K. S. INSTITUTE OF TECHNOLOGY

#14, Raghuvanahalli, Kanakapura Main Road,
Bengaluru-560109.

DEPARTMENT OF MECHANICAL ENGINEERING

V SEMESTER

ENERGY CONVERSION LAB

(18MEL58)

NAME: _____

SEM/SEC: _____

BRANCH: _____

USN: _____

LAB MANUAL & OBSERVATION

COURSE OBJECTIVES

The objectives of Energy laboratory is

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

COURSE OUTCOMES

The expected outcome of Energy lab is that the students will be able

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

VISION OF THE DEPARTMENT

- **"To groom incumbents to compete with their professional peers in mechanical engineering that brings recognition"**

MISSION OF THE DEPARTMENT

- **To impart sound fundamentals in mechanical engineering.**
- **To expose students to new frontiers.**
- **To achieve engineering excellence through experiential learning and team work.**

PROGRAM EDUCATIONAL OBJECTIVES (PEO's)

- **PEO1:** To produce graduates who would have developed a strong background in basic science and mathematics and ability to use these tools in Mechanical Engineering.
- **PEO2:** To prepare graduates who have the ability to demonstrate technical competence in their fields of Mechanical Engineering and develop solutions to the problems.
- **PEO3:** To equip graduates to function effectively in a multi-disciplinary environment individually, within a global, societal, and environmental context.

PROGRAM SPECIFIC OUTCOMES (PSO's)

- It is expected that a student in mechanical engineering will possess an:
- **PSO1:** Ability to apply concept of mechanical engineering to design a system, a component or a process/system to address a real world challenges
- **PSO2:** Ability to develop effective communication, team work, entrepreneurial and computational skills

PROGRAM OUTCOMES (PO's)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

SAFETY PRECAUTIONS

1. Instruments in the laboratory are highly delicate and costlier, handle it carefully.
2. Don't try to use instruments beyond its measuring range.
3. Allow gentle pressure to tighten the screws.
4. As for as possible mount the instrument in the stand or keep it over the table and note down the readings.
5. Collect only the measuring instrument required for the particular experiment.
6. Do not handle any instrument without knowing the proper method of using it.
7. Hand over the instruments to the lab personnel after completing the experiment.
8. While mounting precision instrument like dial gauges take utmost care to avoid damages due to slippage.
9. Take care to see that are no scratches made on polished surfaces.
10. In the eventuality of some problem with the instrument please inform the lab personnel immediately.
11. Do not try to tamper with the instruments.
12. You are liable to be fined if any instruments have been damaged while in your possession.

SYLLABUS

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

ENERGY CONVERSION LABORATORY

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

Sl. No.	Experiments
	PART A
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 lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
5	Valve Timing/port opening diagram of an I.C. Engine.
	PART B
6	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 Variable Compression Ratio I.C. Engine.
7	Measurements of Exhaust Emissions of Petrol engine.
8	Measurements of Exhaust Emissions of Diesel engine.
	PART C (OPTIONAL)
9	Visit to Automobile Industry/service stations.
10	Demonstration of p θ , pV plots using Computerized IC engine test rig

Scheme of Examination:

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

CONTENTS

PART A

PART B

K. S. INSTITUTE OF TECHNOLOGY

#14, Raghuvanahalli, Kanakapura Main Road, Bengaluru – 109.

INDEX CARD

NAME:_____ USN: _____

LAB/CODE:_____ SEM: _____

BRANCH:_____ BATCH: _____

NAME OF FACULTY: _____

SL. NO	DATE OF CONDUCTION	PARTICULARS	MARKS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
		TOTAL	
		AVG. RECORD MARKS OBTAINED	

AVG. RECORD MARKS(20)	OBSERVATION MARKS (10)	TEST(10)	TOTAL INTERNAL MARKS (40)

Signature of Student Signature of Staff Signature of HOD

PART-A

EXPERIMENT NO. 1

CLEVELAND APPARATUS

AIM: To determine the flash and fire point of the lubricating oil using Cleveland apparatus.

APPARATUS: Cleveland flash and fire point apparatus, thermometer and Broom sticks.

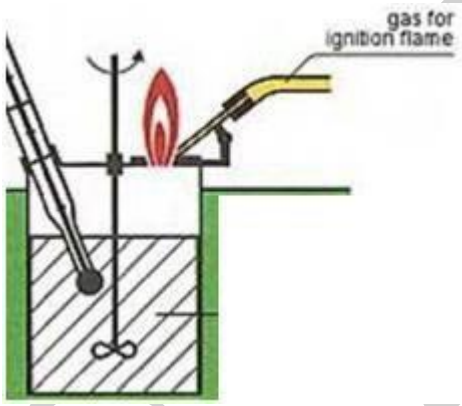


Figure: Cleveland Apparatus.

THEORY:

Write the theory for properties of oils with definition.

PROCEDURE:

1. The apparatus is setup as shown in the figure, 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.

OBSERVATION:

1. Type of oil : _____
2. Initial Temperature of Oil : _____

TABULAR COLUMN:

TEMPERATURE °C	REMARKS	FLASH POINT °C	FIRE POINT °C

RESULT: Flash point of the given oil is _____
Fire point of the given oil is_____

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

EXPERIMENT NO. 2

PENSKY MARTENS APPARATUS

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

APPARATUS: Pensky Martens apparatus, thermometer, Broom sticks.

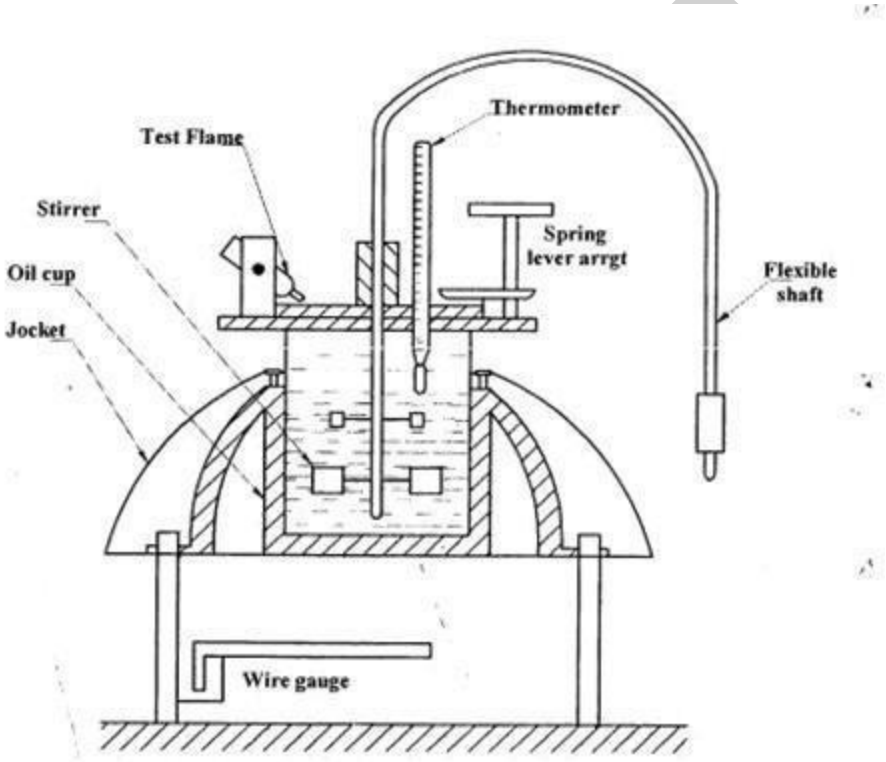


Figure :Pensky Martenz's Flash Point Apparatus

THEORY:

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

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

PROCEDURE:

1. The apparatus is setup as shown in the figure, 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.

OBSERVATION:

1. Type of oil : _____
2. Initial temperature of Oil : _____

TABULAR COLUMN:

TEMPERATURE °C	REMARKS	FLASH POINT °C	FIRE POINT °C

RESULT: Flash point of the given oil is _____
Fire point of the given oil is_____

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

EXPERIMENT NO. 3

JUNKERS GAS CALORIMETER

AIM: To Determine the Lower Calorific Value of given gaseous fuel.

