LABORATORY MANUAL

18MEL58 ENERGY CONVERSION LAB

2019-2020

DEPARTMENT OF MECHANICAL ENGINEERING
ATRIA INSTITUTE OF TECHNOLOGY
Adjacent to Bangalore Baptist Hospital
Hebbal, Bengaluru-560024

Department of Mechanical Engineering

Vision

To be a center of excellence in Mechanical Engineering education and interdisciplinary research to confrontreal world societal problems with professional ethics.

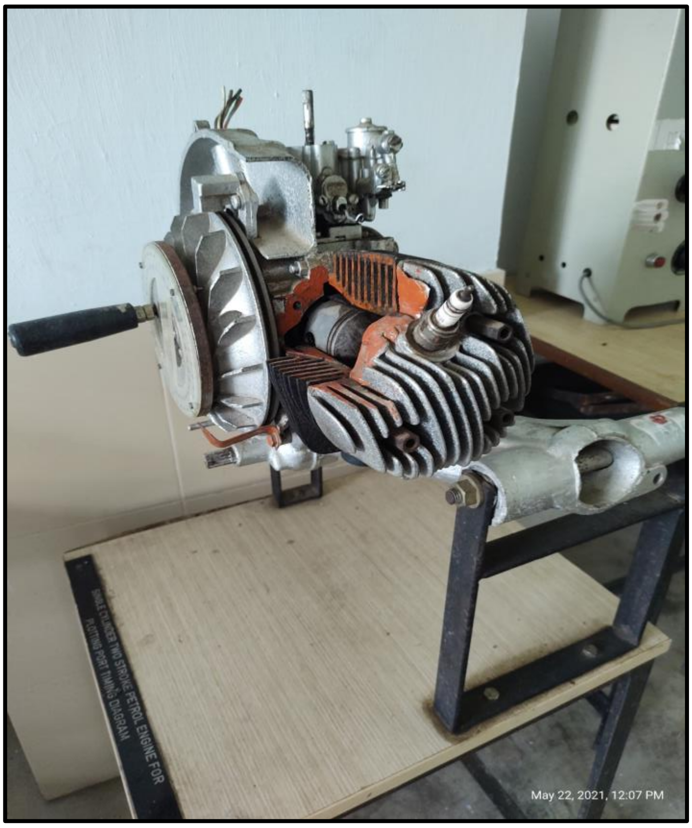
Mission

1. To push the frontiers of pedagogy amongst the students and develop new paradigms in research.

2. To develop products, processes, and technologies for the benefit of society in collaboration withindustry and commerce.

3. To mould the young minds and build a comprehensive personality by nurturing strong professionals with human ethics through interaction with faculty, alumni, and experts from academia/industry.

TWO STROKE PETROL ENGINE



The first commercial two-stroke engine involving In cylinder compression is attributed to Scottish engineer Dugald Clerk, who patented his design in 1881. However, unlike most later two-stroke engines, his had a separate charging cylinder. The crankcase-scavenged engine, employing the area below the piston as a charging pump, is generally credited to Englishman Joseph Day. On 31 December 1879, German inventor Karl Benz produced a two-stroke gas engine, for which he received a patent in 1880 in Germany. The first truly practical two-stroke engine is attributed to Yorkshireman Alfred Angas Scott, who started producing twin-cylinder water-cooled motorcycles in 1908.

FOUR STROKE DIESEL ENGINE

In testing a replica of the Lenoir engine in 1861, Otto became aware of the effects of compression on the fuel charge. In 1862, Otto attempted to produce an engine to improve on the poor efficiency and reliability of the Lenoir engine. He tried to create an engine that would compress the fuel mixture prior to ignition, but failed as that engine would run no more than a few minutes prior to its destruction. Many other engineers were trying to solve the problem, with no success.

In 1864, Otto and Eugen Langen founded the first internal combustion engine production company, NA Otto and Cie (NA Otto and Company).

ENERGY CONVERSION LAB

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.

Course Objectives:

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

Course Outcomes: At the end of this course students are able to,

1. Perform experiments to determine the properties of fuels and oils.
2. Conduct experiments on engines and draw characteristics.
3. Test basic performance parameters of I.C. Engine and implement the knowledge in industry.
4. Identify exhaust emission, factors affecting them and report the remedies.
5. Determine the energy flow pattern through the I C Engine 6. Exhibit his competency towards preventive maintenance of IC engines.

PART – A (Individual Experiments)

1. Lab layout, calibration of instruments and standards to be discussed
2. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten's (closed) / Cleveland's (Open Cup) Apparatus.
3. Determination of Calorific value of solid, liquid and gaseous fuels.
4. Determination of Viscosity of a lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
5. Analysis of moisture, volatile matter, ash content and fixed carbon of solid and liquid fuel samples
6. Valve Timing / port opening diagram of an I.C. Engine.

PART – B (Group Experiments)

7. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal efficiency, 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.
8. Measurements of Exhaust Emissions of Petrol engine.
9. Measurements of Exhaust Emissions of Diesel engine.
10. Demonstration of p θ, p V plots using Computerized IC engine test rig.

PART – C (Optional)

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

Scheme of Examination:

ONE question from part.A: 50 Marks
ONE question from part.B: 30 Marks
Viva -Voice : 20 Marks
Total: 100 Marks

EXPERMENT NO. 1

ABEL'S PENSKY APPARATUS

AIM: To determine the flash and fire point of the lubricating oil using Abel"s Pensky apparatus

APPARATUS: Abel"s flash and fire point apparatus, thermometers and Broom sticks.

THEORY: Write the theory on following topics

a. Properties of oils with definition.

DESCRIPTION OF THE EQUIPMENT:

Used for determining of the closed cup Flash point of Petroleum Products, their mixtures, others liquids & Paints having Flash Point below 700C. The apparatus consists of one brass cup and cover fitted with shutter mechanism test flame arrangement (Oil test jet or Gas test jet) and stirrer, placed on a water bath made of copper sheet double walled. The outer jacket of the water bath is fitted with a stand. For electrically heated apparatus, heater is fitted to the stand the heat of which may be controlled different temperature regulation system of operated on 220 Volts AC mains. For Gas heated model the drum is heated by a burner. (without burner).

PROCEDURE:

1. The apparatus is setup as shown in the fig. A thermometer is inserted in the oil cup.
2. Before starting the room temperature is noted. The oil is heated for every 2^0 rise in temperature is observed for the momentary flash.
3. The temperature at which flash appears is the flash point and is noted.
4. The oil is further heated till the oil catches the fire and burns continuously at least for 5sec and it is the fire point and is noted.
5. The flame is then put off

PRECAUTIONS:

1. Clean the water tank regularly after use
2. Do not run the equipment if the voltage is below 180V
3. Check all the electrical connections before running
4. Before starting and after finishing the experiment the mains should be put off.
5. Do not attempt to alter the as this may cause damage to the whole sysem.

SPECIFICATIONS:

1. Outer Chamber : Made of Copper
2. Inner Chamber : Made of Copper
3. Voltage : 230 Volt A.C. supply
4. Wattage : 750 Watts
5. Heater: Electrically heated with energy regulator
6. Cup made: Brass
7. Test usage: For testing oil temperature of flash range of ambient to 700^oC

TABULAR COLUMN:

Type of oil:

Temperature ^oC	Remarks	Flash point ^oC	Fire point ^oC

RESULT:

Flash and Fire point of the given oil is__________& _____________

EXPERMENT NO. 2

PENSKY MARTENS APPARATUS

AIM: To determine the flash and fire point of the lubricating oil by Pensky martens apparatus

APPARATUS: Pensky marten‟s apparatus, thermometer, Broom sticks.

DESCRIPTION OF THE EQUIPMENT:

This is widely used for determination of closed cup Flash Point of Fuel Oil, cut back asphalts, other viscous material and suspension of solids having a flash point about 490C(1200F).The apparatus serve the purpose according to IP 34, ASTM-D-93-58T, IS-1448(P:I) 1960(P:21) and IS 1209/1958 method B. The apparatus consists of Brass Test cup with handle removable cup cover with spring operated rotating shutter having pilot jet, stirrer with flexible shaft. The assembly rests in Air Bath which is covered with Dome shape metal top. The cup is fitted with insulated handle and locking arrangement near cup flange. The assembly rests on a round shaped heater with different temperature regulation system suitable for operation on 220 Volts AC main

PROCEDURE:

1. The apparatus is setup as shown in fig. A thermometer is inserted in the oil cup.
2. Before starting the room temperature is noted. The oil is heated for every 2^0 rise in temperature is observed for the momentary flash.
3. The temperature at which flash appears is the flash point is noted.
4. The oil is further heated till the oil catches the fire and burns continuously at least for 5sec and it is the fire point and is noted
5. The flame is then put off

PRECAUTIONS:

1. Clean the water tank regularly after use
2. Do not run the equipment if the voltage is below 180V
3. Check all the electrical connections before running
4. Before starting and after finishing the experiment the mains should be put off.
5. Do not attempt to alter the as this may cause damage to the whole system.

SPECIFICATIONS:

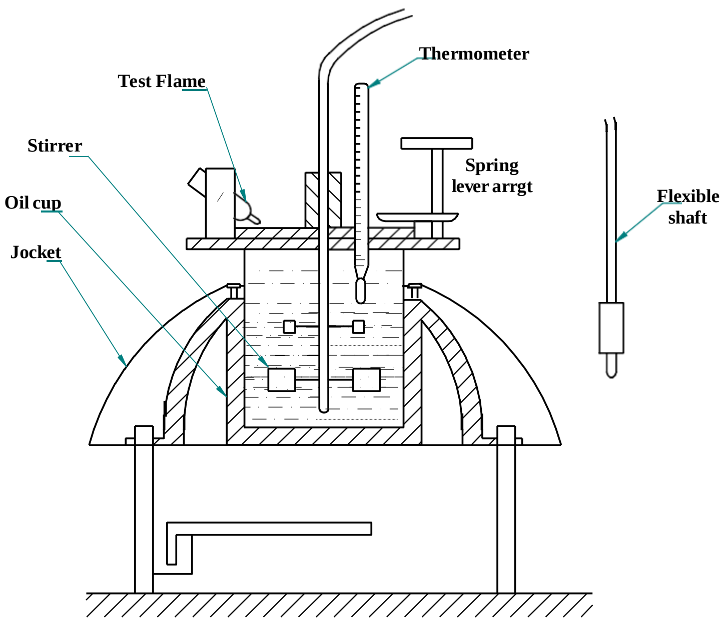
1. Enamel finished bench top steel case.
2. Cast iron stove, electrically heated with stainless steel external shield.
3. Pt100 probe for sample temperature acquisition..
4. Oil cup, brass,
5. Electric stirrer, 100 rpm.
6. Electric fan for a quick cooling of the stove at the end of the test.
7. For 220V/50 Hz connections, 900 W power consumption.
8. Dimensions (l x w x h) (mm) 240 x 330 x 450. Weight: 10 kg approximately.

TABULAR COLUMN:

Type of oil:

Temperature ^{o}C	Remarks	Flash point ^{o}C	Fire point ^{o}C

RESULT: Flash and Fire point of the given oil is__________& _____________



EXPERIMENT. NO. 3

CLEVELAND APPARATUS

AIM: To determine flash and fire point of given oil

APPARATUS: Cleveland apparatus, thermometer, spirit lamp and sticks

DESCRIPTION OF THE APPARATUS:

The apparatus is used for determination of Flash Point & Fire Point of Petroleum products except fuel oil with open flash 800 ^{o}C as per specification IP 36/57, IS 1448(P:69) 1969 and ASTM-D-92-67. The apparatus consists of a cup heating plate to specific dimensions thermometer clip and test flame attachment with swivel joint for passing over liquid surface in the prescribed manner, heater is controlled by means of different types of regulators fitted to the apparatus suitable for operation on 220 Volts AC mains.

PROCEDURE:

1. Clean and dry the oil cup
2. Pour the fresh sample of oil into the cup to the level indicated by the filling mark
3. Switch on the heater to supply heat
4. Heat the oil and stir it at the rate of one or two revolutions per second
5. Apply the test flame at the interval of 1oC temperature rise. At the port and do not stir while applying the flame.
6. Record the temperature at which a distinct bluish coloured flash occurs
7. Continue the heating and introduce the test flame as before
8. Record the temperature at which oil catches the flame and ignites.
9. Switch of the heater and clean up the cup

PRECAUTIONS:

1. Clean the water tank regularly after use
2. Do not run the equipment if the voltage is below 180V
3. Check all the electrical connections before running
4. Before starting and after finishing the experiment the mains should be put off.
5. Do not attempt to alter the as this may cause damage to the whole system

SPECIFICATIONS:

1. Test Method: As Per 1448-P-69/ASTMD-92

2. Heating: Electrical
3. Temperature Control: Energy Regulator
4. Test Flame: Gas or Oil
5. Body: Made of mild steel and powder coated and cup made of brass with wooden hands
6. Voltage: 230 Volts AC Supply

TABULAR COLUMN:

Type of oil:

Temperature °C	Remarks	Flash point °C	Fire point °C

RESULT: Flash and Fire point of the given oil is__________& _____________

Cleveland Apparatus

EXPERIMENT. NO. 4

RED WOOD VISCOMETER

AIM: To determine the kinematic and absolute viscosities of the given oil using red wood viscometer.

