when the water formed is not condensed is called the **Lowe r Calorific Value (LCV)**. The relation between the **HCV** and the **LCV** is given by:

$$HCV = LCV + mH_20 \times h_{fg}$$

Where, mH_2O is the mass of H2O formed, in kg, during combustion and hfg is the latent heat of water at 25^0C in kJ/kg which can be taken as 2442 kJ/kg.

However, the **correct definition** of calorific value is as follows: Calorific value of a fuel is defined as the negative of the standard heat of reaction at constant pressure of the reaction in which the fuel burns completely with oxygen.

PROCEDURE: -

1. One gram of fuel is taken in a dry crucible
2. The crucible is placed is placed inside the bomb and fuse which is placed in contact with the fuel sample.
3. The bomb filled with oxygen to a pressure of 25kg/cm^2.
4. Water is filled in the calorimeter and the bomb is placed inside it. The level of the water should completely cover the bomb.
5. The initial temperature of water is noted.
6. The fuel is ignited by pressing the FIRE BUTTON.
7. The water is stirred continuously until the experiment completed.
8. The temperature starts to increase and at intervals of 30 Sec, temperatures are recorded for about 5 minutes.

OBSERVATION: -

1. Sample of the fuel..
2. The weight of fuel W_1=............................ (grams)
3. Weight of water in container W_2=2000 (grams)
4. Water equivalent of calorimeter C_w=0. 6519kg
5. The initial temperature of water T_1=....................... (^{0}C)
6. The final temperature of water T_2=...................... (^{0}C)
7. Specific heat of water C_{pw}=4. 186 kJ/kg^{0}K.

TABULAR COLUMN:-

Trial No.	Time (Seconds)	Temperature (^{o} C)
1		
2		
3		
4		
5		
6		
7		
8		

FORMULA:

From energy balance consideration

The heat released by the fuel = Heat absorbed by the water and the calorimeter

$$C_v \times W_1 = (W2 + Cw)Cpw(T2 - T1) \quad ;$$

where
C_v is calorific value of the fuel in kJ/kg

Then,

$$C_v = \left[\frac{(W2+Cw)Cpw(T2-T1)}{(W1)}\right] \text{in kJ/kg.}$$

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT NO 6

BOY'S GAS CALORIMETER

AIM: To determine the calorific value of given sample gas fuel.

APPARATUS USED:

Boy's calorimeter, Thermometer.

EXPERIMENTAL SETUP:

It consists of a stainless-steel chamber in which known quantity of gas is burnt. The heat released by the combustion of gas is transferred to the gas. The gas flow meter is used to measure the quantity of gas supplied and water flow meter is used to measure the flow rate of water, a thermometer is used to measure temperature at the inlet and outlet.

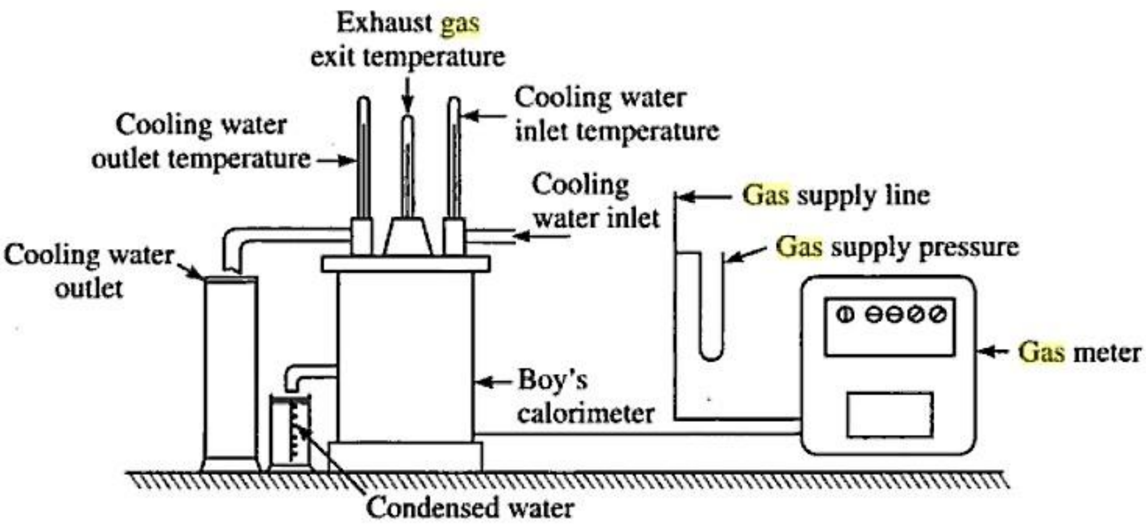


Fig.6: Experimental Setup of Boys Gas Calorimeter

PROCEDURE:

1.Allow the water to flow through the copper tube.

2.Adjust the water flow rate to any desired value and also gas flow rate.

3.Ignite the gas and allow sufficient time to reach the steady state condition.

4.The temperature of water is noted down at the inlet and outlet.

5.Tabulate the result and calculate calorific value.

OBSERVATION:

Sample of fuel given is....................

TABULAR COLUMN:

Trial No.	Volume of water flow rate (V_w- LPM)	Volume of gas flow rate (Vg-LPM)	Temperature of water at inlet (T_1-^{0}C)	Temperature of water at outlet (T_2-^{0}C)	Calorific value of fuel (CV-kJ/kg)

FORMULA:

From energy balance amount of heat liberated by combustion of gas is equal to heat absorbed by the water.

$$C_{vg} \, x V_g \text{ x } \rho_g = Vw \text{ x } \rho_w \text{ x } C_{pw} \, (T_2 - T_1)$$

Then,

$$C_{vg} = \frac{[Vw \text{ x } \rho w \text{ x } Cpw(T2 - T1)]}{(Vg \text{ x } \rho g)}$$

ρ_g =density of gas -0.0012 kg / litre (NTP).
ρ_w = density of water – 1kg/litre.
C_{pw} = specific heat of water = 4.186 kJ/kg^{0}K.

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT NO -7

PLANIMETER

AIM: To measure area of regular and irregular figures using planimeter.

APPARATUS USED: Polar planimeter.

EXPERIMENTAL SETUP:

The planimeter consists of two arms. The tracer arm is fitted with a tracing point, which is guided on the outline of the figure, the area of which is required. The trace arm has a carriage, which is adjustable to the various positions. The carriage is fitted with a measuring wheel which has a scale on its circumference divided into 100 equal parts. The Vernier attached to it gives 1/10th of the above division, connected to the shaft of the wheel, by means of a small worm it has a recording disc which is divided into 10 equal parts. Each division of the disc indicates one complete revolution of the measuring wheel. The tracing point is also provided with a handle and an adjustable support so that the tracing needle should not dig into the paper. The other arm known as radius bar is fitted with a needlepoint which acts as a pole or stationary point during the measurement. During measurement the pole point is fixed outside or inside the figure depending on its size.