APPARATUS: Gas tank(fuel), governor, gas flow meter, stop watch, calorimeter, thermometer, beaker.

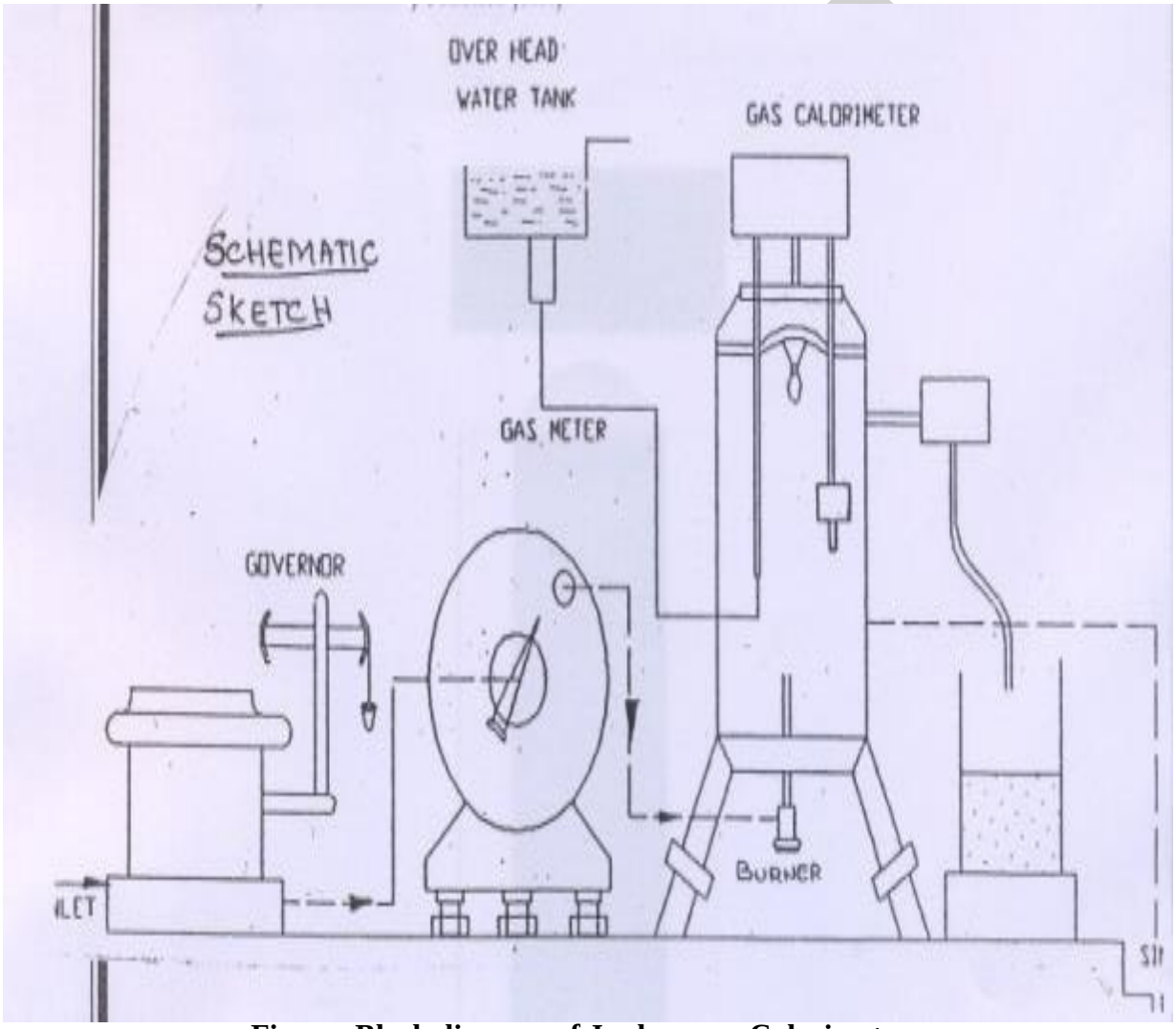


Figure :Block diagram of Junkers gas Calorimeter.

THEORY: Write the theory on following topics

a. Definition of calorific value.
b. Types of calorific values and their definitions.
c. Types of calorimeters and their applications.
d. Construction features of Junkers gas calorimeter.

PROCEDURE:

1. Turn on the water by opening the control valve knob of the gas calorimeter to setting ON.
2. Adjust the water supply in such a way that there will be only a small amount of overflow of excess water to sink. By this air bubbles inside the water circulating will be outlet.
3. Remove the burner from the calorimeter open the outlet tap of the governor. Allow the gas to pass for three or four revolution as indicated by the flow meter then light the burner and adjust the air regulator sleeve and the gas tap to get an luminous flame. Clamp the burner keeping it to the top most position.
4. Adjust the flow of water to get a temperature difference of 12^0 C to 15^0 C between the water inlet and outlet temperature. This is important if the flow of water is less than that required, there will be a high temperature difference and water may escape as the steam, so the water flow is to be adjusted in such a way that there will not be formation of steam.
5. Allow the water outlet thermometer to indicate a steady temperature which may take about 20 to 30 min. Keep the measuring jar beneath the swinging water outlet tube and simultaneously count the number of revolution made by the gas flow meter pointer to find the volume of gas consumed during the test period. When the pointer has made two or three revolutions swing the water outlet back to waste.
6. Also immediately note the temperatures of water inlet and outlet as well as gas flow meter keeping the water flow and gas flow same repeat the experiment trice or four times and take the average of the reading and calculate the calorific value of the gas.

OBSERVATION:

1. Type of Fuel.

TABULAR COLUMN:

Sl. No.	V_{g1} ml	V_{g2} ml	V_g ml	V_w ml	t s	T_1 ^oC	T_2 ^oC	HCV kJ/kg

Where,

Vg= Volume of gas supplied, ml

$=V_{g2}-V_{g1}$

V_{g1} and V_{g2} are initial and final readings of gas flow meter, ml

Vw= Volume of water collected=1000ml

t= Time taken for collecting 1000ml of water, s

T_1= Initial temperature of water, ºC

T_2= Final Initial temperature of water, ºC

HCV= Higher Calorific Value of given gaseous fuel, KJ/kg

$$HCV = C_{pw} \times \frac{V_w}{V_g} \times (T_2 - T_1)$$

CALCULATION:

RESULT: HCV of given fuel is _____

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

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 and spirit Level.

