Department of Mechanical Engineering
Internal Combustion Engine Lab

Laboratory Incharge
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Actual Cut Section of 4-Stroke
Single Cylinder Diesel Engine

List of Equipments with Price

S. No.	List of Equipments	Date	Price (in Rs.)
1	Lubricating system in CI Engines	12.04.2018	9009
2	Single Cylinder Four Stroke Water Cooled Diesel Engine Test Rig	12.01.2015	51200
3	A Single Cylinder Two Stroke Petrol Engine Test Rig With Rope Brake Dynamometer	12.01.2015	43200
4	A Single Cylinder Four Stroke Petrol Engine Test Rig With Rope Brake Dynamometer	12.01.2015	51200
5	Actual Cut Section of 2-Stroke Petrol Engine	27.03.2015	16500
6	Actual Cut Section of 4-Stroke Petrol Engine	27.03.2015	22500
7	Actual Cut Section of 4-Stroke Diesel Engine	27.03.2015	25000
8	Carburetor - Solex Type (Actual cut section)	27.03.2015	2500

Total Cost- =2, 21,209/-

List of Major Equipments with Price

S. No.	List of Equipments	Date of Purchase	Price (in Rs.)
1	Single Cylinder Four Stroke Water Cooled Diesel Engine Test Rig	12.01.2015	51200
2	A Single Cylinder Two Stroke Petrol Engine Test Rig With Rope Brake Dynamometer	12.01.2015	43200
3	A Single Cylinder Four Stroke Petrol Engine Test Rig With Rope Brake Dynamometer	12.01.2015	51200

List of Equipments purchased in Last Three Years with Price

S. No.	List of Equipments	Date of Purchase	Price (in Rs.)
1	Lubricating system in CI Engines	12.04.2018	9009

LAB MANUAL

INTERNAL COMBUSTION ENGINE LAB

(ME-501)

IPS Academy, Indore

Institute of Engineering & Science

Mechanical Engineering Department

LAB MANUAL

Internal Combustion Engines

(ME-501)

Name ………………………………………………

Session ……………Semester ……………………..

Enrollment No. ……………..

Contents

Vision of the Institute

To be the fountainhead of novel ideas & innovations in science & technology & persist to be a foundation of pride for all Indians.

Mission of the Institute

M1: To provide value based broad Engineering, Technology and Science where education in students are urged to develop their professional skills.

M2: To inculcate dedication, hard work, sincerity, integrity and ethics in building up overall professional personality of our student and faculty.

M3: To inculcate a spirit of entrepreneurship and innovation in passing out students.

M4: To instigate sponsored research and provide consultancy services in technical, educational and industrial areas.

Vision of the Department

To be a nationally recognized, excellent in education, training, research and innovation that attracts, rewards, and retains outstanding faculty, students, and staff to build a Just and Peaceful Society.

Mission of the Department

M1: Imparting quality education to the students and maintaining vital, state-of-art research facilities for faculty, staff and students.

M2: Create, interpret, apply and disseminate knowledge for learning to be an entrepreneur and to compete successfully in today's competitive market.

M3: To inculcate Ethical, Social values and Environment awareness.

Program Education Objectives (PEOs)

PEO1: To enrich graduates with fundamental knowledge of Physics, Chemistry and advanced mathematics for their solid foundation in Basic Engineering science.

PEO2: To provide graduates to design the solution of engineering problems relevant to mechanical engineering design through the process of formulating, executing & evaluating a design solution as per need with socio-economic impact consideration and related constraints.

PEO3: To provide graduates with experience in learning and applying tools to solve theoretical and open ended mechanical engineering problems.

PEO4: To provide a contemporary grounding in professional responsibility including ethics, global economy, emerging technologies and job related skills such as written and oral communication skills and to work in multidisciplinary team.

PEO5: Prepare graduates to be interested, motivated, and capable of pursuing continued life-long learning through beyond curriculum education, short term courses and other training programme in interdisciplinary areas.

Program Outcomes (POs)

Engineering Graduates will be able to:

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

PO2: Problem analysis: Identify, formulate, and analyze mechanical engineering problems to arrive at substantiated conclusions using the principles of mathematics, and engineering sciences.

PO3: Design/development of solutions: Design solutions for mechanical engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: An ability to design and conduct experiments, as well as to analyze and interpret data.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to mechanical engineering problems with an understanding of the limitations.

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

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

PO8: Ethics: An understanding of professional and ethical responsibility.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10: Communication: Ability to communicate effectively. Be able to comprehend and write effective reports documentation.

PO11: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply this to Mechanical engineering problem.

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

Program Specific Outcomes (PSOs)

PSO1: Engage professionally in industries or as an entrepreneur by applying manufacturing and management practices.

PSO2: Ability to implement the learned principles of mechanical engineering to analyze, evaluate and create advanced mechanical system or processes.

Course Outcomes (COs)

CO1 Discuss the knowledge of internal combustion engine components and fuel Air cycles, Actual and theoretical Cycle.

CO2 Evaluate the Normal and Abnormal combustion aspect of SI Engines.

CO3 Evaluate the Concept of Normal and Abnormal combustion aspect of CI Engines and design of combustion chamber.

CO4 Utilize the concept of carburetion and working of Auxiliary system Ignition system, Lubrication system Fuel injector and nozzles.

CO5 Explain the methods of supercharging and turbo charging and their Importance.

Content beyond syllabus

1. Study of MPFI system used in modern vehicles.
2. Study of DTS-SI and contemporary technologies.

Laboratory Regulations and Safety Rules

1. Read the instructions mentioned in the manual carefully and then proceed for the experiment.
2. Mishandling of lab equipment will not be tolerated at all. If any student is found guilty; he/she should be punished/ discarded from the lab.
3. Care must be taken while dealing with electrical connections.
4. Issued the needed/ supporting equipments by the concerned teacher/lab technician & return the same duly before leaving the lab.
5. If any defect or discrepancy noticed in the particular instrument/equipment while the students are using, they will be fined/ punished for the same.
6. Put your bags on the rack outside the lab before entering in lab.
7. Switch off the lights, fans and all the equipments used, before leaving lab.
8. Students will replace their chairs to its specific position before leaving the lab.

INDEX

S. No.	Experiment	Date	Grade	Signature
1	To Study the construction details & working principal of 2-Stroke / 4- Stroke Petrol Engine.			
2	To study the constructional details & working principles involved in a 2-Stroke & 4-Stroke Diesel Engines.			
3	To Prepare Heat Balance Sheet for a Single Cylinder Two Stroke Petrol Engine Test Rig with Electrical Dynamometer			
4	To draw the heat balance sheet of a Four Stroke Single Cylinder Diesel Engine Test Rig.			
5	To draw the heat balance sheet and conduct a performance test on the Four Stroke Single Cylinder petrol Engine.			
6	To Study and Determine the effect of A/F Ratio on the performance of the Two-Stroke, Single-Cylinder Petrol Engine.			
7	To study and draw the valve timings diagram Four-Stroke, Single-Cylinder Diesel Engine.			
8	Study of the lubrication and cooling system in IC Engine.			
9	Study of carburetor.			
10	Study of ignition system.			

Experiment No.1

Aim: -To Study the construction details & working principal of 2-Stroke / 4- Stroke Petrol Engine.

Apparatus Used: - Models of 2-Stroke/4-Stroke Engines.

Theory: - The working Principle of Engines.

2-Stroke (S.I) Engines:

In a 2-Stroke engine, the filling process is accompanied by the change compressed in a crank case or by a blower. The induction of compressed charge moves out the product of combustion through exhaust ports. Therefore, no piston stroke is required. For these 2-strokes one for compression of fresh charge and second for power stroke. The charge conducted into the crank case through the spring loaded valve when the pressure in the crank case is reduced due to upward motion of piston during the compression stroke. After the compression & ignition expansion takes place in usual way. During the expansion stroke the charge in crankcase is compressed. Near the end of the expansion stroke, the piston uncovers the exhaust ports and the cylinder pressure drops to atmosphere pressure as combustion produced leave the cylinder.

Construction Details

1. Cylinder: - It is a cylindrical vessel or space in which the piston makes a reciprocating produces.
2. Piston: - It is a cylindrical component fitted into the cylinder forming the moving boundary of combustion system. It fits in cylinder perfectly.
3. Combustion Chamber: - It is the space enclosed in the upper part of cylinder, by the cylinder head & the piston top during combustion process.
4. Inlet Manifold: - The pipe which connects the intake system to the inlet valve of engine.
5. Exhaust Manifold: - The pipe which connects the exhaust system to the exhaust valve of engine.
6. Inlet / Exhaust Valves: - They are provided on the cylinder head to head to regulate the charge coming into or going out of the chamber.
7. Spark Plug: - It is used to initiate the combustion process in S.I engines.
8. Connecting Rod: - It connects piston & the crank shaft.

9. Crank shaft: - It converts the reciprocating motion of the piston into useful rotary motion of output shaft.
10. Gudgeon pins: - It forms a link between connection rod and the piston.
11. Cam shaft: - It controls the opening & closing of the valves.
12. Cam: - They open the valves at the correct tunes.
13. Carburetor: - Used in S.I engine for atomizing & vaporizing and mixture it with air in varying Proportion.