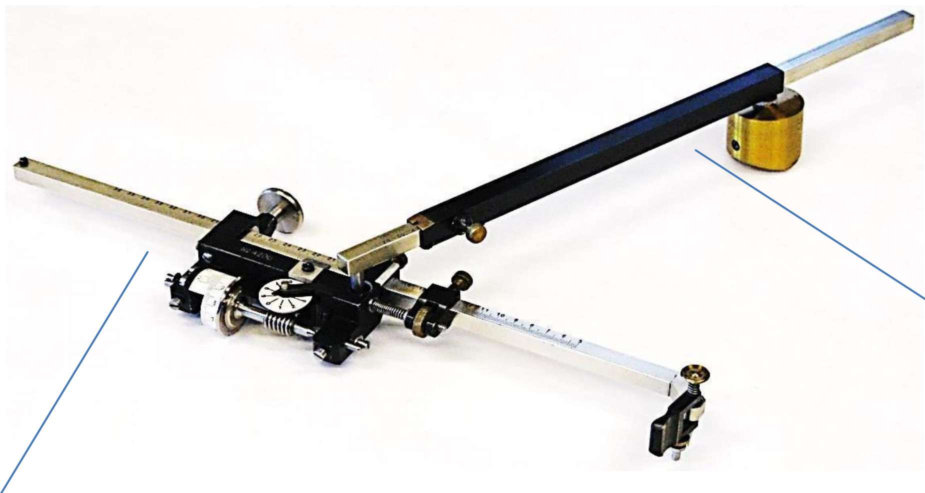


Fig.7: Polar Planimeter

THEORY:

For regular surface area can be obtained by calculation, but for irregular surface it is very difficult to calculate area, which can be obtained by integrating the area. The integration of the area is complicated, to overcome this difficulty; a mechanical device called planimeter is used. Planimeter is a form of integrator which converts graphical area into numerical values. planimeter consists of two arms hinged at a point. One arm is a pivot arm and the other arm is the tracing arm. The tracing arm is moved along the boundary of the plane area whose area is to be determined. The planimeter mainly consists of: 1. Tracing arm with main scale, Vernier scale, Rotating disc and rotating drum with Vernier scale. 2. Pivot arm with a ball point at one end and a cylindrical weight with pin at the other end. 3. Magnifying lens.

PROCEDURE

1. The figure is placed/drawn on a sheet of paper and firmly fixed to a flat surface like drawing board.
2. The carriage position of the tracer arm is set to the standard value (refer to the table-col. 2 available with the instrument, for example 1:1 scale the position on tracing arm is 32.20)
3. Planimeter pole point is fixed either inside or outside the area to be measured. If possible, it is always advisable to fix the needlepoint outside., as it is more accurate (to measure large area place the pole within the diagram, otherwise divided it into 3-4 segments, and the pole is placed outside for each segment and the final readings are added together.
4. The start point for the tracing is marked on the boundary, and tracer point is placed on the start point. The recording disc & measuring wheel are set to read zero (i.e., the initial reading of the instrument is zero).
5. The tracer point is moved on the curve and is brought back to the start point.
6. The readings of the reading disc, measuring wheel and the Vernier are noted, (Note: if the reading disc more than one full turn during tracing, number of revolutions should be note down)
7. The accuracy of the instrument may be checked by comparing the reading of the instrument with a test – figure of known area.
8. Tabulate the readings and find out the percentage error.

OBSERVATION

Instrument no. ....

Scale of measurement............................

Tracer arm setting....................................

Constant for area calculations-c=23.5

` (To be considered when the pole point is inside the area)

Multiplication factor for area (in cm^2)-M=....................

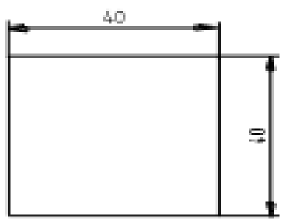
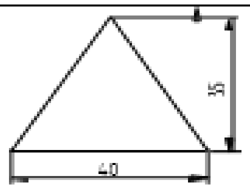
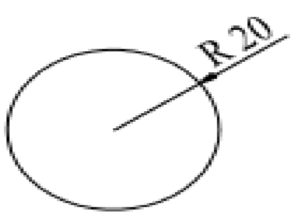
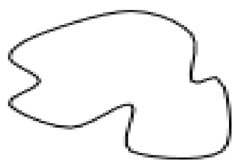
(1 unit on reading disc=$100cm^2$)

L.C of recording disc-Lc_d=....................

L.C of a main scale of the measuring wheel–Lc_w=.................

L.C. of Vernier for measuring wheel –Lc_v=..................

TABULAR COLUMN:

S.N	Shape of the Figure	Actual area (Cm^2)	Measured area (Cm^2)	% Error
1				
2				
3				
4		---		

CALCULATIONS:

The total of the reading of the –X= (rd+10xN) x Lcd $+r_w+$ Lc_w+ Lc_v x r_v

r_d, r_w, r_v is the readings of the disc, wheel & the Vernier for a given diagram respectively, and N is the no. of full turns of the recording disc.

Area –A=M x X cm^2**.** For the case when the pole point is outside the test area.

$$\textbf{\% error} = \frac{\textbf{Theoretical Area (Cm2) – Measured Area (Cm2)}}{\textbf{Measured Area (Cm2)}} \text{X } 100$$

CONCLUSIONS/INFERENCE:

(To be written by the student)

EXPERIMENT NO 8

VALVE TIMING DIAGRAM

AIM: To draw the valve- timing diagram for a 4-Stroke horizontal Diesel Engine.

APPARATUS USED: Given engine, spirit level, measuring tape.

APPARATUS DESCRIPTION:

The horizontal four stroke diesel engine has a flywheel on one side and brake drum on the other side of the crank shaft. The camshaft connected to the crankshaft, the end of which has a cam with roller followers. These followers upon rotation over the cam operate the inlet and exhaust valve mechanisms. Two extreme positions of the piston namely inner dead centre (IDC) and outer dead centre (ODC) can be obtained by keeping the crank in the horizontal position. Spirit level is placed on the flat side of the crank to get the exact extreme position. The roller follower on the cam will be indicative of the position of the valves.

THEORY:

The poppet valve of the engine is generally operated and closed by cam mechanism. The clearance between cams, tappet arid value must be slowly taken up and valve slowly lifted in order to avoid noise, wear and tear. Again, values cannot be closed abruptly so that it balances back to its seat for the same reason. This means valve opening and closing periods should be spread over a considerable number of crank shaft degrees since it is necessary to start opening the inlet valve of the four-stroke engine before TDC on the exhaust stroke pressure, which would result in the back flow in the inlet manifold. Since both valves are open at TDC position, they are said to be overlapped. Opening the inlet valve during the early part of the compression stroke allows for charging of the engine cylinder at higher speeds, this also necessary to reduce the compression ratio of the engine at high speeds a hence to avoid knocking in SI engines. The exhaust valve opens before the completion of power stroke to allow most of gases to escape in the blow down process before the exhaust stroke are well underway.

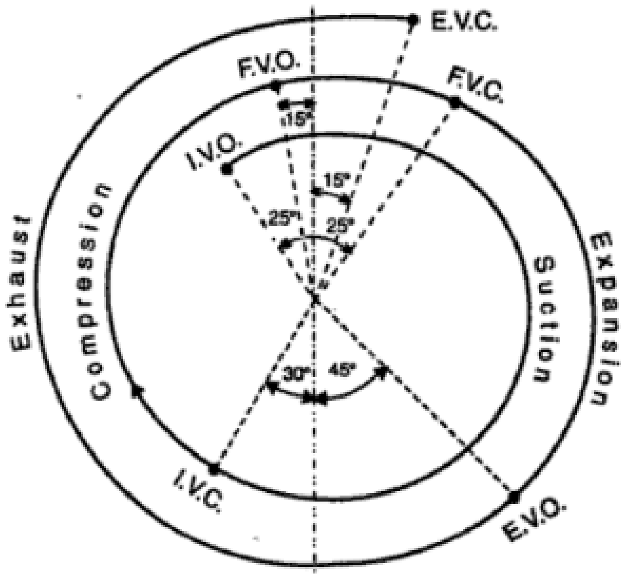


Fig.8: Actual VTD (4-S Diesel Engine)

PROCEDURE:

1. Decompression lever is set to open position.
2. The flywheel is rotated clockwise for two revolutions to observe cam orientation, identify two extreme positions of the piston and different strokes in one cycle operation.
3. The fly wheel is rotated clockwise and position is moved to inner dead center (IDC). This position is checked using spirit level.
4. A mark is made on the flywheel corresponding to IDC.
5. The fly wheel is rotated clockwise to get the other extreme position of the piston, ODC and is marked.
6. The flywheel is brought back to the starting position (IDC) to identify SUCTION STROKE. Position indicating the beginning of inlet valve open (IVO) towards the end of the EXHAUST STROKE of the previous cycle, can be obtained by turning the fly wheel in anticlockwise direction. Position of IVO is marked on the flywheel.
7. The flywheel is rotated clockwise to identify the end of the suction stroke, the inlet valve closes (IVC) in the compression stroke and this position is obtained and marked with reference to ODC.

