QMP 7.1 D/F

Channabasaveshwara Institute of Technology

(An ISO 9001:2008 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Mechanical Engineering

LAB MANUAL

(2015-16)

Energy Conversion Engineering Laboratory

(10MEL58)

B.E - V Semester

Name : ____________________________________

USN : ____________________________________

Batch : __________________ Section : ___________

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Department of Mechanical Engineering

Energy Conversion Engineering Laboratory

August 2015

Prepared by:

SUSHMA .S

Assistant Professor

Reviewed by:

NAGESH S B

Assistant Professor

Approved by:

Professor & Head,

Dept. of Mechanical Engg.

SYLLABUS

Energy Conversion Engineering Laboratory

Sub Code: 10 MEL58	**IA Marks : 25**
Hrs/week : 03	**Exam Marks : 50**
Total Lecture Hrs: 48	**Exam Hours : 03**

PART – A

1. Determination of Flash Point and Fire Point of lubricating oil using Abel Pensky and Marin (Closed) / Cleavland (Open cup) Apparatus.
2. Determination of Calorific value of solid, liquid and gaseous fuels.
3. Determination of Viscosity of a lubricating oil using Redwoods, Saybolts and Torsion Viscometers.
4. Valve Timing/ port opening Diagram of an I.C. Engine (4 stroke/ 2 stroke.)
5. Use of Planimeter.

PART – B

1. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal efficiencies, SFC, FP, 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

Scheme of Examination:
ONE question from part -A: 20 Marks
ONE question from part -B: 20 Marks
Viva -Voice: 10 Marks
Total: 50 Marks

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NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.
DEPARTMENT OF MECHANICAL ENGG.

CONTENTS

ENERGY CONVERSION ENGINEERING LBROTARY OBJECTIVE & OUTCOMES:

OBJECTIVES:

This lab will help students to see how energy can be converted from one form to another. Students will observe the loss in useful energy as a result of such a conversion and measure the efficiency for such conversions.

- To make students familiar with the design and operating characteristics of internal combustion engines.
- To apply analytical techniques to the engineering problems and performance analysis of internal combustion engines.
- To study the thermodynamics, combustion, heat transfer, friction and other factors affecting engine power, efficiency and emissions.
- To introduce students to the environmental and fuel economy challenges facing the internal combustion engine.
- To introduce students to future internal combustion engine technology .

OUTCOMES:

- Students are able to differentiate among different internal combustion engine designs.
- Students are able to recognize and understand reasons for differences among operating characteristics of different engine types and designs.
- Given an engine design specification, predict performance and fuel economy trends with good accuracy.
- Learn to compare and contrast experimental results with theoretical trends, and to attribute observed discrepancies to either measurement error or modelling limitations.
- Develop an ability to optimize future engine designs for specific sets of constraints (fuel economy, performance, emissions).

‘Instructions to the Candidates’

1. Students should come with thorough preparation for the experiment to be conducted.

2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.

3. Experiment should be started only after the staff-in-charge has checked the experimental setup.

4. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.

5. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.

6. Practical record should be neatly maintained.

7. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.

8. Theory regarding each experiment should be written in the practical record before procedure in your own words.

EXPERIMENTAL SETUP:

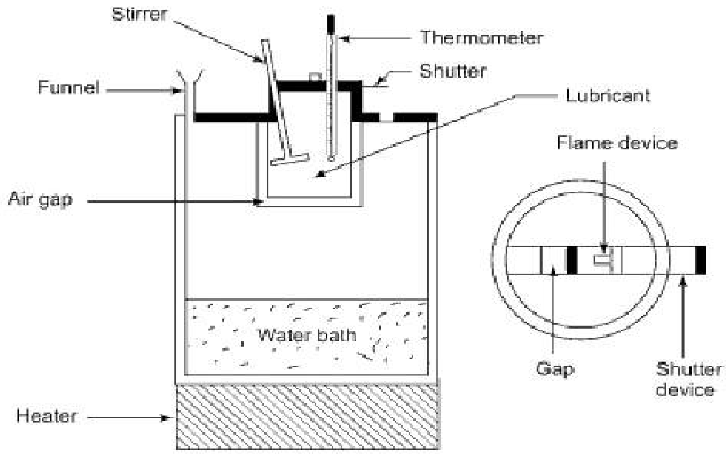


Figure: Abel's Flash Point Apparatus.

OBSERVATION:

Type of oil used:

TABULAR COLUMN:

Sl. No	Oil Temperature in ^{0}C	Observations (Yes or No)
		Flash Point
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

RESULT:

The flash point of a given sample of oil = ------- ^{0}C

EXPERIMENT NO 1

ABEL'S FLASH POINT APPARATUS

AIM:

To determine the flash point of given oil by Abel's Flash Point Apparatus.

TERMINOLOGY:

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

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

APPARATUS:

Abel's flash point apparatus & Thermometers.

DISCRIPTION:

The Abel's flash point apparatus is mainly used to determine the flash point of fuel oils flashing between 2^0C to 49 ^{0}C. It consists of a sealed water bath with a provision of an air chamber to hold the oil cup and circulate cold water for below ambient determination and an external heater for above ambient determinations. The oil cup is provided with a lid and sliding ports for the introduction of test flame. Within the oil cup a circular marking to indicate the level of oil to be taken for the test. The whole arrangement is mounted on a cylindrical enclosed stand.

PROCEDURE:

1) Clean the oil cup with any solvent and wipe it dry.
2) Fill water into the water jacket to its full level and insert into the cylindrical stand.
3) Pour water into the air chamber, which surrounds the oil cup to a depth of 38 mm.
4) Pour fuel oil to be tested into the oil cup up to the circular mark and place the oil cup into the air chamber of the water bath.
5) Close it with the lid having sliding ports.
6) Insert the water and oil thermometers in their respective holders.
7) Keep the entire set up on a heater and heat the water at a very slow rate.
8) Maintain a low flame on the wick and apply the flame to the oil surface by sliding the port at every 2^0 C rise in temperature of the oil under test.
9) Record the temperature at which the first flash occurs and report as flash point.
10) To determine the flash point of fuel oils below room temperature, circulate cold water in the water bath to at least 15^0C below the expected flash point of the fuel oil sample and follow steps 8 & 9.

EXPERIMENTAL SETUP

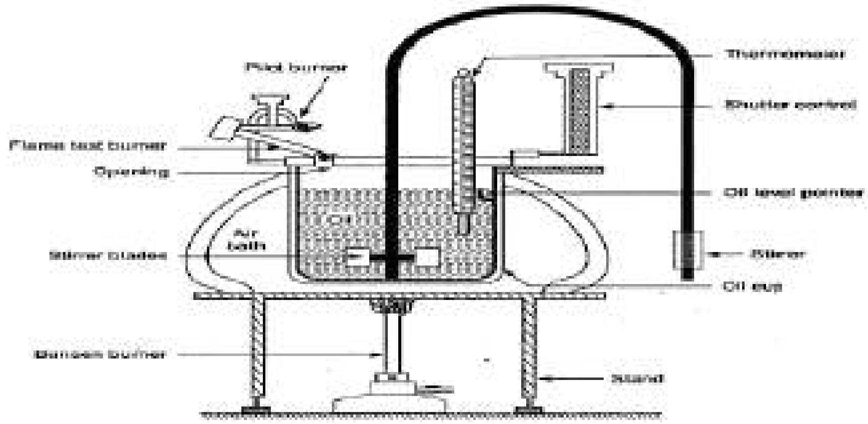


Figure :Pensky Martenz's Flash Point Apparatus

OBSERVATION:

Type of oil used:

TABULAR COLUMN:

Sl. No	Oil Temperature in ^{0}C	Observations (Yes or No)
		Flash Point
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

RESULT:

Flash Point of given oil = --------- ^{0}C

EXPERIMENT NO 2

PENSKY MARTENZ'S FLASH POINT APPARATUS

AIM:

To determine the flash point of oil by Pensky Marten's Apparatus.

PRINCIPLE:

The temperature at which an oil gives off inflammable vapour is on the greatest importance in the case petroleum products & lubricating oils. If these oils are sufficiently volatile at ordinary temperatures, the issuing vapours will form an explosive mixture with air and cause fire hazards to ensure safety and to avoid this risk certain minimum temperatures are laid down for burning and lubricating oils below which it should not given off inflammable vapours. Flash point and fire point give these values of temperature.

APPARATUS:

Pensky Marten's apparatus, thermometers.

DISCRIPTION:

This apparatus is used to determine the flash point of fuel oils and lubricating oils. Flashing above 49 ^{0} C. It consists of an oil cup with a circular marking for oil level indication. A lid to cover the oil cup with sliding shutters with ports, oil stirring mechanism and dipping wick holder, cast iron oil cup holder (air bath), electric heater with control.

PROCEDURE:

1) Install the apparatus on a table near a 230V, 50Hz, 5amps single-phase power source. Keep the electrical heater on the table with an asbestos sheet under it. Position the CI cup holder (air bath) on the heater. Insert the oil cup into the bath and position it.
2) Pour the oil to be tested up to the mark into the oil cup.
3) Close the lid.
4) Connect the heater to the electrical power source and heat the oil at a slow steady rate of 1^0 to 2^0C /min with the help of the regulator. Keep stirring the oil with the stirring mechanism.
5) Maintain a small flame on the wick.
6) Introduce the flame to the oil surface by operating the circular handle, which makes the maintained flame to dip into the oil cup by opening the shutter. This is done at every half minute, only after the sample oil reaches around 15^0 C to 17 ^{0}C or before the expected flash point. (Flash point is different for different oils)
7) Record the temperature at which first flash occurs and report as flash point of the sample oil.
8) To stop the experiment, switch of the heater and allow it to cool.