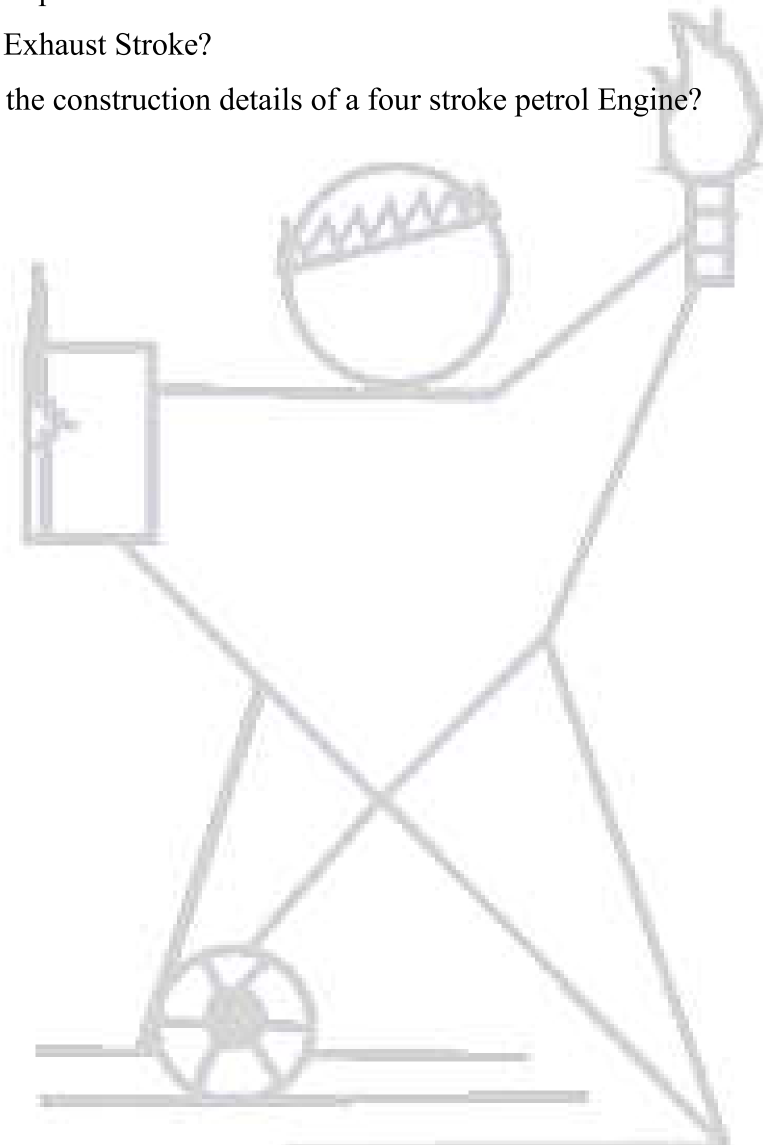
Four Stroke (S.I) Engine:

In a four stroke engine, the cycles of operations is completed in 4 strokes of piston or 2 revolution of crank shaft. Each stroke consists of 180° & hence the fuel cycle consists of 720° of crank rotation. The 4-Strokes are: -

- **Suction or Intake Stroke: -** In starts at, when the piston is at top dead centre & about to move downwards. The inlet valve is open at that time and exhaust valve is closed due to suction created by the motion of the piston towards the bottom dead centre, the charge containing air fuel mixture is drawn into the cylinder. When the piston reaches BDC the suction stroke ends and inlet valve is closed.
- **Compression Stroke:** The charge taken into the cylinder during suction stroke is compressed by return stroke of piston. During this stroke both the valves are closed. The mixture which fills the entire cylinder volume is now compressed into the clearance volume. At the end, the mixture is ignited with the help of electrode of spark plug. During the burning process the chemical energy of fuel is converted to heat energy. The pressure is increased in the end due to heat release.
- **Expansion Stroke:** The burnt gases escape out and the exhaust valve opens but inlet valve remaining closed the piston moves from BDC to TDC and sweeps the burnt gases out at almost atmospheric pressure. The exhaust valve gets closed at the end of this stroke. Thus, for one complete cycle of engine, there is only one power stroke while crank shaft makes 2 revolutions.
- **Exhaust Stroke:** During the upward motion of the piston, the exhaust valve is open and inlet valve is closed. The piston moves up in cylinder pushing out the burnt gases through the exhaust valve. As the piston reaches the TDC, again the inlet valve opens and fresh charge is taken in during next downward movement of the piston and the cycle is repeated.

Questions

1. Describe the working principle of 2-Stroke petrol Engine?
2. Describe the working principle of 4-Stroke petrol Engine?
3. What is Suction Stroke?
4. What is compression Stroke?
5. Describe Expansion / Power Stroke?
6. Describe Exhaust Stroke?
7. What are the construction details of a four stroke petrol Engine?



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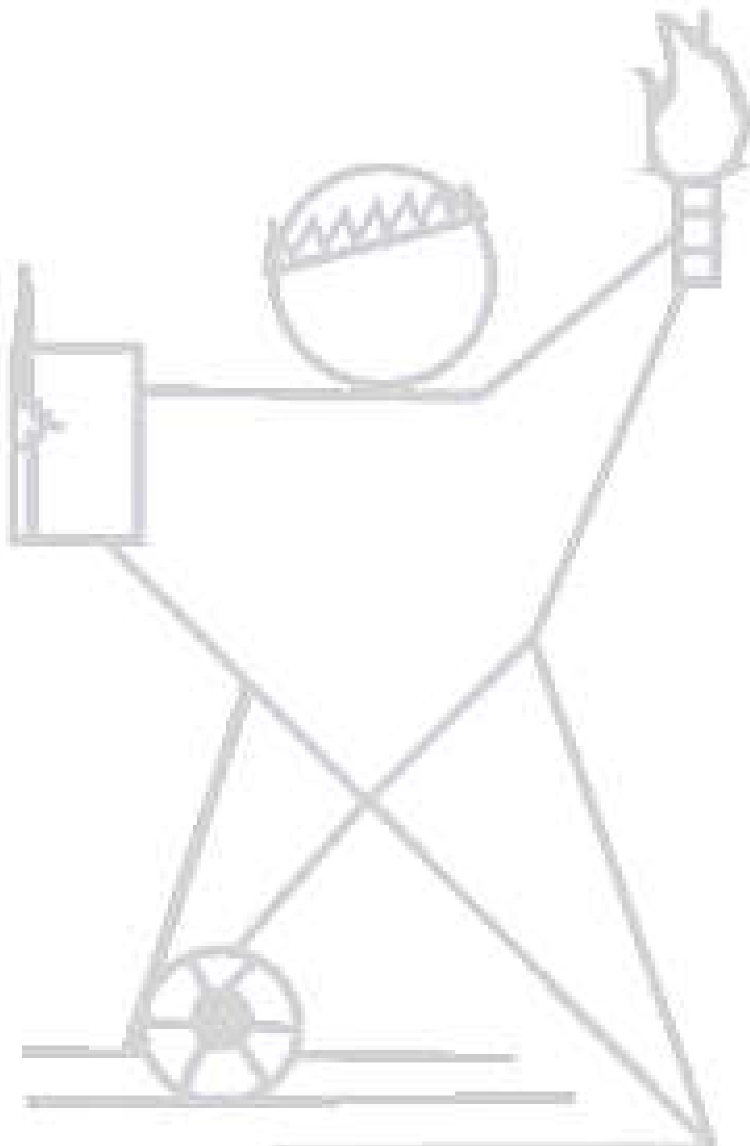

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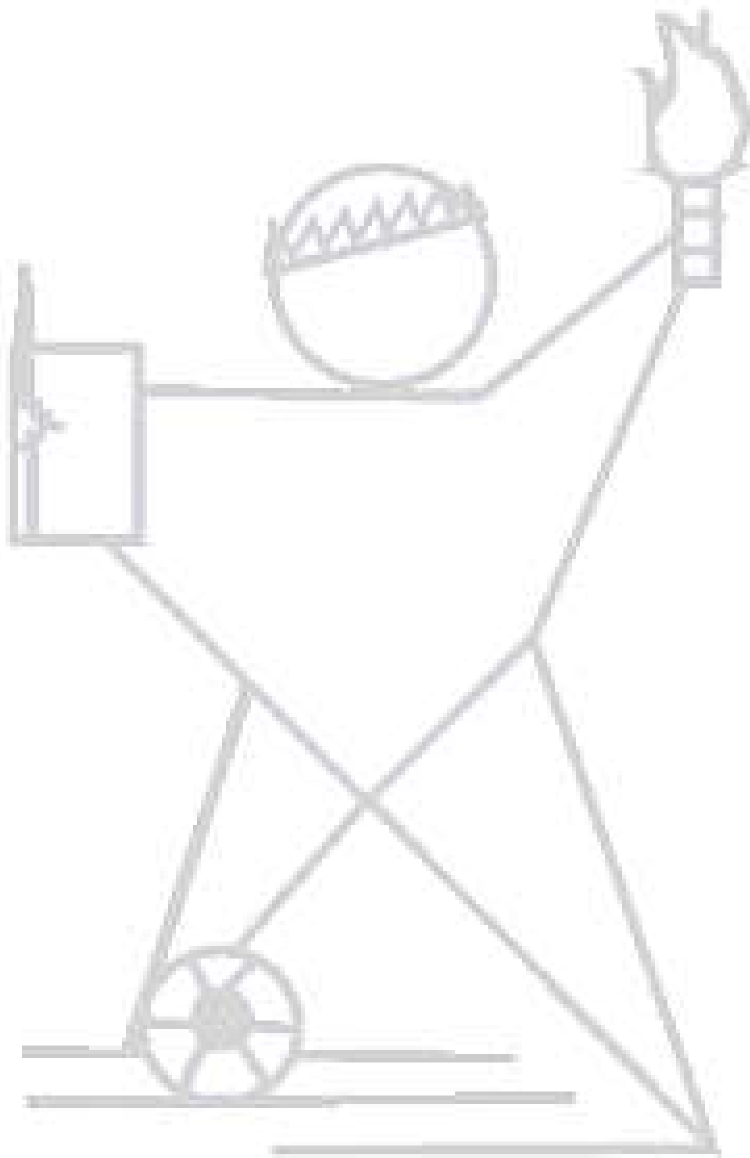


Experiment No.2

Aim: To study the constructional details & working principles involved in a 2-Stroke & 4-Stroke Diesel Engines.