8. Towards the end of compression stroke fuel opens (FVO). This position is obtained by observing the movement of the plunger in the fuel pump. These positions marked with reference to IDC.
9. The fuel valve closes (FVC) at the beginning of the power stroke. This position is obtained when the plunger moves to the extreme position in the fuel pump. Corresponding position is marked with reference to IDC.
10. Further rotate the flywheel clockwise indicates the completion of the power stroke. The exhaust valve opens (EVO) before the end of the power strokes and this position is marked with reference to ODC.
11. Movement of the piston from ODC to IDC now indicates the completion of the exhaust. Towards the end of this stroke, the inlet valve opens (IVO) and the cycle repeats thereafter.
12. The exhaust valve opens (EVC) in the suction stroke of the following (next) cycle and this position is obtained and marked with reference to IDC.
13. The distance of the valve positions between IVO, IVC, FVO, FVC, EVO, EVC with reference positions (IDC/ODC) are measured on the flywheel.
14. The angles are found, the valve timing diagram is drawn (note: draw a horizontal line, marking its left end as IDC &right end as ODC, plot the diagram in clockwise direction).

OBSERVATION: -

Circumference of the fly wheel. (C) ....m

Radius of the flywheel (R)............................m

C= 2x**Pi**xR

$$R = \frac{C}{2x\mathbf{Pi}} \quad (m)$$

Where, **Pi = 3.14159**

TABULAR COLUMN:

Sl. No.	Crank position (From-to)	Arc Length (S – m)	Angle in deg.
1	IVO-IDC		
2	FVO-IDC		
3	IDC-FVC		
4	IDC-EVC		
5	EVO-ODC		
6	ODC-IVC		

Position of crank:

IDC – Inner Dead Centre
IVO – Inlet Valve Open
FVO – Fuel Valve Open
EVO – Exhaust Valve Open

ODC – Outer Dead Centre
IVC – Inlet Valve Close
FVC – Fuel Valve Close
EVC – Exhaust Valve Close

FORMULA:

Total Angle (degrees) = $\frac{S \times 180}{R \times \pi}$

Suction Stroke = SS = (IVO to IDC) + (IDC to ODC) + (ODC to IVC) in ^{0}

Compression Stroke = CS = (IDC to ODC) – (ODC to IVC) in ^{0}

Power Stroke = PS = (IDC to ODC) – (EVO to ODC) in ^{0}

Exhaust Stroke = ES = (EVO to ODC) + (ODC to IDC) + (IDC to EVC) in ^{0}

Sum of all the stroke angles = SS+CS+PS+ES = in ^{0}

Fuel supply = (FVO to IDC) + (IDC to FVC) in ^{0}

Angle of overlap = (IVO to IDC) + (IDC to EVC) in ^{0}

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT NO 9

PERFORMANCE TEST ON 4-STROKE DIESEL ENGINE WITH MECHANICAL LOADING TEST RIG

(**Four Stroke, Single Cylinder, Water Cooled, Mechanical Loading**)

AIM:

To conduct a performance test on a four-stroke vertical diesel engine and to determine brake power, fuel consumption, specific fuel consumption, friction power, indicated power, brake thermal efficiency and indicated thermal efficiency.

APPARATUS USED:

Four stroke Vertical Diesel Engine test rig, tachometer, stop watch.

APPARATUS DESCRIPTION: -

The experimental setup consists of a single cylinder 4 stroke vertical diesel engine coupled to a rope brake dynamometer, the fuel (diesel) is supplied separately through a measuring flask by means of which, the volume of fuel supplied to the engine can be determined. The rope brake dynamometer is coupled to the engine. Load is applied on the engine and the corresponding weight on the pan and spring balances are recorded. The engine should run always at rated speed (1500rpm).

THEORY:

Heat engine is a device which converts heat energy into mechanical work. Engine performance is an indication of the degree of success with which it is doing its assigned job, i.e. the conversion of the chemical energy in to the useful work. The degree of success is compared on the basis of 1) Specific Fuel Consumption 2) Brake Mean Effective Pressure 3) Specific Power Output 4) Specific Weight etc. The engine performance can be obtained by running the engine at constant speed for variable load by adjusting the throttle. In this experiment engine is mechanically loaded and experiment is carried out. The test rig consists of 4 Stroke diesel engine connected to rope brake dynamometer.

PROCEDURE:

1. The engine is started by hand cranking and as the required momentum is attained, decompression lever is set to close position and the engine starts.
2. At no load condition the time required for 25cc of fuel consumption is noted.
3. Apply the load of 5kg (25% of full load – 20kg) Spring balance reading and the time taken for 25cc of fuel consumption are noted.
4. The above procedure is repeated for different loads (50%,75% and 100% of full load)
5. After all the trials are over; the load on the engine is slowly reduced to zero by removing the weights.
6. The readings are tabulated and performance parameters are calculated.
7. Plot the performance characteristics curves:

FC vs BP
SFC vs BP
T vs BP
BTE vs BP
ITE vs BP
ME vs BP

SPECIFICATION OF THE ENGINE:

Make:
Rated power output:
Stroke:
Compression ratio: 16.5:1
Cylinder capacity:
Specific Fuel Consumption:

OBSERVATIONS:

Circumference of fly wheel:
Radius of fly wheel:

TABULAR COLUMN

Sl. no	Load in %	Brake Load (W)		Spring balance Reading (S)		Effective load We = (W-S)	Speed (rpm)	Time taken for 25cc of fuel Sec.	Fuel consumption (kg/hr)	Heat input (Q) kW
		kg	N	kg	N					
1	0									
2	25									
3	50									
4	75									
5	100									

Torque (N-m)	BP (kW)	SFC (kg/kWhr)	FP (KW)	IP (KW)	ME (%)	BTE (%)	ITE (%)

Calculations:

Full Load Calculations:

$$BP = BP = \frac{2xPIxNxW\ exR}{60X\ 1000}\ kW$$

Where; BP= Rated Power; N= Rated Speed; R= Radius of Brake drum

$$W_e = \frac{BPx\ 60x1000}{2xPIxNxR}\ N$$

Where; W_e= Full Load in Newton

Full Load W_e =............N ....kg

Effective Load (W_e) = (W – S) N

Torque (T) = W_e x R Nm

Where R = Radius of the brake drum = 0.175m

Brake power,

$$BP = \frac{2xPIxNxT}{60x1000} \text{ KW}$$

Where, N= Speed in Rpm Pi = 3.14159

$$\text{Fuel consumption, } F_c = \frac{25 \text{ x Sg x } 3600}{1000 \text{ x t}} \quad \text{kg/hr}$$

Where, Specific gravity of diesel = 0.8 t= Time taken for the consumption of 25 cc of diesel.

$$\text{Heat input per sec, Q=} \frac{\text{CV x Fc}}{3600} \quad \text{KW}$$

Where, Calorific value of diesel C_v = 43000 kJ/kg
Fc = Fuel consumption in kg/hr

$$\text{Specific fuel consumption, SFC} = \frac{Fc}{BP} \quad \text{kg/KW-hr}$$

Plot the graph of fuel consumption vs Brake power and determine friction power from the graph.

FP from the graph = kW

where FP is the frictional power obtained from the graph m_f V/S BP.