APPARATUS: Red wood viscometer, stop watch, 50ml standard flask, thermometer

THEORY: Write the theory on following topics

a. Red Wood Viscometer description.
b. Definition of absolute viscosity, kinematic viscosity, viscosity index
c. Grading of lubricants, Single grade, Multi grade oils
d. Derivation of viscosity formula

DESCRIPTION OF THE EQUIPMENT:

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 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. The instrument is cleaned and leveled. The oil is poured into the cylinder up to the mark provided the thermometer is placed inside.
2. At the room temperature, time for flow of 50cc into the standard flask is noted.
3. The oil is again poured into the cylinder up to the mark and the heater is switched ON
4. The temperature of oil is adjusted as required. The oil and water are continuously stirred during the experiment.
5. When the temperature is steady at the desired value the contact from the orifice is removed to allow the oil to flow into 50ml standard flask.
6. The time taken for 50cc oil flow is recorded.

PRECAUTIONS:

1. Clean the water tank regularly after use
2. Do not run the equipment if the voltage is below 180V

3. Check all the electrical connections before running
4. Before starting and after finishing the experiment the mains should be put off.
5. Do not attempt to alter the as this may cause damage to the whole system
6. For testing the fluids below 90ºC use the water bath and above 100ºC use oil bath
7. Do not stir the sample while testing

SPECIFICATIONS:

1. Flask=50ml
2. Heater=750W
3. Specific gravity of linseed oil=0.915
4. Nozzle diameter=1.82mm, length-10mm

TABULAR COLUMN:

Type of oil:

Sl. No.	T ^{0}C	m_1 kg	m_2 kg	m kg	t S	ρ kg/m^3	S	RWN	ν m^2/S	μ N-S/m^2

Where

T= Temperature of oil, ^{0}C

m_1 = Mass of empty flask, kg

m_2 = Mass of flask with oil, kg

m = Mass of oil collected, kg = m_2-m_1

t = Time taken for collecting 50cc of oil in seconds

ρ = Density of oil, kg / m^3

$$\rho = \frac{m}{50 \times 10^{-6}}$$

S=Specific gravity of the oil

RWN= Red Wood Number

$$S = \frac{\rho}{100}$$

ν = Kinematic viscosity, m^2/S

$$\nu = \left[0.26t - \frac{188}{t}\right] \times 10^{-6}$$

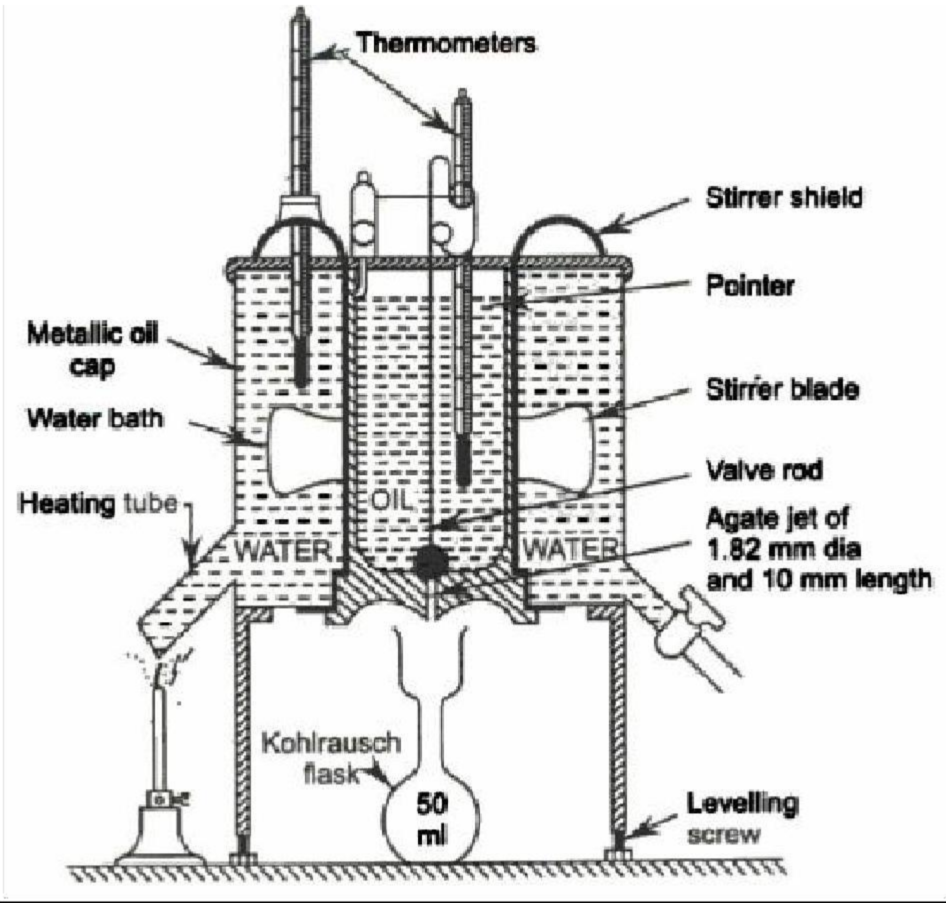
μ = Absolute viscosity, $N\text{-}S/m^2$

$$\mu = \nu \times \rho$$

GRAPH: 1. T v/s μ

2. T v/s ν

RESULT: Viscosity of given oil ____________________



Redwood Viscometer

EXPERMENT NO. 5.

SAYBOLT VISCOMETER

AIM: To determine the viscosity of the given sample of oil using Saybolt viscometer

APPARATUS: Saybolt viscometer, Thermometer, Stopwatch, 60cc Flask, Balance.

THEORY: Write the theory on following topics

a. Saybolt Viscometer description.
b. Derivation of viscosity formula

DESCRIPTION OF THE EQUIPMENT:

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. The instrument is cleaned and leveled. The oil is poured into the cylinder up to the mark provided the thermometer is placed inside.
2. At the room temperature, time for flow of 60cc into the standard flask is noted.
3. The oil is again poured into the cylinder up to the mark and the heater is switched ON
4. The temperature of oil is adjusted as required. The oil and water are continuously stirred during the experiment.
5. When the temperature is steady at the desired value the contact from the orifice is removed to allow the oil to flow into 60ml standard flask.
6. The time taken for 60cc oil flow is recorded.

PRECAUTIONS:

1. Clean the water tank regularly after use
2. Do not run the equipment if the voltage is below 180V
3. Check all the electrical connections before running
4. Before starting and after finishing the experiment the mains should be put off.

5. Do not attempt to alter the as this may cause damage to the whole system

6. For testing the fluids below 90°C use the water bath and above 100°C use oil bath
7. Do not stir the sample while testing

SPECIFICATIONS:

1. Flask=60ml
2. Heater=500W
3. Specific gravity of linseed oil=0.915
4. Nozzle diameter=1.82mm, length-10mm

TABULAR COLUMN:

Type of oil:

Sl. No.	T ^{0}C	m_1 kg	m_2 kg	m kg	S s	ρ kg/m^3	ν m^2/ S	μ N-S/m^2

Where

T= Temperature of oil, **^{0}C**

m_1 = Mass of empty flask, kg

m_2 = Mass of flask with oil, kg

m = Mass of oil collected, kg = m_2-m_1

S = Time taken for collecting 60cc of oil in seconds or Say-bolt seconds

ρ = Density of oil, kg / m^3 = m/(60x10^{-6})

ν = Kinematic viscosity, m^2/ S

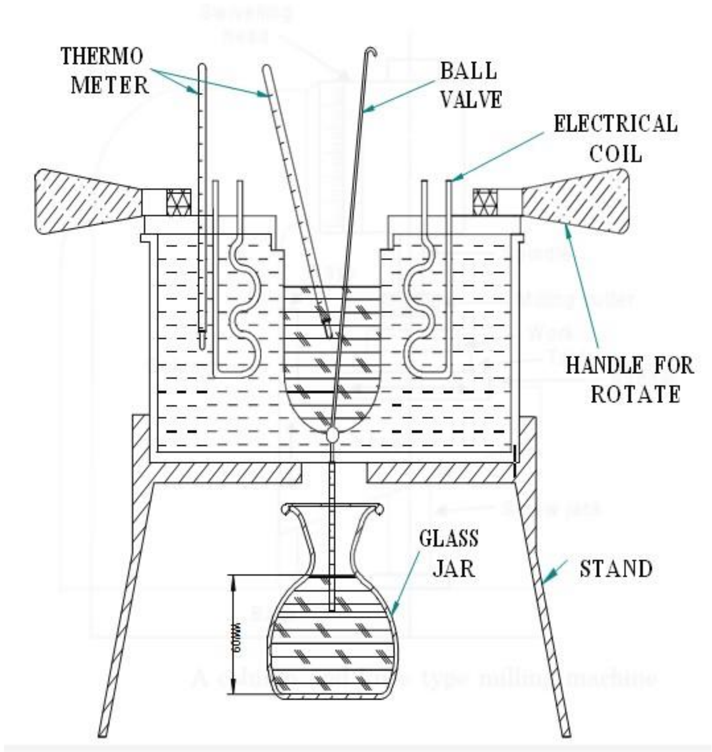
$$\nu = [0.22S - \frac{180}{S}] \times 10^{-6}$$

μ = Absolute viscosity, N-S/m^2

$$\mu = \nu \times \rho$$

GRAPH: 1. T v/s μ 2. T v/s ν

RESULT:


THERMO METER
BALL VALVE
ELECTRICAL COIL
HANDLE FOR ROTATE
GLASS JAR
STAND

EXPERIMENTNO.6

TORSIONVISCOMETER

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

APPARATUS: Torsion Viscometer, sample oil & thermometer

DESCRIPTION OF THE APPARATUS:

The torsion viscometer consists of a flywheel with a pointer suspended in horizontal position by means of a torsion wire. The wire is fixed to the torsion head at the top. Adopters are used to adjust the length of the wire. Surrounding the flywheel, there is a circular scale graduated in degrees. A Cylinder is attached to the flywheel. The instrument is supported on a tripod with leveling screws. 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 to 360).A pointer is attached to the flywheel to indicate the angular movement of the flywheel. Oil cup to hold the oil under test;

PROCEDURE:

1. Install the apparatus on a plain flat table and level it with leveling screws
2. Insert the torsion wire with end connectors into the tube vertically downwards with the top end connector of the wire fixed to a stationary head
3. Insert the bottom end connector of the wire into the top portion of the flywheel and secure it.
4. Fix the solid cylinder to the bottom portion of the flywheel.
5. Pour clean filtered oil to be tested into the oil cup up to about 5mm to 10mm below the top of the oil cup and place it on the platform provided and properly position it.
6. Slightly lift the top 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 to 0^0) andsecure it in thereleasepin.
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 to 0^0) andmovesbeyondzero

purely by virtue of its momentum. This angular movement beyond zero (over swing) is recorded and the viscosity of the oil under test in Redwood seconds is obtained from the graph provided.