OBSERVATION:

Type of oil used:

TABULAR COLUMN:

Sl. No	Oil Temperature in ^{0}C	Observations (Yes or No)	
		Flash point	Fire point
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10			

RESULT:

1) Flash Point of given oil = ------^{0}C

2) Fire Point of given oil = -------- ^{0}C

EXPERIMENT NO 3

FLASH POINT AND FIRE POINT BY CLEAVELAND (OPEN CUP)APPARATUS

AIM:

To determine the flash point and fire point of petroleum products by cleaveland (Open cup) appartaus.

APPARATUS:

Cleaveland apparatus, thermometer.

PROCEDURE:

1. Keep the apparatus on a table near a 230V, 50Hz, 5 amps power source.
2. Clean the oil cup with a soft cloth and fill the oil to be tested into the cup up to the mark.
3. Place the oil filled cup on heater; insert the thermometer into the clip, until the thermometer sensor bulb just dip into the oil surface.
4. Switch on the heater and heat the oil at a faster rate for first few min (2- 3 min) and control the heating rate at very slow rate (10^0C rise in 60 seconds) as athe oil approaches the flash point.
5. Apply a test flame at every 1.5^0C rise in temperatue.
6. Record the temperature at which first flash occurs and report as flash point of the sample oil.
7. To obtain the fire point, continue heating at the same rate and keep applying the test flame to the surface of oil.
8. At approximately 10^0C to 15^0C rise in oil temperature above the flash point , applying the test flame the oil surface continue to burn for 5 to 6 seconds. Record the temperature at this point which is the fire point of the oil under test.
9. Tabulate the readings and declare the temperature as flash point and fire poin t of the oil under test.

OBSERVATIONS:

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

Water equivalent of Calorimeter (W) 2330 Cal/ ^{0}C

CALCULA TIONS:

$$WT = HM$$

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

Where: W = Water equivalent of Calorimeter Cal/^{0}C

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

T= Rise in temperature due to combustion of solid fuel inside the Bomb ^{0}C.

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

EXPERIMENT NO 4

BOMB CALORIMETER

AIM:

To determine the calorific value of solid fuels.

APPARATUS:

The Bomb Calorimeter mainly consists of the following:

1. Stainless steel Bomb
2. Calorimeter Vessel with Bomb support and insulating base
3. Water Jacket with outer body
4. Lid for water Jacket
5. Stirrer assembly with F.H.P. motor
6. Bomb firing unit with Electronic Digital Temperature Indicator
7. Pellet Press
8. Stand and dial pressure gauge
9. Connecting tubes(copper tubes O_2 Cylinder to pressure gauge & pressure gauge to bomb)
10. Connecting electrical leads(Firing unit to water jacket & water jacket to bomb)
11. Crucible Stainless steel
12. Gas release valve
13. Oxygen cylinder valve

DISCRIPTION:

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

A known amount of the sample is burnt in a sealed chamber. The air is replaced by pure oxygen.

The sample is ignited electrically. As the sample burns, heat is produced. The rise in temperature is determined Since, barring heat loss the heat absorbed by calorimeter assembly and the rise in temperature enables to calculate the heat of combustion of the sample.

W Water equivalent of the calorimeter assembly in calories per degree centigrade (2330 cal / ^{0}C)

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

H Heat of combustion of material in calories per gram

M Mass of sample burnt in grams

Then W T = HM

"H" is calculated easily since W, T and M are known.

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

PROCEDURE:

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

20. Tabulate all the readings and calculate the calorific value of the solid fuel under test.
21. To close the experiment switch "OFF" the stirrer and main switch, open the shell lid and take out the Bomb assembly from the calorimeter vessel. Release all the flue gases from the Bomb with the help of release valve, unscrew the cap open the lid and observe all the fuel sample is burnt completely.
22. Clean the Bomb and crucible with clean fresh water and keep it dry.

TABULAR COLUMN:

Sl. No.	Water flow rate			Weight of gas	Difference X Kg	Time for X Kg in sec	Gas flow Kg/s	Water Temperature			Calorific Value Cv K_{cal} / kg
	LPM	LPS	Kg/s	Initial -Final X1 - X2 Kg Kg				T_{in} ^0C	T_{out} ^0C	Δt ^0C T_{out}- T_{in}	
1.											
2.											
3.											
4.											
5.											
6.											

CALCULATION:

The calorific value of gaseous fuel

$$C_v = \frac{W_w \times Cp_w \times \Delta t}{W_f} \qquad = K_{cal} / kg$$

Where

W_w = weight of water flowing through Calorimeter in Kg/s (1 Kg=1 liter water)
Cp_w = specific heat of water is 4.187 J/grams ^{0}C, 1 Kcal / Kg ^{0}C
Δt = difference between water inlet and outlet temperature
W_f = weight of Gaseous fuel burnt in Kg/s

RESULT:

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

EXPERIMENT NO 5

BOY'S GAS CALORIMETER

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

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

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

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

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

PROCEDURE:

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

EXPERIMENTAL SETUP

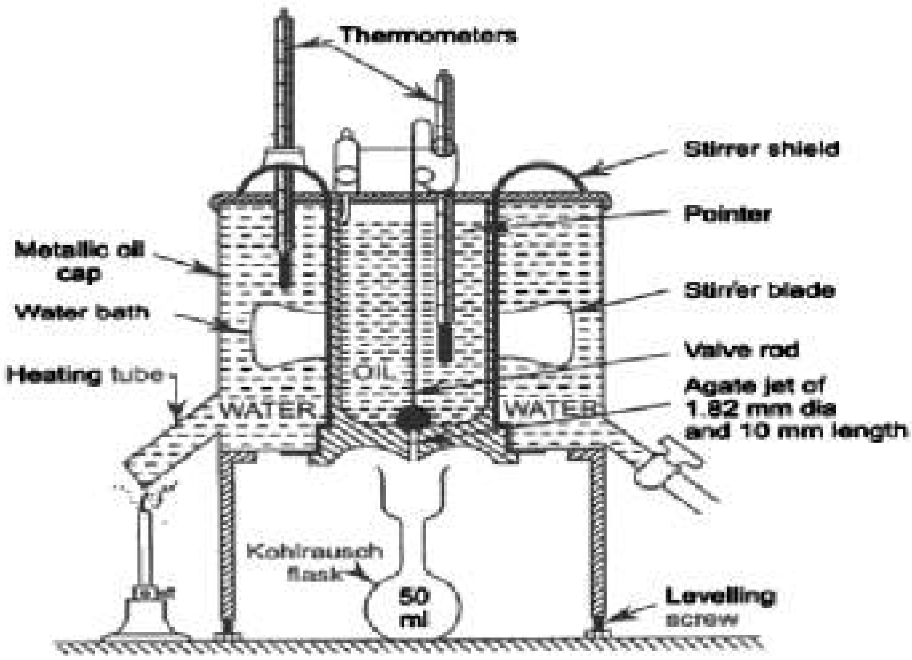


Figure: Experimental Steup

OBSERVATION:

Type of oil used:

TABULAR COLOUMN:

Sl. No.	Temperature of oil in ^0C	Time for collecting 50 ml.of oil in t (sec)
1.		
2.		
3.		

EXPERIMENT NO 6

REDWOOD VISCOMETER

AIM:

To determine the viscosity of the given oil using redwood viscometer at different temperatures. Expressed in terms of Redwood seconds

APPARATUS:

1. Redwood Viscometer, 50ml Receiving flask, thermometers and stopwatch

DESCRIPTION OF THE APPARATUS:

Redwood viscometer Consists of a cylindrical oil cup furnished with a gauge point, agate / 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 convexed, 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 50ml marking, to measure 50 ml of oil flow against time. The water bath with oil cup is supported on a tripod stand with leveling screws.

PROCEDURE:

1) Clean the oil cup with a solvent preferably C.T.C (Carbon Tetra chloride) and wipe it dry thoroughly with a paper napkins or a soft cloth (do not use cotton waste) and the orifice jet with a fine thread.
2) Keep the water bath with oil cup on the tripod stand and level it.
3) Pour water into the water bath up to 15 to 20mm below the top portion
4) Keep the ball (valve) in position and pour clean filtered oil sample (use strainer not coarser than BS 100 mesh) to be tested into the oil cup up to the gauge point and cover it with the lid.
5) Take a clean dry 50ml flask and place it under the orifice jet of the oil cup and center it.
6) Lift the ball (valve) and simultaneously start a stop watch and allow the oil into the receiving flask.
7) Adjust the receiving flask (50ml) in such a way that the oil string coming out of the jet strikes the neck of the flask to avoid foaming (formation of air bubbles) on the oil surface.
8) Wait till the oil level touches the 50 ml mark stop the watch and record the time in sec.
9) Repeat the experiment at different temperatures above ambient.

CALCULATION

$$V = A.t - \frac{B}{t} \quad \text{in} \quad m^2/s$$

Where V= Kinematic viscocity of the oil in m^2/s
t= Time for filling of 50ml of sample oil in sec.