Apparatus Used: Model of 2-Stroke / 4-Stroke Diesel Engine.

Theory:

Four Stroke (C.I.) Engine:

In four strokes C.I. Engine compression ratio is from 16 to 20. During suction stroke air is inducted. In C.I. engines high pressure. Fuel pump and injectors are provided to inject the fuel into combustion chamber and ignition chamber system is not necessary.

Construction Details

1. Suction: - During suction stroke, air is inducted through inlet valve.

2. Compression: - The air inducted is compressed into the clearance volume.

3. Expansion: - Fuel injection starts nearly at the end of the compression stroke. The rate of injection is such that the combustion maintains the pressure constant inspired of piston movement on its expansion stroke increasing the volume. After injection of fuel, the products of combustion chamber expand.

4. Exhaust: - The piston travelling from BQC to TDC pushes out the products of combustion out of cylinder.

Two Stroke (C.I.) Engine:

In two stroke engines, the cycle is completed in one revolution of the crankshaft. In 2-stroke engine, the filling process is accomplished by the charge compressed in crankcase or by a blower. The induction of compressed charge moves out of the exhaust ports. Therefore, no piston strokes are required for these 2 operations. Two strokes are sufficient to complete the cycle one for compressing the fresh charge and other for expansion or power stroke.

1. Compression: - The air or charge is inducted into the crankcase through the spring loaded inlet valve when the pressure in crankcase is reduced due to upward motion of piston.

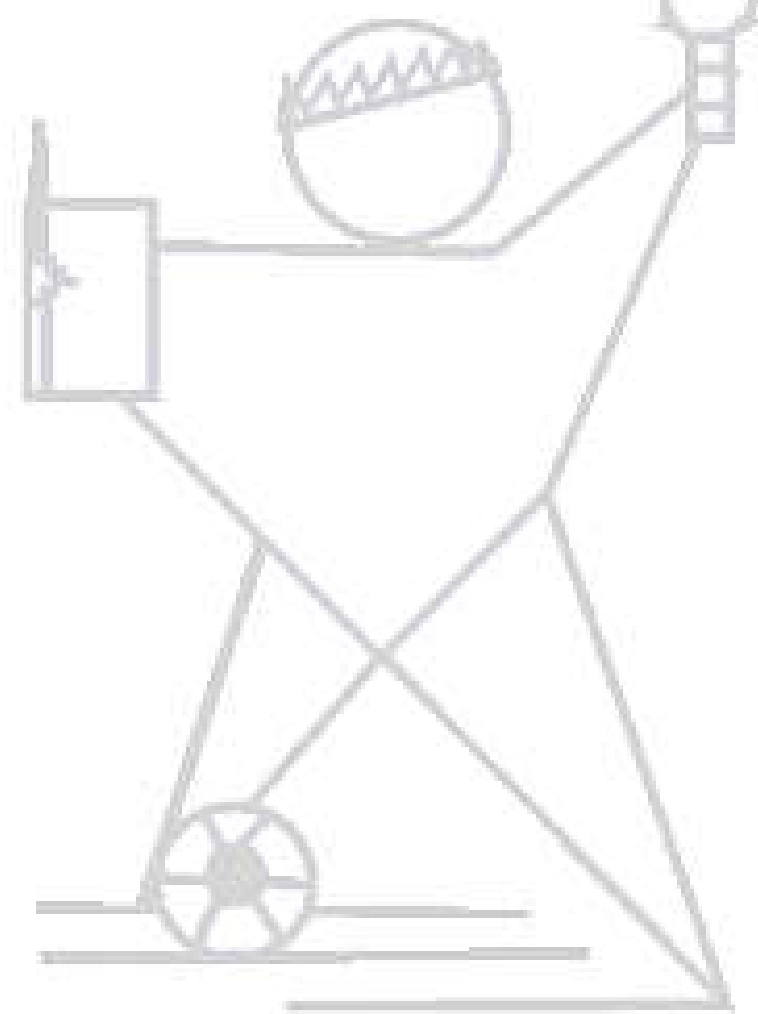
2. Expansion: - During this, the charge in the crankcase is compressed. At the end the piston uncovers the exhaust ports and cylinder pressure drops to the atmospheric pressure. Further movement of piston opens the transfer ports, permitting the slightest compressed charge in the crankcase to enter the engine cylinder.

Construction Details

1. Cylinder: - In it the piston makes a reciprocating process motion.
2. Piston: - It is a cylindrical component fitted into the cylinder forming the moving boundary of the combustion system. It fits into cylinder.
3. Combustion Chamber: - The space enclosed in the upper part of the cylinder, by the head and the piston top during the combustion process.
4. Inlet/ Outlet ports: - They are provided on the side of cylinder to regulate the charge coming in and out of cylinder.
5. Fuel Injector: - It injects the fuel in combustion chamber to initiate combustion process for power stroke.
6. Connecting Rod: - It interconnects crank shaft and the piston.
7. Fly Wheel: - The net torque imparted to the crankshaft during one complete cycle of operation of the engine fluctuates cow sing change in angular velocity of shaft. In order to achieve uniform torque an internal mass is attached to the output shaft & this is called as fly wheel.

Questions

1. Describe the working principle of 2-Stroke Diesel Engine?
2. Describe the working principle of 4-Stroke Diesel Engine?
3. Why Diesel Engines don't have spark plug??
4. Describe Expansion / Power Stroke?
5. What are the construction details of a four stroke Diesel Engine?
6. What is the main deference in 2-Stroke Diesel Engine and 4-Stroke Diesel Engine?



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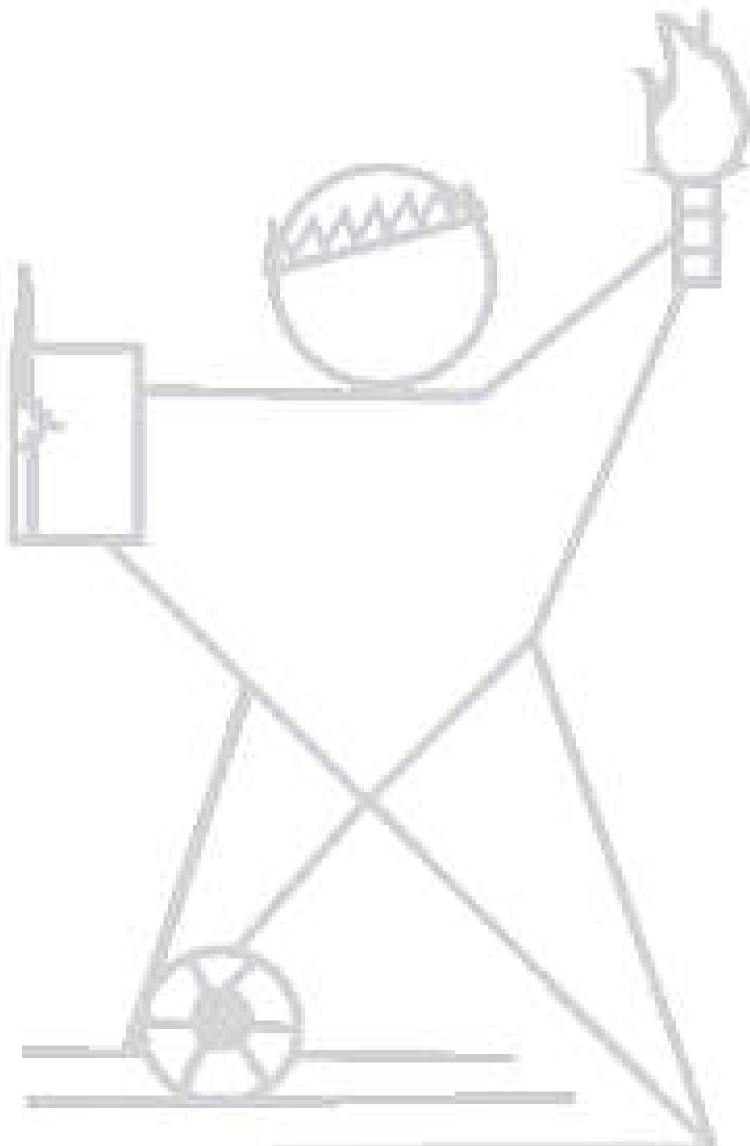