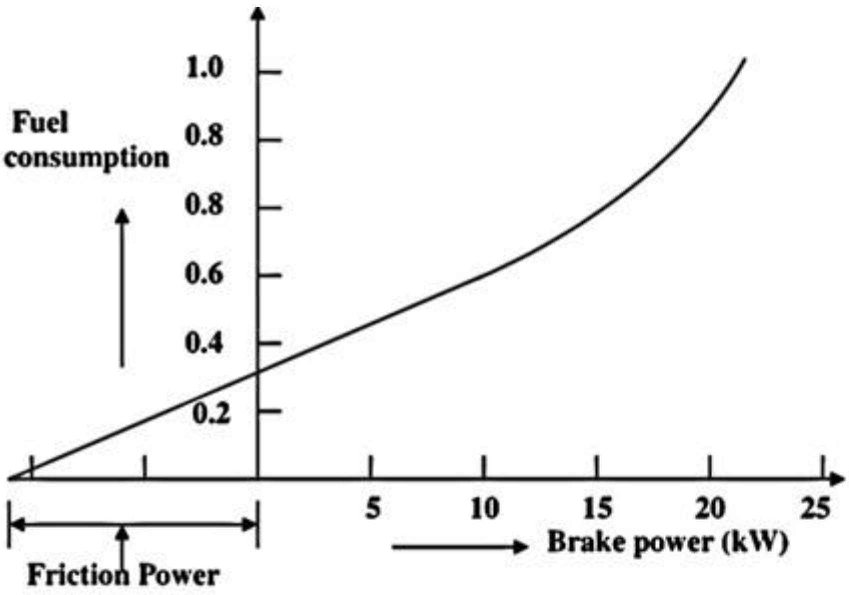


Fig.9: Willan's Line Method

IP = BP + FP kW

Mechanical Efficiency = ME = $\frac{BP X 100}{IP}$ %

Brake thermal efficiency - BTE = $\frac{BP X 100}{Q}$ %

Indicted thermal efficiency – ITE = $\frac{IP X 100}{Q}$ %

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT NO 10

PERFORMANCE TEST ON FOUR STROKE PETROL ENGINE WITH ELECTRICAL LOADING TEST RIG

(**Four Stroke, Single Cylinder, Multi Fuel, Electrical Loading**)

AIM: To conduct an Experiment on Four stroke petrol engine and to draw the performance characteristics curves.

APPARATUS USED: - Petrol start- kerosene test rig, Tachometer, Stopwatch.

APPARATUS DESCRIPTION:

The experimental setup consists of a single cylinder petrol start- kerosene run engine. The fuel (kerosene) is supplied separately through a measuring flask by means of which, the volume of fuel supplied to the engine can be determined. The output from the engine is coupled to a generator which in turn is connected to lamp load, which has an ammeter and a voltmeter fixed to it. Two separate loads are provided on the board, which can be connected to the lamp load. All lamps must be switched off before it is connected to the board. Switching the lamps ON, loads the engine and the corresponding current load may be read on the ammeter. The engine can be stopped by completely stopping the supply of fuel to the engine.

PROCEDURE: -

1. The engine is started by hand cranking.
2. At no load condition (no lamps ON), voltmeter and ammeter readings are recorded and, time required for 25 cc of fuel consumption is noted.
3. Lamps are switched ON to load the engine to 2-amp (say 25%), voltmeter and ammeter readings are taken and time for 25cc of fuel consumption is noted.
4. The above procedure is repeated for every 2amps increase in lamp load (Maximum of 10 amps – FULL LOAD).
5. After all the trials are over; the load on the engine is slowly reduced to zero by switching OFF all the lamps.
6. The readings are tabulated and performance parameters are calculated.
7. Plot the performance characteristics curves:

   FC vs BP
   SFC vs BP
   BTE vs BP
   ITE vs BP
   ME vs BP

SPECIFICATION OF THE ENGINE:

Max. Power output =................HP..................... (kW)

Rated speed =......................... rpm.

Name plate details of the alternator:

Rated voltage =......................... volts.

Rated current =.............................amps.

TABULAR COLUMN

Sl. no	Load (% of full load)	Ammeter Reading	Voltmeter Reading	Speed N rpm	Time taken for 25cc of fuel t Sec.	Fuel consumption kg/hr	Heat input Q KW	BP KW	SFC kg/kWhr
		I Amps	V Volts						
1	0								
2	25								
3	50								
4	75								
5	100								

FP (KW)	IP (KW)	ME (%)	BTE (%)	ITE (%)

CALCULATIONS:

Full Load Calculations:

Brake power, BP = $\frac{V \times I \times \cos\phi}{1000 \times \eta_g}$

Where, BP = Rated power in kW; V= Rated Voltage; cos ϕ= power factor=1; η_g= efficiency of the generator = 0.9

Full Load I = $\frac{BP \times 1000 \times \eta_g}{V \times \cos\phi}$ Amps

Brake power, BP = $\frac{V.I.\cos\phi}{1000 \times \eta_g}$ kw

Where; η_g= 0.9, cosϕ = 1.0

Fuel consumption, FC = $\frac{25 \times S_g \times 3600}{1000 \times t}$ kg/hr

Where; Sp. gr. of Kerosene = 0.80;
t= Time taken for the consumption of 25 cc of kerosene.

Heat input Q= $\frac{C_v \times Fc}{3600}$ kW

Where; Cv= Calorific Value of Kerosene= 43100kJ/kg

Specific fuel consumption, SFC = $\frac{Fc}{BP}$ kg/kW-hr

Plot the graph of fuel consumption vs Brake power and determine friction power (FP) from the graph.

FP from the graph = kW

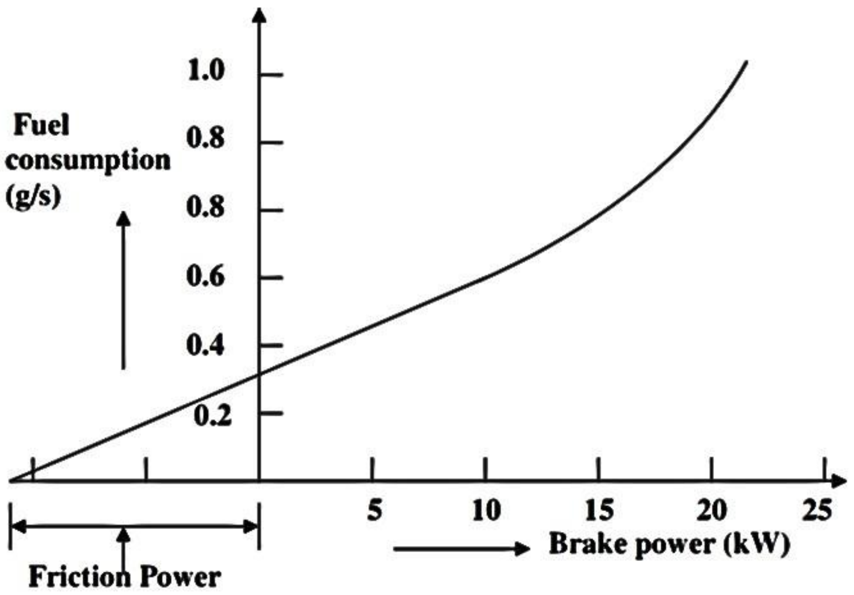


Fig.10: Willan's Line Method

IP = BP + FP kW

Mechanical Efficiency = ME = $\frac{BP \times 100}{IP}$ %

Brake thermal efficiency - BTE = $\frac{BP \times 100}{Q}$ %

Indicted thermal efficiency – ITE = $\frac{IP \times 100}{Q}$ %

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT NO 11

PERFORMANCE TEST ON FOUR STROKE DIESEL ENGINE WITH ELECTRICAL LOADING TEST RIG

(**Four Stroke, Single Cylinder, Electrical Loading**)

AIM: To conduct an Experiment on Four stroke diesel engine and to draw the performance characteristics curves.

APPARATUS USED Diesel Engine coupled to an alternator, Tachometer, Stopwatch. Lamp Load, Voltmeter and Ammeter.