Commonly used values of A & B for Viscometers are:

Viscometer	A X 10^6	B X 10^6
Redwood	0.26	172
Saybolt	0.24	190

GRAPH:

Plot the graph of temperature verses Kinematic viscocity

CONCLUSION:

EXPERIMENTAL SETUP

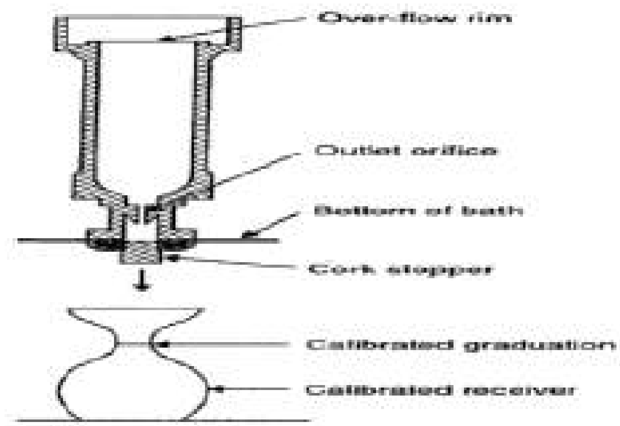


Figure: Saybolt Viscometer

OBSERVATION:

Type of oil used:

TABULAR COLUMN:

Sl. No.	Temperature of oil in ^0C	Time for collecting 60 ml.of oil in t (sec)
1.		
2.		
3.		

EXPERIMENT NO 7

SAYBOLT VISCOMETER

AIM:

To determine viscosity of the given oil using Say Bolt Viscometer at different temperatures expressed in terms of Saybolt seconds.

APPARATUS:

Say Bolt Viscometer, 60ml receiving flask, thermometers & stopwatch.

DISCRIPTION:

The apparatus mainly consists of a standard cylindrical oil cup surrounded with a water bath with an immersion heater and a stirring device. The apparatus is supplied with two S.S. Orifice jets namely Universal jet & Furol jet, which can be fitted at the bottom of the oil cup as per our requirement. A rubber cork stopper arrangement is provided also at the bottom to facilitate start and stop the oil flow from the Viscometer. Two thermometers are provided to measure water bath temperature and oil temperature under test. A round flat-bottomed flask with a 60-ml marking on the neck is provided to measure 60 ml of oil flow against time. The oil cup with the water bath is supported on a stand with levelly screws.

PROCEDURE:

1) Clean the oil cup with a solvent preferably C.T.C (Carbon Tetra chloride) and wipe it dry thoroughly with a paper napkins or a soft cloth (do not use cotton waste) and the orifice jet with a fine thread.
2) Keep the water bath with oil cup on the tripod stand and level it.
3) Pour water into the water bath up to 15 to 20mm below the top portion.
4) Close the Orifice opening from bottom with the rubber cork provided. Pour oil to be tested into the strainer by keeping the strainer on the oil cup until the oil fills up in the oil cup as well as in side well. Withdraw the excess oil in the side well and position the thermometers in water bath and oil cup.
5) Take a clean dry 60ml flask and place it under the orifice jet of the oil cup and center it.
6) Pull the rubber cork open and simultaneously start a stopwatch and allow the oil into the receiving flask.
7) Adjust the receiving flask (60ml) in such a way that the oil string coming out of the jet strikes the neck of the flask to avoid foaming (formation of air bubbles) on the oil surface.
8) Wait till the oil level touches the 60 ml mark, stop the watch and record the time in sec.
9) Repeat the experiment at different temperatures above ambient.

CALCULATION

$$V = At - \frac{B}{t} \quad \text{in } m^2/s$$

Where V= Kinematic viscocity of the oil in m^2 / s
t= Time for filling of 60 ml of sample oil in sec.

Commonly used values of A & B for Viscometers are:

Viscometer	A X 10^6	B X 10^6
Redwood	0.26	172
Saybolt	0.24	190

GRAPH:

Plot the graph of temperature verses Kinematic viscocity

CONCLUSION:

EXPERIMENTAL SETUP

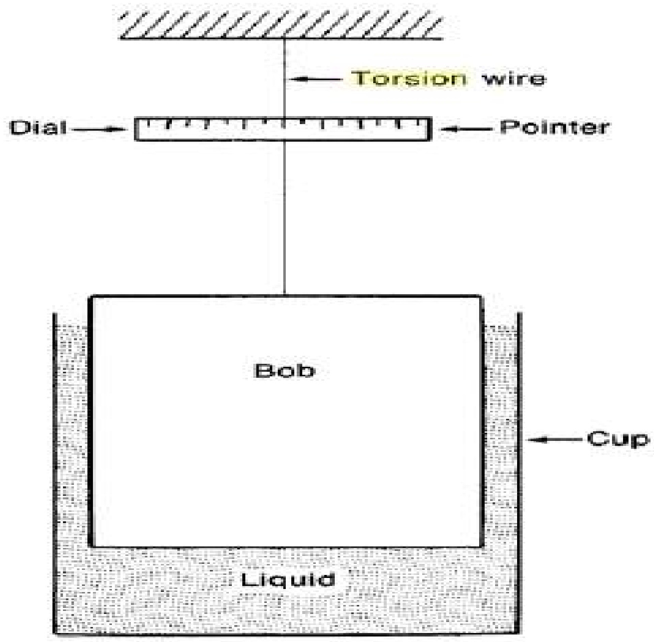


Figure: Experimental Setup Of Torsion Viscometer

OBSERVATION:

Type of oil used:-

TABULAR COLUMN:

Sl.no	Temperature of oil in ^0C	Angular rotation on the disk in degrees	Corresponding redwood seconds from graph
1			
2			
3			

GRAPH:

Plot the graph of temperature verses redwood second

EXPERIMENT NO 8

TORSION VISCOMETER

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

APPARATUS:
Torsion Viscometer, sample oil & thermometer.

DISCRIPTION:
The apparatus consists of a device to hold a solid cylinder and a flywheel by means of a Torsion wire with end connectors. A release pin is provided to hold the flywheel in horizontal position. The flywheel is, surrounded by a graduated scale in degrees (0^0 to 360^0). A pointer is attached to the flywheel to indicate the angler movement of the flywheel. Oil cup to hold the oil under test

PROCEDURE:

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

SKETCH

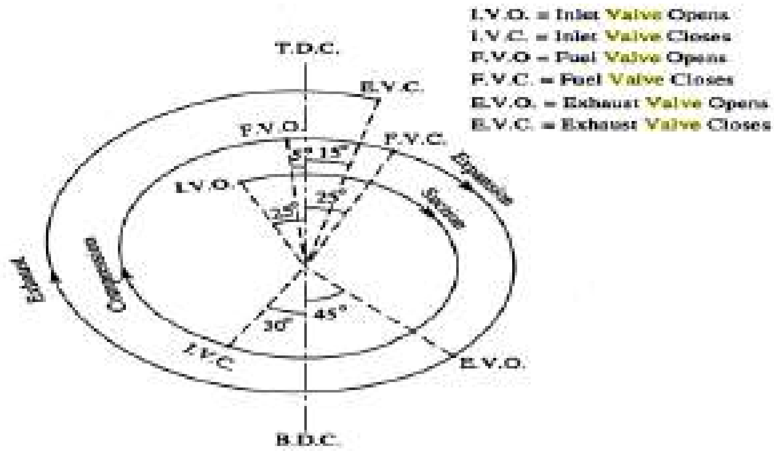


Figure : Valve Timing Diagram of A Four Stroke Disel Engine

TABULAR COLOUMN:

SI. No.	Event	Position of the crank	Angle θ (in degree)
1	I V O	ATDC	
2	I V C	ABDC	
3	E V O	BBDC	
4	E V C	ATDC	

Where:

I V O – Inlet valve opens
I V C – Inlet valve closes
E V O – Exhaust valve opens
E V C – Exhaust valve closes
BTDC – Before top dead centre,
ABDC – After bottom dead centre
BBDC – Before bottom dead centre
ATDC – After top dead centre

EXPERIMENT NO 9

VALVE TIMING DIAGRAM
(CUT SECTION DIESEL ENGINE)

AIM:

To draw valve timing diagram for given engine and calculate different periods.

THEORY:

In a four stroke engine opening and closing of valves and fuel injection do not take place exactly at the end of dead centre positions. The valves open slightly earlier and close after that respective dead centre position .The fuel injection also occurs prior to the full compression ie before the piston reaches the dead centre position. both the valve operate at some degree on either side in terms of crank angle from dead centre position.

DISCRIPTION:

Cut section, 4 Stroke, single cylinder, constant speed .water cooled, vertical diesel engine, 5 BHP 1500 rpm

PROCEDURE:

1. Rotate flywheel freely by hand, fix a reference point on the body of the engine near the flywheel
2. Now while rotating observe piston at TDC (Top dead centre) and mark with chalk on flywheel with reference to the point
3. Similarly by rotating, mark the position of bottom dead center (BDC).
4. It is to be observed that it takes to rotation of flywheel to complete one cycle of operation.
   (one cycle is suction, compression, power & exhaust strokes)
5. Now identify inlet and exhaust valves.
6. Find out direction of rotation of flywheel (crank shaft)
7. Bring flywheel to TDC position (pointer).
8. Go on rotating flywheel slowly and observe position (functioning) of both the valves .
9. Now observe when inlet valves opens mark it on flywheel inlet valve open (IVO)
10. Slowly rotate flywheel, and observe when inlet valve closes (IVC.)
11. Rotate further observe when exhaust valve opens (EVO)
12. Rotate further & observe when exhaust valve closes (EVC).
13. Same time note down IVO & mark all these on flywheel
14. With small thread &scale find out circumference of flywheel
15. With marking of IVO,IVC,EVO &EVC find out lengths with thread &scale.
16. Then draw spiral diagram with data in marking on flywheel.