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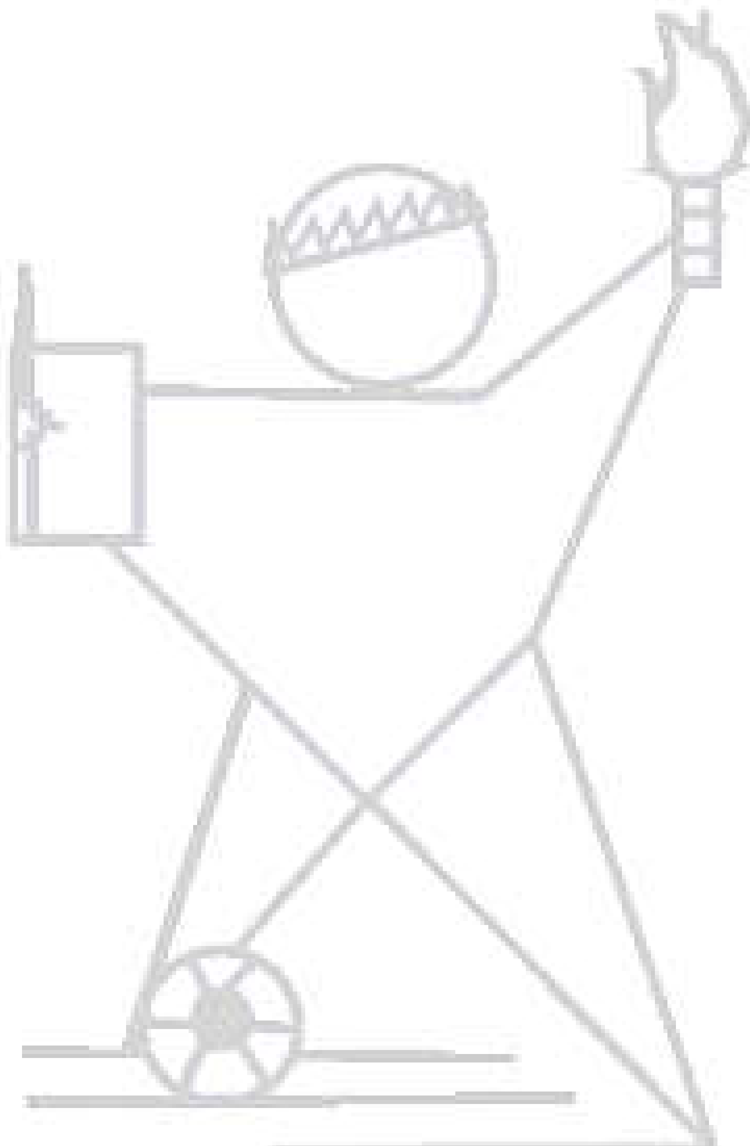

Experiment No.03

Aim: To Prepare Heat Balance Sheet for a Single Cylinder Two Stroke Petrol Engine Test Rig with Electrical Dynamometer.

Apparatus Used: Single Cylinder Two Stroke Petrol Engine Test Rig.

Theory: -

Introduction: Petrol Engines are widely used for various applications. Two stroke petrol engines are preferred for automobiles, because of their higher power to weight ratio and smooth operation. This test rig consists of a two stroke petrol engine coupled with electrical dynamometer. A loading arrangement provided to load the engine. Various measurements are provided so that performance of engine at various loads and speeds can be estimated.

Specification:

1) Engine – Two Stroke, Single Cylinder, and horizontal air cooled engine
2) Dynamometer – An electrical alternator is coupled directly to engine with heater as loading bank.
3) Orifice diameter – _ _ _ _ _ mm
4) Measurements & Controls –
   a) Calibrated burette for fuel intake measurement.
   b) Orifice meter with water manometer for air intake measurement.
   c) Exhaust gas calorimeter to measure heat carried away by exhaust gases.
   d) Multi-channel Digital Temperature Indicator.
   e) Ammeter & Voltmeter to measure the load.

Experimental Procedure:

1) Put sufficient petrol along with 2% self mixing 2 T oil in the tank.
2) Check oil level in the gearbox of the engine. If necessary add SAE-40 oil. Oil level should be always oil up to oil indicator hole.
3) Switch ON ignition switch.
4) Start the water supply to calorimeter.

5) Starter stitch is provided to start the engine. Otherwise alternate arrangement is also provided as, pull the choke and give a sharp kick, engine will start. As engine starts release the choke.
6) Slowly increase the accelerator and set the engine speed.
7) Put load on the engine by switching ON MCB one by one on heater bank.
8) Then close the burette cock and note down the time for 10 ml of fuel consumption, manometer difference, Ammeter, Voltmeter, calorimeter water flow rate and speed.
9) Note down the temperatures from T1 to T4.
10) Increase the load in steps by keeping the speed constant with the help of accelerator.
11) Repeat the procedure for different load.

Thermocouples Details –

T_1 = Water inlet temperature to calorimeter in ^0C

T_2 = Water outlet temperature from calorimeter in ^0C

T_3 = Exhaust gas inlet temperature to calorimeter in ^0C

T_4 = Exhaust gas outlet temperature from calorimeter in ^0C

Observation Table:

Sr. No	**Load (kg)**	**Speed (rpm)**	**h_1 mm**	**h_2 mm**	**Time for 10 cc of fuel consumption in sec**	**T_1**	**T_2**	**T_3**	**T_4**
1.									
2.									
3.									
4.									

Calculations:

1 Brake Power –

Brake power is given by

$$\mathbf{BP} = \frac{2\,\pi\,N \times T}{60 \times 1000} \quad \mathbf{kW}$$

Where, N = Crank shaft RPM and

T = Torque produced by the engine

2 Fuel Consumption –

Let time required for 10 ml of fuel consumption will be 't_f' sec

$$\mathbf{m_f} = \frac{10 \times 3600 \times \text{specific gravity of fuel}}{t_f \times 1000} \quad \mathbf{kg/hr}$$

Where, Specific gravity of petrol = 0.7

3. Specific Fuel Consumption –

$$\mathbf{sfc} = \frac{m_f}{BP}\,\mathbf{kg/kW\ hr}$$

4. Heat supplied by fuel –

$Q_f = m_f$ x calorific value of fuel

Where, calorific value of Petrol = 43,890 KJ / kg

5. Heat equivalent to BP –

HBP = BP x 3600 KJ / hr

6. Brake Thermal or Overall Efficiency –

$$\eta_{bth} = \frac{\text{Heat Equivalent to BP}}{\text{Heat supplied by the fuel}} \times 100\%$$

$$\eta_{bth} = \frac{HBP}{Q_f} \times 100\%$$

7. Air fuel ratio –

Mass flow of air $\mathbf{m_a} = \mathbf{C_d} \text{ x } \mathbf{A} \sqrt{\mathbf{2\ g\ H_{air}}}$ **x 3600 m^3 / sec**

Where,

C_d = coefficient of discharge = 0.62

A = area of orifice =

D = Diameter of Orifice = mm

g = 9.81 m / s^2

$$H_{air} = h_w \left(\frac{\rho_w}{\rho_a}\right) - 1 \text{ meter}$$

h_w = Manometer Difference Reading

ρ_w = density of water = 1000 kg / m^3

ρ_a = density of air = 1.193 kg / m^3

NOTE – Air consumption obtained is approximate because the carburetor design does not permit air tight entry from orifice.

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

Heat Balance Sheet:

Heat Carried Away by Exhaust Gases –

From heat balance of calorimeter

Heat gained by exhaust gases in calorimeter = Heat gained by water

$$m_g \times C_{pg} \times (T_3 - T_4) = m_w \times C_{pw} \times (T_2 - T_1)$$

There fore, $$m_g \times C_{pg} = \frac{m_w \times C_{pw} \times (T_2 - T_1)}{(T_3 - T_4)}$$

Where, m_{eg} = Mass flow of exhaust gases

c_{peg} = Specific heat of exhaust gases

m_w = Calorimeter water flow rate = lit / hr by using 1 lit Jar

c_{pw} = Specific heat of water = 4.18 KJ / kg ^{0}K

Hence, heat carried away by exhaust gases on ambient temperature basis

$$\mathbf{H_{eg}} = \boldsymbol{m_g} \times \boldsymbol{C_{pg}} \times (\boldsymbol{T_3} - \boldsymbol{T_1})$$

Precautions –

1) Check water supply and oil level in engine before starting the engine.
2) 2% 2T oil must be added to the petrol.
3) Never stop the engine on load.

Questions

1. What is volumetric efficiency?
2. What is air fuel ratio in two stroke single cylinder petrol engine?
3. What is air delivery ratio in two stroke single cylinder petrol engine?
4. What is tapping efficiency?
5. Define pressure lose co-efficient?