To conduct the experiment above ambient, the oil is heated in a separate container to above5^0 C to 7^0C beyond the desired oil temperature and follow steps 5 to l2

PRECAUTIONS:

1. Clean the oil tank regularly after use
2. Do not run the equipment if the voltage is below 180V
3. Check all the electrical connections before running
4. Before starting and after finishing the experiment the mains should be put off.
5. Do not attempt to alter the as this may cause damage to the whole system

SPECIFICATIONS:

1. Capacity of oil tank=
2. Diameter and length of the wire=
3. Dimensions of the bob=

TABULAR COLUMN:

Type of Oil:

Sl. No.	T °C	ω Degree	R	υ m^2/s

Where,

T= Temperature to which oil is heated, oC

ω= Circular scale reading, degrees

R= Redwood seconds taken from graph provided

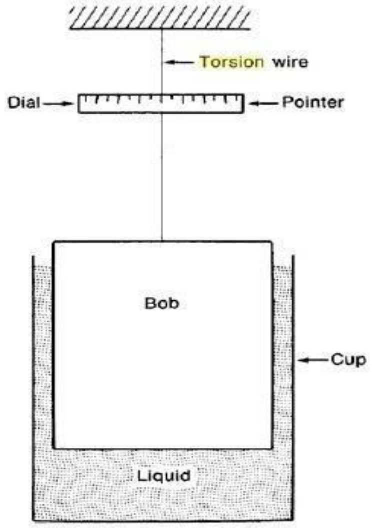
ν= Kinematic viscosity, m2/s

$= (0.260R - \frac{170}{R}) \times 10^{-6}$ for 34<R<100

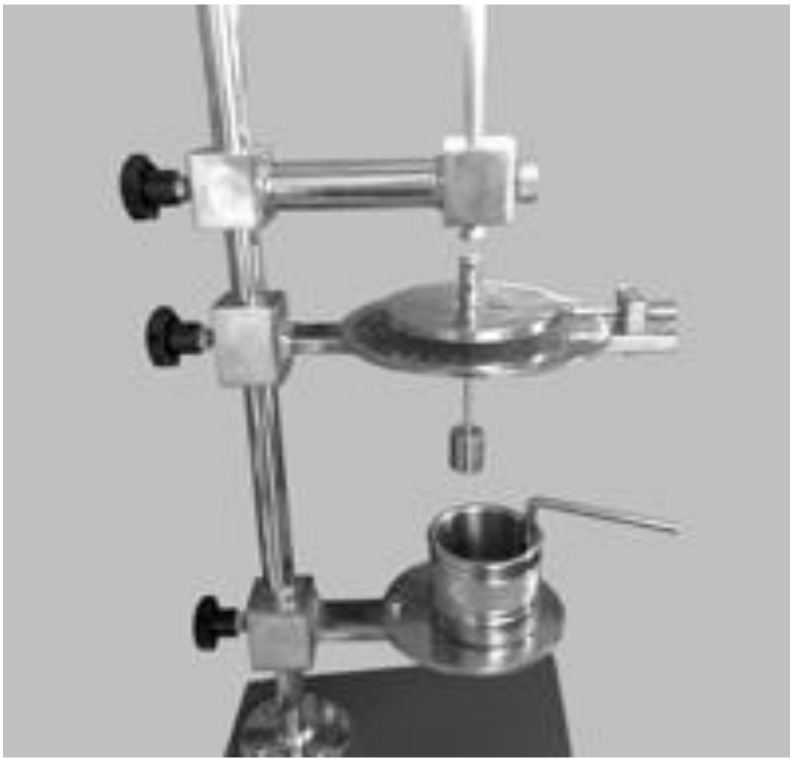
$= (0.247R - 50/R) \times 10^{-6}$ for 100<R<2000

GRAPH: T v/s ν

RESULTS: Kinematic viscosity of oil is



Schematic diagram of torsion viscometer



Torsion viscometer

EXPERIMENT NO. 7

VALVE TIMING DIAGRAM

AIM: To draw the value timing diagram of the given engine

APPARATUS: Given engine, measuring tape, scale.

THEORY: Write the theory on following topics

a. Difference between 2-stroke and 4-stroke engine.
b. Define the valve over lapping.
c. Difference between SI and CI Engines.
d. Significance of valve timing diagram
e. Draw the theoretical valve time diagram for 4- stroke SI engine.
f. Draw the theoretical valve time diagram for 2- stroke CI engine.

PROCEDURE:

1. Note the location of the inlet and exhaust valves of the given engine.
2. The flywheel is turned in clockwise direction and the positions of TDC and BDC are identified with respect to the crank position
3. The circumferential length of flywheel is measured with help of thread and ruler
4. The flywheel is turned in clock wise direction and the position and inlet valve begins to open is marker.
5. This point is measured from the initial reference mark (TDC) and this length is noted.
6. The flywheel turned in the same direction and the position of inlet valve closing and exhaust valve opening and exhaust valve closing are noted and corresponding length with respective to the reference marks.
7. The reading is recorded in the tabular column and corresponding angles turned (in degrees) are determined.

SPECIFICATIONS:

1. Engine type-4 stroke diesel engine[
2. Bore and stroke =70mm and 110mm
3. Diameter of fly wheel=

TABULAR COLUMN:

Sl. No.	Valve position	S m	θ degree	Remarks
1	IVO			

2	IVC			
3	EVO			
4	EVC			
5				

Where,

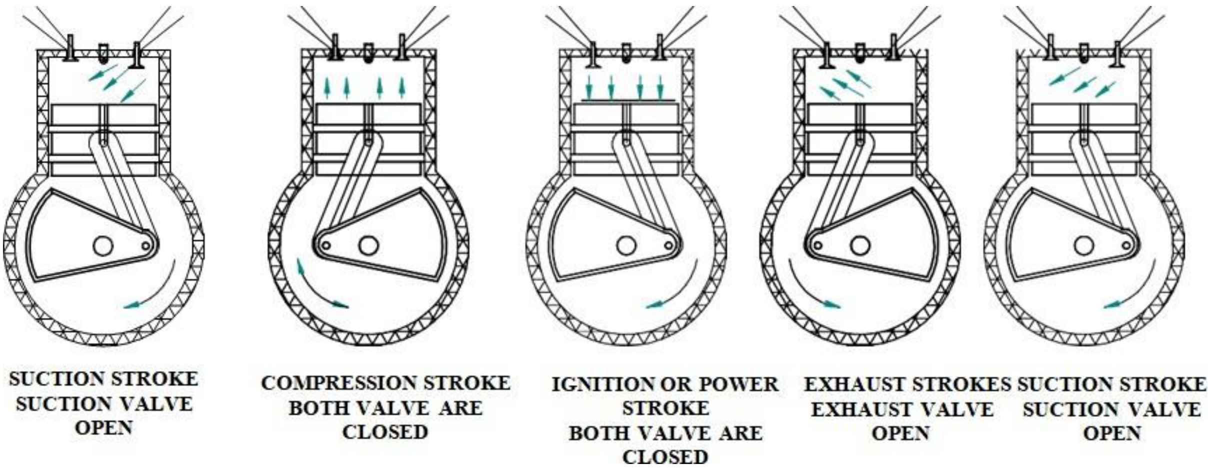
S = Arc length, cm

$\theta = (S \times 360)/(\pi \times D)\ in\ degrees$

D=Flywheel diameter, m

Name of the stroke	Crank angle degree
Suction	
Compression	
Expansion	
Exhaust	

RESULT: Valve timing diagram for 4-stroke diesel engine is shown in figure



EXPERMENT NO. 8

PLANIMETER

AIM: To calibrate the Planimeter.

APPARATUS: Planimeter, drawing board and sheet, drawing instruments

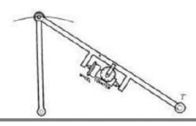
THEORY: Write the theory on following topics

a. Different methods used for measuring irregular area
b. Principle of planimeter
c. Construction features of planimeter

DESCRIPTION OF THE EQUIPMENT:

Amsler's Polar and Linear Planimeters

In 1854. Jakob Amslcr invented the polar planimeter a brilliant and simple device for measuring the area of a region. Schematic drawings of polar and linear planimeters are shownin Figures. The main part of each is a movable rod, called the tracer arm. With a tracer point at one end(labeled T). A wheel is attached to the rod with its axis parallel to the rod. The wheel is equipped with a scale typically calibrated in square inches or square centimeters. It is similar to a map reader wheel in that it can roll both forwards and backwards, and we will call it the measuring wheel. In a linear planimeter, the end of the tracer arm opposite the tracer point is restricted to follow a linear track, along which it can slide freely. In contrast, in a polar planimeter, the tracer rod is hinged to a second rod, the pole arm, forming an elbow. The end of the pole arm opposite the hinge, called the pole, is fixed so that the pole arm can pivot around it consequently the elbow follows the arc of a circle as it moves. To operate a planimeter, the user selects a starting point on the boundary of the region to be measured, places the tracer point there, and sets the counter on the wheel to zero. The user then moves the tracer point once around the boundary of the region, as shown in Figure. The tracer point is typically a stylus or a point marked on a magnifying glass to facilitate the tracing. In a polar planimeter, as the tracer point moves, the elbow at die hinge will flex and the angle between the pole arm and the tracer arm will change. In a linear planimeter, the end of the tracer arm in the track will slide along the track. In both planimeters the wheel rests gently on the paper, partially rolling and partially sliding, depending on how the tracer point is moved. If the pointer is moved parallel to the tracer arm, the wheel slides and does not roll at all. If the pointer is moved perpendicular to the tracer arm, the wheel rolls, and does not slide at all. Motion of the pointer in any other direction causes the wheel to both roll and slide. When the tracer point returns tothe starting point, the user can read the area from the scaleonthewheel



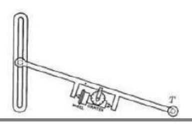


Fig: Polar planimeter Fig: Linear planimeter
Figure: Digital plani-meter

PROCEDURE:

1. Fix the figure whose area is to be determined on a smooth surface, preferably on a horizontal drawing board.
2. Set the index to read 100Sq cm on the tracing arm if the area is required in square cm.
3. Fix the anchor point inside or outside the figure such that the tracer is able to trace the

whole boundary of the area.

4. Mark a starting point on the boundary of the figure & place the tracer on the starting point. Note the initial reading.
5. Move the tracer slowly along the boundary of the area in clock wise direction, until it comes back to the starting point
6. The No. of times the zero of the dial passes the fixed index mark neither in a clockwise or anticlockwise direction during the above process should be carefully noted. Record the final reading F & compute the area by using the above equation.

PRECAUTIONS:

1. Do not dismantle and alter the equipment as this may cause damage to the whole system
2. Percentage of error is calculated only for regular areas

SPECIFICATIONS:

1. Length of tracing arm=
2. Length of anchoring arm=
3. Multiplier=
4. Planimeter constant=

TABULAR COLUMN:

SL. NO.	Shape of the plane	A_{th} cm^2	PLANIMETER READING			A_m cm^2	% Error
			I	F	M		
1	Square						
2	Circle						

3	Triangle						
4	Rectangle						
5	Ellipse						

Where

A_{th}= The theoretical area of the given shape, cm^2

I = Initial reading

F = Final reading

M = Multiplier of planimeter, 100 cm^2

A_m = Measured area of the given shape cm^2.

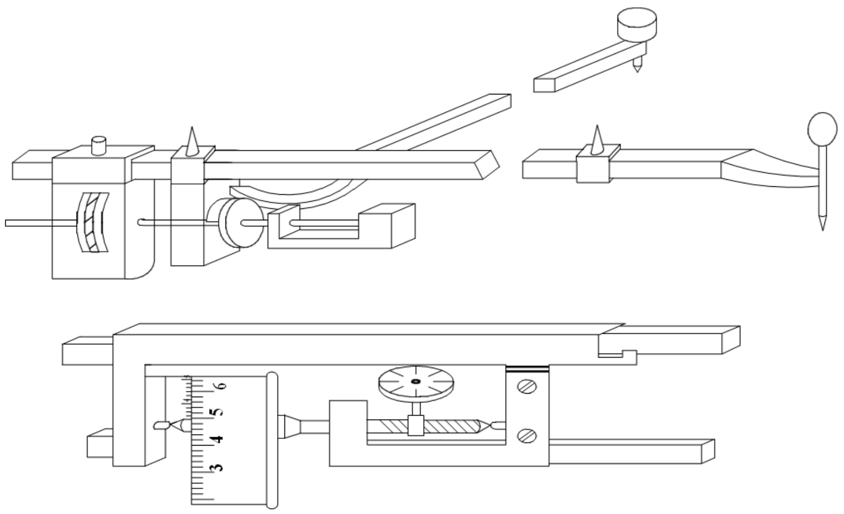
$A_m = M(F - I \pm 10 \times N + C)$

N= No. of rotations of the disc (+ ve for clockwise direction, -ve foe anticlockwise direction)

C= constant of planimeter, considered only when the anchor point is kept inside the plane

% Error= $\frac{Ath - Am}{A_{th}} \times 100$

RESULTS: The percentage error of area measured is tabulated as shown.



EXPERIMENT NO.9

BOY'S GAS CALORIMETER

AIM: To determine the calorific value of given gaseous fuel.

APPARATUS: Boy's Gas calorimeter, LPG gas burner etc.,

THEORY: This experiment is based on the method of heat transfer by burning known quantity of gaseous fuel for heating a known quantity of water that circulates. Counter flow heat exchange takes place between burning gas and circulating water with the assumption that heat absorbed by circulating water is equal to the heat released by the gaseous fuel, and the calorific value of the fuel can be determined. Calorific value is defined as the number of heat units developed by complete combustion of unit normal value of given gaseous fuel.

PROCEDURE:

1. Fix the gas burner on the scissor jack.

2. Connect the water supply to the inlet of the Rotameter and allow water to circulate through the calorimeter.

3. Open the valve of the LPG cylinder and adjust the gas flow meter to the required flow. Light the gas burner and raise the jack to bring the burner above the chimney.