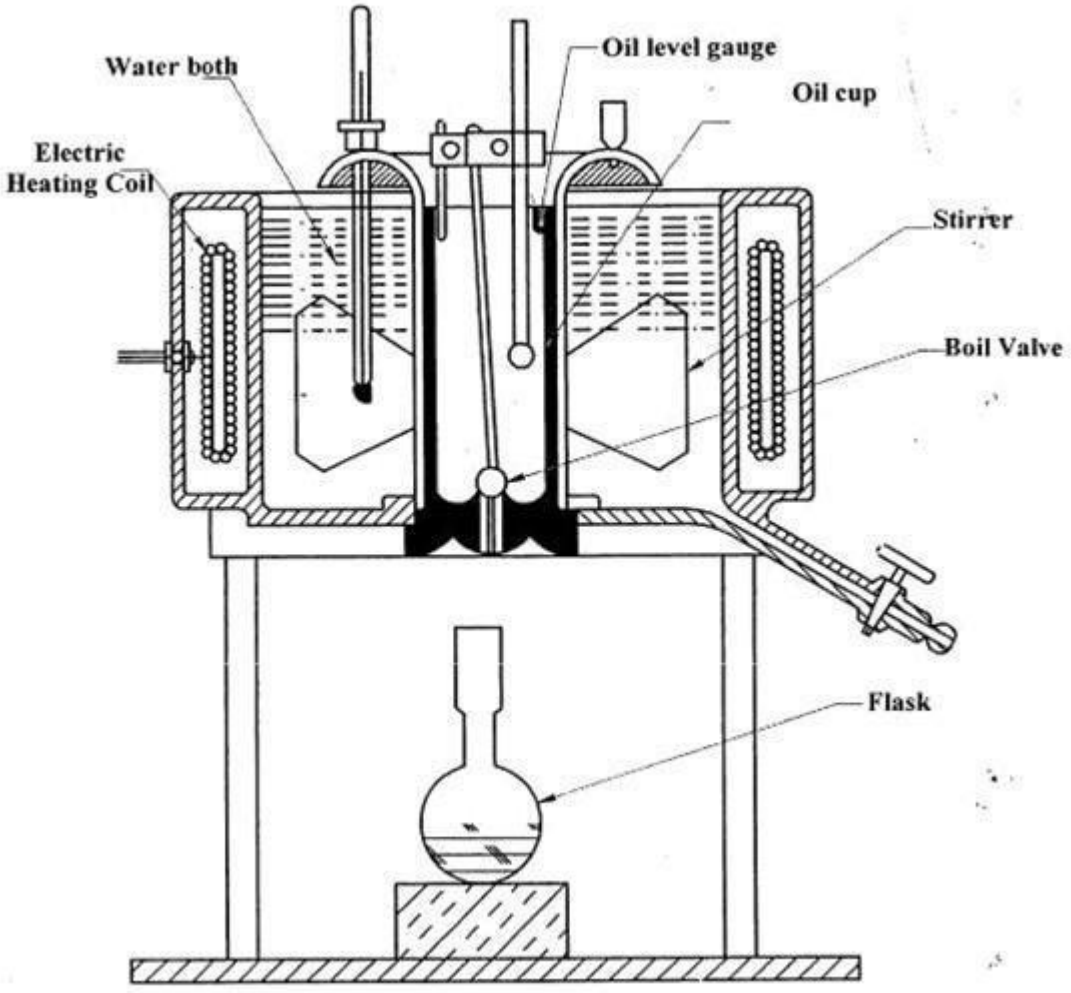


Figure: Redwood Viscometer Apparatus

THEORY:

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

Write the theory on following topics

1. Red wood viscometer description
2. Definition of absolute viscosity ,kinematic viscosity, viscosity index.
3. Grading of lubricants ,single grade, multi grade oils.
4. Derivation of viscosity formula.

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.

OBSERVATION:

1. Type of oil.

TABULAR COLUMN:

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 60cc of oil in seconds

ρ = Density of oil, kg / m^3

$$\rho = \frac{m}{60 \times 10^{-6}}$$

S=Specific gravity of the oil,

$$S = \frac{\rho}{1000}$$

RWN= Red Wood Number

$$RWN = \frac{100 \times S \times t}{535 \times 0.915}$$

ν = Kinematic viscosity, m^2/ s

$$\nu = \left[0.26t - \frac{179}{t}\right] \times 10^{-6} \quad \text{----------} \rightarrow (t = 34\text{-}100)$$

$$\nu = \left[0.247t - \frac{50}{t}\right] \times 10^{-6} \quad \text{----------} \rightarrow (t = 100\text{-}200)$$

μ = Absolute viscosity, N-s/m^2

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

CALCULATION:

GRAPHS: 1) μ V/s T 2) ν V/s T

RESULT: Kinematic Viscosity of given oil_____at temperature of _____

Absolute Viscosity of given oil_____at temperature of _____

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

EXPERIMENT 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.

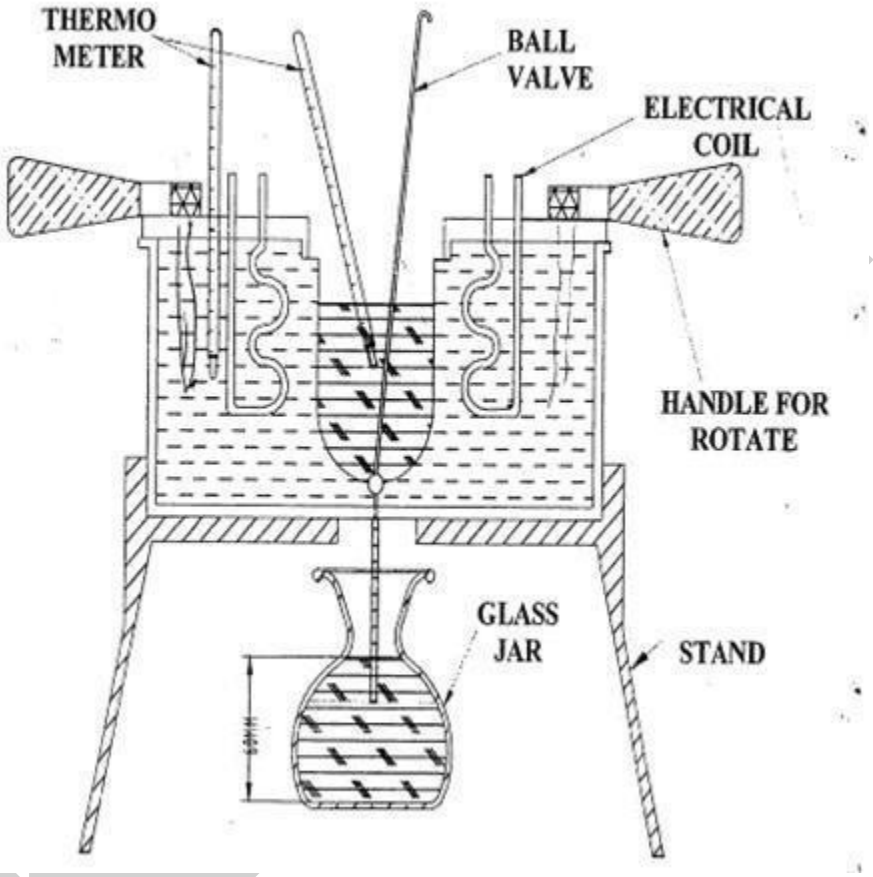


Figure: Saybolt Viscometer

THEORY:

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.

Write the theory on following topics
1.Saybolt viscometer description
2.Derivation of viscosity formula.

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.

TABULAR COLUMN:

Sl. No.	T ^{0}C	m_1 kg	m_2 kg	m kg	t 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

t = Time taken for collecting 60cc of oil in seconds

ρ = Density of oil, kg / m^3

$$\rho = \frac{m}{60 \times 10^{-6}}$$

ν = Kinematic viscosity, m^2/ s

$$\nu = \left[0.33t - \frac{0.12}{t}\right] \times 10^{-4}$$

μ = Absolute viscosity, N-s/m^2

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

CALCULATIONS:

GRAPHS: 1) μ V/s T 2) ν V/s T

RESULT: Kinematic Viscosity of given oil_____at temperature of _____

Absolute Viscosity of given oil_____at temperature of _____

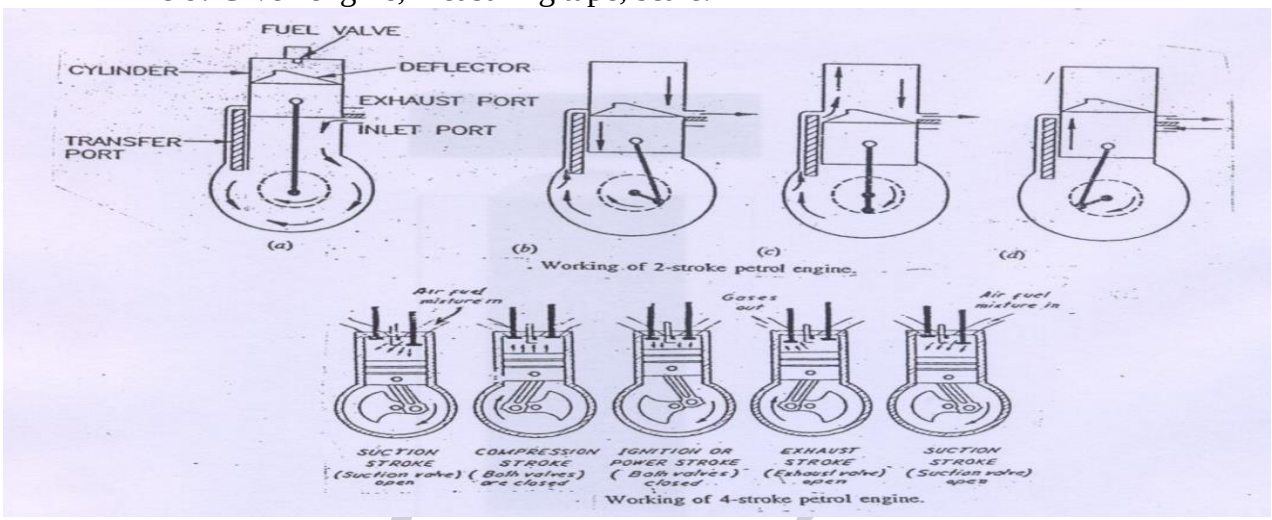
Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

EXPERIMENT NO. 6

VALVE TIMING DIAGRAM

AIM: To draw the value timing diagram of 4 stroke engine and port diagram of 2 stroke engine.