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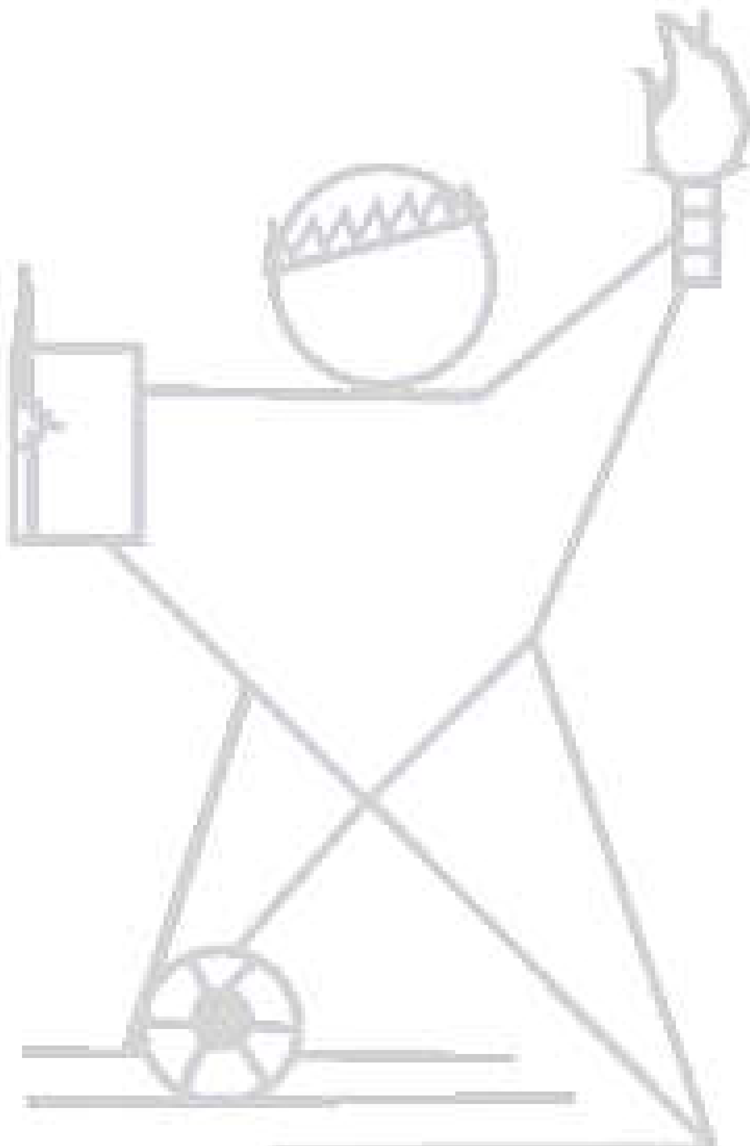

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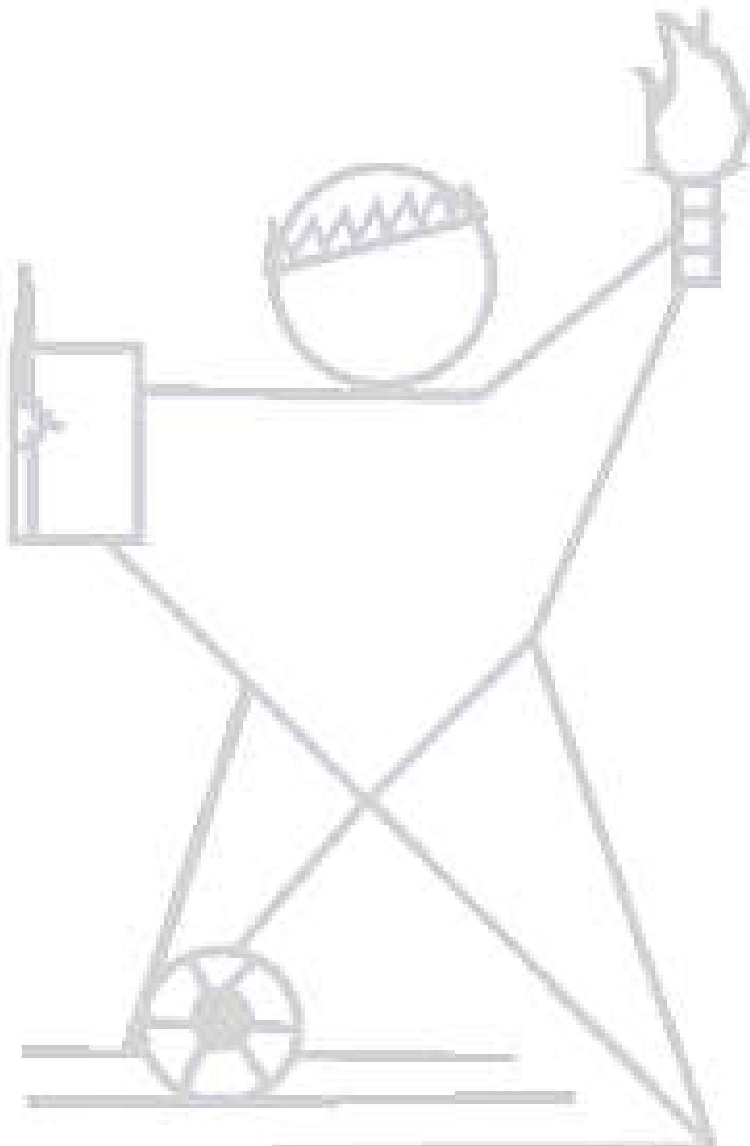

Experiment No.04

Aim: To draw the heat balance sheet of a Four Stroke Single Cylinder Diesel Engine Test Rig.

Apparatus Used: Four Stroke Single Cylinder Diesel Engine Test Rig.

Theory: -

Description: The Test Rig consists of a vertical single cylinder water cooled compression ignition type diesel engine. It is coupled to a loading dynamometer, which in this case is Rope Brake Dynamometer. All the components are mounted on heavy duty M S channel.

A desk type control panel consists of the following instrumentation –

Digital RPM Indicator to measure the speed of the engine.

1) Digital temperature indicator to measure various temperatures.
2) Differential manometer to measure quantity of air sucked into cylinder.
3) Burette with manifold to measure the rate of fuel consumed during test.

<u>Air Intake Measurement</u> –

The suction side of the engine is connected to an Air tank. The atmospheric air is drawn into the engine cylinder through the air tank. The manometer is provided to measure the pressure drop across an orifice provided in the intake pipe of the Air tank. This pressure drop is used to calculate the volume of air drawn into the cylinder.

<u>Fuel Measurement Arrangement</u> –

The fuel is supplied to the engine from the main fuel tank through a graduated measuring fuel gauge (Burette)

<u>Lubrication</u> – The engine is lubricated by mechanical lubrication.

Lubricating oil recommended – SAE-40 OR Equivalent.

Loading Arrangement –

Mechanical Rope Brake Dynamometer –

Basically, the brake drum is directly coupled to the engine flywheel and a rope brake wound around the brake drum. Both ends of the rope is connected to the spring balance separately. The load on the engine can be varied step by step by rotating hand wheel and stud provided on the dynamometer frame.

Specification:

Engine	Four Stroke Single Cylinder
BHP	5 HP
RPM	
FUEL	DIESEL
NUMBER OF CYLINDER	SINGLE
BORE	…….mm
STROKE LENGTH	…….mm
STARTING	CRACKING
WORKING CYCLE	FOUR STROKE
METHOD OF COOLING	WATER COOLED
METHOD OF IGNITION	COMPRESSION IGNITION

Rope Brake Dynamometer –

DIAMETER OF THE DRUM – mm

EFFECTIVE DIAMETER – mm

Procedure:

1) Fill up the <u>PETROL</u> into the fuel tank mounted on the panel frame.
2) Check the lubricating oil in the oil sump.
3) Connect the instrumentation power input plug to a 230 V, single phase power source. Now the digital meters namely, RPM and Temperature indicators display the respective readings.

To conduct the performance test on the engine –

4) Open the fuel valve and ensure no air trapped in the fuel line.
5) Start the engine and allow it to settle at rated speed.
6) Apply the load by rotating the hand wheel on the Dynamometer gradually to the desired load.
7) Note down all the required parameters mentioned below.
    a. Speed of the engine from digital RPM indicator.
    b. Load from the spring balance.
    c. Fuel consumption from burette.
    d. Quantity of air flow from manometer.
    e. Different temperatures from Temperature indicator.
8) Load the engine step by step and wait for some time in each step.
9) Note down the corresponding parameters.
10) Turn off the fuel knob provided on the panel after the test.

Observation:

R = radius of the arm at the end of dynamometer

= Effective brake drum radius (m)

D = Diameter of Orifice = 15mm = 0.015m

Density of Petrol = 0.75 gram / cc

Density of Water = ρ_w = 1000 kg / m^3

Density of Air = ρ_a = 1.193 kg / m^3

C. V. = calorific value of Diesel = 453556 KJ / kg

Diameter of Engine Bore = d = 87.5 mm

Length of Stroke = L = 110 mm

h_1 and h_2 = manometer readings in mm

Time required for 10 cc of fuel consumption =……… t sec (1ml=1cc)

Thermocouples Details:

T_1 = Water inlet temperature to engine jacket & calorimeter in ^0C

T_2 = Water outlet temperature from engine jacket calorimeter in ^0C

T_3 = Exhaust gas inlet temperature to calorimeter in ^0C

T_4 = Exhaust gas outlet temperature from calorimeter in ^0C

Observation Table

Sr. No	Load (kg)	Speed (rpm)	h_1 mm	h_2 mm	Time for 10 cc of fuel consumption in sec	T_1	T_2	T_3	T_4

Calculation:

Performance Test –

Break Power –

Brake power is given by $\mathbf{BP} = \frac{2\,\pi\, N \times T}{60 \times 1000}$ **kW**

Where, N = Crank shaft RPM and

T = Torque produced by the engine in N-m

= Spring Balance Difference x 9.81 x Effective Brake drum Radius

Mass of Fuel Consumed –

$$\mathbf{mfc = \frac{X \times 0.82 \times 3600}{100 \times t}} \quad \text{kg/hr}$$

Where, X = burette reading in cc

0.82 = density of Diesel in gram / cc

t = time taken in seconds.