4. Note down the readings for different flow rates of water and tabulate the readings.

OBSERVATION TABLE:

FORMULAE:

From Heat balance Heat released by the gaseous fuel = Heat absorbed by the water mw * Cw * ρw (T3 – T2) = mg * ρg * C.V

C.V of fuel = mw * Cw * ρw (T3 – T2) / mg * ρg

Where ρg = Density of gas, 0.0012 kg/ lit

ρw = Density of water , 1.0 kg/ lit at N.T.P

Cw = Specific heat of water, 4.2 kJ/ kg

Model calculation: Let Mass of water = 2 lpm, 1/30 kg/sec

Mass of gas = 1.5 / 60 kg/sec

Temperature of water at outlet = T3 = 46 deg.C

Temperature of water at inlet = T2 = 27 deg.C

C.V of gas = {1/30 * 1 * 4.2 * (46 – 27) } / { (1.5/60) * 0.0012}

C.V of gas = 88,666 kJ/ kg

<u>RESULT:</u> The average Calorific Value of inlet gas is_________kJ/kg or____kJ/ m3

EXPERIMENT NO. 11

4-STROKE PETROL ENGINE

AIM: To determine the performance Characteristic of a 4-stroke petrol engine

APPARATUS: 4-Stroke petrol engine test rig, stop watch, fuel etc.

THEORY: Write the theory on following topics

a. Definitions of IP, BP, FP, mechanical efficiency, thermal efficiency (brake and indicated), volumetric efficiency, ISFC, BSFC, relative efficiency, air standard efficiency
b. Methods to measure FP
c. Methods to measure IP

DESCRIPTION OF THE EQUIPMENT:

The equipment consists of a brand new GREAVES make MK25 model petrol engine of 3HP (2.2kW) capacity and is air cooled. The engine is coupled to an AC dynamometer. Coupling is done by an extension shaft and pulley in a separate bearing house and is belt driven. The dynamometer is provided with load switches for varying the load. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with a channel selector to select the position. An optical sensor connected to digital indicator is fixed at the shaft of the engine to record its speed. An air box with an orifice and manometer is connected to the inlet of the engine and is used for measuring air consumption. A volumetric flask with a fuel distributor is provided for the measurement of fuel supplied to the engine. The test rig is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts

PROCEDURE:

1. Check the fuel in the tank.
2. Switch ON the power supply & console and ensure ignition switch is ON.
3. Keep the loading switches in off position initially. Allow the petrol and start the engine by cranking. Run the engine at no load conditions, Note down time taken for 10cc consumption of petrol (tf) and time for 5 rotations of energymeter disc (t), hw and N
4. Apply the load on AC generator by switching on loading switches. Now speed of the engine will reduce. Bring back the original speed of the engine by increasing air-fuel supply using accelerator.

Note down t_f, t, hw

5. Repeat the procedure 4 to 5 for different loads

6. Tabulate the corresponding readings.
7. Once the experiment is over, keep the petrol control valve in closed position and switch of the console & power supply

PRECAUTIONS:

1. Always set the accelerator knob to the minimum condition and start the engine
2. Frequently, at least once in three months, grease all visual moving parts
3. Do not stand in front of orifice of air box
4. The level of fuel in the fuel tank should be checked.

SPECIFICATIONS:

Max power of the engine = 2.2KW

Rated speed = 3000rpm

Bore = 70mm

Stoke = 66.7mm

Compression ration = 4.76 : 1

Starting of the engine- by rope

Loading – electrically air heater connected to DC generator

Cooling – air cooling for the cylinder

Diameter of the orifice of the air tank intake = 0.015m

C_d of orifice = 0.62

Specific gravity of petrol=0.74

Calorific value of petrol=44000 kJ/kg

Generator efficiency=0.75

Transmission efficiency=0.85

Energymeter constant=

TABULAR COLUMN:

Sl. No	E_l kW	W kg	t_f s	N rpm	h_w m H_2O	m_f kg/s	BP kW	BSFC kg /kWh	5_{bt} %	V_a m^3/s	V_{th} m^3/s	η_v %	m_a kg/s	A:F

Where

E_l= Electrical Load applied, kW

W=Torque load on the generator, kg

t_f = Time taken for 10cc of fuel consumption, s

N = engine speed in rpm

h_w = Difference in monometer head, meter of water, m of H_2O

m_f = Mass of fuel kg/s

$$= \frac{V_f \times S \times 1000}{t_f}$$

V_f = Volume of fuel consumed = $10x10^{-6}$ m^3

S = specific gravity of petrol

BP = Brake power kw

$$BP = \frac{2\pi N_g T}{60000 \times y_g \times y_t}$$

Ng= Generation speed, rpm =N/2

T=Torque developed, Nm

T=WxR

R= Perpendicular distance at which load is applied=0.15m

η_g= Generator efficiency

η_g =Transmission efficiency

BSFC=Brake Specific Fuel Consumption, kg/kWh

$$BSFC = \frac{mf}{BP} \times 3600$$

5_{bt} =Brake thermal efficiency, %

$$5_{bt} = \frac{BP}{m_f \times CV} \times 100$$

CV = Calorific value of petrol, kJ/kg

V_a= Actual volume of air consumed, m^3/S

$$V_a = C_d \times A_o \sqrt{2gh_a}$$

C_d = Coefficient of discharge = 0.62

A_o = Area of orifice,

$$A_o = \frac{\pi \times d_o^2}{4}$$

d_o = Diameter of Orifice, m

h_a = Head of the air, m

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

ρ_w = Density of water = 1000 kg /m^3

ρ_a = Density of air, kg/ m3

$$\rho_a = \frac{p_a}{RT_a}$$

P_a = Atmospheric pressure = 101.3 kPa

R= Gas Constant for air = 0.287 kJ/kgK

T_a = Ambient temperature, K

V_s = Swept volume of cylinder m^3/s

$$V_s = \frac{\pi D^2 LN}{60 \times 4 \times 2}$$

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

D = Diameter of cylinder, m

L = Stroke length, m

A:F=Air-Fuel ratio

$$A:F = \frac{m_a}{m_f}$$

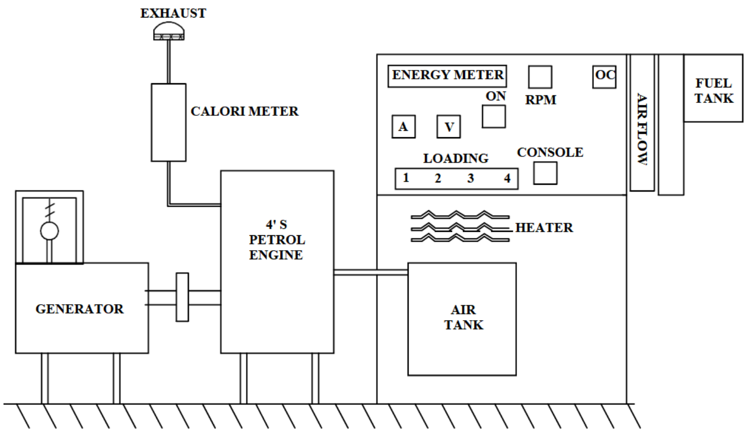
m_a = Mass of air kg/s

$$m_a = \rho_a \times V_a$$

GRAPH:

FC	Vs	BP
SFC	Vs	BP
η_{bth}	Vs	BP
η_v	Vs	BP
A:F	Vs	BP

RESULTS:



EXPERIMENT NO. 12

TWO STROKE PETROL ENGINE

AIM: To conduct a performance test on two stroke petrol engine and draw the performance characteristic curves.

APPARATUS: 2-stroke engine test rig, stop watch

THEORY: Write the theory on following topics

a. Working of 2-stokr petrol engine
b. Advantages of 2-stroke engines

DESCRIPTION OF THE APPARATUS:

The compact and single engine test rig consisting of a two stroke, single cylinder, air cooled, and variable speed petrol engine coupled to a balanced brake drum by the flange coupling. The engine is kick-start type. A brake drum is mounted on a shaft with bearing blocks. Continuous water supply arrangement is provided to the brake drum for cooling. Rope braking arrangements with spring balances are provided for loading the engine. Screws rods are provided for easy loading. The whole arrangement is mounted on a sturdy iron channel base plate. The control panel houses a water manometer, a multi-point digital temperature indicator and a digital rpm meter. A burette with a three-way cock is used for the fuel flow measurement. The fuel line is connected with a three way cock for the experimental needs such as (i). To supply fuel from the fuel tank to the engine, (ii). To fill fuel in the burette from the fuel tank (iii). To supply fuel from the burette to the engine.

PROCEDURE:

1. Start the engine at no load and allow idling for some time till the engine warm up
2. Note down the time taken for 10cc of fuel consumption using stopwatch and fuel measuring burette.
3. Open the fuel line to fill burette and supply fuel to run the engine from the fuel tank again.
4. Load the engine gradually to the desired value.
5. Allow the engine to run at this load for some time in order to reach steady state condition and note down the time taken for 10 cc of fuel consumption.
6. Repeat the experiment by applying additional loads to the desired values.
7. Release the load gradually and stop the engine.
8. Tabulate the readings as shown and calculate the result.

PRECAUTIONS:

1. The engine should be checked for no load condition.
2. The level of fuel in the fuel tank should be checked.
3. The cooling water inlet for brake drum should be opened when loading.
4. Do not stand in front of orifice of air box

SPECIFICATIONS:

Engine Make: Bajaj

Rated Power=4kW

Rated Speed=3000 rpm

Stroke Volume =100cc

Cooling Medium: Air cooled

Loading type: Rope brake dynamometer

Specific gravity of petrol=0.74

Calorific value of petrol= = 44,000 kJ/kg

Orifice diameter= 15mm

TABULAR COLUMN:

Sl. No.	S_1 kg	S_2 kg	t_f s	N rpm	h_w m of H_2O	BP kW	BSFC kg/kWh	η_{bt} %	V_a m^3/s	V_{th} m^3/s	η_v %	m_a kg/s	A:F

Where,

S1, S2= Spring balance readings, kg

tf=Time taken for 10cc consumption of petrol, s

N=Speed of the engine, rpm

hw= Difference in manometer, m of water

BP= Brake power developed, kW

$$=\frac{2\pi NT}{60000}$$

T= Torque induced, Nm

$$= (S_1 - S_2) \times 9.81 \left(\frac{D_b + d_r}{2}\right)$$

D_b= Brake drum diameter, m

d_r= Belt thickness, m

BSFC= Brake Specific Fuel Consumption, kg/kWh

$$= \frac{m_f}{BP} \times 3600$$

m_f= Mass flow rate petrol, kg/s

$$= \frac{V_f \times S \times 1000}{t_f}$$

S= Specific gravity of petrol

η_{bt}=Brake thermal efficiency

5bt =Brake thermal efficiency, %

$$5_{bt} = \frac{BP}{m_f \times CV} \times 100$$

CV= Calorific value of petrol kJ/kg

V_a= Actual volume of air consumed, m^3/S

$$V_a = C_d \times A_o \sqrt{2gh_a}$$

C_d = Coefficient of discharge = 0.62

A_o = Area of orifice,

$$A_o = \frac{\pi \times a_o^2}{4}$$

d_o = Diameter of Orifice, m

h_a = Head of the air, m

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

ρ_w= Density of water = 1000 kg $/m^3$

ρ_a= Density of air, kg/ m3

$$\rho_a = \frac{p_a}{RT_a}$$

P_a = Atmospheric pressure = 101.3 kPa

R= Gas Constant for air = 0.287 kJ/kgK

T_a = Ambient temperature, K

V_{th} = Theoretical or Swept volume of cylinder m^3/s

$$V_{th} = \frac{\pi D^2 LN}{4 \times 60}$$

D = Diameter of cylinder, m

L = Stroke length, m

$$\eta_v = \frac{V_a}{V_{th}} \times 100$$

A:F=Air-Fuel ratio

$$A:F = \frac{m_a}{m_f}$$

m_a = Mass of air kg/s

$m_a = \rho_a \times V_a$

GRAPHS:

FC	Vs	BP
SFC	Vs	BP
η_{bth}	Vs	BP
η_v	Vs	BP
A:F	Vs	BP

RESULTS:

EXPERIMENT NO. 13

FOUR STROKE SINGLE CYLINDER DIELSEL ENGINE

AIM: To conduct a performance test on a single cylinder 4 –stroke diesel engine and draw the heat balance sheet

APPARATUS: Single cylinder Diesel Engine Test Rig, stop watch

THEORY: 1.Explain the combustion stages of CI Engine

2. Define Octane and Cetane numbers
3. Define HUCR and its significance
4. Knocking in diesel engine

DESCRIPTION OF THE EQUIPMENT:

The compact and simple engine test rig consisting of a four stroke single cylinder, water cooled, constant speed diesel engine coupled to an alternator by flexible coupling. The engine is started by hand cranking using the handle by employing the decompression lever. The engine is loaded using electrical lighting load bank. The loading arrangement consists of a set of lamps and switches on the panel board. A voltmeter and an ammeter are used to record the load on the alternator. A burette is connected with the fuel tank through a control valve for fuel flow measurement. Provision is made to circulate water continuously through the engine jacket.