SKETCH

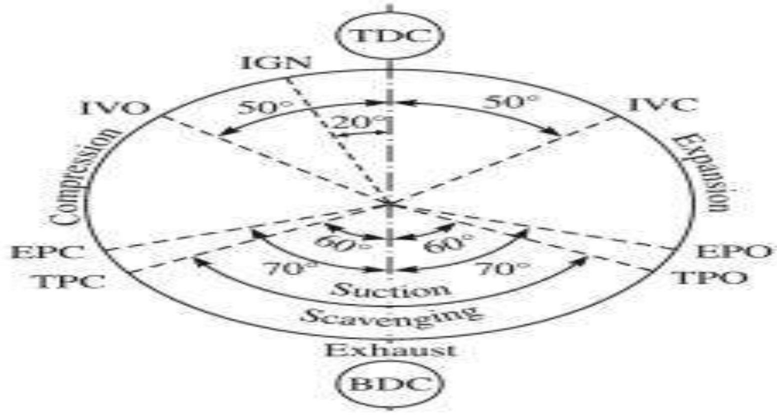


Figure : Port Timing Diagram of A Two Stroke Petrol Engine.

TABULAR COLOUMN:

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

Where:

I P O – Inlet port opens　　I P C – Inlet port closes
T P O – Transfer port opens　　T P C – Transfer port closes
E P O – Exaust port opens　　E P C – Exaust port closes
BTDC – Before top dead centre,　　ABDC – After bottom dead centre
BBDC – Before bottom dead centre　　ATDC – After top dead centre

EXPERIMENT NO 10

PORT TIMING DIAGRM
(Cut section petrol engine)

AIM: To draw port timing diagram for a given petrol engine.

THEORY :

Hear in this type of engines ports which takes charge of air and fuel mixture and removes exhaust from the cylinder it self, by virtue of position of piston. When piston moves inside the cylinder it closes & opens ports. In two stroke engines one revolution of crank shaft completes one cycle .

INLET PORT: Through which mixture of fuel and air enters the crank casing.

EXHAUST PORT: Through which the burnet (exhaust) gas exits

TRANFER PORT: Through which air and fuel mixture enters the cylinder head

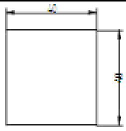
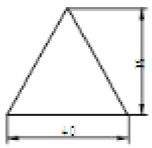
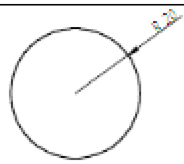
DISCRIPTION:

Cut section of Two Stroke, Single cylinder Automobile petrol engine

PROCEDURE:

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

OBSERVATION & TABULATION:

Sl.no	Shape of figure	Measured Area	Actual Area	% Error
1				
2				
3				
4				

CALCULATION

$$\text{Percentage error} = \frac{(\text{Actual area} - \text{Measured area})}{\text{Actual area}} \times 100$$

EXPERIMENT NO 11

PLANIMETER

AIM: To determine surface area of a given drawing

DISCRIPTION: Planimeter , Drawing board, Drawing board pins

The planimeter mainly consists of :

a) Tracing arm with main scale, vernier scale, Rotating disc and rotating drum with vernier scale

b) Pivot arm with a ball point at one end and a cylindrical weight with pin at the . other end .

c) Magnifying lance.

PROCEDURE :

1. Keep the drawing board on a plain table.
2. Fix the drawing sheet containing the regular or irregular shape of drawing . (with the help of drawing board pins.) of which the surface area is to be determined .
3. Take out the Planimeter (Tracing arm and pivot arm) from the box and place it on the drawing board.
4. Set the main scale of the tracing arm to the specified set point with the vernir scale “zero” coin side with the main scale setting (use Magnifying lance if required)
5. Place the tracing arm horizontally with the tracing point on the periphery of the drawing whose surface area to be determined.
6. Fix the pivot arm approximately perpendicular to the tracing arm, by inserting the ball point into its appropriate position on the tracing arm and press the pin on the other side of the pivot arm against the board in position.
7. Roughly move the tracing arm. along the periphery of the drawing in clock wise direction to ascertain free and easy movement of the tracing arm and bring back to the starting point.
8. Now carefully rotate the scale dram manually by thumb so that rotating disc indicates “zero”, and the “zero” of the drum scale coin side with “zero” of the its Vernier scale “zero” .
9. Ascertain that the tracing point is on the periphery of the drawing
10. Now slowly move the tracing pin along the periphery of the drawing in clock wise direction without ms lifting the tracing pin or moving away from the line of the drawing and come back to the starting point.
11. Carefully record the reading indicated by the rotating disc as well as the drum scale with the vernier scale and declare the area in appropriate units.

TABULAR COLOUMN:

Engine speed in rpm	Spring balance reading		Fuel burette readings		Air flow manometer reading in mm of water	Air inlet temperature in °c	Water temperature for engine in °C		Exhaust gas temperature before calorimeter in °C	Water inlet temp for calorimeter in °C	Water outlet temp for calorimeter in °C	Exhaust gas temperature after calorimeter in °C
N	F_1	F_2	Volume in ml	Time in Sec	h_m	T_1	T_2	T_3	T_4	T_5	T_6	T_7

NOTE: TEMPERATURE POINTS,

T_1 = AIR INLET TEMPERATURE . .

T_2 = ENGINE HEAD WATER INLET.

T_3 = ENGINE HEAD WATER OTLET

T_4 = EXHAUST GAS OUTLET TEMPERATURE

T_5 = WATER INLET TEMPERATURE FOR CALORIEMETER

T_6 = WATER OUTLET TEMPERATURE FOR CALORIEMETE

T_7 = EXHAUST OUTLET TEMPERATURE AFTER CALORIEMETER

CALCULATIONS:

1. BRAKE POWER (BP):

$$BP = \frac{2 \pi N \times 9.81 \times F \times r}{60000} \quad KW$$

Where,

N = RPM of Engine

r = Radius of Brake drum = 0.15 m

F = in Kgf read from Spring Balance (F_1-F_2)

EXPERIMENT NO 12

FOUR STROKE, SINGLE CYLINDER, DIESEL ENGINE TEST RIG (Mechanical Loading with Exhaust gas Caloriemeter & Water Colled)

AIM: To conduct performance test on four - stroke water Cooled diesel Engine

DESCRIPTION:

The Test Rig consists of Four-Stroke diesel Engine (WATER Cooled) to be tested for performance is coupled to break drum assembly. The arrangement is made for the following measurements of the set-up.

1) The Rate of Fuel Consumption is measured by using Volumetric Pipette.

2) Air Flow is measured by Manometer, connected to Air Box.

3) The different mechanical loading is achieved by loading the engine through rope – break drum assembly attached to weighing balance.

4) The engine speed is measured by electronic digital meter.

5) Temperature at air inlet, engine exhaust gas, engine water inlet and outlet and calorimeter inlet and outlet are measured by electronic digital temperature indicator with thermocouple.

6) Water flow is measured by water flow meter or rotameter.

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

SPECIFICATIONS:

*	ENGINE TYPE	:	4-Stroke , Single Cylinder Diesel Engine
*	MAKE	:	Kirloskar.
*	MAXIMUM POWER, ‘ P ’	:	5 HP.
*	RATED SPEED, ‘ N ’	:	1500 RPM.
*	BORE , ‘ D ’	:	80mm.

2. MASS OF FUEL CONSUMED PER MINUTE (m_f) :

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

Where,

ρ_P = density of Diesel = 0.86g/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

T = time taken for fuel flow

3. TOTAL FUEL CONSUMPTION (TFC):

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

Where,

m_f = kg/min

60 = Conversion from min to hr.

4. SPECIFIC FUEL CONSUMPTION (SFC):

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

5. HEAT INPUT (HI) :

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

Where,

TFC in Kg/h.

C_V = Calorific Value of Diesel = 40,000 KJ/Kg

*	STROKE, ‘L’	:	110mm.
*	STARTING	:	By Hand crank
*	LOADING	:	Mechanical loading connected to break drum assembly
*	COOLING	:	Water cooling.

MEASUREMENTS:

*	AIR INTAKE	:	By Volumetric Tank with Orifice Dia d = 0.016m connected to Manometer (water), C_d = 0.62
*	SPEED	:	By digital RPM indicator.
*	FUEL FLOW	:	By Volumetric Pipette.