Specific Fuel Consumption

$$\mathbf{sfc = \frac{mfc}{BP}} \quad \text{kg / kW hr}$$

Heat Supplied By Fuel

$\mathbf{h_f = mfc \times}$ **calorific value of fuel**

Where, calorific value of Diesel = 453556 KJ / kg

Actual Volume of Air Sucked in to the Cylinder

$\mathbf{V_a = C_d \times A \times \sqrt{2\,g\,H} \times 3600 \ \ m^3 / hr}$

Where, C_d = coefficient of discharge = 0.62

A = area of orifice =

D = Diameter of Orifice=………. (m)

g = 9.81 m / s^2

$$\mathbf{H = \frac{h \times \rho_w}{1000 \times \rho_a}} \quad \text{meter of water}$$

Where, h = Manometer Difference Reading

ρ_w = density of water = 1000 kg / m^3

ρ_a= density of air = 1.193 kg / m^3

Swept Volume –

$V_s = (\pi/4 \times d^2 \times L \times N/2)/60$

Where, d = diameter of bore = mm

L = length of stroke = mm

N = speed of the engine in rpm

Volumetric Efficiency –

$\eta_v = V_a / V_s \times 100\ \%$

Heat Balance Sheet:

Heat Carried Away by Exhaust Gases –

From heat balance of calorimeter

heat gained by exhaust gases in calorimeter = heat gained by water

$$m_g \times C_{pg} \times (T_3 - T_4) = m_w \times C_{pw} \times (T_2 - T_1)$$

There fore, $$m_g \times C_{pg} = \frac{m_w \times C_{pw} \times (T_2 - T_1)}{(T_3 - T_4)}$$

Where, m_g = Mass flow of exhaust gases

c_{peg} = Specific heat of exhaust gases

m_w = Calorimeter water flow rate = lit / hr by using 1 lit Jar

c_{pw} = Specific heat of water = 4.18 KJ / kg ^{0}K

Hence, heat carried away by exhaust gases on ambient temperature basis

$H_{eg} = (m_{eg} \times c_{peg}) \times (T_3 - T_2)$

t	P	c_p	$\nu * 10^6$
[°C]	[kg/m³]	[kJ/kgK]	[m²/s]
0	1.295	1.042	12.2
100	0.95	1.068	21.54
200	0.748	1.097	32.8
300	0.617	1.122	45.81
400	0.525	1.151	60.38
500	0.457	1.185	76.3
600	0.405	1.214	93.61
700	0.363	1.239	112.1
800	0.33	1.264	131.8
900	0.301	1.29	152.5
1000	0.275	1.306	174.3
1100	0.257	1.323	197.1
1200	0.24	1.34	221

Questions:

1. Define valve timing in four stroke petrol engine?
2. What is overlapping?
3. What is inlet valve?
4. What is exhaust valve?
5. What do you mean by ignition?
6. What are the various types of ignition systems that are commonly used?

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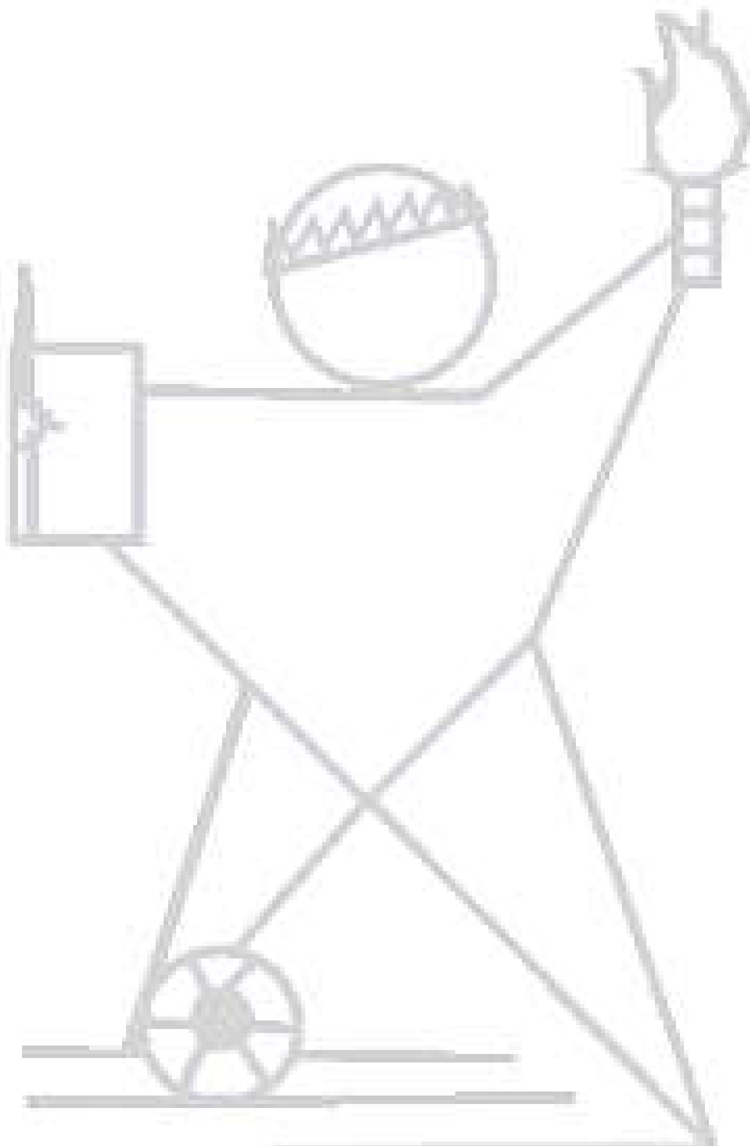

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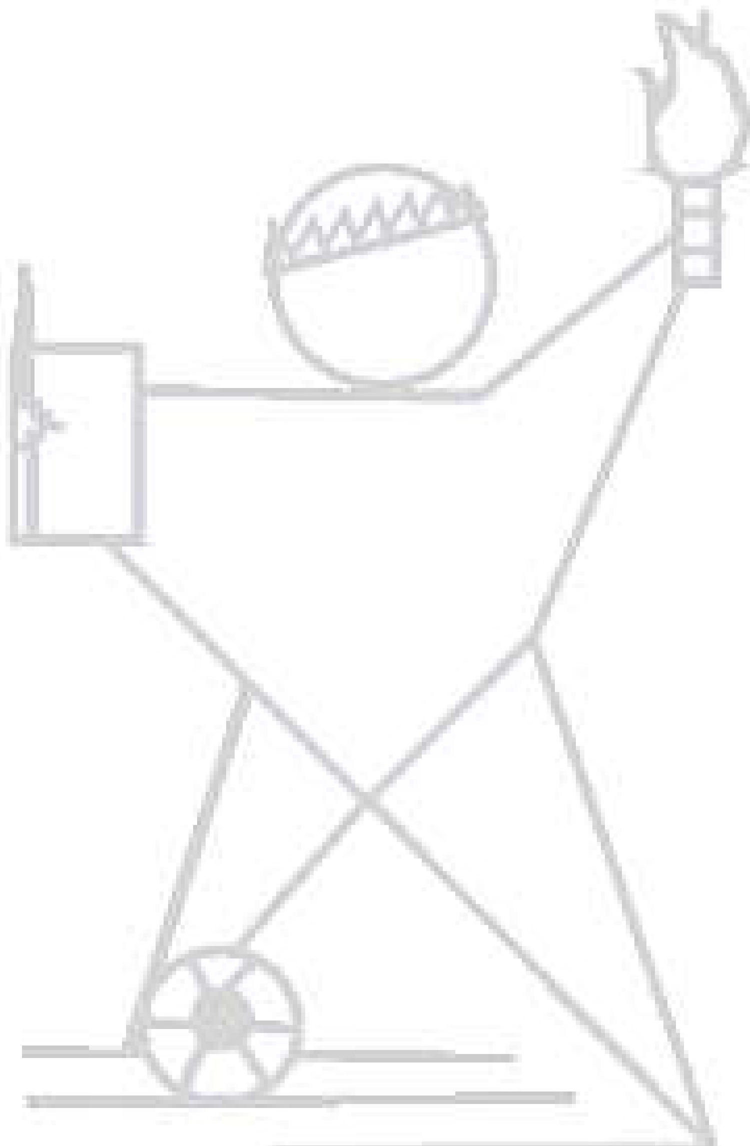

Experiment No. 05

Aim: To draw the heat balance sheet and conduct a performance test on the Four Stroke Single Cylinder petrol Engine.