PROCEDURE:

1. Switch ON the power supply, console and start the engine by cranking.
2. Run the engine at a particular speed and note down the readings such as t_f for 10cc consumption of fuel, t for 5 rotations of energy meter disc, h_w, V_w, V_{wc}, T_1, T_2, T_3, T_4, T_5 and T_6.
3. Apply the electrical load say 0.5kW. Now the speed of the engine reduces. Bring back the original speed of the engine by increasing fuel supply using choke. Note down the readings t_f for 10cc consumption of fuel, t for 5 rotations of energy meter disc, h_w, V_w, V_{wc}, T_1, T_2, T_3, T_4, T_5 and T_6.
4. Repeat the steps 3 for different electrical loads say1.0, 1.5, 2.0, 2.5kW etc.
5. After completion of the experiment, release the load on generator, cut-off the fuel supply and stop the engine.

PRECAUTIONS:

1. The engine should be checked for no load condition.

2. The cooling water inlet for engine should be opened.
3. The level of fuel in the fuel tank should be checked.
4. The lubrication oil level is to be checked before starting the engine.

SPECIFICATIONS:

Calorific value of diesel = 42000 kJ/kg

Specific gravity of diesel = 0.8275

Compression ratio of engine = 16:1

Bore = 80mm

Length of the stroke, L = 110mm

Rated speed of the engine = 1200rpm

Rated power= 3.68 KW

Loadingtype:Electricalloading

Generator efficiency=0.85

Orifice diameter=20mm

Energy meter constant=

TABULAR COLUMN:

Sl. No	El kW	N rpm	t_f s	t s	h_w m H_2O	V_w lpm	V_{wc} lpm	T_1 °C	T_2 °C	T_3 °C	T_4 °C	T_5 °C	T_6 °C	m_f kg/s	BP kW	BSFC kg /kWh	5_{bt} %	FP kW	IP kW	η_m %	V_a m^3/s	m_a kg/s	η_v %	A:F

Where,

E_l=Electrical load applied, kW

N=Speed of the engine, rpm

t_f=Time taken for consumption of 10cc diesel, s

t= Time taken for n revolutions of energymeter disc, s

h_w= Head difference in water manometer, m of water

V_w= Volume flow rate of water through engine jacket, lpm

V_{wc}= Volume flow rate of water through exhaust gas calorimeter, lpm

T_1, T_2= Inlet and outlet temperatures of engine jacket cooling water, °C

T_3, T_4= Inlet and outlet temperatures of water circulated in exhaust gas calorimeter, °C

T_5= Exhaust gas temperature after calorimeter, °C

T_6= Air temperature in air box, °C

m_f= Mass flow rate of fuel, kg/s

$$= \frac{V_f \times S \times 1000}{t_f}$$

V_f= Volume of fuel supplied=10×10^{-6} m^3

S=Specific gravity of diesel

BP = Brake power kw

$$BP = \frac{n\times3600}{k\times t\times y_g}$$

n= Number of rotations of energymeter disc

k=Energymeter constant

5_g=Generator efficiency

BSFC=Brake Specific Fuel Consumption, kg/kWh

BSFC = $\frac{mf}{\ } \times 3600$

V_f= Volume of fuel supplied=$10x10^{-6}$ m^3

S=Specific gravity of diesel

BP = Brake power kw

BP $= \frac{n\times 3600}{k\times t\times y_g}$

n= Number of rotations of energymeter disc

k=Energymeter constant

5_g=Generator efficiency

BSFC=Brake Specific Fuel Consumption, kg/kWh

BSFC $= \frac{mf}{BP}\times 3600$

5_{bt} =Brake thermal efficiency, %

$5_{bt=} \frac{BP}{m_f\times CV}\times 100$

CV = Calorific value of diesel, kJ/kg

FP = Frictional power, kW (From Willan‟s line Graph)

IP = Indicated power, kW

IP = BP + IP

$\eta_{m\ =}$ Mechanical Efficiency

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

V_a = Actual volume of air consumed, m^3/s

$V_a = C_d \times A_o\sqrt{2gh_a}$

C_d = Coefficient of discharge = 0.62

A_o = Area of orifice,

$A_o = \frac{\pi\times d_o^2}{4}$

d_o = Diameter of Orifice, m

h_a = Head of the air, m

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

ρ_w = Density of water = 1000 kg $/m^3$

ρ_a = Density of air , kg/ m^3

$$\rho_a = \frac{p_a}{RT_a}$$

P_a = Atmospheric pressure = 101.3 kPa

R= Gas Constant for air = 0.287 kJ/kgK

η_v =Volumetric efficiency, %

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

V_s = Swept volume of cylinder m^3/s

$$V_s = \frac{\pi D^2 LN}{60 \times 4 \times 2}$$

D = Diameter of cylinder, m

L = Stroke length, m

$$A:F = \frac{ma}{mf}$$

m_a = Mass of air kg/s

$$m_a = \rho_a \times V_a$$

<u>Heat Balance Sheet on minute basis</u>

1. Heat supplied by fuel $Q_s = m_f \times CV \times 60$, kJ/min
2. Heat equivalent to Brake power = BP × 60 kJ/ min
3. Heat absorbed by the engine jacket cooling water, = $m_w C_{pw} (T_2-T_1)$, kJ/min

   m_w=Mass of water collected, kg/sec=V_w, kg/min

   C_{pw} = Specific heat of water= 4.187 kJ/kg ^{0}C
4. Heat carried away by the water circulated in exhaust gas calorimeter

   =$m_{wc} C_{pw} (T_4-T_3)$ kJ/min

   m_{wc}= Mass of water circulated in exhaust gas calorimeter=V_{wc}, kg/min
5. Heat carried away by exhaust gasses = $m_g \times C_{pg} \times (T_5-T_6)$x60

   m_g=Mass of exhaust gases, kg/sec = $m_a + m_f$

   C_{pg}=Specific heat of exhaust gases= 1.01kJ/kgK
6. Unaccounted heat equivalent = 1-(2+3+4+5), kJ/min

Sl.No.	Details	Heat in kJ/min	%
1	Heat supplied		
2	Heat equivalent of BP		
3	Heat absorbed by the engine jacket cooling water		
4	Heat absorbed by the exhaust calorimeter cooling water		
5	Heat carried away by exhaust gasses		
6	Unaccounted heat equivalent		
	Total		100

GRAPH:

FC Vs BP

SFC Vs BP

η_{bth} Vs BP

η_v Vs BP

A:F Vs BP

RESULTS:

EXPERMENT NO. 14

VARIABLE COMPRESSION RATIO 4-STROKE PETROL ENGINE

AIM: To determine the performance characteristics of a variable compression ratio 4-stroke petrol engine at different compression ratio

APARATUS: Variable compression ratio petrol engine test rig, stop watch

THEORY: Define HUCR, what is its significance? How it is obtained?

Explain the combustion stages of SI engine

PROCEDURE:

1. Set the compression ratio
2. Check the fuel in the tank.
3. Switch ON the power supply & console and ensure ignition switch is ON.
4. Keep the loading switches in off position initially. Allow the petrol and start the engine by cranking. Run the engine at no load conditions, Note down time taken for 10cc consumption of petrol (tf) and time for 5 rotations of energymeter disc (t), hw and N
5. Apply the load on AC generator by switching on loading switches. Now speed of the engine will reduce. Bring back the original speed of the engine by increasing air-fuel supply using accelerator.
6. Note down t_f, t, hw
7. Repeat the procedure 4 to 5 for different loads
8. Tabulate the corresponding readings.
9. Repeat the experiment for different compression ratios
10. Once the experiment is over, keep the petrol control valve in closed position and switch of the console & power supply

PRECAUTIONS:

1. Always set the accelerator knob to the minimum condition and start the engine
2. Frequently, at least once in three months, grease all visual moving parts
3. Do not stand in front of orifice of air box
4. The level of fuel in the fuel tank should be checked.

SPECIFICATIONS:

Max power of the engine = 2.2KW

Rated speed = 3000rpm

Bore = 70mm

Stoke = 66.7mm

Compression ratios =

Starting of the engine- by rope

Loading – electrically air heater connected to DC generator

Cooling – air cooling for the cylinder

Diameter of the orifice of the air tank intake = 0.015m

C_d of orifice = 0.62

Specific gravity of petrol=0.74

Calorific value of petrol=44000 kJ/kg

Generator efficiency=0.75

Transmission efficiency=0.85

Energymeter constant=

TABULAR COLUMN:

Sl. No	E_l kW	W kg	t_f s	N rpm	h_w m H_2O	m_f kg/s	BP kW	BSFC kg /kWh	5_{bt} %	V_a m^3/s	V_{th} m^3/s	η_v %	m_a kg/s	A:F

Where,

E_l= Electrical Load applied, kW

W=Torque load, kg

t_f = Time taken for 10cc of fuel consumption, s

t = Time taken for n revolutions of energy meter disk, s

h_w = Difference in monometer head, meter of water, m of H_2O

m_f = Mass of fuel kg/s

$$= \frac{V_f \times S \times 1000}{t_f}$$

V_f = Volume of fuel consumed = 10×10^{-6} m^3

S = specific gravity of petrol

BP = Brake power kw

BP = $\frac{2\pi N_g T}{60000 \times y_g \times y_t}$

Ng= Generator speed, rpm

=N/2

T=Torque developed, Nm

T=WxR

R= Perpendicular distance at which load is applied=0.15m

η_g= Generator efficiency

η_g =Transmission efficiency

BSFC=Brake Specific Fuel Consumption, kg/kWh

BSFC = $\frac{mf}{BP} \times 3600$

5_{bt} =Brake thermal efficiency, %

$5_{bt=}$ $\frac{BP}{m_f \times CV} \times 100$

CV = Calorific value of petrol, kJ/kg

V_a = Actual volume of air consumed, m^3/S

$$V_a = C_d \times A_o \sqrt{2gh_a}$$

C_d = Coefficient of discharge = 0.62

A_o = Area of orifice,

$A_o = \frac{\pi \times d_o^{\cdot}}{4}$

d_o = Diameter of Orifice, m

h_a = Head of the air, m

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

ρ_w = Density of water = 1000 kg /m^3

ρ_a = Density of air, kg/ m3

$$\rho_a = \frac{p_a}{RT_a}$$

P_a = Atmospheric pressure = 101.3 kPa

R= Gas Constant for air = 0.287 kJ/kgK

T_a = Ambient temperature, K

V_s = Swept volume of cylinder m^3/s

$V_s = \frac{\pi D^2 LN}{60 \times 4 \times 2}$

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

D = Diameter of cylinder, m

L = Stroke length, m

A:F=Air-Fuel ratio

$A:F = \frac{m_a}{m_f}$

m_a = Mass of air kg/s

$m_a = \rho_a \times V_a$

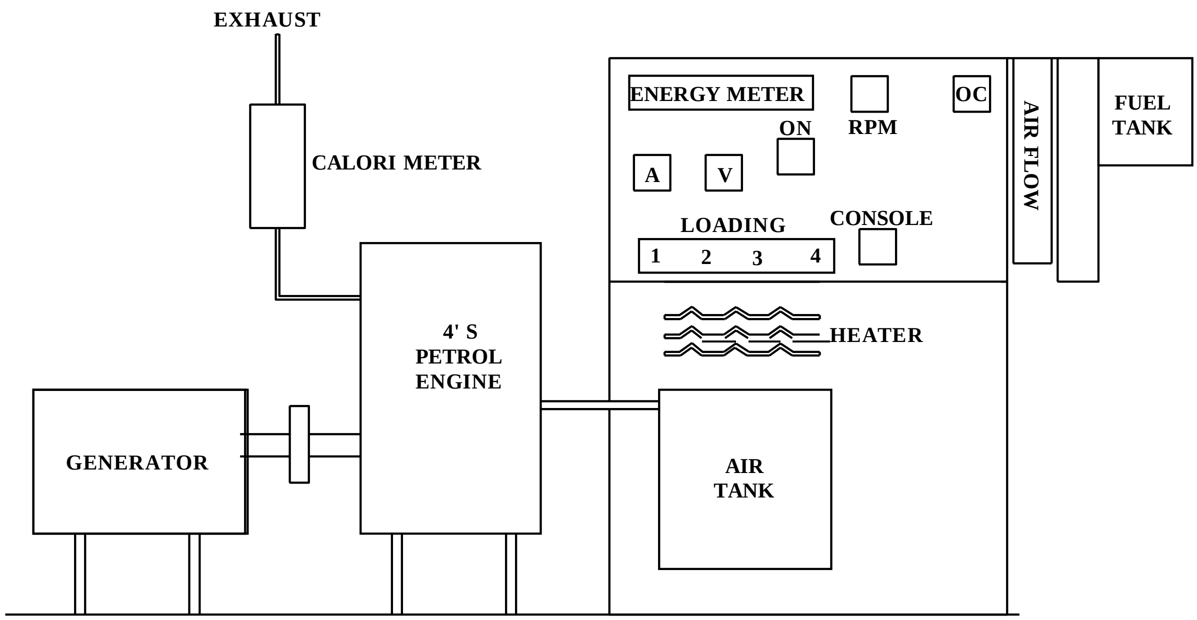
GRAPH:

FC	Vs	BP
SFC	Vs	BP
η_{bth}	Vs	BP
η_v	Vs	BP
A:F	Vs	BP

RESULTS:

FC	Vs	BP
SFC	Vs	BP
η_{bth}	Vs	BP
η_v	Vs	BP
A:F	Vs	BP

RESULTS:



Variable Compression Ratio Engine Test Rig

EXPERIMENT NO. 15

MORSE TEST

AIM: To determine Indicated Power of multi cylinder spark ignition engine.