APPARATUS: Given engine, measuring tape, scale.



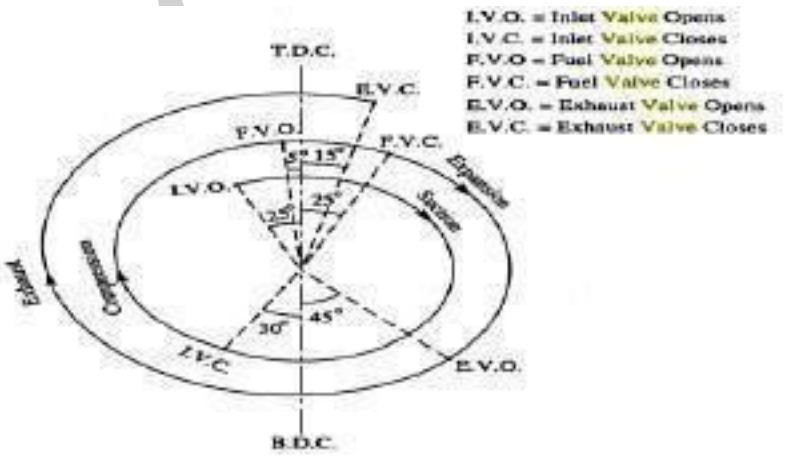


Figure : Valve Timing Diagram of A Four Stroke Diesel Engine

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. Draw the theoretical valve time diagram for 4- stroke SI engine.
e. Draw the theoretical valve time diagram for 2- stroke CI engine.

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

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 are recorded in the tabular column and corresponding angles turned (in degrees) are determined.

OBSERVATION:

1. Type of Engine.

TABULAR COLUMN:

Sl. No.	VALVE POSITION	PISTION POSITION	L (cm)	θ o
1				
2				
3				
4				
5				

Where

L = Arc length , cm

$$\theta = \frac{L \times 360}{\pi \times D}$$

θ *in degrees*

D=flywheel diameter

Name of the Stroke	Crank angle degree
Suction	
Compression	
Expansion	
Exhaust	

CALCULATION:

RESULT: The actual Valve timing diagram of 4 stroke engine and port timing diagram of 2 stroke engine are drawn.

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

EXPERIMENT NO. 7

PLANIMETER

AIM: To determine the area of irregular figure by using a planimeter.

APPARATUS: Planimeter.

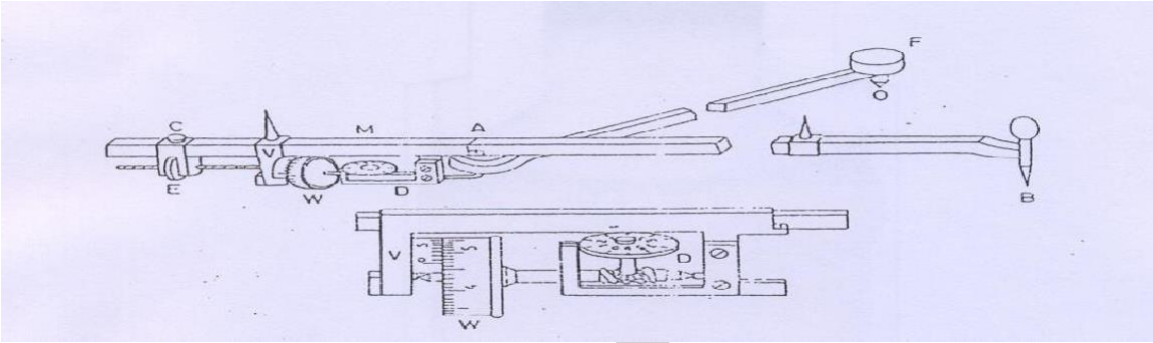


Figure : Planimeter

THEORY:

The planimeter mainly consists of :

a. Tracing arm with main scale, vernier scale, Rotating disc and rotating drum with vernier scale.
b. Pivot arm with a ball point at one end and a cylindrical weight with pin at the . other end.
c. Magnifying lens.

Write the theory on following topics

1. Different methods used for measuring irregular area.
2. Principle of planimeter.
3. Construction features of planimeter.

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.

OBSERVATION:

1. Type of Planimeter.

TABULAR COLUMN:

SL. NO.	SHAPE OF THE FIGHER	A_I mm^2	PLANIMETER READING			A mm^2	% ERROR $= \frac{A_I - A}{A_I} \times 100$
			I	F	M		
1	SQUARE						
2	CIRCLE						
3	TRIANGLE						
4	RECTANGLE						
5	IRREGULAR						

Where

A_I is the Theoretical area of the given shape, mm^2

I = Initial reading

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

F = Final reading

M = Multiplier of planimeter, 100

N = Number of times the rotating disc passed the fixed index mark (+ve CW,) (-ve CCW)

C = Constant of planimeter

A = True area of the given shape in mm^2.

CALCULATIONS:

RESULT:

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

PART-B

EXPERIMENT NO. 8

PERFORMANCE TEST OF A 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.

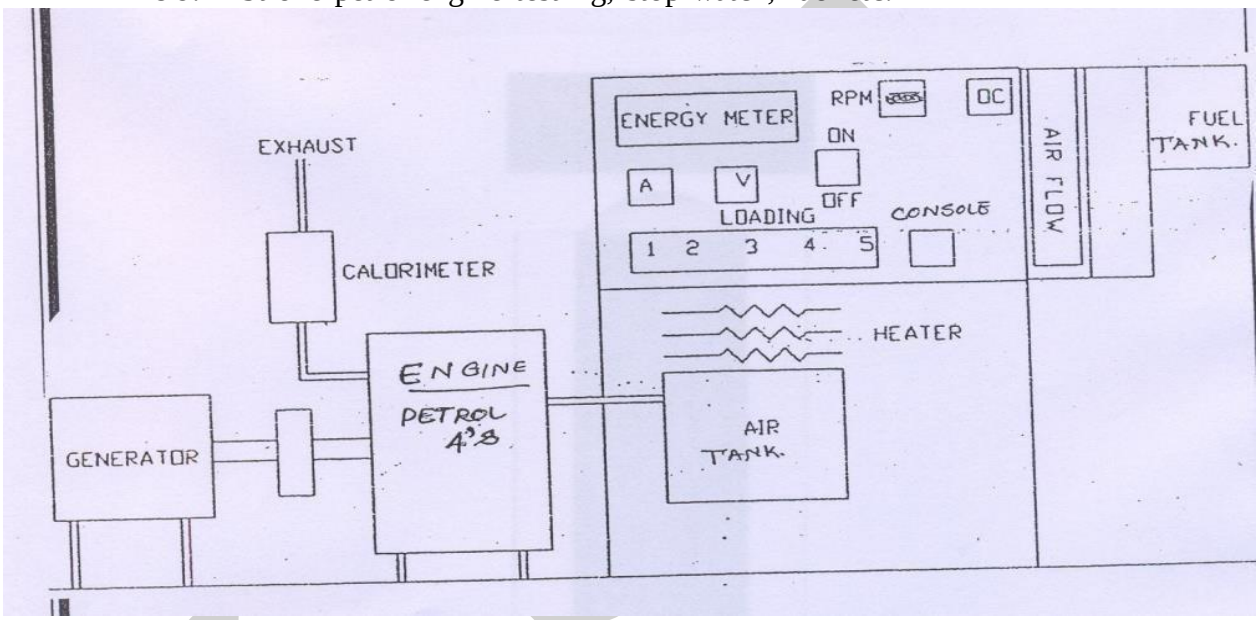


Figure : Block diagram of 4 stroke petrol engine test rig.