APPARATUS DESCRIPTION:

The experimental setup consists of a single cylinder 4-S diesel engine coupled to an alternator. The fuel (diesel) is supplied separately through a measuring flask by means of which, the volume of fuel supplied to the engine can be determined. The engine speed can be varied by operating the fuel valve. The output from the engine goes to the distribution board, which has an ammeter and a voltmeter fixed to it. Two separate loads are provided on the board, which can be connected to the lamp load. All lamps must be switched off before it is connected to the board. Switching the lamps ON, loads the engine and the corresponding ammeter and voltmeter readings can be recorded. Engine is run at the rated speed always. The engine can be stopped by completely stopping the supply of fuel to the engine.

PROCEDURE:

1. The engine is started by hand cranking.
2. The speed of the engine is set to rated speed (1500 rpm) by controlling the fuel valve.
3. At no load condition (no lamps ON), voltmeter and ammeter readings are recorded and, time required for 25 cc of fuel consumption is noted.
4. Lamps are switched ON to load the engine to 2-amp (say 25%), voltmeter and ammeter readings are taken and time for 25cc of fuel consumption is noted.
5. The above procedure is repeated for every 2amps increase in lamp load (Maximum of 10 amps – FULL LOAD).
6. After all the trials are over; the load on the engine is slowly reduced to zero by switching OFF all the lamps.
7. The readings are tabulated and performance parameters are calculated.

8. Plot the performance characteristics curves

FC	vs	BP
SFC	vs	BP
BTE	vs	BP
ITE	vs	BP
ME	vs	BP

SPECIFICATION OF THE ENGINE:

Max. Power output =................HP..................... (kW)

Rated speed =........................ rpm.

Name plate details of the alternator –

Rated voltage =........................ volts.

Rated current =............................amps.

TABULAR COLUMN

Sl. no	Load (% of full load)	Ammeter Reading	Voltmeter Reading	Speed N rpm	Time taken for 25cc of fuel t Sec.	Fuel consumption kg/hr	Heat input Q KW	BP KW	SFC kg/kWhr
		I Amps	V Volts						
1	0								
2	25								
3	50								
4	75								
5	100								

FP (KW)	IP (KW)	ME (%)	BTE (%)	ITE (%)

CALCULATIONS:

Full Load Calculations:

Brake power, BP = $\frac{V.I.\cos \phi}{1000X\eta_g}$

Where, BP = Rated power in kW; V= Rated Voltage; cos ǿ= power factor=1; η_g= efficiency of the generator = 0.9

Full Load I = $\frac{BP \times 1000X\eta_g}{V \times \cos \phi}$ Amps

Brake power, BP = $\frac{V.I.\cos \phi}{1000X\eta_g}$ kw

Where; η_g= 0.9, cosǿ = 1.0

Fuel consumption, Fc = $\frac{25 \times S_g \times 3600}{1000 \times t}$ kg/hr

Where; Sp. gr. of diesel = 0.827;
t= Time taken for the consumption of 25 cc of petrol.

Heat input **Q**= $\frac{C_v \times Fc}{3600}$ kW

Where; Cv= Calorific Value of Diesel = 45,350 kJ/kg

Specific fuel consumption, SFC = $\frac{Fc}{BP}$ kg/kW-hr

Plot the graph of fuel consumption vs Brake power and determine friction power (FP) from the graph.

FP from the graph = kW

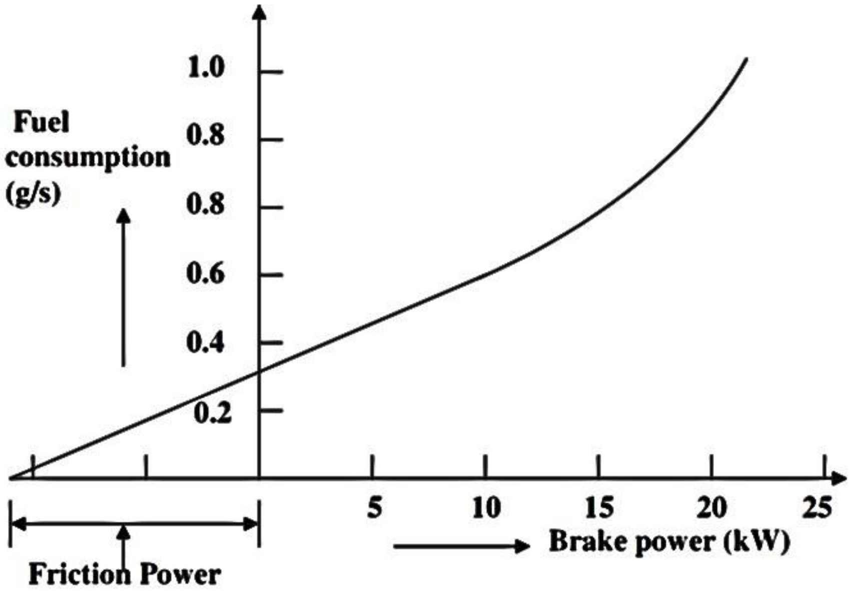


Fig.11: Willan's Line Method

IP = BP + FP kW

Mechanical Efficiency = ME = $\frac{BP \times 100}{IP}$ %

Brake thermal efficiency - BTE = $\frac{BP \times 100}{Q}$ %

Indicted thermal efficiency – ITE = $\frac{IP \times 100}{Q}$ %

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT- 12

PERFORMANCE TEST ON TWO STROKE PETROL ENGINE TEST RIG

(Two Stroke, Single Cylinder, Rope Brake Dynamometer)

AIM: To conduct a performance load test on the engine and to determine Brake Power, Brake Specific Fuel Consumption, Brake Thermal Efficiency and Volumetric efficiency.

APPARATUS USED Petrol Engine coupled to an Rope Brake Dynamometer, Tachometer, Stopwatch.

PROCEDURE

1. Start the engine by kick holding frame handle provided for the same in the base.
2. Now the engine will run at the rated speed of 750 rpm.
3. Allow the brake drum cooling water by operating the gate valve for a less flow.
4. Increase the accelerator screw rod gradually clock wise to run the engine at 3000rpm (approx.) take reading to no load condition.
5. Load the engine in the order of ¼, ½, ¾ and full load by varying accelerator screw rod of engine to meet speed of 3000rpm approximately.
6. Note down all the required parameters mentioned below,
   a) Speed of the engine (N) from digital rpm indicator
   b) Fuel consumption from burette
   c) Quantity of air from manometer.
   d) Repeat steps to increase the load on the engine.
      i. ¼ load
      ii. ½ load
      iii. ¾ load
      iv. Full load
7. Tabulate the results and plot the characteristic curves.

FC	vs	BP
SFC	vs	BP
BTE	vs	BP
η_{Vol}	vs	BP

8. To stop the engine after the experiment is over reducing the load simultaneous decreasing the speed gradually and switch off engine using on/off switch provided on the panel board and close the cooling water gate valve of brake drum.

ENGINE SPECIFICATION

MAKE	:	BAJAJ
BHP	:	2.5 HP
SPEED	:	300RPM
NO. OF CYLINDER	:	ONE
COMPRESSION RATIO	:	7.4:1
BORE	:	54mm
STROKE	:	54mm
ORIFICE DIAMETER	:	20mm
TYPEOF IGNITION	:	FLY WHEE MAGNETO
TYPE OF COOLING	:	AIR COOLED
TYPE OF STARTING	:	KICK START

ROPE BRAKE DYNAMOMETER

MAKE	:	TTE
BRAKE DRUM	:	MILD STEEL
ROPE DIAMETER	:	10mm
HANGER WEIGHT	:	1/2 Kgs
LOADING ARM RADIUS	:	100mm

TABULAR COLUMN

Sl. no	Load (% of full load)	Dead Weight W		Spring balance Reading S		Effective Load	Speed N rpm	Manometer difference h=h2-h1 m	Time taken for 25cc of fuel t Sec	Fuel consumption FC kg/hr	Heat input Q KW
		Kgs	N	Kgs	N	We N					
1	0										
2	25										
3	50										
4	75										
5	100										

BP (KW)	SFC (kg/kW hr)	BTE (%)	Volumetric Efficiency η_{Vol}

CALCULATIONS

BP= $\frac{2x\ \Pi x\ N\ x\ T}{60\ x\ 1000}$ **kW**

Where,

T= Torque in N/m

T=$\frac{9.81(W-S)(D+d)}{2}$ **N-m**

N= speed of the engine in RPM

W= dead weight in kg+ hanger weight ½ kg in N

S= spring balance reading in N

D= diameter of brake drum in m(190mm)

d= diameter of the rope in m.