APPARATUS: Engine setup, thermometer, tachometer.

THEORY: Write theory on methods used for measuring IP and FP

PROCEDURE:

1. The engine is started and allowed to turn for some time.
2. The engine is loaded to max. value by using hydraulic dynamometer and throttle position is adjusted to get the desired rate speed, load and speed values are noted.
3. Current supplied to sparkling of Internal cylinder is stopped by operating lever.
4. Load is now decreased to bring spring back to original value without altering the position. Reading of the spring balance is noted down.
5. Now current supplied to spark plug of 2^{nd} cylinder is stopped soon after the current supply to the spark plug of the original rated speed the load is varied.
6. In the same manner the experiment is repeated for different out-off the engine.

DESCRIPTION OF THE EQUIPMENT:

Thetestrigcomprisesofthefollowing:

1. Four stroke, Engine coupled to Eddy current Dynamometer, with the arrangement to cut off the cylinder
2. Measurement and control panel
3. Temperature Sensors.

PRECAUTIONS:

1. Always set the accelerator knob to the minimum condition and start the engine
2. Frequently, at least once in three months, grease all visual moving parts
3. The level of fuel in the fuel tank should be checked.

SPECIFICATIONS:

Type: 4 stroke, four cylinder car engine with hydraulic loading.

Rated power= 10HP (1.36kw)

Rated speed: 1500 rpm

Distance between the centers of dynamometer to the point spring balance loading= 43.5cm

TABULAR COLUMN:

Condition of the engine	W N	N rpm	BP kW	IP kW	η_m
All cylinders firing	W=		BP=	IP=	
Cylinder 1 is cut off	W_1=		BP_1=	IP_1=	
Cylinder 2 is cut off	W_2=		BP_2=	IP_2=	
Cylinder 3 is cut off	W_3=		BP_3=	IP_3=	
Cylinder 4 is cut off	W_4=		BP_4=	IP_4=	

W= Load applied on the engine through dynamometer when all cylinders firing, N

W_1= Load applied on the engine when cylinder 1 cut-off, N

W_2= Load applied on the engine when cylinder 2 cut-off, N

W_3= Load applied on the engine when cylinder 3 cut-off, N

BP= Brake power of the engine when all cylinders firing, kW= WN/K

BP_1= Brake power of the engine when cylinder 1 is cut-off= W_1N/K

BP_2= Brake power of the engine when cylinder 2 is cut-off =W_2N/K

BP_3= Brake power of the engine when cylinder 3 is cut-off =W_3N/K

K= Dynamometer constant= $\frac{60\times1000}{2\pi R}$

R= Distance between the centers of dynamometer to the point spring balance loading, m

IP= Indicated power of the engine, kW=$IP_1+IP_2+IP_3+IP_4$

IP_1= Indicated power of the cylinder 1=$BP-BP_1$

IP_2= Indicated power of the cylinder 2=$BP-BP_2$

IP_3= Indicated power of the cylinder 3=$BP-BP_3$

IP_4= Indicated power of the cylinder 4=$BP-BP_4$

η_m= Mechanical efficiency

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

RESULTS:

VIVA- QUESTIONS

1. What is Viscosity?

   Ans: Viscosity is resistance for fluids to flow (one layer over other layer)

2. Where do you require the property viscosity?

   Ans: Viscosity is single important property lubricating oils should support load, carry away the heat and provide a fluid film between parts, which have relative motion thereby reducing friction. This viscosity decreases with increase in temperature.

3. Do the instruments you use give the viscosity directly?

   Ans: No, they the time taken for the collection of a fixed quality of oil while passing through a standard orifice in a standard flask. It is known as SUS (say bolt Universal seconds when universal tip is used with say bolt viscometer or say bolt seconds when furol tip(thick oil) Reword seconds when redwood viscometer is used. It is also known as viscosity index or specific viscosity.

4. What are the types of viscosity?

   Ans: Absolute viscosity and dynamic viscosity

5. What is SAE?

   Ans: SAE means Society of Automobile Engineers. SAE40 is more viscous than SAE30 at high temperatures but at low temperatures SAE30 is more viscous than SAE40, some standard values are SAE 20 – 58 sus ; SAE 30- 70 SUS; SAE 40-85 SUS;SAE 50- 110 SUS; at 98.8^{0}C etc.,

6. What is the influence of structural composition on viscosity of oils?

   Ans: Larger the number of carbon atoms the higher the viscosity. Out of two compounds having the same number of carbon atoms, the one with lower content of hydrogen will be more viscous.

7. What is the quantity of oil to be collected with Redwood viscometers?

   Ans: 50 ml.

8. What is the quantity of oil to be collected with Saybolt viscometer?

   Ans: 60 ml.

9. Why castor oil is not used as lubricating oil in IC engines?

Ans: Even though it is highly viscous at low temperatures as the temperature increases the viscosity decreases very rapidly. Hence this is not used as lubricating oil in IC engines.

10. What is Flash point?

    Ans: It is the minimum temperature at which oil vapors give a momentary flash when a naked flame is introduced into the vapors.

11. What is Fire point?

    Ans: It is the minimum temperature at which oil vapors burn continuously when a naked flame is introduced into the vapors.

12. What is the significance of the flash and fire point test?

    Ans: Comparing the flash and fire point with standard values one can find out any adulteration of oil. Crank case dilution can also determined.(When rings are worn out the compression gases leaks into crake case and get mixed with lubricating oil in the sump which reduces the flash point. The test also informative in giving the storage temperature for safety. This test is usually conducted for lubricating oils.

13. What are the different instruments used to determine flash point?

    Ans: Cleveland (Open cup) apparatus Pensky Marten‟s (closed cup apparatus Abel‟s (closed cup) apparatus.

14. Which flash and fire point apparatus gives more accurate values?

    Ans: Abel‟s flash point apparatus. In this the heating is very slow. First water surrounding the oil cup is heated. Energy will be transmitted to the oil cup through air present between the outer jacket and the oil cup. Closed cup instruments give accurate values. However, the fire point determination by closed cup has no significance.

15. Out of flash point and fire point, which shall be higher /

    Ans: Fire point will be greater than flash point by 2 to 5^0 C.

16. How can you identify flash point /

    Ans: When a naked flame is introduced into the vapors, the vapors give a momentary bluish flash followed by audible sound and then go out for want of more vapors.

17. What is the main difference between Pensky Marten‟s flash point apparatus and Abel‟s flash point apparatus?

    Ans: The heating is very fast in the case of Pensky Marten‟s apparatus where as in Abel‟s flash point apparatus the heating is very slow.

18. When naked flame is introduced in to the vapors‟ in the case of closed cup apparatus?

    Ans: The flame should be introduced into the vapors at every degree raise in temperature.

19. What is calorific value?

    Ans: It is deified as the amount of heat energy liberated by the complete combustion of 1 kg fuel or 1$m^3$of fuel

20. What is HCV?

    Ans: Higher calorific value or higher heating value is defined as the amount of heat energy liberated by the complete combustion of 1 kg of fuel or 1$m^3$of fuel (at STP)When the products of combustion are cooled to room temperature and pressure or standard temperature and pressure.

21. What is L.C.V?

    Ans: Lower calorific value is defined as the amount of heat energy liberated by the complete combustion of 1kg of fuel or 1$m^3$of fuel (at STP)When the products of combustion are not cooled.

22. Why H C V is greater than L.C.V?

    Ans: Most of the fuel consists of hydrogen which combines with oxygen to form steam when the products of combustion are cooled .Water vapor steam present will condense liberating latent heat of condensation which can be made use.

23. For What type of fuels bomb calorimeters used?

    Ans: For the determination of H.C.V of liquid and solid fuels bomb calorimeter is used.

24. What calorific value you get when Junker‟s gas calorimeter is used?

    Ans: H.C.V. of gaseous fuel

25. For Which gas you have determined HCV using Junker‟s gas calorimeter?

    Ans: L.P.G

26. What is pressure?

    Ans: Pressure is the external force exerted per unit area by the substance.

27. What is absolute pressure?

    Ans: Absolute pressure is the total pressure which is equal to the sum of atmospheric pressure and gauge pressure. If gauge pressure is greater than atmospheric, it will be taken as +ve. If gauge pressure is less than atmospheric; it is taken as -ve

28. What is the type of pressure gauge you have calibrated?

Ans: Dead weight pressure gauge.

29. Why calibration is required?

    Ans: During usage of the pressure gauge, it may indicate wrong values, because of inertia and worn out of parts. Hence frequently the pressure gauges are to be calibrated with standard gauges.

30. What is a thermocouple?

    Ans: Thermocouple is a device which consists of two dissimilar metal wires and fixed together at their ends. When the ends are kept at different temperatures e.m.f. (D.C.Microvolts) will be induced. These are used to determine temperature rapidly.

31. What are the materials that are used as Thermocouple materials?

    Ans: Copper-constantan, Iron-constantan, Chrome-Alumel

32. What is V.T.D?

    Ans: Valve time diagram which is drawn for 4-stroke engines

33. Why V.T.D. is obtained for engines?

    Ans: During the operation, some of the parts are worn out, tappet clearance will be changed, because of which the valves will not be opened and closed as specified by the manufacturer. In actual engines only tappet clearance will be checked both hot and cold with respect to the standard manufacturer"s specification with the help of feeler gauges.

34. How valves opening and closing is checked?

    Ans: By feeling the push rods or by using feeler gauges which shall be placed between rocker arm and valve stem (lappet clearance)

35. How can you say when the value is about to open?

    Ans: Feeler gauge and push rod will get tightened.

36. When the valves open and close?

    Ans: Even though theoretically valves are to be opened and closed at dead centre position, in actual practice valves are opened before dead centre positions and closed after the other dead centre positions. Because of inertia, valves cannot be opened and closed at dead centre positions instantaneously. Due to this they are made to open early, hence as the dead centre position is reached, valves will be fully opened. Valves are made to close after the other dead centre so as make use of the momentum associated.

37. When the inlet valve will be opened and closed?

Ans: Inlet valve will be opened 10^0 to 25^0 before TDC (IDC) and closed 25 to 40^0 after B.D.C. The suction process shall take place 225^0 to 250^0 The aim is to supply more quantity of charge as possible.

38. When the exhaust valve will be opened and closed?

    Ans: Exhaust value will be opened 25 to 40^0 before B.D.C. and closed 10 to 15^0 after TDC. The exhaust process shall take place 225^0 to 240^0 C.A. The aim is to force out large quantity of products of combustion as possible.

39. What is valve over lap?

    Ans: It is the period during which both the valves are opened simultaneously.

40. What is charge in S.I or petrol engine?

    Ans: Air-Petrol mixture.

41. What is charge in C.I. or Diesel engine?

    Ans: Air is the charge.

42. What is the charge of an I.C. Engine?

    Ans: The quantity that enters the engine cylinder during suction stroke.

43. What are T.D.C. & B.D.C. for a horizontal engine?

    Ans: Corresponding to TDC the dead centre is called inner dead centre and corresponding to BDC it is outer dead centre in horizontal engine.

44. What are the main differences between S.I and C.I engines?

    Ans: In S.I. engine fuel is supplied with the help of carburetor during suction stroke .Ignition is done with the help of ignition coil, spark plug, compression ratio is 6 to 10 and follows Otto cycle. The S.I. engine is compact and high speed engine.

    In C.I. engine fuel is supplied with the help of fuel injector just before the completion of compression stroke. The high pressures and temperature existing in the cylinder assisted by turbulence causes the ignition at number of favorable spots. Compression ratio is 12 to 25. Follows diesel cycle. Presently high speed C.I. engine has the compression ratio of 8 to 12 and works on dual cycle. The C.I. engine is bulky and is suitable for heavy vehicles or heavy duty power plant generator sets.

45. What the differences between 2-stroke and 4-stroke engines?

    Ans: In 4-stroke engine the working cycle will be completed in 4-stroke of the piston or in two revolutions of the crank shaft. Requires valve mechanism, mechanical efficiency is low, volumetric efficiency brake thermal efficiency are high, requires less lubricating oil, larger fly wheel & un even turning moment.

In 2-stroke engines the working cycle will be completed in 2-strokes of the piston or one revolution of the crank shaft. Mechanical efficiency is high. Volumetric efficiency & brake thermal efficiency are low. Because of power in every revolution develops twice the power than that of-stroke engine. Requires more lubricating oil. Occupies less space.

46. Define mechanical efficiency of an engine.

    Ans: It is the ratio of BP to IP or brake thermal efficiency to indicated thermal efficiency or the ratio of brake mean effective pressure to the indicated mean effective pressure.