THEORY: Write the theory on following topics

- **a.** Define break power and what are the methods to measure BP.
- **b.** Define frictional power and what are the methods to measure FP.
- **c.** Define the indicated power and what are the methods to measure IP.
- **d.** Define mechanical efficiency.

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

1. The Rate of Fuel Consumption is measured by using Volumetric Pipette.
2. Air Flow is measured by Manometer, connected to Air Box.
3. The different electrical loading is achieved by loading the engine through eddy current dynamometer.
4. The engine speed is measured by electronic digital meter.

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

PROCEDURE:

1. Check the fuel in the tank.
2. Switch ON the power supply & console on the panel board and Ensure ignition switch in ON.
3. But keep the loading switches in off position initially. Allow the petrol and start the engine by using rope.
4. Apply the load AC generator by switching on loading switches. Allow some time until the speed stabilizes.
5. Repeat the procedure 4 to 5 different loads at constant speed i.e., 0.5KW load each.
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.

OBSERVATIONS: SPECIFICATION OF ENGINE :

Max power of the engine = 2.4KW

Rated speed = 3000rpm

Bore = 70mm

Stoke = 66.7mm

Compression ration = 4.76 : 1

Starting of the engine by rope

Loading – Eddy current dynamometer

Cooling – air cooling for the cylinder

Diameter of the orifice of the air tank intake = 0.01m

C_d of orifice = 0.62

TABULAR COLUMN:

Sl. No	E_l kW	t_f s	t s	h_w m H_2O	m_f kg/s	V_a m^3/s	m_a kg/s	BP kW	BSFC kg /kWh	Q_s kW	η_{bt}	η_v	A:F

Where

E_l= Electrical Load applied , kW

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

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

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

m_f = Mass of fuel kg/s

$$= \frac{Vf \times S}{1000 \times t} = kg/s$$

v_f = Volume of fuel consumed = 10cc

s = specific gravity of fuel

t = time taken for 10 cc fuel consumed, sec

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

Ta = Ambient temperature, K

m_a = Mass of air kg/s

$$m_a = \rho_a \times V_a$$

CV = Calorific value kJ/m^3

BP = Brake power kW

BP $= \frac{3600 \times n}{K \times t}$

n = Number of revolution of energy meter

K = 1500 energy meter constant

BSFC = $\frac{mf}{BP} \times 3600 = \cdots \ldots kg/kw$ h

$\eta_{bt} = \frac{BP}{Qs} \times 100\,\%$

A:F = $\frac{Ma}{Mf}$

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

Vs = 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

N = Number of revolutions of crank shaft per min

CALCULATION:

GRAPHS :

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

RESULT: The maximum brake thermal efficiency was found to be_____% at _____ load.

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

EXPERIMENT NO. 9

PERFORMANCE CHARACTERSTICS OF A VARIABLE COMPRESSION RATIO OF PETROL ENGINE

AIM: To determine the performance characteristics of a variable compression ratio of petrol engine test rig at different compression ratio and at a fixed speed.

.

APPARATUS: Variable compression ratio petrol engine test rig, air inlet tank, digital tachometer, energy meter, temperature indicator.

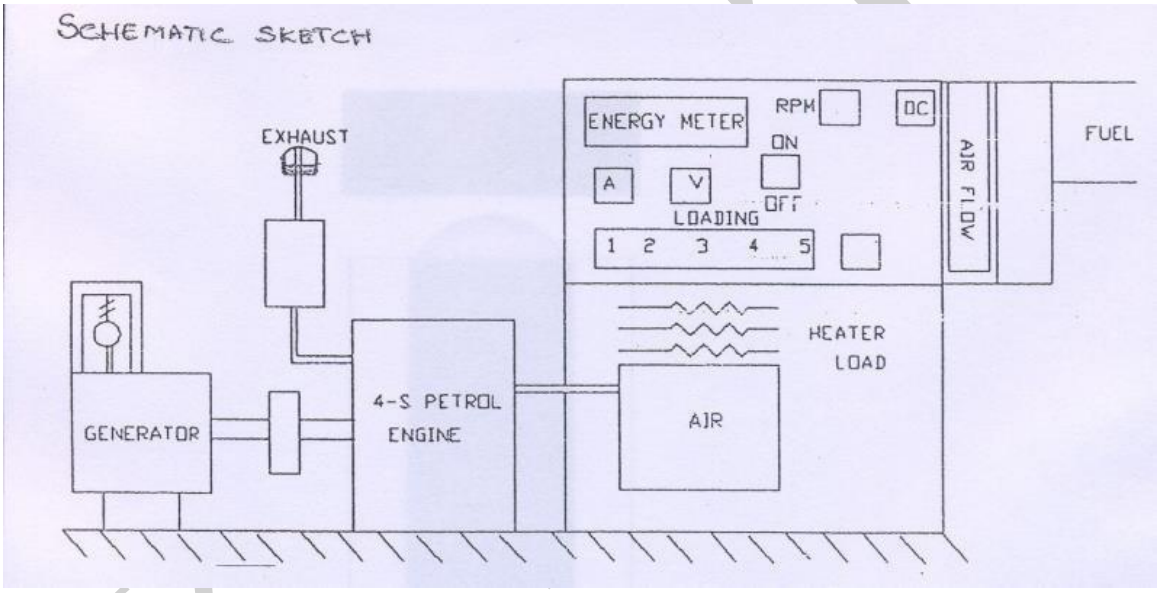


Figure : Block diagram of VCR 4 stroke petrol engine test rig.

THEORY : Write the theory on following topics

a. Define Specific Fuel Consumption.
b. What are the methods to measure fuel consumption?
c. Define compression ratio.
d. Define volumetric efficiency.
e. Define thermal efficiency.
f. Brake thermal efficiency.

PROCEDURE:

1. Fill the fuel tank with neat petrol.
2. Check the sufficient lubricating oil in the oil pump.
3. Connect the control panel to electrical mains ie., 440 volts, 3 phase, 15A neutral connection.
4. Select the compression ratio by using proper combination of head and spacer.

5. Keep the engine throttle to fully open position.
6. Put on the mains to check mains on indicator.
7. Put on the console, blower of DC machine is running and all the indicating instruments glow.
8. Block the dynamometer torque arm.
9. Push he start button so that engine starts.
10. Switch on the electrical loading resistance.
11. Unlock the torque arm and make it horizontal by taking the reading in spring balance.
12. For different load positions control the speed at constant valve. Take down the reading for different parameter and tabulate them.
13. After the experiment is over close the petrol valve inlet to the carburetor to avoid riching for subsequent start of engine.
14. Repeat the experiment for different compression ratio by maintaining the engine speed as constant.

TABULAR COLUMN:

STANDARD HEAD

Sl. No	E_l kW	t_f s	t s	h_w m H_2O	m_f kg/s	V_a m^3/s	m_a kg/s	BP kW	BSFC kg /kWh	Q_s kW	η_{bt}	η_v	A:F

HEAD

Sl. No	E_l kW	t_f S	t S	h_w m H_2O	m_f kg/s	V_a m^3/S	m_a kg/S	BP kW	BSFC kg /kWh	Q_s kW	η_{bt}	η_v	A:F