Apparatus Used: Four Stroke Single Cylinder petrol Engine test rig.

Description: The Test Rig consists of a vertical single cylinder water cooled compression ignition type diesel engine. It is coupled to a loading dynamometer, which in this case is Rope Brake Dynamometer. All the components are mounted on heavy duty M S channel.

A desk type control panel consists of the following instrumentation –

1) Digital RPM Indicator to measure the speed of the engine.
2) Digital temperature indicator to measure various temperatures.
3) Differential manometer to measure quantity of air sucked into cylinder.
4) Burette with manifold to measure the rate of fuel consumed during test.

<u>Air Intake Measurement</u> –

The suction side of the engine is connected to an Air tank. The atmospheric air is drawn into the engine cylinder through the air tank. The manometer is provided to measure the pressure drop across an orifice provided in the intake pipe of the Air tank. This pressure drop is used to calculate the volume of air drawn into the cylinder.

<u>Fuel Measurement Arrangement</u> –

The fuel is supplied to the engine from the main fuel tank through a graduated measuring fuel gauge (Burette)

<u>Lubrication</u> –

The engine is lubricated by mechanical lubrication.

Lubricating oil recommended – SAE-40 OR Equivalent.

Loading Arrangement –

Mechanical Rope Brake Dynamometer –

Basically, the brake drum is directly coupled to the engine flywheel and a rope brake wound around the brake drum. Both ends of the rope is connected to the spring balance separately. The load on the engine can be varied step by step by rotating hand wheel and stud provided on the dynamometer frame.

Specification

ENGINE	– FOUR STROKE SINGLE CYLINDER
BHP	– 3.5 HP
RPM	–
FUEL	_ PETROL
NUMBER OF CYLINDER	– SINGLE
BORE	– mm
STROKE LENGTH	– mm
STARTING	– CRACKING
WORKING CYCLE	– FOUR STROKE
METHOD OF COOLING	– WATER COOLED
METHOD OF IGNITION	– COMPRESSION IGNITION

Rope Brake Dynamometer:

DIAMETER OF THE DRUM	– mm
EFFECTIVE DIAMETER	– mm

Procedure:

1) Fill up the PETROL into the fuel tank mounted on the panel frame.
2) Check the lubricating oil in the oil sump.
3) Connect the instrumentation power input plug to a 230 V, single phase power source. Now the digital meters namely, RPM and Temperature indicators display the respective readings.

To conduct the performance test on the engine –

4) Open the fuel valve and ensure no air trapped in the fuel line.
5) Start the engine and allow it to settle at rated speed.
6) Apply the load by rotating the hand wheel on the Dynamometer gradually to the desired load.
7) Note down all the required parameters mentioned below.
   a. Speed of the engine from digital RPM indicator.
   b. Load from the spring balance.
   c. Fuel consumption from burette.
   d. Quantity of air flow from manometer.
   e. Different temperatures from Temperature indicator.
8) Load the engine step by step and wait for some time in each step.
9) Note down the corresponding parameters.
10) Turn off the fuel knob provided on the panel after the test.

Observation:

R = radius of the arm at the end of dynamometer

= Effective brake drum radius

= 16 cm

D = Diameter of Orifice = 15 mm = 0.015 m

Density of Petrol = 0.75 gram / cc

Density of Water = δw = 1000 kg / m^3

Density of Air = δa = 1.193 kg / m^3

cv = calorific value of petrol = 48000 KJ / kg

Diameter of Engine Bore = d = 55 mm

Length of Stroke = L = 36 mm

h_1 and h_2 = manometer readings in mm

Time required for 10 cc of fuel consumption = t sec (1ml=1cc)

Thermocouples Details:

T_1 = Exhaust gas inlet temperature to calorimeter in ^{0}C

T_2 = Exhaust gas outlet temperature from calorimeter in ^{0}C

T_3 = Water inlet temperature to engine jacket & calorimeter in ^{0}C

T_4 = Water outlet temperature from engine jacket calorimeter in ^{0}C

Observation Table:

Sr. No	Load (kg)	Speed (rpm)	h_1 mm	h_2 mm	Time for 10 cc of fuel consumption in sec	T_1	T_2	T_3	T_4

Calculations:

Performance Test:

Brake Power :

$$BP = \frac{2\,\pi\,N \times T}{60 \times 1000} \quad kW$$

Where, N = RPM of the engine

T = Torque (in N-m)

= Spring Balance Difference x 9.81 x Effective Brake drum Radius

Mass of Fuel Consumed :

$$mfc = \frac{X \times 0.75 \times 3600}{100 \times t} \quad kg/hr$$

Where, X = burette reading in cc

0.75 = density of diesel in gram / cc

t = time taken in seconds.

Specific Fuel Consumption:

$$\mathbf{sfc = \frac{mfc}{BP}} \quad \text{kg / kW hr}$$

Heat supplied by fuel:

$h_f = mf_c$ x calorific value of fuel

Where, calorific value of Petrol = 48000 KJ / kg

Actual Volume of Air Sucked in to the Cylinder –

$$\mathbf{V_a = C_d \times A \times \sqrt{2\,g\,H} \times 3600 \quad m^3 / hr}$$

Where, C_d = Coefficient of discharge = 0.62

A = area of orifice =

D = Diameter of Orifice = m

$g = 9.81$ m / s^2

$$\mathbf{H = \frac{h \times \rho_w}{1000 \times \rho_a}} \quad \text{meter of water}$$

Where, h = Manometer Difference Reading

δw = density of water = 1000 kg / m^3

δa = density of air = 1.193 kg / m^3

Swept Volume:

$$V_s = \frac{\pi D^2 \times L \times N \times 60}{4 \times 2} \text{ in } m^3/\text{hr.}$$

Where, d = diameter of bore = m

L = length of stroke = m

N = speed of the engine in rpm

Volumetric Efficiency :

$$\eta_v = V_a / V_s \times 100\ \%$$

Heat Balanced Sheet:

Heat Carried Away by Exhaust Gases – From heat balance of calorimeter heat gained by exhaust gases in calorimeter = heat gained by water

$$\boldsymbol{m_g \times C_{pg} \times (T_3 - T_4) = m_w \times C_{pw} \times (T_2 - T_1)}$$

There fore, $$\boldsymbol{m_g \times C_{pg} = \frac{m_w \times C_{pw} \times (T_2 - T_1)}{(T_3 - T_4)}}$$

Where,

t	ρ	c_p	$\nu * 10^6$
[^{O} C]	[kg/m^3]	[kJ/kgK]	[m^2/s]
0	1.295	1.042	12.2

m_{eg} = Mass flow of exhaust gases

c_{peg} = Specific heat of exhaust gases

m_w = Calorimeter water flow rate = lit / hr by using 1 lit Jar

c_{pw} = Specific heat of water = 4.18 KJ / kg ^{0}K

Hence, heat carried away by exhaust gases on ambient temperature basis

$$H_{eg} = (m_{eg} \text{ x } c_{peg}) \text{ x } (T_3 - T_2)$$

100	0.95	1.068	21.54
200	0.748	1.097	32.8
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500	0.457	1.185	76.3
600	0.405	1.214	93.61
700	0.363	1.239	112.1
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900	0.301	1.29	152.5
1000	0.275	1.306	174.3
1100	0.257	1.323	197.1
1200	0.24	1.34	221

Questions:

1. Mention the simplified various assumptions used in fuel Air-cycle Analysis
2. Explain the significance of the fuel-Air cycle ?
3. What is the difference between Air – Standard cycle & Fuel – Air cycle analysis?
4. Define carburetion?
5. What are the different Air – Fuel Mixture on which an Engine can be operated?
6. Explain the rich mixture, Lean Mixture & Stoichiometric Mixture ?

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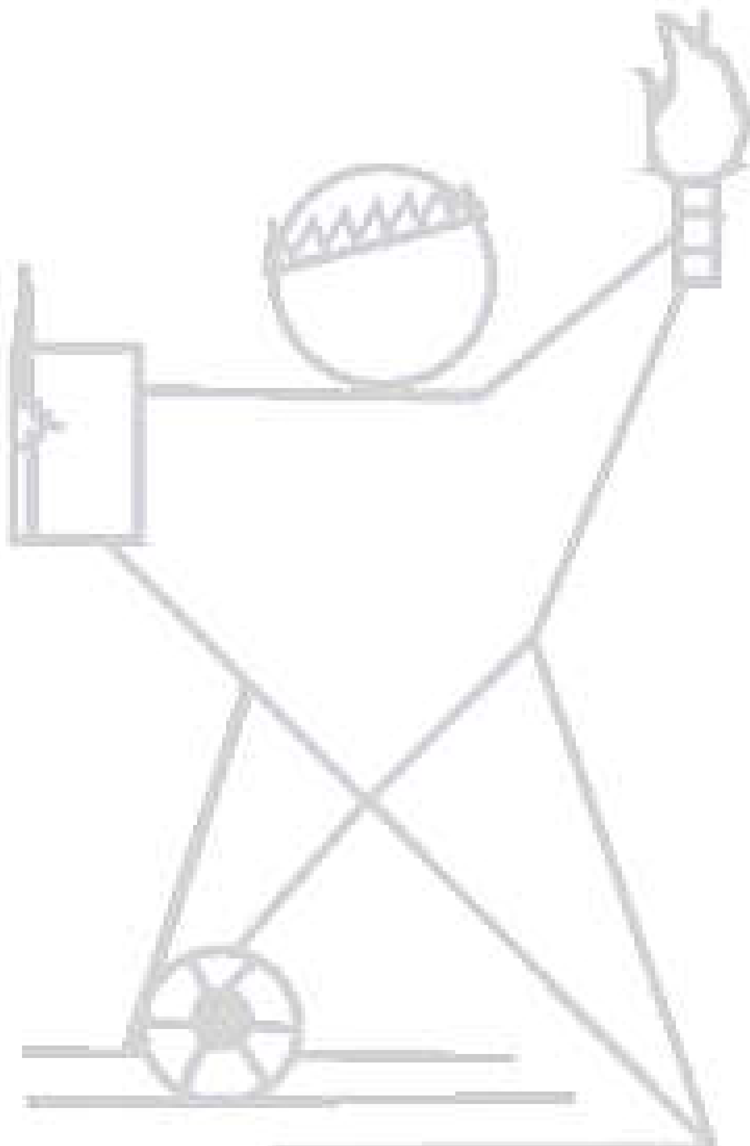