OPERATION:

1) Check the diesel in the tank.
2) Allow diesel and start the engine by using Hand crank.
3) Keep the weighing balance to read zero position, initially.
4) Apply the Load to engine by adjusting the weighing balance
5) Allow some time so that the speed stabilizes.
6) Now take down temperature, petrol flow rate and air consumption.
7) Repeat the procedure (4) & (6) for different loads.
8) Tabulate the readings as shown in the enclosed sheet.
9) After the experiment is over, keep the petrol control valve closed

6. BRAKE THERMAL EFFICIENCY (η_{Btherm}) :

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

7. AIR - FUEL RATIO: (A/F)

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

Where, m_f is in kg/min

$m_a = 60 \times C_d \times A \times V_a \times \rho_a$ in Kg / min

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

$C_d = 0.62$,

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

h_m in mm of Water from manometer reading

$g = 9.81 \ m/s^2$

ρ_a = Density of Air

$= 1.10 \ Kg/m^3$

ρ_w = Density of water

$= 1000 \ Kg/m^3$

8. INDICATED POWER (IP) :

IP = (BP + FP) KW

Where,

FP = (1/3) *BP (1/3 of maximum BP by Willans Curve)

9. MECHANICAL EFFICIENCY: (η_m)

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

HEAT BALANCE SHEET

1. Heat Input:

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

2. **Heat Equivalent to Brake Power:**

$H_{BP} = BP_{Eng}$ $\qquad$ BP_{Eng} in KW

3 . Heat Carried away by cooling Water (Calorimeter) :

$H_{wg} = m_{wg} C_{Pw} \Delta T_{wg}$ $\qquad$ kj/s

Where,

$m_{wg} = \frac{1}{t}$ in kg/s

t= time taken to collect 1000 ml of water in sec.

$C_{Pw} = 4.18$ KJ/Kg K

$\Delta T_{wg} = (T_6 - T_5)$ K

4. Heat Carried away by Exhaust Gas:

$H_{Eg} = m_{Eg} c_{pg} \Delta T_{Eg}$ $\qquad$ KJ/s

Where,

$m_{Eg} = (m_a + m_f)/60$ in Kg/s

$C_{Pg} = 1.05$ KJ/Kg K

$\Delta T_{Eg} = (T_4 - T_7)$ K

5. Heat Lost due to FRICTION POWER :

$H_{FP} = (1/3)^* BP$ (1/3 of maximum BP by Willan's Curve)

6 . Unaccounted Heat Lost:

$H_u = (1) - [(2) + (3) + (4) + (5)]$

TABULAR COLOUMN:

Load in KW	Speed N in rpm	Energy meter reading for 3 rev in secs	Air consumption in mtrs of water read on manometer (h_m)	Fuel consumption		Temperature				
				Volume in ml	Time in sec	Air Inlet Temperature in °C T_1	Exhaust gas (inlet to calorimeter) temperature in °C T_2	Calorimeter Water Inlet Temperature in °C T_3	Calorimeter Water outlet Temperature in °C T_4	Exhaust gas (outlet from calorimeter) temperature in °C T_5

NOTE: TEMPERATURE POINTS,

T_1 = AIR INLET TEMPERATURE
T_2 = EXHAUST GAS TEMPERATURE BEFORE CALORIE METER
T_3 = CALORIE METER WATER INLET TEMPERATURE
T_4 = CALORIEMETER WATER OUTLET TEMPERATURE
T_5 = EXHAUST GAS TEMPERATURE AFTER CALORIE METER

LIST OF FORMULAE

1. Electrical Power as indicated by Energy Meter:

$$Bp_{shaft} = \frac{n \times 60 \times 60}{1200 \times t} \quad KW.$$

Where,
n = Number of revolutions of energy meter disc.
t = is the time taken by the Energy meter for n revolutions, in seconds.

EXPERIMENT NO 13

TWO STROKE, SINGLE CYLINDER, PETROL ENGINE TEST RIG

AIM : To Conduct performance test on 2 - stroke Air Cooled Petrol Engine

DESCRIPTION:

The Test Rig consists of Four-Stroke Petrol Engine to be tested for performance is connected to an alternator coupled to electrical coils to apply load on engine. The arrangement is made for the following measurements of the set-up:

1. The Rate of Fuel Consumption is measured by using the Burette reading against the known time.
2. The water flow rate for exhaust gas calorimeter is measured separately by measuring jar & stop clock.
3. The load to the engine applied by coils which are all coupled with alternator.
4. The engine speed (RPM) is measured by digital counter.
5. Temperature at different points is measured by electronic digital temperature indicator with thermocouple.

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

SPECIFICATIONS:

*	TYPE	:	2-Stroke Petrol Engine (Air Cooled), Spark Ignition.
*	MAKE	:	Bajaj.
*	RATED POWER OUTPUT	:	2.5 HP, at 3000 RPM.
*	BORE & STROKE	:	57mm x 57mm.
*	COMPRESSION RATIO	:	7.4 : 1
*	BREAK DRUM RADIUS	:	0.15m

2. MASS OF FUEL CONSUMED PER MINUTE (m_f) :

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

Where,

ρ_P = density of petrol

= 0.72 gm/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

Volume of pipette =pipette reading

3. TOTAL FUEL CONSUMPTION (TFC):

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

Where,

m_f = kg/min

60 = Conversion from min to hr.

4. SPECIFIC FUEL CONSUMPTION (SFC):

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

6. HEAT INPUT (HI) :

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

Where,

TFC in Kg/h.

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

*	STARTING	:	By Kick Start.
*	LOADING	:	ELECTRICAL LOADING
*	DIA OF ORIFICE	:	14mm

OPERATION:

1) Check the Petrol in the tank.
2) Allow petrol, Start the engine by using kick start.
3) Set the engine output speed (using the accelerator stick) at less than 1350 rpm.
4) Allow some time so that the speed stabilizes.
5) Apply load from switches given on the panel
6) Note down the time taken for particular quantity of fuel consumed by the engine from the burette Note down the diff. temperatures.
7) Repeat the procedure (5) to (6) for different loads.
8) Tabulate the readings as shown in the enclosed sheet.
9) After the experiment is over, keep the petrol control valve at closed position, to avoid riching of the engine for subsequent operation.

PRECAUTIONS:

1. Do not shut down the engine when maximum load applied
2. After completion of experiments turn off the fuel supply valve.
3. Do not turn off water supply immediately when experiments completes wait for 15 to 30 minutes to maintain the engine temperature cool.
4. Change engine oil when oil turns to black color.
5. Frequently at least once in three months, grease all visual moving parts.
6. At least every week, operate the unit for five minutes to prevent any clogging of the moving parts.

7. AIR - FUEL RATIO: (A/F)

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

Where, m_f in kg/min

$m_a = 60 \times C_d \times A \times V_a \times \rho_a$ Kg / min

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

$= 133.47\sqrt{h_m}$

Whrer, $C_d = 0.62$,

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

h_m in mm of Water from manometer reading

$g = 9.81 \ m/s^2$

ρ_a = Density of Air

$= 1.10 \ Kg/m^3$

ρ_w = Density of water

$= 1000 \ Kg/m^3$

8. INDICATED POWER (IP) :

IP = (BP + FP) KW

Where,

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

9. MECHANICAL EFFICIENCY: (η_m)

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

GRAPHS:

1. TFC Vs BP
2. Brake thermal efficiency Vs BP
3. Mechanical efficiency Vs BP
4. SFC Vs BP

TABULAR COLOUMN:

Load In KW	Engine speed in rpm			Fuel burette readings		Temperatures in °C					Air Flow mano Meter readings In mm of water (h_m)	Energy meter reading for 3 rev in sec
		Volt Meter reading	Ammeter reading	Volume In ml	Time in sec	Air inlet	Exhaust outlet	Water Inlet To Calori Meter	Water Outlet To calori Meter	exhaust outlet calori Meter		
		In Volts	In Amps			T_1	T_2	T_3	T_4	T_5		

CALCULATIONS

1. Electrical Power as indicated by Energy Meter:

$$Bp_{shaft} = \frac{n \times 60 \times 60}{1200 \times t} \quad KW.$$

Where,
n = Number of revolutions of energy meter disc.
t = is the time taken by the Energy meter for n revolutions, in seconds.

2. MASS OF FUEL CONSUMED PER MINUTE (m_f):

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

Where,
ρ_P = density of Petrol

= 0.737gm/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

EXPERIMENT NO 14

SINGLE CYLINDER,FOUR STROKE PETROL ENGINE TEST RIG

AIM : To Conduct performance test on 4 - stroke Air Cooled Petrol Engine

DESCRIPTION:

The Test Rig consists of Four-Stroke Petrol Engine to be tested for performance is connected to an alternator coupled to electrical coils to apply load on engine. The arrangement is made for the following measurements of the set-up:

1. The Rate of Fuel Consumption is measured by using the Burette reading against the known time.

2. The water flow rate for exhaust gas calorimeter is measured separately by measuring jar & stop clock.

3. The load to the engine applied by coils which are all coupled with alternator.

4. The engine speed (RPM) is measured by digital counter.

5. Temperature at different points is measured by electronic digital temperature indicator with thermocouple.

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

ENGINE SPECIFICATIONS:

*	TYPE	:	4-Stroke petrol Engine (Air cooled)
*	MAKE	:	Greves
*	RATED POWER OUTPUT	:	3 HP, 3000 RPM.
*	BORE DIAMETER ‘ D ‘	:	70mm
*	STROKE LENGTH ‘ L ‘	:	66.7mm
*	COMPRESSION RATIO	:	16.5 : 1
*	CYLINDER CAPACITY	:	553 cc
*	STARTING	:	By Hand Cranking.
*	DIA OF ORIFICE	:	12 mm.

3. TOTAL FUEL CONSUMPTION (TFC):

TFC = m_f x 60 in Kg / h.

Where,
m_f = kg/min
60 = Conversion from min to hr.

4. SPECIFIC FUEL CONSUMPTION (SFC):

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

5. HEAT INPUT (HI) :

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

Where,
TFC in Kg/h.
C_V = Calorific Value of Petrol = 48,000 KJ/Kg (approx.)