Where

E_l= Electrical Load applied , kW

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

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

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

m_f = Mass of fuel kg/s

$$= \frac{Vf \times S}{1000 \times t} = kg/s$$

v_f = Volume of fuel consumed = 10cc

s = specific gravity of fuel

t = time taken for 10 cc fuel consumed, sec

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

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

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

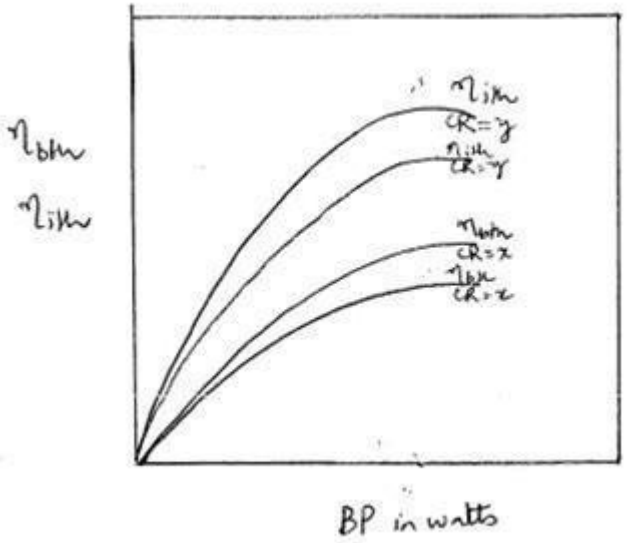
R= Gas Constant for air = 0.287 kJ/kgK

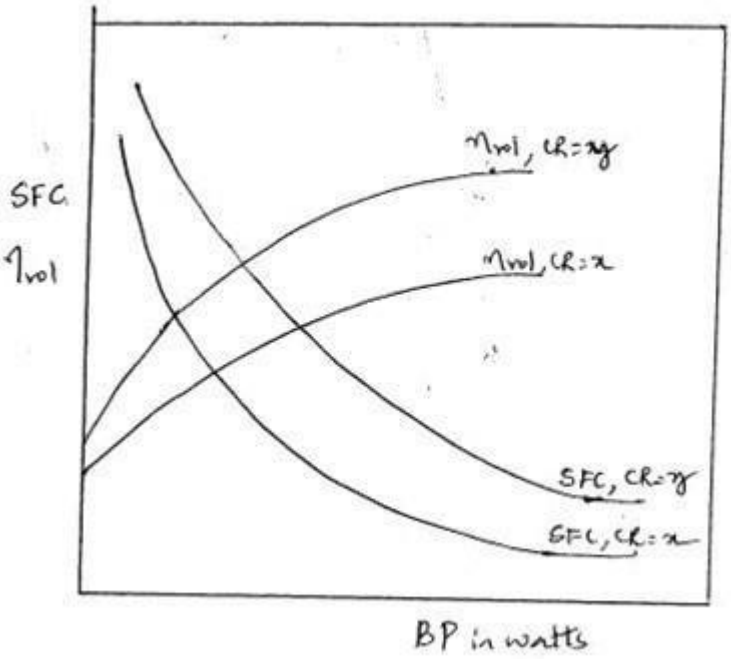
Ta = Ambient temperature, K

m_a = Mass of air kg/s

$$m_a = \rho_a \times V_a$$

CV = Calorific value kJ/m^3





BP = Brake power kW

BP = $\frac{3600 \times n}{K \times t}$

n = Number of revolution of energy meter

K = 1500 energy meter constant

BSFC = $\frac{mf}{BP} \times 3600 = \cdots \ldots kg/kw$ h

$\eta_{bt} = \frac{BP}{Qs} \times 100\ \%$

A:F = $\frac{Ma}{Mf}$

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

Vs = Swept volume of cylinder m^3/s

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

D = Diameter of cylinder, m

L = Stroke length , m

N = Number of revolution per min

CALCULATION:

GRAPHS :

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

RESULT:

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

EXPERIMENT NO. 10

PERFORMANCE TEST ON A 4-STROKE VERTICAL SINGLE CYLINDER DIESEL ENGINE

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

APPARATUS: Single cylinder Diesel Engine Test Rig, stop watch, fuel, beaker, etc.,

THEORY:

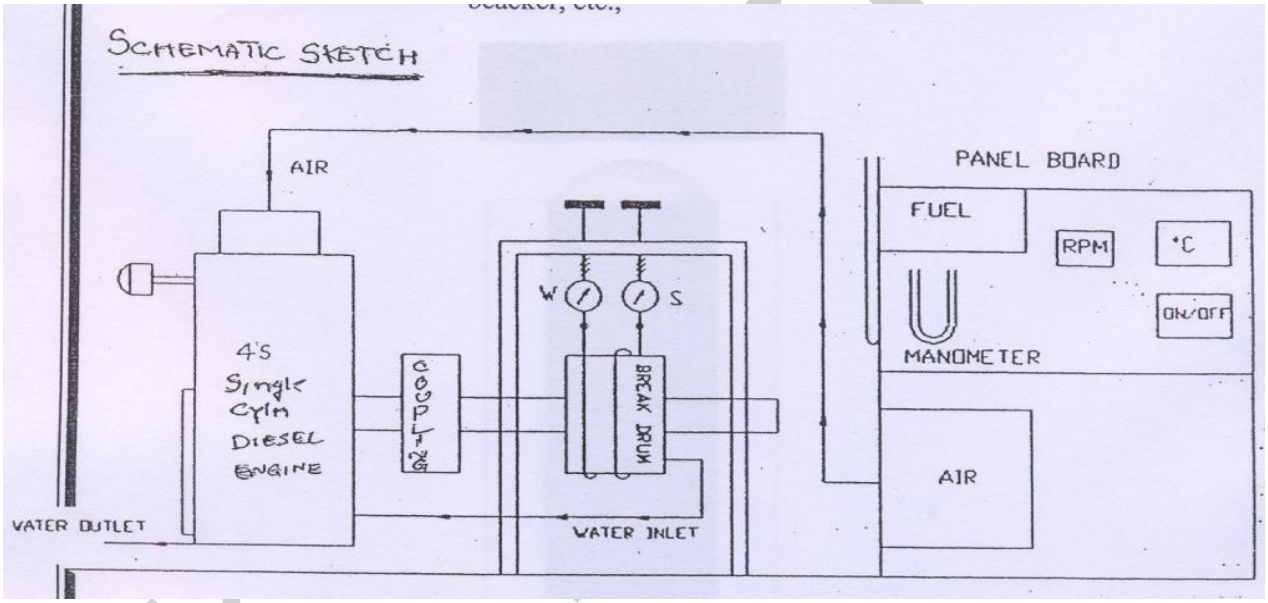


Figure : Block diagram of 4 stroke diesel engine test rig.

PROCEDURE:

1. Switch On the power supply to the panel board and Start the engine by cranking.
2. Maintain the speed of engine as constant and note down the speed.
3. The engine is loaded by applying the mechanical load on the brake drum and different reading are noted.
4. The temperature of cooling water at inlet and outlet is noted. The quantity of fuel supply is also measured.
5. The load on the engine is increased gradually and different readings are noted again the experiment is conducted for different loads 2kg, 4kg, 6kg, 8kg, and 10kg.
6. Note down all the readings and calculate the requirement

OBSERVATION:

Calorific value of diesel = 44100 kJ/Kg

Specific gravity of diesel = 0.8275

Compression ratio of engine = 16:1

Bore = 80 mm

Length of the stroke, L = 110mm

Rated speed of the engine = 1200rpm

Rated power 3.68 KW

Brake drum diameter = 350mm

Rope diameter = 0.015m

TABULAR COLUMN:

Sl. No	W kg	T N-m	t_f s	hw m of H_2O	t s	T_1 °c	T_2 °c	Ta °c	Tg °c	m_f kg/s	Va m^3/s	ma kg/s	BP kW	BSFC kg /kWh	Q_s kW	η_{bt}	η_v

Sl.No	A:F	FP	IP	η_m

Where

W= Applied Load, kg

T = Torque , N-m

$T = (W - S) \times Re \times 9.81$

Re = Effective diameter = $\frac{D+d}{2}$ m

D= Diameter of the drum

d = Diameter of rope

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

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

t = Time for collecting 1 liter of water.