$\textit{Fuel Consumption} = \frac{X\ x\ 0.72\ x\ 3600}{t\ x\ 1000}$ kg/hr

Where X cc is volume of fuel in t secs.

Density of fuel for (petrol) = 0.072 gms/cc

Specific Fuel Consumption =**SFC** = $\frac{FC}{BP}$ kg/kWh

Actual Volume of Air Flow into the cylinder at RTP (Va)

$V_a = C_d \times A \times \sqrt{2gha}\frac{\rho w}{\rho a} x3600\ m^3/hr$

Where, C_d co-efficient of discharge = 0.62

A= area of cross section of orifice = $\frac{\pi(d2)}{4}$ in m^2

d = dia of orifice = 20mm = 2.0 cm

h = ($h_a \frac{\rho w}{\rho a}$) in m

ρ_a = 1.193 kg/m^3 (density of air)

ρ_w = 1000 kg/m^3 (density of water)

h= manometer reading in m

h_a = Head of air

SWEPT VOLUME (V_s) = $\frac{\pi}{4}$ D^2 x L x N x 60 in m^3/hr

Where;

D is dia of piston = 0.054 in m

L is Stroke length = 0.054 in m

N is speed of the engine = in RPM

VOLUMETRIC EFFICENCY (η_{Vol}) = $\frac{Va}{Vs}$ x 100 %

BRAKE THERMAL EFFICIENCY (BTE) = $\frac{BP}{Q}$ **X 100 %**

Q = $\frac{FC}{3600}$ X C_v kW

Where FC = Fuel Consumption in kg/hr

C_v = Calorific value of petrol = 45.5 x 10^3 kJ/kg

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT-13

PERFORMANCE TEST ON FOUR STROKE PETROL ENGINE WITH MCCHANICAL LOADING TEST RIG

(Single Cylinder, Rope Brake Dynamometer)

AIM: To conduct performance load test on the engine and to determine Brake Power, Specific Fuel Consumption, Brake Thermal Efficiency and Volumetric Efficiency.

APPARATUS USED Petrol Engine coupled to an Rope Brake Dynamometer, Tachometer, Stopwatch.

PROCEDURE

1. Put on main panel board socket to a5 amps/230 v AC plug point near the rig.
2. Connect the water source of ½'' line to brake drum inlet mention as green line.
3. Provide a water drain line of 1'' to remove the scraper water from brake drum.
4. The engine speed is governed by engine.
5. Switch on the engine using on/off switch provided on the engine cover.
6. Check the lubricating oil level in the sump once while (for every 10 hours of running)
7. Fill up the petrol with 50 ml 2T oil for every one litre of petrol mounted on the panel frame.
8. Open the petrol cock provided underneath the petrol tank and in the frame.
9. Start the engine by kick holding frame handle provided for the same in the base.
10. Now the engine will run at 750 rpm respectively.
11. Allow the brake drum cooling water by operating the gate valve for a less flow.
12. Load the engine in order of ¼, ½, ¾ and full load and check engine speed of 3000rpm approximately.
13. Note down all the required parameters mentioned below,
    a) Speed of the engine (n) from digital rpm indicator
    b) Fuel consumption from burette
    c) Quantity of air from manometer.
14. Repeat steps to increase the load on the engine.
    1) ¼ load 2) ½ load 3) ¾ load 4) Full load
15. With the results obtained from above said parameters and the calculations, draw the characteristic curves.

FC	vs	BP
SFC	vs	BP
BTE	vs	BP
η_{Vol}	vs	BP

14. To stop the engine after the experiment is over reducing the load simultaneous decreasing the speed gradually and switch off engine using on/off switch provided on the panel board and close the cooling water gate valve of brake drum.

ENGINE SPECIFICATION

MAKE	:	GREAVES
BHP	:	2.5 HP
SPEED	:	300RPM
NO. OF CYLINDER	:	ONE
COMPRESSION RATIO	:	4.67:1
BORE	:	70mm
STROKE	:	66.7mm
ORIFICE DIAMETER	:	20mm
TYPEOF IGNITION	:	FLY WHEE MAGNETO
TYPE OF COOLING	:	AIR COOLED
TYPE OF STARTING	:	KICK START

ROPE BRAKE DYNAMOMETER

MAKE	:	TTE
BRAKE DRUM	:	MILD STEEL
ROPE DIAMETER	:	10mm
HANGER WEIGHT	:	1/2 Kgs
LOADING ARM RADIUS	:	100mm

TABULAR COLUMN

Sl. no	Load (% of full load)	Dead Weight W		Spring balance Reading S		Effective Load	Speed N rpm	Manometer difference h=h2-h1 m	Time taken for 25cc of fuel t Sec	Fuel consumption FC kg/hr	Heat input Q KW
		Kgs	N	Kgs	N	We N					
1	0										
2	25										
3	50										
4	75										
5	100										

BP (KW)	SFC (kg/kW hr)	BTE (%)	Volumetric Efficiency η_{Vol}

CALCULATIONS

BP= $\frac{\mathbf{2x\ \Pi x\ N\ x\ T}}{\mathbf{60\ x\ 1000}}$ **kW**

Where,

T= Torque in N/m

T=$\frac{\mathbf{9.81(W-S)(D+d)}}{\mathbf{2}}$ **N-m**

N= speed of the engine in RPM

W= dead weight in kg+ hanger weight ½ kg in N

S= spring balance reading in N

D= diameter of brake drum in m(190 mm)

d= diameter of the rope in m. (10 mm)

$$\boldsymbol{Fuel\ Consumption} = \frac{\boldsymbol{X\ x\ 0.72\ x\ 3600}}{\boldsymbol{t\ x\ 1000}} \text{ kg/hr}$$

Where X cc is volume of fuel in t secs.

Density of fuel for (petrol) = 0.072 gms/cc

Specific Fuel Consumption =**SFC** = $\frac{\boldsymbol{FC}}{\boldsymbol{BP}}$ kg/kWh

Actual Volume of Air Flow into the cylinder at RTP (Va)

$$\mathbf{V_a = C_d\ x\ A\ x\ \sqrt{2gha}\frac{\rho w}{\rho a}x3600\ m^3/hr}$$

Where, C_d co-efficient of discharge = 0.62

A= area of cross section of orifice = $\frac{\boldsymbol{\pi(d2)}}{\mathbf{4}}$ in m^2

d = dia of orifice = 20mm = 2.0 cm

h = (h_a $\frac{\boldsymbol{\rho w}}{\boldsymbol{\rho a}}$) in m

ρ_a = 1.193 kg/m^3 (density of air)

ρ_w = 1000 kg/m^3 (density of water)

h= manometer reading in m

h_a = Head of air

SWEPT VOLUME (V_s) = $\frac{\pi}{4}$ D^2 x L x N x 60 in m^3/hr

Where;

D is dia of piston = 0.054 in m

L is Stroke length = 0.054 in m

N is speed of the engine = in RPM

VOLUMETRIC EFFICENCY (η_{Vol}) = $\frac{Va}{Vs}$ x 100 %

BRAKE THERMAL EFFICIENCY (BTE) = $\frac{BP}{Q}$ **X 100 %**

Q = $\frac{FC}{3600}$ X C_v kW

Where

FC = Fuel Consumption in kg/hr

C_v = Calorific value of petrol = 45.5 x 10^3 kJ/kg

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT-14

PERFORMANCE TEST ON FOUR STROKE SINGLE CYLINDER VARIABLE COMPRESSION RATIO PETROL ENGINE TEST RIG COUPLED TO DC GENERATOR

AIM: To conduct a performance test on the VCR engine for different compression ratios and to draw the heat balance sheet.