6. BRAKE THERMAL EFFICIENCY (η_{Btherm}) :

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

OPERATION:

1. Check the petrol in the Petrol tank.
2. Allow Petrol, start the engine by using hand cranking.
3. The engine is set to the speed of 1500 RPM.
4. Apply load from switches given on the panel
5. Note down the time taken for particular quantity of fuel consumed by the engine from the burette
6. Note down the diff. temperatures.
7. Repeat the procedure (5) to (9) for different loads.
8. Tabulate the readings as shown in the enclosed sheet.
9. After the experiment is over, keep the Petrol control valve at closed.

RUNNING THE ENGINE:

The fuel level, cooling arrangement and lubricating system are checked. The engine is started by hand cranking. For this, the decompression lever is set in the vertical position. The crank shaft is rotated by hand cranking till sufficient energy is gained by the flywheel (to over come the compression pressure). Immediately the decompression lever is knocked down and the fuel system is put into action by releasing the lever of the fuel pump. The engine is allowed to run idle for 5 minutes to achieve steady state.

7. AIR - FUEL RATIO: (A/F)

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

Where, m_f is in kg/min

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

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

$C_d = 0.62,$

$$A = \frac{\pi d^2}{4} \text{ in } m^2 \quad , d = 0.012m$$

h_m in mm of Water from manometer reading

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

ρ_a = Density of Air

$= 1.10 \text{ Kg/m}^3$

ρ_w = Density of water

$= 1000 \text{ Kg/m}^3$

8. INDICATED POWER (IP) :

IP = (BP + FP) KW

Where,

FP is obtained from Willian's line Diagram (i.e.1/3 rd of the max BP)

9. MECHANICAL EFFICIENCY: (η_m)

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

READINGS TO BE TAKEN:

1. *To determine the Fuel Consumption Rate:*

The fuel supply from the fuel tank to engine is disconnected by means of 3-way distributed which is provided on the right side of the control panel. The engine receives fuel from measuring pipette tube. The fuel level in the pipette starts decreasing. The time‘t ‘sec for the consumption of known volume ‘v’cc. Of fuel is noted by using a stopwatch.

2. *To determine Brake Power:*

The speed of the engine ‘N ‘RPM and the effective load applied by electrical heaters should be noted down. or voltage and current should be noted down.

PRECAUTIONS:

1. Do not run the engine without fuel supply.
2. Do not shut down the engine when maximum load applied to Engine.
3. After completion of experiments turn off the fuel supply valve.
4. Change engine oil when oil turns to black color.
5. Frequently at least once in three months, grease all visual moving parts.
6. At least every week, operate the unit for five minutes to prevent any clogging of the moving parts.

HEAT BALANCE SHEET

1. Heat Input:

$$HI = \frac{T.F.C.}{60\times60} \times CV \quad KJ/s$$

2. Heat Equivalent to Brake Power:

$H_{BP} = BP_{Eng}$ BP_{Eng} in KJ/s

3. Heat carried away by cooling water (Calorimeter):

$H_{wg} = m_{wg}c_{Pw}\Delta T_{wg}$ KJ/s

Where:

$m_{wg} = \frac{1}{t}$ in kg/s

t= time taken to collect 1000 ml of water in Sec.

$C_{pw} = 4.18$ KJ/kg ^{0}K

$\Delta T_{wg} = (T_4-T_3)\ ^0K$

4. Heat Lost due to Friction:

$H_{FP} = 1/3 * BP_{max}$

5. Heat carried away by Exhaust Gas:

$H_{Eg} = m_{Eg}c_{pg}\Delta T_{EG}$ KJ/s

$m_{Eg} = (m_a+m_f)/60$ Kg/s

$C_{pg} = 1.05$ KJ/kg ^{0}K

$\Delta T_{EG} = (T_2-T_5)\ ^0K$

6. Unaccounted Heat Lost:

$H_u = (1) - [(2) + (3) + (4) + (5)]$

GRAPHS:

6. TFC Vs BP
7. Brake thermal efficiency Vs BP
8. Mechanical efficiency Vs BP
9. SFC Vs BP

TABULAR COLOUMN:

load in KW	Speed in rpm (N)	Voltmeter reading in volts	Current in amps	Fuel Cosumption	Energy meter reading for 3 revs	Manometer reading in mm (h_m)	Temperatures in °C		Compression ratio
							T_1	T_2	

NOTE: TEMPERATURE POINTS,

T_1 = AIR INLET TEMPERATURE

T_2 = ENGINE HEAD WATER INLET

T_3 = ENGINE HEAD WATER OTLET

T_4 = EXHAUST GAS OUTLET TEMPERATURE

T_5 = WATER INLET TEMPERATURE FOR CALORIEMETER

T_6 = WATER OUTLET TEMPERATURE FOR CALORIEMETE

T_7 = EXHAUST OUTLET TEMPERATURE AFTER CALORIEMETER

CALCULATIONS:

1. BRAKE POWER (BP):

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

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

Where,

n = No. of revalution of energy meter.

Em = Energy meter constant = 1200 revln/ KW-hr

t = time for ‘n’ revln of energy meter in sec.

η_{trans} =Transmission efficiency =0.7

EXPERIMENT NO 15

VARIBLE COMPRESSION RATIO PETROL ENGINE TEST RIG.

(Electrical Loading)

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

DESCRIPTION:

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

1) The Rate of Fuel Consumption is measured by using Volumetric Pipette.

2) Air Flow is measured by Manometer, connected to Air Box.

3) The different mechanical loading is achieved by loading the engine through rope – break drum assembly attached to weighing balance.

4) The engine speed is measured by electronic digital meter.

5) Temperature at air inlet, engine exhaust gas, engine water inlet and outlet and calorimeter inlet and outlet are measured by electronic digital temperature indicator with thermocouple.

6) Water flow is measured by water flow meter or rotameter.

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

SPECIFICATIONS:

* ENGINE TYPE : 4-Stroke , Single Cylinder,Air cooled Petrol Engine,spark ignition .

* MAKE : Greaves

* MAXIMUM POWER, ‘ P ’ : 2.2 KW.

* RATED SPEED, ‘ N ’ : 3000 RPM.

* BORE , ‘ D ’ : 70mm.

2. <u>MASS OF FUEL CONSUMED PER MINUTE</u> (m_f) :

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

Where,

ρ_P = density of petrol = 0.72gm/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

T = time taken 20cc of fuel cosumtion.

3. <u>TOTAL FUEL CONSUMPTION</u> (TFC):

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

Where,

m_f = kg/min

60 = Conversion from min to hr

4. <u>SPECIFIC FUEL CONSUMPTION</u> (SFC):

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

5. <u>HEAT INPUT</u> (HI) :

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

Where,

TFC in Kg/h.

C_V = Calorific Value of Diesel = 48,000 KJ/Kg

*	STROKE, ‘ L ’	:	66.7 mm.
*	STARTING	:	By Rope
*	LOADING	:	Electrical loading
*	COOLING	:	Air cooling for cylinder and water cooling for auxillary cylinder.

MEASUREMENTS:

*	AIR INTAKE	:	By Volumetric Tank with Orifice Dia d = 0.016m connected to Manometer (water), C_d = 0.62
*	SPEED	:	By digital RPM indicator.
*	FUEL FLOW	:	By Volumetric Pipette.

RUNNING THE ENGINE:

The fuel level, cooling arrangement and lubricating system are checked. The engine is started by Rope. For this, the Rope is wound around the starting pulley in a clockwise direction and give a pull to rotate the engine, pulling the Rope clear of the starting pulley. Allow the engine to run for 5 minutes to achieve steady state.

READINGS TO BE TAKEN :

1. To determine the Fuel Consumption Rate:

The fuel supply from the fuel tank to engine is disconnected by means of 3-way distributed which is provided on the right side of the control panel. The engine receives fuel from measuring pipette tube. The fuel level in the pipette starts decreasing. The time‘t ‘secs. for the consumption of known volume ‘v’cc. of fuel is noted by using a stopwatch.

2. To determine Brake Power:

Apply the Load to the AC Generators by Switching - ON the loading switches. When each switch is turned on 0.5KW of heat will be generated in corresponding heater.

6. <u>BRAKE THERMAL EFFICIENCY</u> (η_{Btherm}) :

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

7. <u>AIR - FUEL RATIO</u>: (A/F)

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

Where, m_f is in kg/min

$m_a = 60 \times C_d \times A \times V_a \times \rho_a$ in Kg / min

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

$C_d = 0.62$,

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

h_m in mm of Water from manometer reading

$g = 9.81 \ m/s^2$

ρ_a = Density of Air

= $1.10 \ Kg/m^3$

ρ_w = Density of water

= $1000 \ Kg/m^3$

8. <u>INDICATED POWER</u> (IP) :

IP = (BP + FP) KW

Where,

FP = (1/3)* BP

9. <u>MECHANICAL EFFICIENCY</u>: (η_m)

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

OPERATION:

1) Check the Petrol in the tank.

2) Check the sufficient lubricating oil in the oil sump (crank case).

3) Check the water circulation to the engine head .

4) Put on the mains, and check ‘mains on’ in the indicator as it glows.

6) Loosen the locking bolt of the auxillary piston-screw rod assembly.

7) Rotate the hand wheel and bring the indicator to the required Compression ratio.

8) Lock the screw rod assembly before conducting the experiment for the Compression ratio selected.