T_1 = Water inlet temperature ^{0}C

T_2 = Water outlet temperature ^{0}C

T_a = Air inlet temperature ^{0}C

T_g = Exhaust gas temperature ^{0}C

m_f = Mass of fuel kg/s

$= \frac{vf \times s}{1000 \times t} = kg/s$

v_f = Volume of fuel consumed = 10cc

s = specific gravity of fuel

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,

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

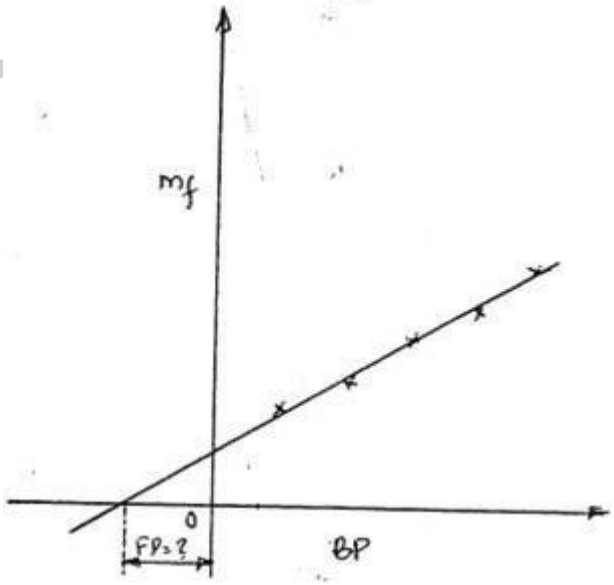
d_o = Diameter of Orifice, m

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

Ta = Ambient temperature, K

m_a = Mass of air kg/s

$$m_a = \rho_a \times V_a$$

CV = Calorific value kJ/m^3

BP = Brake power kW

$$BP = \frac{2\pi N T}{6000}$$

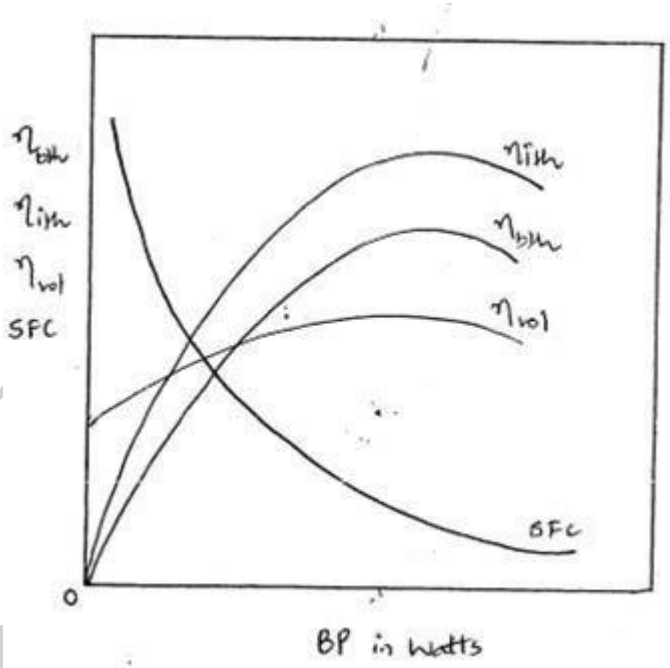
N = Number of revolution of crank shaft per minute

$$BSFC = \frac{mf}{BP} \times 3600 = \cdots \ldots kg/kw \text{ h}$$

Q_s = Heat supplied , kW

$Q_s = m_f \times CV$

CV = Calorific value of fuel



$$\eta_{bt} = \frac{BP}{Qs} \times 100\ \%$$

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

Vs = 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

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

FP = Frictional power, kW (From Graph)

IP = Indicated power , kW

IP = BP + IP

η_m = Mechanical Efficiency

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

Heat Balance Sheet on minute basis:

Sl.No.	Details	Heat in kJ/min	%
1	Heat supplied Qs		
2	Heat equivalent of BP		
3	Heat equivalent of Friction power		
4	Heat absorbed by cooling water		
5	Heat carried away by exhaust gasses		
6	Unaccounted heat equivalent		
	Total		

1. Heat supplied by fuel $Q_s = m_f \times CV \times 60$

2. Heat equivalent to Brake power = BP $\times$ 60 , kJ / min

3. Heat equivalent to Frictional power = $F_p \times 60$, kJ/min

4. Heat absorbed by cooling water, = $m_w C_{pw} (T_2-T_1)$, kJ/min

   Mass of water = Vol. Of water collected x 60/ time, kJ/min
   i.e. 1 lts and C_{pw} = 4.187 kJ/kg ^{0}C

5. Heat carried away by exhaust gasses = $m_g \times C_{pg} \times (T_g-T_a)$

   $\therefore m_g = m_a + m_f$

Unaccounted heat equivalent = 1-2-3-4-5, kJ /min

CALCULATIONS:

GRAPHS :

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

RESULT:

Date of Commencement	SIGNATURE OF STUDENT	**Marks / Remarks:**
Date of finish	SIGNATURE OF STAFF	

VIVA QUESTIONS

1. **What is Viscosity ?**
   Viscosity is resistance for fluids to flow one layer over other layer.
2. **Where do you require this property.**
   Viscosity (OR) 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 ?**
   No, 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. Redwood seconds when redwood viscometer is used. It is also known as viscosity index or specific viscosity.
4. **What are the units of viscosity?**
   Absolute viscosity (or) dynamic viscosity
   Gm/cms (or) Poise centipoises
   Kinematic viscosity cm^2/s (or) centistokes.
5. **What is SAE?**
   SAE40 is more viscous than SAE30, at high temperatures but at low temperatures SAE30 is more visous than SAE40, some standard values are SAE20 – 58 SUS; SAE 30- 70 SUS; SAE 40-85 SUS;SAE 50- 110 SUS; at 98.8^0C etc.,
6. **What is the influence of structural composition on viscosity of oils?**
   The 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?**
   50 ml.
8. **What is the quantity of oil to be collected with saybold viscometer /**
   60 ml.
9. **What castor oil is not used as lubricating oil in IC engines?**
   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 i.c. engines.
10. **What is Flash point ?**
    It is the minimum temperature at which oil vapours give a momentary flash when a naked flame is introduced into the vapours.
11. **What is Fire point ?**
    It is the minimum temperature at which oil vapours burn continuously when a naked flame is introduced into the vapours.
12. **What is the significance of the test?**
    Knowing the flash point will indicate the crude from which the tested oil is derived from standard tables, similarly any adulteration can be found out. 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 point0.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 /

Cleveland (Open cup) apparatus Pensky Marten's (closed cup) apparatus Abel's (closed cup) apparatus.

14. Which gives more accurate values ?

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 instrumented shell give accurate values. However, the fire point determinate by closed cup has no significance.

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

Fire point will be greater than flash point by 2 to 5^0 c.

16. How can you identify flash point ?

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

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

The heating is very rapid in the case of Pen sky 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?

The flame should be introduced into the vapours at every degree raise in temperature.

19. What is calorific value?

It is deified as the amount of heat energy liberated by the complete combustion of 1 kg fuel or $1m^3$of fuel (at STP).

20. What is HCV?

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 $1m^3$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?

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

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

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

23. For What type of fuels bomb calorimeters used?

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?

H.C.V.

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

L.P.G

26. What is pressure?

Pressure is the force exerted per unit area.

27. What is absolute pressure?

Absolute pressure is the total pressure which is equal to the sum of atmospheric pressure and gauge pressure if pressure is greater than atmospheric .if pressure is less than atmospheric; absolute pressure is equal to the difference of atmospheric and the vacuum gauge pressure.

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

Dead weight pressure gauge.

29. Why calibration is required?

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

30. What is a thermocouple?

Thermocouple is a device which consists of two dissimilar and fixed together at 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?

Copper-constantan, Iron-constantan, Chrome-Alumel

32. What is V.T.D?

Valve time diagram which is drawn for 4-stroke engines

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

During 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 tappel 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 be checked?

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

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

Feeler gauge and push rod will get lightened.

36. When are the valves are to be opened and closed?

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 values 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?

Inlet valve will be opened 10^0 to 25^0 before TDC(IDC) and closed 25 t0 40^0 after BDC(ODC) The suction process shall take place 225^0 to 250^0 C.A. The aim is to introduce as much quantity of change as possible.

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

Exhaust value will be opened 25 to 40^0 before BDC.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 as much of products of combustion out as possible.

39. What is valve over lap ?

It is the period during which both the valves are opened.