47. What is SFC? Why it is determined?

    Ans: SFC is the ratio of mass of fuel consumed to BP per hour .i.e. it is fuel consumed per unit power developed per hour. It is determined to compare the performance of different capacity engines.

    It is 0.2 kg/kWh for CI engines.

    0.35 kg/kWh for SI engines.

48. What is brake thermal efficiency?

    Ans: It is the ratio of the BP to the energy supplied. It is also known as overall efficiency. It is about 35% for CI engines.15 to 20% for SI engines.

49. What is volumetric efficiency?

    Ans: It is the ratio of the actual volume of charge drawn into the cylinder to the theoretical volume of charge drawn or stroke volume of the engine cylinder.

    It is about 80% for CI engines and for SI engines it increases with increase of load.

    In the case of compressor, the volumetric efficiency decreases with increase of pressure.

50. What is indicated power & brake power?

    Ans: Indicated power is the power available or actual heat power in the engine cylinder, where as brake power is the power available at the crank shaft or power out shaft. IP-BP.=FP (frictional power)

51. What is maximum load for an engine?

    Ans: The load calculated at the rated speed for the maximum power developed by the engine (as specified by the manufacturer).

52. Why the engine has to be run at the rated speed?

Ans: As the load on the engine decreases, the speed increases and as the load increases, the speed decreases. If the engine is run at rated speed, the performance will be the best.

53. What is governing?

    Ans: Governing is the process of running the engine at constant speed.

    In S.I. engine quantity of air fuel mixture is varied to get constant speed, hence it is quantitative governing or throttle governing.

    In C.I. engine qualitative governing is adopted as the quantity of fuel is varied for the same quantity of air.

54. What is the range of air-fuel ratio for S.I & C.I. engines?

    Ans: For S.I. Engines 6:1 to 18:1 as rich, 22:1 is the lease limit

    For C.I engines it varies from 90:1 to 25:1

55. Define relative efficiency.

    Ans: It is defined as the ratio of the brake thermal efficiency or indicated thermal efficiency to the air standard efficiency.

56. How do you identify air cooled engines from water cooled engines?

    Ans: Air cooled engines have fins (extended surfaces) which increases the heat transfer from the cylinder by providing more area. Water cooled engines have water jacket around the cylinder and a radiator.

57. What is compression ratio?

    Ans: It is the ratio of the total cylinder volume (stroke volume +Clearance volume) to the clearance volume.

58. What is clearance ratio?

    Ans: It is the ratio of clearance volume to the stroke volume.

59. What is a compressor?

    Ans: Compressor is a device which increases the pressure of the working fluid by pressure ratio greater than 2.5.

60. What is reciprocating air compressor?

    Ans: Low pressure air is drawn into the cylinder of a compressor and is compressed to high pressure with the help of piston and it delivers high pressure air. It is a positive displacement machine (working fluid is confined positively).

61. What is the expression for volumetric efficiency of compressor?

$\eta_v = 1 - c\,[(pd/p1)^{1/n} - 1]$

62. Why multistage compression is preferred?

    Ans: If the compression is performed in multi stages, the work required for compression gets reduced. The compression may approach isothermal compression. In multistage compression the working fluid after compression in one stage is taken to an inter cooler in which the temperature of the working fluid is reduced. The work required in subsequent stages gets reduced.

63. Give the expression for work required for a single stage compressor.

$$IP = \frac{n}{n-1} P_1 V_1 \left[\left\{\frac{P_2}{P_1}\right\}^{\frac{n-1}{n}} - 1\right]$$

64. What is the condition for minimum work required for a 2-stage compression with perfect inters cooling?

    Ans: $P_2 = \sqrt{P_1 P_3}$

    Intermediate pressure is the geometrical mean of supply and delivery pressure. Minimum work required /cycle $= 2n/(n-1)\; p_1 v_1\, [(p_3/p_1)^{(n-1)/2n} - 1]$

65. What is meant by 2-stageair compressor?

    Ans: If compression is done in two cylinders it is know as 2-stage compressor. Air will be drawn into the L.P. cylinder (low pressure cylinder) then into inter cooler where working fluid is cooled. The air is compressed to the delivery pressure in the HP cylinder. (Higher pressure cylinder). The cylinders between Low pressure and high pressure cylinders are called as intermediate cylinders.

66. What is single acting and double acting cylinders?

    Ans: If working fluid is introduced into the cylinder from one side of the piston it is known as single acting and if the working fluid is introduced from both sides of the piston they are known as double acting compressors.

    In single acting the cycle is completed in one revolution of the crank shaft and in double acting two working cycles are completed in one revolution of the crank shaft.

67. What is mechanical efficiency of a compressor?

    Ans: It is the ratio of the indicated power required to the actual power required (b.p)

68. What approach is followed in thermodynamics?

Ans: Macroscopic approach (classical) in which combined action of number of molecules is considered. In microscopic approach the behavior of individual molecule is studied.

69. What is the difference between intensive and extensive properties?

    Ans: Mass or volume dependent properties are extensive.

    E.g.; energy, enthalpy, entropy, mass, volume etc.

    Mass independent properties are intensive.

    E.g.; pressure, temperature, density and all extensive properties per unit Mass.

    If a matter is divided into two equal halves each one will have the same intensive property of the original matter but half that of the extensive property of the original matter.

70. What is a property?

    Ans: Property is an exact differential .It is a point function .it does not depend on the path the system is brought to that given state.

71. What are the different types of systems?

    Ans: A system is defined as any region in space or any quantity of matter on which attention is focused for study. A system is separated from its surrounding by a boundary. A system and its surroundings together is called universe. A system of fixed mass and identity is a closed system. No matter crosses but energy crosses. Gas retained in a cylinder with piston is an example.

    A system in which matter as well as energy crosses the system boundary is an open system. All engineering appliances are examples.

    An isolated system is one which is un-influenced by the surroundings

    (Universe is assumed as an isolated system).

72. What is Zeroth law of thermodynamics?

    Ans: When two bodies have equality of temperature with a third body separately, the two bodies will have same equality of temperature. The third body is nothing but thermometer.

    Hence zeroth law of thermodynamics leads the temperature measurement.

73. What is Temperature?

    Ans: Temperature is a property which determines whether or not a system is in thermal equilibrium with the surroundings.

74. What is thermodynamic equilibrium?

Ans: When a system is in mechanical equilibrium chemical equilibrium and in thermal equilibrium then it is said to be in thermodynamic equilibrium.

75 .What is a cycle?

Ans: If a system undergoes number of different processes and finally returns to its initial position then the system is said to have undergone a thermodynamic cycle.

76. Define first law of thermodynamics.

Ans: During any cycle a closed system undergoes the cyclic integral of heat is equal to the cyclic integral of work. The energy of an isolated system remains constant.

The perpetual motion machine of the first kind (PMM-I) is impossible to construct. Energy can neither be created nor destroyed. A PMM-I is one which creates energy which is not possible.

77. What is the consequence of 1^{st} law of thermodynamics?

Ans: Energy is a property.

78. What is steady flow process?

Ans: A steady flow is one which is independent of time. Most of the engineering application is steady flow devices.

79. What is the quasistatic process?

Ans: A quasistatic process is one in which the deviation from thermodynamic equilibrium is infinitesimal and each state through which the system passes are equilibrium states.

80. What is expression for work done for closed system?

Ans: W=PdV

81. What is expression for work done for open system?

Ans: Vdp

82. What are different names for constant volume process?

Ans: Isometric process,

83. What are different names for constant pressure process?

Ans: Isobaric or isopiestic process.

84. What are different names for constant temperature process /

Ans: Isothermal process or hyperbolic process.

85. What is a reversible adiabatic process?

Ans: Isentropic process.

86. What are the values of polytrophic index for various processes?

    Ans: For constant volume process n =0

    For constant pressure process n=0

    For constant temperature process n =1

    For reversible adiabatic process n =r

87. What is enthalpy process?

    Ans: Throttling process or wire drawing process.

88. What is the limitation of first law of thermodynamics?

    Ans: It does not say whether a particular process is possible or not. It does not specify the extent of conversion of heat into work.

89. Which are the high grades of energy?

    Ans: Work, electrical work, K.E. etc.

90. Which is the low grade form of energy?

    Ans: Heat energy.

91. Define Enthalpy.

    Ans: Enthalpy is defined as the sum of internal energy and the product of pressure and volume for any system.

    i.e. = u + pv.

    For an open system it may be define as the sum of internal energy and flow work. It is the total energy.

92. What is a heat engine?

    Ans: Heat engine is a device which operates in a thermodynamic cycle and does certain amount of net positive work as a result of heat transfer from a high temperature reservoir and to a low temperature reservoir.

93. What is a heat pump?

    Ans: Heat pump is a device which operates in a thermodynamic cycle and transfers heat energy from a low temperature body to a high temperature body by receiving work.

94. What is a reservoir?

    Ans: A reservoir is a body from which and to which heat energy can be transferred without change in temperature.

95. What is a source & sink?

Ans: A source is a high temperature reservoir and sink is a low temperature reservoir.

96. What is a reversible process?

Ans: A reversible process is one which once having taken place can be reversed leaving no changes either in the system or in the surroundings.

97. What are the factors that render a process irreversible?

Ans: Friction, heat transfer between finite temperature difference, mixing of two gases, unrestrained expansion, electrical resistance, magnetic effects etc.

98. What is available energy?

Ans: The energy that can be made use of from the energy supplied for useful work. The energy beyond the dead state (sink conditions) cannot be made use.

Available energy $=\eta_{carnot}$ xq

99. What is irreversibility?

Ans: Loss in available energy is known as irreversibility.

100. What is irreversibility during a heat r=transfer process with temperature T_1 & T_2 ?

Irreversibility $=T_o\Delta s$

$=T_o[(Q/T_2) - (Q/T_1)]$

Where T_o be dead state temperature "Q" is heat transferred.

101. Write expressions for available energy for closed and open systems.

Ans: For closed systems available energy $=(u_1 - u_o) + P_o (v_1 - v_o) - T_o (S_1 - S_o)$

Where $Po(v_1-v_o)$ is displacement work at boundary.

For open system available energy $= (h_1-h_o) - T_o (S_1-S_o)$

102. Define Kelvin –Planck statement of second law of thermodynamics.

Ans: It is impossible to construct a device which operates in a thermodynamic cycle and does certain net positive work and exchanging heat with single reservoir.100% efficiency is not possible PMM-II perpetual motion machine of the second kind which produces 100% efficiency is impossible. Energy received cannot be completely converted into work.

103. Define Clausius statement.

Ans: It is impossible to construct a device which operates in a thermodynamic cycle and transfer heat energy from low temperature body to a high temperature body without receiving work.

The cop. (coefficient of performance) cannot be infinity. This is also known as PMM-II.

104. Define efficiency.

Ans: Efficiency is defined as the ratio of the work done to the energy supplied.

105. Define C.O.P.

Ans: Coefficient of Performance is defined as the ratio of the desired effect to the energy supplied.

106. Define C.O.P of a refrigerator.

In refrigerator, refrigerating effect (cooling) is the desired effect. C.O.P. is defined as the ratio of refrigerating effect to the energy supplied.

107. Define C.O.P. of heat pump.

Ans: Here the desired effect is the heat rejected C.O.P of heat pump is defined as the ratio of heat rejected to the energy supplied.

108. What is the relationship between C.O.P of heat pump and C.O.P of refrigerator?

Ans: C.O.P of heat pump –C.O.P of refrigerator =1.

109. What is another name of second law of thermodynamics?

Ans: Law of degradation of energy.

110. What is entropy?

Ans: It is a property which determines the disorder of a system. The higher the disorder, the higher the entropy. Every process tends to reach a more probable state from less probable state. That is entropy indicates the probability. It is said that the disorder goes on increasing and finally reaches a most probable state. Ludwig – Boltzmann gives a relation for absolute entropy s= K In where S is absolute entropy, K is constant and w is probability. At most probable state (w=1) entropy is zero.

111. Define Third Law of Thermodynamics.

Ans. It is defined as at absolute zero temperature the entropy of a pure substance is zero. Nernst –Siman statement states that, it is impossible, by any procedure, no matter however idealized, to reduce a system to absolute zero, in a finite number of operations.

112. What is clausius theorem?

Ans: $\S(\delta Q/T)_{Rev} = 0$

113. What is clausius inequality ?

Ans: $\S(\delta Q/T \leq 0$ where equality sign for reversible process.

114. What is PMM –III ?

Ans: Perpetual motion machine of the third kind do not have friction. Which once set in motion will run indefinitely.

115. What is mean effective pressure?

Ans: Ii is a hypothetical or theoretical pressure which when acts throughout the stroke length of the piston will produce the same work as that of the actual cycle or engine.

i.e. = [work / cycle / Stroke volume

116. Give the relation for BP

Ans: BP= πdNw / 60 kw. When W is in kN.