DESCRIPTION OF THE TEST RIG

The VCR Engine is a single cylinder, Air Cooled, SI type petrol engine. It is coupled to a loading dynamometer, which is the case is a DC Generator and Resistive Load Bank. The overhead cylinder head made of Cast Iron is water cooled externally and has an counter position above the original piston in the main engine. The counter piston is actuated by a screw road mechanism.

PROCEDURE

1. Put on main panel board socket to 5 amps/230 v AC plug point near the rig.
2. Connect the water source of ¼’’ line to auxiliary cylinder head.
3. Provide a water drain line of ¼’’ as outlet from auxiliary cylinder head.
4. Check the lubricating oil level in the sump once a while (for every 10 hours of running)
5. Fill up the petrol in the tank mounted on the panel frame.
6. Open the petrol cock provided underneath the petrol tank and in the burette.
7. Start the engine by wounding the rope around the pulley of magneto fly wheel and pull the rope at once to start (if not started try once again)
8. Now the engine will run at 750 rpm respectively.
9. Engage the governor lever towards engine flywheel to run at 3000rpm(approx) to take no load observation.
10. Load the engine in by operating thermostat knob down wise gradually and simultaneously watch the speed engine upto 2800 to 3000rpm
11. Note down all the required parameters mentioned below,
    a) Speed of the engine (n) from digital rpm indicator
    b) Fuel consumption from burette
    c) Quantity of air from manometer.

12. Repeat steps to increase the load on the engine.
    a) ¼ load 2) ½ load 3) ¾ load 4) Full load
13. With the results obtained from above said parameters and the calculations, draw the characteristic curves.

FC	vs	BP
SFC	vs	BP
BTE	vs	BP
η_{Vol}	vs	BP

14. For changing compression ratio to the other level bring engine to normal speed that is ideal speed by reducing the load and simultaneously.
15. Unscrew the lever on the compression ratio wheel changing the ratio by operating the wheel and lock the lever without engine stopping
16. By rotating clock wise the compression ratio decrease and start coming up to 2.5:1
17. By rotating anti-clock wise the compression ratio increase and start moving up to 10:1.

ENGINE SPECIFICATION

BHP	:	2.5 HP
RATED SPEED	:	300RPM
NO. OF CYLINDER	:	ONE
BORE	:	70mm
STROKE	:	66.7mm
COMPRESSION RATIO	:	2.5:1 to 10:1

DC GENERRATOR SHUNT WOUND

RATED VOLTAGE	:	220 V DC
RATED SPEED	:	3000 RPM
RATING	:	2.2 kW Max.

TABULAR COLUMN

Sl. no	Load (% of full load)	Ammeter Reading	Voltmeter Reading	Speed N rpm	Manometer difference h=h2-h1 m	Time taken for 25cc of fuel t Sec	TC_1	TC_2	TC_3	TC_4	TC_5
		I Amps	V Volts								
1	0										
2	25										
3	50										
4	75										
5	100										

Fuel Consumption FC Kg/hr	Heat input Q kW	BP KW	SFC kg/KW-hr	BTE (%)	Volumetric Efficiency η_{Vol}

TC1 – Exhaust gas inlet to calorimeter

TC2 – Exhaust gas outlet from calorimeter

TC3 – Water inlet to Calorimeter

TC4 – Water outlet from calorimeter

TC5 – Air passing over the Engine.

HEAT BALANCE SHEET

Heat Input per second	kW	%	Heat Expenditure per second	kW	%
Heat supplied by the combustion of fuel	**Q**	**100%**	a) Heat in BP		
			b) Heat carried by exhaust gas		
			c) Heat carried away by water		
			d) Heat Unaccounted = Q - (a+b+c)		
Total	**Q**	**100**			**100**

Calculations:

$$\mathbf{BP} = \frac{2x\ \Pi x\ N\ x\ T}{60\ x\ 1000}\quad \mathbf{kW}$$

Where,

T= Torque in N/m

$$\mathbf{T} = \frac{9.81(W-S)(D+d)}{2}\quad \mathbf{N\text{-}m}$$

N= speed of the engine in RPM

W= (dead weight in kg+ hanger weight ½ kg) in N

S= spring balance reading in N

D= diameter of brake drum in m(190 mm)

d= diameter of the rope in m. (10 mm)

$$\textit{Fuel Consumption} = \frac{X\ \ x\ 0.720\ x\ 3600}{t\ \ x\ 1000}\quad \text{kg/hr}$$

Where X cc is volume of fuel in t secs.

Density of fuel for (petrol) = 0.072 gms/cc

Specific Fuel Consumption =**SFC** = $\frac{FC}{BP}$ kg/kWh

Actual Volume of Air Flow into the cylinder at RTP (Va)

$$\mathbf{V_a = C_d \times A \times \sqrt{2gha}\frac{\rho w}{\rho a} \times 3600\ m^3/hr}$$

Where, C_d co-efficient of discharge = 0.62

A= area of cross section of orifice = $\frac{\pi(d2)}{4}$ in m^2

d = dia of orifice = 20mm = 2.0 cm

h = ($h_a \frac{\rho w}{\rho a}$) in m

ρ_a = 1.193 kg/m^3 (density of air)

ρ_w = 1000 kg/m^3 (density of water)

h= manometer reading in m

h_a = Head of air

SWEPT VOLUME (V_s) = $\frac{\pi}{4}$ D^2 x L x N x 60 in m^3/hr

Where;

D is dia of piston = 0.054 in m

L is Stroke length = 0.054 in m

N is speed of the engine = in RPM

VOLUMETRIC EFFICENCY (η_{Vol}) = $\frac{Va}{Vs}$x 100 %

BRAKE THERMAL EFFICIENCY (BTE) = $\frac{BP}{Q}$ **X 100 %**

Q = $\frac{FC}{3600}$ X C_v kW

Where

FC = Fuel Consumption in kg/hr

C_v = Calorific value of petrol = 45.5 x 10^3 kJ/kg

Heat Balance Sheet

1. Heat input, Q = $Q = \frac{FC}{3600} \times C_v$ **kW**
2. Heat in terms of BP = a – BP kW
3. Heat carried away by exhaust gas =
=b = (Mass of fuel + Mass of air) X C_{Pg} X (T_{C1}-T_{C2}) kW Where;
C_{Pg} = Specific heat of gas in kJ/kg K
4. Heat carried away by water =
$C_{PW} = m_w \times C_{Pw} \times (TC_4 - TC_3)$
CPw = Specific heat of water = 4.187 kJ/kg K

Heat Input per second	**kW**	**%**	**Heat Expenditure per second**	**kW**	**%**
Heat supplied by the combustion of fuel	**Q**	**100%**	a) Heat in BP		
			b) Heat carried by exhaust gas		
			c) Heat carried away by water		
			d) Heat Unaccounted = Q - (a+b+c)		
Total	**Q**	**100**			**100**

CONCLUSIONS/INFERENCE:

(to be written by the student)

EXPERIMENT-15

PERFORMANCE TEST ON FOUR STROKE FOUR CYLINDER PETROL ENGINE WITH MECHANICAL ROPE BRAKE LOADING AND WITH MORSE TEST RIG

Aim: To conduct Performance test on the engine, and to draw the heat balance sheet.

Description of Apparatus:

The mechanical brake drum is fixed to the engine. Flywheel and the engine is mounted on a MS channel frame and further mounted on anti-vibro mounts. Panel board is used to fix burette with 3-way cock, digital temperature indicator with selector switch, digital RPM indicator and U tube manometer.