40. What is charge in S.I or petrol engine?
Air-fuel mixture.

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

42. What is the change for an I.C.engine?
The quantity that enters the engine cylinder during suction stroke.

43. What are TDC.& BDC for an horizontal engine ?
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 ?
In SI 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 follows otto cycle.
In CI 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 ignition in CI Engines at number of favourble spots. Compression ratio is 12 to 25.Follows diesel cycle.
In present day high speed CI Engine the compression ratio is 8 to 12 and works on dual cycle. The SI Engine are compact and high speed engine. The CI Engine are bulky and are suitable for heavy vehicles or heavy duty power plant generator sets

45. What the differences between 2-stroke and 4-stroke engines ?
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.
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 ?
SFC is the ratio of fuel consumed to BP.i.e it is fuel consumed per unit power developed.it is determined to compare the performance of different capacity engines. It is 0.2 kg/KWh for CI Engine, 0.35 kg/KWh for SI Engines

48. What is brake thermal efficiency ?
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 ?
It is the ratio of the actual mass drawn into the cylinder to the theoretical mass that can be drawn. It is constant for CI engines about 80% and for SI engines it increases with increase in load. In the case of compressor the volumetric efficiency decreases with increase in pressure

50. What is indicated power & brake power?
Indicated power is the power available in the engine cylinder where as brake power is the power available at the crank shaft or power out shaft.l.p-b.p.=FP (frictional power).

51. What is maximum load for an engine?

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

52. Why the engine are run at the rated speed?

As the load on the engine decreases, the speed increases and as the load increases, the speed decreases. To run the engine at the rated speed at which the performance will be the best, fuel quantity is varied.

53. What is governing?

Governing is the process of running the machines at rated speed.

In SI engine quantity of air fuel mixture is varied hence it is quantitative governing or throttle governing. In CI 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 SI & CI engines ?

For SI engines 6:1 to 18:1 has both lean & rich limit.22:1 is the lease limit

For CI engines it varies from 90:1 to 25:1

55. Define relative efficiency.

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?

Air cooled engines have fine (extended surfaces) which increases the heat transfer from the cylinder by providing more area. Water cooled engines have water jacket around the cylinder.

57. What is compression ratio?

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

58. What is clearance ratio?

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

59. What is a compressor?

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?

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 clearance volumetric efficiency of compressor?

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

62. Why multistage compression is preferred ?

If the compression is performed in stage the work required for compression gets decreases. 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 compression.

$n/n-1.p_1v_1[(p_{2/}p_1)^{n-1/n}-1]$

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

$P_2=\sqrt{p}_1p_2$

Intermediate pressure is the geometrical mean of supply and delivery pressure. Minimum work required /cycle $=2n/n-1\ p_1v_1\ [(p_3/p_1)^{n-1/2n}-1]$

65. What is meant by stage of compression ?

If compression is done in two cylinder it is known as 2-stage compressor. Air will be drawn into the LP 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).

If there are more than two cylinders intermediate cylinders are used.

66. What is single acting and double acting cylinders ?

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 will be complete 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?

It is the ration of the indicated power required to the actual power required (BP)

68. What approach is followed in thermodynamics?

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?

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?

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?

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?

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?

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

74. What is thermodynamic equilibrium?

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?

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.

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 1st law of thermodynamics?

Energy is a property.

78. What is steady flow process?

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

79. What is the quasistatic process?

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?

P dv

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

Vdp

82. What are different names for constant volume process?

Isometric process,

83. What are different names for constant pressure process?

Isobaric or isopiestic process.

84. What are different names for constant temperature process?

Isothermal process or hyperbolic process.

85. What is a reversible adiabatic process?

Isentropic process.

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

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 an enthalpy process?
Throttling process or wire drawing process.

88. What are the limitation of first law of thermodynamics?
It do not say whether a particular process is possible or not.it do not specify the extent of conversion of heat into work.

89. Which are the high grades of energy?
Work, electrical work, K.E.etc.,

90. Which is the low grade form of energy?
Heat energy.

91. Define Enthalpy.
Enthalpy is defined as the sum of internal energy and the product of pressure and volume for any system.
i.e.h = 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?
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 ?
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?
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?
A source is a high temperature reservoir and sink is a low temperature reservoir.

96. What is a reversible process?
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 renders a process irreversible?
Friction heat transfer between finite temperature difference mixing of two gases, unrestrained expansion, electrical resistance, magnetic effects etc.,

98. What is available energy?
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?
Loss in available energy is known as irreversibility.

100. What is irreversibility during an heat r=transfer process with temperature T1 & T2 ?
Irreversibility $=T_o\Delta s$
$=T_o[(Q/T_2)-(Q/T_1)]$
Where T_o is dead state temperature "Q" is heat transferred.

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

It is impossible to construct a device which operates in a thermodynamic cycle and does certain net positive work and exchanging heat with a 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.

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.

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

105. Define C.O.P.

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

106. Define COP of a refrigerator.

In refrigerator, refrigerating effect (cooling) is the desired effect COP is defined as the ratio of Refrigerating effect to the energy supplied.

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

Here the desired effect is the heat rejected COP of heat pump is defined as the ratio of heat rejected to the energy supplied.

108. What is the relationship between COP of heat pump and COP of refrigerator?

COP of heat pump –COP of refrigerator =1.

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

Law of degradation of energy.

110. What is entropy?

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.

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?

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

113. What is clausius inequality?

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

114. What is PMM –III?

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?

It is an hypothetical or theoretical pressure which when acts through out the stroke length of the piston will produce the same work as that of the actual cycle or engine.

MEP = [work / cycle] / Stroke volume

116. Give the relation for BP.

BP = πdNw / 60 KW Where 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.

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

118. Give relation for FP

IP-BP = FP.

119. What is Willian's line ?

It is a curve drawn f.c. Vs BP 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?

It is a constant speed test for multi cylinder engine in which the ignition is cut off successively (in SI 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?

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?

A pure substance is one which is having uniform chemical composition through out. It can exist in all three forms. Eg: Steam refrigents etc.,

123. What is Gibb's phase rule?

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 of water?

0.01 ^{0}C and 0.006113 bar

125. What is critical point of water?

374.14^0 C and 221.13 bar

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

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

127. Which engines are most suitable for supercharging?

CI engines are most suitable. However racing vehicles of SI engines type also use supercharging to reduce the size or bulk.

128. What are the affects of super charging?

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?

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?

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?

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?

In SI 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?

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 vapour 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 petrol 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?

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 vapour 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?

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 follows joule or Brayton cycle (Constant pressure heat addition cycle).

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

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

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

Normal heptanes ($C_7 H_{16}$). This is considered as the worst (or very poor) fuel for SI engines.

138. How the SI engine fuels are rated?

The SI engine fuels are rated by octane number (O.N.)

Octane number is defined as the percentage by volume of iso octane in a mixtue 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?

ON = 100 + (PN-100) / 3

And 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 SI engine fuels?

Additives are the compounds, which shall increase the knock resistance of s.i. engine fuels. They are tetra methy! Lead (TML) AND Tetra Ethy! Lead (TEL). Now a days these additives are banned as they cause lead poisoning.

141. What is the rating of CI engine fuels?

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 CN?

CN 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?

The higher the OP the better it is suited for SI engines and has less CN which cannot be used in C.I. engines and vice-versa.

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

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

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 IC engine fuels.

145. What is detonation in SI engines?

It is an abnormal combustion taking place in SI 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 with out 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 influences detonation?

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 SI 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?

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

148. Explain surface ignition.

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.

Some times 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 SI engines.

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 uses over head valve engines.

150. Explain the combustion phenomenon in CI engines.

The combustion in C.I. engines is similar to combustion of heterogeneous mixtures, where as combustion in S.I. engines is 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 uncontrolled combustion. Once the fuel injection

starts the combustion will not be initiated instantly. Favourable 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 uncontrolled buming 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 furbulence 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.

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 paraffins 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?

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.

REFERENCE BOOKS:

1. **Thermodynamics , An engineering approach**, Yunus, A. Cengel and Michael A.Boies, 6th Ed., Tata McGraw Hill pub. Co., 2002,

2. **Fundamental of Classical Thermodynamics,** G.J. Van Wylen and R.E. Sontang Wiley eastern.

3. **Basic and applied Thermodynamics**, P.K. Nag, 2nd Ed., Tata McGraw Hill Pub. Co, 2002.

4. **Applied Thermodynamics**, Rajput, Laxmi Publication

5. **Applied Thermodynamics**, B.K. Venkanna, Swati B. Wadavadagi, PHI, New Delhi, 2010.

****