9) Allow petrol and start the engine by using Rope.

10) Keep the Loading knob in OFF positions, initially.

11) Apply the Load to the AC Generators by Switching - ON the loading switches.

12) Allow some time so that the speed stabilizes.

13) Now take down readings of Air flow, temperature indicator, fuel flow, engine speed and power consumption.

14) Repeat the procedure (9) & (13) for different loads.

15) Tabulate the readings as shown in the enclosed sheet.

16) After the experiment is over, keep the petrol control valve at closed position.

17) Allow water to flow for some time through auxiliary piston head after completion of the experiment

10. VOLUMETRIC EFFICIENCY: (η_{vol})

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

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

a) V_t = Theoretical Volume

$$= \frac{\pi \times D^2 \times L \times N}{4 \times \mathbf{2}} \quad \text{in } m^3/\text{min}$$

Here, D = Bore Diameter = 0.07m, L= Stroke Length = 0.0667m

N = Speed in RPM.

b) V_s = Swept volume at STP

$$= V_a \times (T_s/T_a)$$

Here, T_a = Ambient Temperature, $^oK = T_1 + 273$

T_s = Standard Temperature ^ok = 288 ^oK

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

and, actual volume of air intake is given by,

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

C_d = 0.62,

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

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

h_w in m of Water from manometer reading

g = 9.81 m/s^2

ρ_a = Density of Air = 1.10 Kg/m^3

ρ_w = Density of water = 1000 Kg/m^3

TABULAR COLOUMN:

Speed in rpm of engine	Spring balance readings in Kg	Air Consumption of water read on manometer in mm	Fuel Consumption Read on meter in kg/h	Temperature in °C				Water flow rate in lpm from engine head	Water flow rate in lpm from caloriemeter
				T_1	T_2	T_3	T_4		

TEMPERATURE POINTS :

T_1 = AIR INLET

T_2 = ENGINE HEAD WATER INLET

T_3 = ENGINE HEAD WATER OTLET

T_4 = WATER INLET TEMPERATURE TO CALORIMETER

T_5 = WATER OUTLET TEMPERATURE FROM CALORIMETER

T_6 = EXHAUST GAS INLET TO CALORIMETER

T_7 = EXHAUST GAS OUTLET TO CALORIMETER

EXPERIMENT NO 16

THREE CYLINDER, 4-STROKE, PETROL ENGINE TEST RIG

AIM:

To Conduct performance test on three cylinder, 4-stroke, petrol engine test rig

DESCRIPTION:

The test Rig consists of Four-Stroke, three Cylinder Petrol Engine to be tested for performance is connected to Dynamometer (Hydraulic dynamometer). The arrangement is made for the following measurements of the set-up:

1. The engine is provided with self-starter arrangement consisting of a battery, dynamo and switch
2. Exhaust gas calorimeter is fitted to draw the Heat Balance Sheet.
3. The water flow rate for cooling the engine is measured separately by measuring jar and stop watch.(By collecting the known amount of water in the measuring jar with respect to time)
4. The water flow rate for exhaust gas calorimeter is measured separately by measuring jar and stop clock.
5. The different Hydraulic loadings are achieved by operating the inlet and outlet valves provided on the frame of the engine.
6. The mechanical energy is measured by Torque arm of the Hydraulic dynamometer.
7. The engine speed (RPM) is measured by electronic digital meter.
8. Temperature at different points is measured by electronic digital temperature indicator with thermocouple.

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

Calculation:

1. BRAKE POWER (BP),

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

Where,
N = RPM of Engine
r = Torque arm distance in m
f = load applied on engine in kg

2. MASS OF FUEL CONSUMED PER MINUTE (m_f):

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

Where,

ρ_P = density of Petrol

= 0.72 gm/ml

60 = Conversion from sec to min

1000 = Conversion from gm to Kg

3. TOTAL FUEL CONSUMPTION (TFC):

TFC = Fuel flow meter reading in kg/h.
TFC = m_f x 60 in Kg / h.

Where,
m_f = kg/min
60 = Conversion from min to hr.

4. SPECIFIC FUEL CONSUMPTION (SFC):

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

ENGINE SPECIFICATIONS:

* TYPE	:	4-Stroke, 3-Cylinder, Petrol Engine (Water cooled)
* MAKE	:	Maruthi
* RATED POWER OUTPUT	:	10 hp at 1500 RPM.
* BORE DIAMETER ‘D’	:	68 mm
* STROKE LENGTH ‘L’	:	72 mm
* COMPRESSION RATIO	:	8.7:1
* STARTING	:	Ignition
* COOLING SYSTEM	:	Water cooled

5. HEAT INPUT (HI):

$$HI = \frac{T.F.C.}{60\times60} \times CV \quad KW$$

Where,
TFC in Kg/h.
CV = Calorific Value of Petrol = 48,000 KJ/kg (approx).

6. BRAKE THERMAL EFFICIENCY (η_{Btherm}):

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

7. AIR - FUEL RATIO: (A/F)

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

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

$m_a = V_a \times \rho_a$ in Kg / min

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

$C_d = 0.62,$

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

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

h_w = Water manometer reading in m.

g = 9.81 m/s^2

ρ_a = Density of Air = 1.10 Kg/m^3

ρ_w = Density of water = 1000 Kg/m^3

OPERATION:

1. Check the petrol in the petrol tank.
2. Allow water to flow through the engine and calorimeter.
3. Allow petrol, start the engine by key provided without engaging the clutch.
4. Engage the clutch, set the engine speed, by adjusting the speed regulator provided at the control panel.
5. Apply load by rotating the two inlet, outlet and drain valves and controlling the supply of water.
6. Now adjust the speed using speed regulator.
7. Now take down the Hydraulic dynamometer load readings in the spring balance.
8. Note down the time for water collected for 1/2 liter in seconds, for both engine and calorimeter, Different temperatures, speed, and fuel consumption meter reading and Air flow across orifice is measured by manometer.
9. Repeat the procedure (5) to (8) for different loads.
10. Tabulate the readings as shown in the enclosed sheet.
11. After the experiment is over, keep the petrol control valve at off position.
12. Stop the water flow by operating the valve.

8. INDICATED POWER (IP) :

IP = (BP+FP) KW

Where,
FP is obtained from
Morse test.

9. MECHANICAL EFFICIENCY : (η_{mech})

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

10. VOLUMETRIC EFFICIENCY:

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

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

a) V_t = Theoretical Volume

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

Here, D = Bore Diameter = 0.068m,
L= Stroke Length = 0.072m

N = Speed in RPM, 3 = No of cylinders.

b) V_s = Swept volume at STP

$= V_a \times (T_s/T_a)$

Here, T_a = Ambient Temperature, $^oK = T1 + 273$

T_s = Standard Temperature $^ok = 288\ ^oK$

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

and, actual volume of air intake is given by,

RUNNING THE ENGINE:

The fuel level, cooling arrangement and lubricating system are checked. The engine is started by the key provided. For this, the key is turned so that heating of the engine takes place after this key is further turned so that engine is started. If air is blocked in the fuel line then remove it by removing the pipe. The water flowing in the engine cooling system and exhaust gas calorimeter is adjusted so that sufficient water is flowing in the system. The engine is allowed to run idle for 5 minutes to achieve steady state.

READINGS TO BE TAKEN:

1. To determine the Fuel Consumption Rate:

   The fuel consumption can be determined directly by digital meter reading in Kg/hr.

2. To determine Air intake:

   A large tank with an orifice is provided to measure the air in flow to the engine. A manometer is provided to measure the pressure head of the Air, which causes its flow. An orifice of diameter 16 mm is used for Engine speed up to 1500 rpm.

3. To determine Brake Power:

   The load can be adjusted by rotating the inlet and outlet valves of the Hydraulic dynamometer. The speed of the engine ‘N’ RPM and the effective Torque controller Loading is noted down.

$V_a = 60 \times C_d \times A \times \sqrt{(2\,g\ \ h_a)}$ m^3/s. {calculated from formulae –(7)}

$C_d = 0.62$,

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

$h_a = \dfrac{\rho_w\, h_w}{\rho_a}$

h_w = Water from manometer reading in m.

g = $9.81\ m/s^2$

ρ_a = Density of Air = 1.10 Kg/m^3

ρ_w = Density of water = 1000 Kg/m^3

GRAPHS:

- T.F.C.Vs B.P
- S.F.C. Vs B.P
- η_{mech} Vs B.P
- $\eta_{B.th}$ Vs B.P

4. <u>To determine the Heat Carried away by Cooling Water</u>:

   The mass flow rate of water 'm_c' kg/min is noted down. The temperature of inlet water and the temperature of outlet water of the engine cooling jacket are also noted.

5. <u>To determine the Heat Carried away by Exhaust Gas</u>:
   i) Exhaust gas temperature inlet and outlet to the calorimeter are noted.
   ii) Mass flow rate of water 'm_e' kg/min in the calorimeter is noted.
   iii) Inlet and Outlet temperatures of water flowing in the exhaust gas calorimeter are noted.

<u>PRECAUTIONS</u>:

7. Do not run the engine without water supply
8. Do not shut down the engine when maximum load applied to dynamometer.
9. After completion of experiments turn off the fuel supply valve.
10. Do not turn off water supply immediately when experiments completes wait for 15 to 30 minutes to maintain the engine temperature cool.
11. Change engine oil when oil turns to black colour (aprox once in 6 months).
12. Engage clutch after engine maintains speed.
13. Frequently at least once in three months, grease all visual moving parts.
14. At least every week, operate the unit for five minutes to prevent any clogging of the moving parts.