= 2πNT / 60 = 2πNWr / 60

= b.m.e.p x LANK / 60

Where K is ½ for 4 –stroke and K is 1 for 2-storke.

b.m.e.p in Kpa

117. Give the relation for IP

Ans: IP =i.m.e.p x LANK / 60

118. Give relation for FP

Ans: IP-BP=FP

119. What is Willian‟s line?

Ans: It is a curve drawn f.c. Vs b.p. or load for diesel engine. It is a straight line. If it is extended towards negative axis of the power or load line it gives FP

120. What is Morse Test?

Ans: It is a constant speed test for multi cylinder engine in which the ignition is cut off successively (in s.i. engines) or fuel supply cut –off (in diesel engines). This will give indicated power of each cylinder.

121. What is the use of heat balance test?

Ans: It shall give how the energy supplied is utilized namely energy for power developed, energy in exhaust gases, energy carried in cooling medium, energy lost in friction etc.,

122. What is a pure substance?

Ans: A pure substance is one which is having uniform chemical composition throughout. It can exist in all three forms. Eg: Steam refrigerants etc.,

123. What is Gibb‟s phase rule?

Ans: f = c + 2-p, where f is degrees of freedom c is no. of components and p is the number of phases co exist.

124. What is critical point?

Ans: It point at which liquids directly converts into gases

125. What is critical point of water?

Ans: 374.14^0 C and 221.13 bar

126. Why steam is used as working fluid in steam turbines?

Ans: It is a pure substance whose specific volume changes rapidly during change of phase.

127. Which engines are most suitable for supercharging?

Ans: C.I engines are most suitable. However racing vehicles of S.I. engines type also use supercharging to reduce the size or bulk.

128. What are the affects of super charging?

Ans: Supercharging increases the density of charge admitted which in turn increases the power output, compensate the altitude affect, reduces the size of the vehicle as in the case of racing vehicles and to increase the power output of the existing engines (boosting).

129. What is the difference between supercharging and turbo charging?

Ans: Normally for increasing the charge admitted into the engine cylinder, roots blower is used. If the blower is operated by the engine crank shaft it is known as supercharging and if the power is derived from the exhaust gas turbine the same device is known as turbo charging.

130. What are the advantages of supercharging?

Ans: The power output increases, mechanical efficiency increases, volumetric efficiency increases and the size of the engine will be reduced.

131. What is the main difference between the ratings of fuels by ON and CN?

Ans: For S.I engines as O.N increases the performance of S.I. engine will improve in all aspects.

Increasing of C.N. will improve the combustion but do not influence the other parameters by larger extent. Higher C.N. causes thermal loading for the engines.

132. What is the main difference between C.I. & S.I. engines in respect of knock?

Ans: In S. I. engines knock or detonation takes place at the end of combustion. It is the last unburned portion which is responsible. The fuel knock takes place at the beginning of combustion. The fuel should have low self ignition temperature.

It is normally taken that the factors that influences knocking in S.I. engines reduces knocking tendency in C.I. engines and vice-versa.

133. If petrol is used in Diesel engine what do you expect?

Ans: Let us assume the engine is in operation with diesel and suddenly the fuel is switched over to petrol. As petrol is used as a cleaning agent the pressures cannot be built up in the plunger fuel pump, lubricating oil will be cleaned off the pump petrol vapor enters the engine cylinder. As the engine cylinder walls are at high temperature fuel injected may burn with violent knocking. After some time the power gets reduced and the fuel (petrol) quenches the cylinder walls and the engine stops. The self ignition temperature of diesel is higher than that of petrol. As such there is no spark plug the combustion cannot sustain and engine comes to rest.

134. What do you expect if diesel is used in a petrol engine?

Ans: Let us assume that the engine is in operation with petrol and if suddenly the fuel is switched over to Diesel. Diesel along with air will be drawn into the carburetor. As the density of diesel is more, less quantity enters and the carburetor will not be able to vapor diesel completely. The mixture as it enters the engine cylinder the combustion may take place for few cycles and soon the cylinder wall will be quenched. Fuel knocking takes place and finally the engine stops.

135. What are the different types of gas turbines?

Ans: Closed cycle gas turbines and open cycle gas turbines. For analysis closed cycles are considered. In practice most of the gas turbines are open cycle gas turbines which follow joule or Brayton cycle (Constant pressure heat addition cycle).

136. How is octane, paraffin is considered as best fuel for S. I. Engines?

Ans: Iso ($C_8 H_{18}$) is an isomer of normal octane which is branched chain paraffin. This is also known as tri –methyl! Pentane. This is used as a standard reference fuel for S.I. engines.

137. Which is the other standard reference fuel for S.I. engines?

Ans: Normal heptanes (C_7 H_{16}). This is considered as the worst (or very poor) fuel for S.I. engines.

138. How the S.I. engine fuels are rated?

Ans: The S.I. engine fuels are rated by octane number (O.N.)

Octane number is defined as the percentage by volume of is octane in admixture of iso octane and normal heptanes which exactly matches the knocking intensity of the test fuel, when tested in a standard C.F.R. (Co-operative fuel research engine) under standard operating conditions.

Iso octane is arbitrarily given an O.N. of 100

Where as normal Heptane is arbitrarily given an O.N. of „o‟

139. How the fuels are rated if O.N. is greater than 100?

Ans: ON = 100 + (PN-100) / 3

Triptane number (T.N.) Triptane is iso heptanes or timothy! Butane A T.N. of 65.5 = 100 O.N. for aviation fuels, fuels having ON greater than hundred are used. Hence they are rated either by P.N. or T.N.

140. What are additives for S.I. engine fuels?

Ans: Additives are the compounds, which shall increase the knock resistance of s.i. engine fuels. They are tetra methyl Lead (TML) AND Tetra Ethyl Lead (TEL). Nowadays these additives are banned as they cause lead poisoning.

141. What is the rating of C.I. engine fuels?

Ans: They are rated by cetane number. C.N. Cetane number is straight –chaine paraffin, which is the best fuel for C.I. engines and arbitrarily given a C.N. of 100. This is (cetane $C_{16}H_{34}$ or Hexadecane) is used as one standard reference fuel. Another standard reference fuel is α – Methyl naphathalene (C_{10} H_7 CH_3) It is arbitrarily given a C.N. of „O‟

At present another reference fuel known as Heptamethyl nonane ($C_{16}H_{34}$) is used which is having a C.N. of 15 for poor quality fuel.

142. What is C.N. ?

Ans: C.N. is defined as the percentage by volume of cetane in a mixture of cetane and alpha-methyl naphathalene (C_o H_{2n-12}) which have the same ignition delay as that of test fuel when tested in C.F.R. engine, under standard operating conditions.

143. What is the relationship between ON and CN?

Ans: The higher the OP the better it is suited for S.I. engines and has less C.N. which can not be used in C.I. engines and vice-versa.

C.N. = $\frac{104-0.N.}{2.75}$

144. What is the relationship between calorific value and number of hydrogen atoms in the fuel?

Ans: The higher the number of hydrogen atoms the higher the heating value, however the higher the ratio of hydrogen to carbon atoms in a fuel the higher the heating value.

Thus petrol C_8H_{18} is having large H/C ratio is having more heating or calorific value, however the higher than diesel oil $C_{12}H_{26}$ (Dodecane). It is known that the calorific value of hydrogen is 146540 kj/kg when compared to carbon calorific value of 33000 kj/kg. This is the reason why paraffin‟s which are having more number of hydrogen atoms are used as i.c. engine fuels.

145. What is detonation in S.I. engines ?

Ans: It is an abnormal combustion taking place in S.i. engines. It is also known as auto ignition, spontaneous ignition, knocking and pinging.

When spark is introduced into the compressed charge before the piston reaches cover dead centre position, there will be preparation period of the charge then oxidation takes place. This period is known as reaction phase. It takes place near the spark plug. Once reaction takes place the actual combustion will be initiated establishing a flame front which actually transposes the surrounding layers. If the flame front travels at a speed such that the flame front eats its way into the unburned portion. The combustion will be normal.

By the time the flame front reaches the last unburnt portion, if that charge attains self ignition temperature, it burns along with the other portion without the assistance of flame front. This is known as auto ignition or spontaneous ignition. For detonation it is the last unburnt portion which is responsible or detonation occurs in S.I. engines at the end of combustion. Because more charge burns at the same time, the rate of pressure rise will be high which may make the pressure wave to strike the cylinder walls giving an audible noise similar to metallic knock and hence it is also known as knocking. The rate of pressure rise should be 1.5 to 2 bar / C.A.

To avoid detonation the fuel should have high self ignition temperature. Branched chain paraffins have high self ignition temperature.

146. What are the factors that influence detonation?

Ans: The higher the charge temperature, pressure density, compression ratio increases detonation tendency. It is found that at approximately 85% of the theoretical air fuel ratio (Rich mixture) the detonation tendency decreases. The higher the speed, valve overlap branching of fuel, and addition of TEL or TML shall decrease knocking tendency.

In S.T engines detonation is the limiting factor for compression ratio. It is known that the higher the compression ratio, the higher the thermal efficiency. It should have high-self ignition temperature to reduce detonation or knocking tendency.

147. What are the other types of abnormal combustion in S.I. engines?

Ans: They are surface ignition; run away, run on wild ping etc.

148. Explain surface ignition.

Ans: During operation certain parts of an engine will be overheated. The parts are exhaust valve, spark plug, red hot carbon deposit, cylinder head etc., They initiate ignition.

If the ignition takes place prior to the normal spark ignition, this surface ignition is known as pre-ignition. If the ignition takes place after normal spark ignition, the ignition is known as post -ignition

Pre-ignition precedes the spark where as detonation follows the spark. Sustained detonation leads to pre-ignition. Pre-ignition tend to increase the temperatures and the peak pressures also occur before the cover dead centre position. In succeeding cycles further advancement takes place and peak pressures oppose the piston movement, this decreasing the power output and leads to rough engine operation.

If the engine continues to run even if the ignition is cut-off is known as run-on condition

If the ignition is very much advanced in addition to the normal spark ignition, it may result to disastrous results like seizure or melting of piston.

Sometimes some fragments of glowing carbon deposit gets detached and move erratically through the combustion chamber causing ignition now and then, known as wild ping.

If the deposits and conditions are favorable, ignition may occur simultaneously at number of places which is known as rumble.

149. Explain the different types of combustion chambers for S.I. engines.

Ans: The combustion chambers are classified as L-head. T-head. I-head and F-head. It is preferable to place exhaust valve which will be hot in the cylinder head. High speed engines use over head valve engines.

150. Explain the combustion phenomenon in C.I. engines.

Ans: The combustion in C.I. engines is similar to combustion of heterogeneous mixtures, where as combustion in S.I. engines are combustion of homogeneous mixtures.

Fuel will be injected into the turbulent or swirling air. The fuel will be injected at about pressures of 200 atm. And sometimes even greater pressure. The fuel will mix with hot air. Where ever the conditions are conducive or favorable the ignition takes place at number of places. Once the ignition is initiated large quantity of fuel awaiting combustion burns simultaneously. This period is known as un=controlled combustion. Once the fuel injection starts the combustion will not be initiated instantly. Favorable conditions are to be reached for ignition. The period between the injection of first droplet of fuel and the initiation of ignition or combustion is known as delay period or ignition lag. The larger the delay period the larger the quantity of fuel awaiting combustion and hence more un-controlled burning which may cause the rate of pressure raise greater than 3.5 bar/CA. So to avoid abnormal combustion or fuel knock in C.I engines the delay period should be low.

The third phase of combustion is the most desirable period which is known as controlled rate of burning. During this period the fuel as it is injected It burns. This controlled rate burning can be identified with a pressure raise of 3 to 3.5 bar/CA.

This controlled rate of burning may be achieved by providing suction swirl (LIP, masking, contour of the manifold), compression turbulence with piston squish (of 1.2 mm to 1.6 mm gap) combustion turbulence using pre combustion chamber (20 to 30% clearance volume and pre chamber is connected to the main chamber with the help of small holes), divided combustion chamber (50% clearance volume and connected to the main chamber with large single hole) air and energy cell.

The fourth stage of combustion is known as after burning which is not preferable as energy will be wasted through exhaust.

151. Write notes on ignition lag or delay period.

Ans: The delay period is very important to avoid fuel knock or starting knock in C.I. engines. The larger the delay period the engine is more prone for knocking. It should be as low as possible. Normally straight chain paraffin‟s have lower self ignition have lower self ignition temperature which are preferable than branched chain paraffins. Delay angle will be reduced from 180 to 80 during which delay period will be reduced from 0.002 s to 0.00089 S. For coarse fuel delay period is around 0.005 s. The finer the atomization the less the delay period. Increasing injection pressures is not a solution as it will lead to starting difficulty.

Increasing CN do not increase the performance of the C.I. engine, will assist combustion but also causes thermal loading.

152. What is supercharging?

Ans: Admittance of the charge into the cylinder larger than what the cylinder would obtain as the result of regular or natural suction stroke is known as super charging. If the charge is admitted as per the normal or natural suction the engines are known as naturally aspirated (NA) engines.