PROCEDURE:

1. Check the lubricating oil in the engine sump with the help of dipstick provided and Connect engine jacket inlet to a water source with a constant head of 5m (0.5 kg/sq.cm) through respective rotameter.
2. Open the gate valves (control valves) and set any desired flow rate on the rotameter.
3. Connect the panel instrumentation input power line to a 230V 50 Hz single-phase power source.
4. Fill Fuel into the tank mounted on the panel frame.
5. Connect the battery terminals to a well-charged 12V battery with the terminals marked (+) (-) respectively to the engine cable terminals.
6. Open Other petrol cock provided underneath the petrol tank and ensures all the knife switch provided for the purpose of mores test are in closed position. Also ensure the accelerator knob is in cut off position (idle position).
7. Insert the ignition key into the starter switch and turn in clockwise by which the Ammeter provided on the bottom of the panel shows negative deflection. Turn the key further clockwise to start the engine. Now the engine is running at idle speed.(Approx. 800- 1000 RPM) on the digital RPM indicator. Ensure the oil pressure gauge read 2 kg/sq.cm to 4 kg/sq.cm
8. Increase the speed by turning the accelerator knob clockwise until the RPM indicator reads approx. 1500. RPM
9. Now load the engine by placing the necessary dead weights on the weighing hanger, to load the engine in steps of ¼, ½, ¾, full and 10% overload. Allow the engine to stabilize on every load change.

10. Record the following parameters indicated on the panel instruments on each load step.
    a. Speed of the engine in RPM indicator.
    b. Fuel consumption rate from burette.
    c. Quantity of air sucked into the engine cylinder from manometer.
11. Temperatures TC1 to TC4 from the temperature indicator by turning the selector switch to respective position.
12. Quantity of water flowing through engine head rotameter.
13. Exact load in kg (W) on the engine by adding the amount of weight added on the pan in kg (W1) plus weight of pan in kg (W2) minus spring balance reading in kg (W3)
14. To stop the engine, turn off the ignition key in anti-clockwise direction.
15. With the above parameters recorded at each step load, the values are calculated for obtaining the efficiency mentioned.

MORSE TEST

Aim: To calculate the BP and Mechanical Efficiency of the engine**.**

Procedure:

Load the engine to maximum load (i.e. 26 kgs) at rated speed (i.e. 1500RPM). Allow it to run for few minutes. Cut off power to one cylinder by pulling the knife switch provided on the engine panel to "CUT OFF" position. Now the engine is running on 3 cylinders only. As the result the speed of the engine decreases, by removing the dead weight on the brake drum reduce the load on the engine slowly, so as the speed of the engine comes back to its rated speed. (That is 1500 rpm approximate). Record the load on the engine. Now without altering the positions on the load brake put back the pulled knife switch to its original position, then the speed of the engine does not reach the rated speed increase or decrease the load as applicable. (If the speed is more increase the load or vice versa). Record the spring balance reading after attaining the rated speed. Follow the similar procedure for rest of the cylinders.

Calculate the BHP when all the four cylinders are working. Similarly calculate the BHP of four cylinders when each of the cylinders is disconnected. By this method indicated horsepower of the engine can be calculated.

ENGINE SPECIFICATION

MAKE	:	FIAT
BHP	:	7.5 HP
SPEED	:	1500 RPM
NO. OF CYLINDER	:	FOUR
COMPRESSION RATIO	:	7.8:1
BORE	:	68mm
STROKE	:	75mm
ORIFICE DIAMETER	:	17mm
TYPEOF IGNITION	:	COMPRESSION IGNITION
METHOD OF LOADING	:	MECHANICAL ROPE BRAKE
METHOD OF COOLING	:	WATER COOLED
METHOD OF STARTING	:	SELF START

TABULAR COLUMN

Sl. no	Load (% of full load)	Dead Weight W		Spring balance Reading S		Effective Load	Speed N rpm	Manometer difference $h=h_2-h_1$ m	Time taken for 25cc of fuel t Sec	Fuel consumption FC kg/hr	Heat input Q KW
		Kgs	N	Kgs	N	We N					
1	0										
2	25										
3	50										
4	75										
5	100										

BP (KW)	SFC (kg/KW-hr)	BTE (%)	Volumetric Efficiency η_{Vol}

Heat Input per second	kW	%	Heat Expenditure per second	kW	%
Heat supplied by the combustion of fuel	**Q**	**100%**	e) Heat in BP		
			f) Heat carried by exhaust gas		
			g) Heat carried away by water		
			h) Heat Unaccounted = Q - (a+b+c)		
Total	**Q**	**100**			**100**

HEAT BALANCE SHEET

CALCULATIONS

BP= $\frac{2x\ \Pi x\ N\ x\ T}{60\ x\ 1000}$ **kW**

Where,

T= Torque in N/m

T=$\frac{9.81(W-S)(D+d)}{2}$ **N-m**

N= speed of the engine in RPM

W= (dead weight in kg+ hanger weight ½ kg) in N

S= spring balance reading in N

D= diameter of brake drum in m(190 mm)

d= diameter of the rope in m. (10 mm)

$Fuel\ Consumption\ = \frac{X\ \ x\ 0.720\ x\ 3600}{t\ \ x\ 1000}$ kg/hr

Where X cc is volume of fuel in t secs.

Density of fuel for (petrol) =0.072 gms/cc

Specific Fuel Consumption =**SFC** = $\frac{FC}{BP}$ kg/kWh

Actual Volume of Air Flow into the cylinder at RTP (Va)

$$V_a = C_d \text{ x A x} \sqrt{2gha\frac{\rho w}{\rho a}} \text{x3600 m}^3\text{/hr}$$

Where, C_d co-efficient of discharge = 0.62

A= area of cross section of orifice = $\frac{\pi(d2)}{4}$ in m^2

d = dia of orifice = 20mm = 2.0 cm

h = ($h_a \frac{\rho w}{\rho a}$) in m

ρ_a = 1.193 kg/m^3 (density of air)

ρ_w = 1000 kg/m^3 (density of water)

h= manometer reading in m

h_a = Head of air

SWEPT VOLUME (V_s) = $\frac{\pi}{4}$ D^2 x L x N x 60 in m^3/hr

Where;

D is dia of piston = 0.054 in m

L is Stroke length = 0.054 in m

N is speed of the engine = in RPM

VOLUMETRIC EFFICENCY (η_{Vol}) = $\frac{Va}{Vs}$x 100 %

BRAKE THERMAL EFFICIENCY (BTE) = $\frac{BP}{Q}$ **X 100 %**

Q = $\frac{FC}{3600}$ X C_v kW

Where

FC = Fuel Consumption in kg/hr

C_v = Calorific value of petrol = 45.5 x 10^3 kJ/kg

Heat Balance Sheet

Heat input, Q **=** $Q = \frac{FC}{3600}$ X C_v kW

Heat in BP = a – BP kW

Heat carried away by exhaust gas =

=b = (Mass of fuel + Mass of air) X CPg X (TC_1-TC_2) kW

Where;

C_{Pg} = Specific heat of gas in kJ/kg K

Heat carried away by water =

C = m_w X C_{Pw} X (TC_4-TC_3)

Where;

CPw = Specific heat of water = 4.187 kJ/kg K

MORSE TEST

BP, WHEN FOUR CYLINDERS ARE WORKING.	=	A
BP OF 3 CYLINDERS WHEN FIRST CYLINDER IS CUTOFF.	=	B1
BP OF 3 CYLINDERS WHEN SECOND CYLINDER IS CUTOFF	=	B2
BP OF 3 CYLINDERS WHEN THIRD CYLINDER IS CUTOFF.	=	B3
BP OF 3 CYLINDERS WHEN FOURTH CYLINDER IS CUTOFF	=	B4

IP OF FIRST CYLINDER	=	IP 1= A-B1
IP OF SECOND CYLINDER	=	IP 2= A-B2
IP OF THIRD CYLINDER	=	IP 3= A-B3
IP OF FOURTH CYLINDER	=	IP 4= A-B4

Total IP of the engine = (IP1 + IP2 + IP3 + IP4) kW

Mechanical Efficiency η_m = $\frac{BP}{IP} X100$ **%**

CONCLUSIONS/INFERENCE:

(to be written by the student)