TABLE OF OBSERVATION AND TABULATION FOR MORSE TEST

SL.NO.	CYLINDER DESCRIPTION	ENGINE SPEED N(RPM)	TORQUE	BRAKE POWER KW	INDICATED POWER KW
1.	All cylinders are firing				
2.	First cylinder is cut off				
3.	Second cylinder is cut off				
4.	Third cylinder is cut off				

MORSE TEST ON THREE-CYLINDER PETROL ENGINE TEST RIG

AIM:

To determine Mechanical Efficiency, Indicated power & frictional power.

APPARATUS:

Hydraulic Dynamometer and multi-cylinder Petrol Engine.

THEORY:

Morse test is used to find a close estimate of indicated power (IP) of a multi-cylinder Engine. In this test the engine is coupled to a suitable Hydraulic dynamometer and the brake power is determined by running the engine at the required speed. The first cylinder is cut out by interrupting the ignition to the first cylinder in the case of a petrol engine.

As a result of cutting out the first cylinder, engine speed will drop. Load on the engine is 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-out. The engine speed will again vary. By adjusting the load on the engine speed brought to original speed and the new BP is recorded (BP_2). Same procedure is continued till the last cylinder is cut-out.

PROCEDURE:

1. Remove all loads on the engine.
2. Start the engine using ignition key.
3. Adjust the throttle valve to obtain the desired speed of the engine.
4. Load the engine to 1/2 of its maximum by the knob provided at the torque controller and adjust the throttle position to any desire speed.
5. Cut-off the first cylinder by cutting off the ignition provided at the engine.
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 off other cylinders on at a time and note down all the readings.

CALCULATION

1. Total Brake Power when all cylinders firing:

$$(BP)_{load} = \frac{2\times\pi\times N\times T\times 9.81}{1000\times 60} \text{ KW}$$

2. Brake Power when first cylinder is cut off:

$$(BP)_1 = \frac{2\times\pi\times N\times T\times 9.81}{60\times 1000} \text{ KW}$$

3. Brake Power when second cylinder is cut off:

$$(BP)_2 = \frac{2\times\pi\times N\times T\times 9.81}{60\times 1000} \text{ KW}$$

4. Brake Power when third cylinder is cut off:

$$(BP)_3 = \frac{2\times\pi\times N\times T\times 9.81}{60\times 1000} \text{ KW}$$

5. Indicated power when first cylinder is not firing:

$(IP)_1 = (BP) - (BP)_1$

Similarly for second, third cylinders are not firing

$(IP)_2 = (BP) - (BP)_2$

$(IP)_3 = (BP) - (BP)_3$

Total Indicated power, $(IP) = (IP)_1+(IP)_2+(IP)_3$ KW

6. <u>Total Friction power</u>

$$(FP) = (IP) - (BP)_{load} \quad KW$$

7. <u>Mechanical Efficiency</u>

$$\eta_{mech} = \frac{\text{Brake Power}}{\text{Indicated power}} \times 100$$

OBSERVATION:

Friction Co Efficient (μ) =

Pendulum (bob) weight (W) = kgf

Radius of the shaft (r) = m

Radius (length of the pendulum) (R) = m

Applied Force on the Bush(P) = kgf

Angle of Swing of the Pendulum (Bob) (θ) = Degree

TABULAR COLOUMN:

Sl No	RPM	Temp. in ^{o}C	Spring force (kgf)	Angle of swing	μ
1					
2					
3					
4					

Friction Co Efficient $\mu = \frac{WR}{Pr} \times \sin\theta$

Where $\frac{WR}{r} = C$ is a constant for the Given equipment

$$\therefore \quad \mu = \frac{C}{P} \times \sin\theta$$

OR

(At any RPM of the shaft) $\mu = \frac{K}{P}$ **Where** $K = C \sin\theta$

Data for the given equipment is:

W = 2.9kg
R = 200mm (0.2m)
r = 16.2mm (0.01625m)
(Constant) C = 35.8kg

ADDITIONAL EXPERIMENT

EXPERIMENT NO 17

THURSTON OIL TESTER

AIM: To determine the co efficient of friction of lubricating oil experimentally by Thurston Oil Tester.

DESRICPTION:

The Thurston Oil Tester is an equipment to determine the co efficient of friction experimentally that exists between metal to metal contact surfaces as in the case of a "bush bearing". in presence of a thin layer of lubricating oil smeared on the contact surface. The co efficient of friction depends on two factors, One the type of lubricating oil and the other surface finished of metals in contact (Bush & Shaft). When the shaft smeared with a thin layer of lubricating oil is rotated at a constant low speed, the bush with a bob weight and adjustable spring load (pendulum) tends to move in the direction of the rotation of the shaft due to friction. This angular displacement of the pendulum is a measure of Coefficient of friction.

APPARATUS:

The Thurston Oil Tester apparatus mainly consists of a shaft with one end of the shaft is with three stepped cone pulley and the other end with a pendulum having a split Bush, bob weight spring loading arrangement and a swing scale and pointer.

AC induction motor of suitable capacity, RPM indicator, glass thermometer etc…

The unit can be operated at three different speeds with the help of a stepped cone pulley.

PROCEDURE:

1. Install the equipment on a strong and sturdy table, near a 230V, 50Hz 5amps. power point.
2. Clean the shaft and the bush with a clean soft cloth.
3. Select any desired speed by shifting the ‘V’ belt to appropriate groove.
4. Apply few drops of oil on to the shaft and smear it on the shaft so as to make a thin film of oil on the shaft. Apply few drops of oil it to the bush as well.
5. Apply desired spring force on the bush by rotating the hand wheel provided at the bottom of the pendulum (Bob).
6. Disengage the bush of its pressure by turning the levers provided on the sides of the bush block.
7. Insert the pendulum (Bob) assembly on the shaft and lock it. Engage the bush by turning the levers back to its original position.
8. Insert the 3 pin plug top in to the 3 pin socket (230V, 50Hz, 5 amps socket)
9. Switch on the motor the pendulum (Bob) assembly swings in the direction of rotation of the shaft.
10. Record the angle of swing at approximately steady state of the pendulum (Bob)
11. Also record the temperature and RPM of the shaft.
12. Switch of the motor.
13. Unlock, disengage and remove the pendulum (Bob) assembly from the shaft.
14. Vary the spring force; repeat the experiment by following steps 2, 4, 6, 7, 9 to 13.
15. The experiment can also be conducted at different speeds of the shaft by shifting the ‘V’ belt on to a different groove and also by selecting a different grade of lubricant oil (SAE 30 to SAE 90)

VIVA QUESTIONS & ANSWERS

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

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

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

4. What is the use of bomb calorimeter?
   Bomb calorimeter is used to determine Calorific value of solid and liquid fuel.

5. Define Higher Calorific value?
   It is the quantiy of heat obtained by the complete combustion of one kg of fuel,when the products of combustion are cooled down to the temeperature of the surrounding air,usually 15^{0} C.it is also called as gross Calorific value.

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

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

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

9. Define kinematic viscosity?
   It is defined as the ratio between the dynamic viscocity and density of fluid. It is denoted by the Greek symbol (v) called 'nu'.

10. What is the use of viscometer?
    It is used to measure viscocity of oil.

11. Define heat engine and classify.

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

    1) External combustion engine
    2) Intrenal combustion engine

12. What do you mean by intrenal combustion engine?

    In intrenal combustion engine combustion takes place within the engine cylinder.
    Eg: Petrol engines, Diesel engines, Gasoline engines etc.

13. What do you mean by External combustion engine?

    In external combustion engine combustion takes place outside the engine cylinder.
    Eg: Steam engine, Steam turbine, etc.

14. What do you mean by bore?

    The inside diameter of the cylinder is called bore.

15. Define compression ratio.

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

16. Define indicated power?

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

17. Define Brake power?

    It is the power avalible at the crank shaft.

18. What is the use dynamometer?

    Dynamometer is used to measure brake power of the engines.

19. Name different types of dynamometer?

    1. Rope brake Dynamometer
    2. Hydraulic Dynamometer
    3. Electric dynamometer

20. What do you mean by heat balance sheet?

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

21. What do you mean swept volume?

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

22. Define mechanical efficiency.
    It is the ratio of brake power to indicated power.

23. Define brake thermal efficiency?
    It is the ratio of brake power developed by the engine to heat supplied by the fuel.

24. Define indicated thermal efficiency?
    It is the ratio of indicated power developed by the engine to heat supplied by the fuel.

25. What do you mean by volumetric efficiency?
    It is defined as the volume flow rate of air into the intake system divided by the rate at which the volume is displaced by the system

26. Differentiate between petrol engine and diesel engine with regard to the suction stroke?
    During suction stroke of petrol engine air fuel mixture will enter the engine cylinder.
    During suction stroke of diesel engine only air will enter the engine cylinder.

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

28. Why is Otto cycle called as constant volume Cycle?
    The cycle is so called because heat is supplied at constant volume.

29. What do you mean by Scavenging?
    Scavenging process is the replacement of combustion products in the cylinder from previous power stroke with fresh air charge to be burned in the next cycle.

30. What do you mean by octane number?
    The octane number of the fuel is the percentage of octane in the reference mixture which knocks under the same conditions as the fuel.

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