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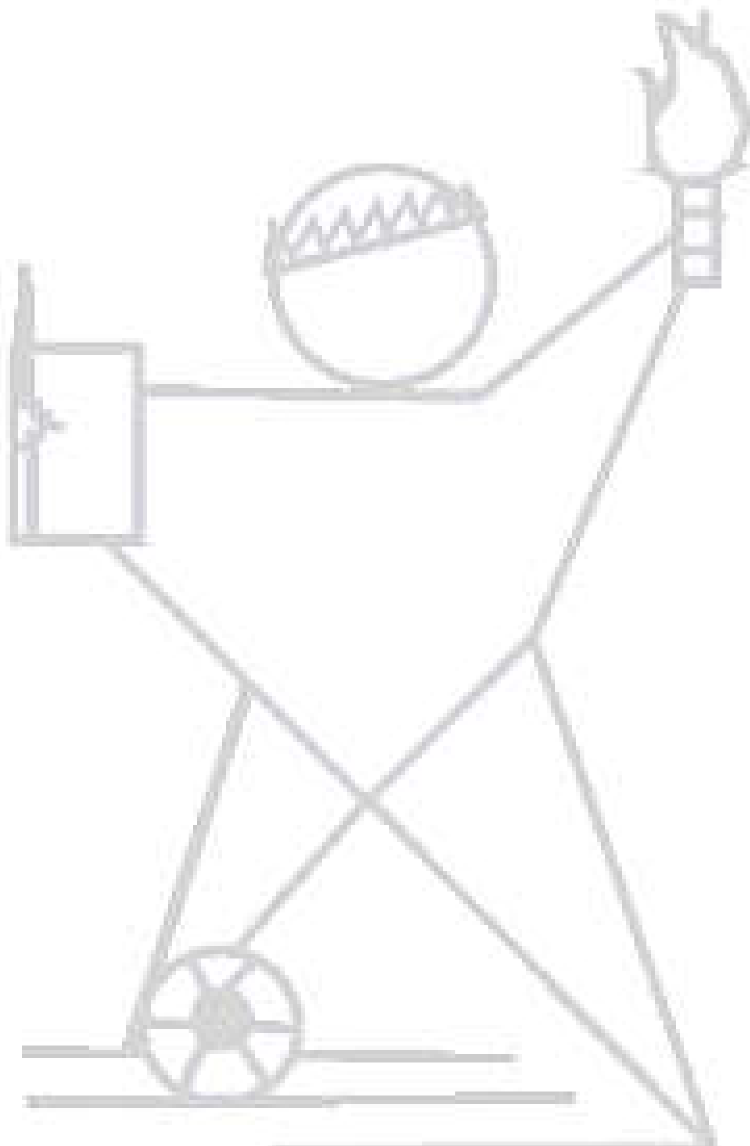

Experiment No. 06

Aim:- To Study and Determine the effect of A/F Ratio on the performance of the Two-Stroke, Single-Cylinder Petrol Engine.

Apparatus Used: Two-Stroke, Single-Cylinder Petrol Engine Test Rig, Stop Watch, and Digital Tachometer.

Theory: Air fuel ratio has a major effect on the performance of the I. C. Engine. The Air fuel ratio of a S. I. Engine lies in the range of 10: 1, to 22: 1 depends upon the power requirements and the economic running of the engine. Richer mixtures are required for idle and full throttle running of the engine.

Whereas for the mid-range , weaker mixtures are required. The mixture corresponding to the minimum fuel consumption is known as the Best Economy Mixture. It is nearly 15:1.Accurate measurement of air flow into the engine is difficult to achieve in practice, due not only to the nature of the air itself, but also the conditions under which the measurement has to be made.The common method of measuring the air flow rate is the tank and orifice method. During suction stroke the pressure inside the tank is less than the atmospheric pressure. The air enters the tank through the orifice plate , and by applying the Bernaulli's equation the air flow rate can be measured. The fuel consumption can be measured by noting down the fuel consumed during specified time. Thus the air fuel ratio can be set to desired value. The accuracy of the air flow measurement depends on the steady state conditions of air flow through the orifice and the damping of the pulsating effect.

Formula Used:

(i) Torque, $\mathbf{T = 9.81 \times W \times R_{Effective}}$ N-m.

Where $R_{Effective} = (D + d)/2$ m,

and W (Load) = $(S_1 - S_2)$ Kg,

(ii) Brake Power, $\mathbf{BP = (2\pi N T) / 60,000}$ KW

; Where N = rpm, T = Torque N-m,

(iii) Fuel Consumption, $\mathbf{m_f = (50\ ml \times 10^{-6} \times \rho_{Fuel}) / (t)}$ Kg/Sec.

Here; 1 ml = 10^{-3} liters, and 1000 liters = 1 m^3

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

(iv) Brake Specific Fuel Consumption, **BSFC = (m_f x 3600) / B P** Kg/ KW . hr

(v) Mass of the Air, $\mathbf{m_a = C_d \times A_0 \sqrt{2\,g\,\Delta h}\ x\ \rho_a \times}$ **Kg / sec**

; Where C_d (Co-efficient of Discharge) = 0.6,

ρ_{air} = (P_a x 10^2) / (R x T_a) Kg/ m^3

A_o (Area of Orifice) = (π d_o^2)/ 4 m^2,

P_a = 1.01325 Bar, R = 0.287 KJ/Kg . K,

T_a = (t_a + 273) K, t_a = Ambient Temperature °C

(vi) Air Fuel Ratio, **A/F = (m_{Air} / m_f)** Kg/ Kg of Fuel

Procedure:

1. Before starting the engine check the fuel supply, and lubrication oil.
2. Set the dynamometer to zero load.
3. Run the engine till it attains the working temperature and steady state condition.
4. Adjust the dynamometer load to obtain the desired engine speed.
5. Note down the dynamometer load reading and fuel consumption rate.
6. Repeat the experiments for various air fuel ratios and different loads, and same speed.
7. Disengage the dynamometer, and stop the engine.
8. Do the necessary calculation, and plot the graphs.

Specifications:

No. of Cylinders, n	Single	-
Calorific Value of Fuel, C.V	42,000	KJ/Kg
Gas Constant, R	0.287	KJ/Kg . K
Ambient Temperature, t_a		^{o} C
Atmospheric Pressure, P_a	1.01325	Bar
Orifice Diameter, d_o	25×10^{-3}	m
Co-efficient of Discharge, Cd	0.6	
Density of fuel (Petrol), ρ_{fuel}	720 to 790	Kg/m^3
Density of Water, ρ_{water}	1,000	Kg/m^3
Brake Drum Diameter, D	156×10^{-3}	m
Rope Diameter, d	18×10^{-3}	m
Bore, D_{bore}	$56.5 \text{ X } 10^{-3}$	m
Stroke, L_{stroke}	58.04×10^{-3}	m
Engine Displacement, V_{swept}	145.45×10^{-6}	m^3
Engine Horse Power, BHP	7.48	BHP at 5500 rpm.

Observation Table:

S. No.	Engine Speed N (rpm)	Dynamometer Spring balance readings (Kg)		Time taken for 50 ml fuel t (Sec.)	Manometer Reading Δ h (meter)
		S_1	S_2		
1.					
2.					
3.					
4.					
5.					

Calculations:

Result Table:

S. No.	Engine Speed N (rpm)	Torque (N-m)	Brake Power (kW)	Air Consumption Rate m_{air} (Kg/hr)	Fuel Consumption Rate m_f (Kg/hr)	BSFC (Kg/kW-hr)	A/F Ratio (Kg/Kg of Fuel)
1.							
2.							
3.							
4.							

Results:

Questions:

1. Mention the simplified various assumptions used in fuel Air-cycle Analysis.
2. Explain the significance of the fuel-Air cycle ?
3. What is the difference between Air – Standard cycle & Fuel – Air cycle analysis?
4. Define carburetion?
5. What are the different Air – Fuel Mixture on which an Engine can be operated?
6. Explain the rich mixture, Lean Mixture & Stoichiometric Mixture ?

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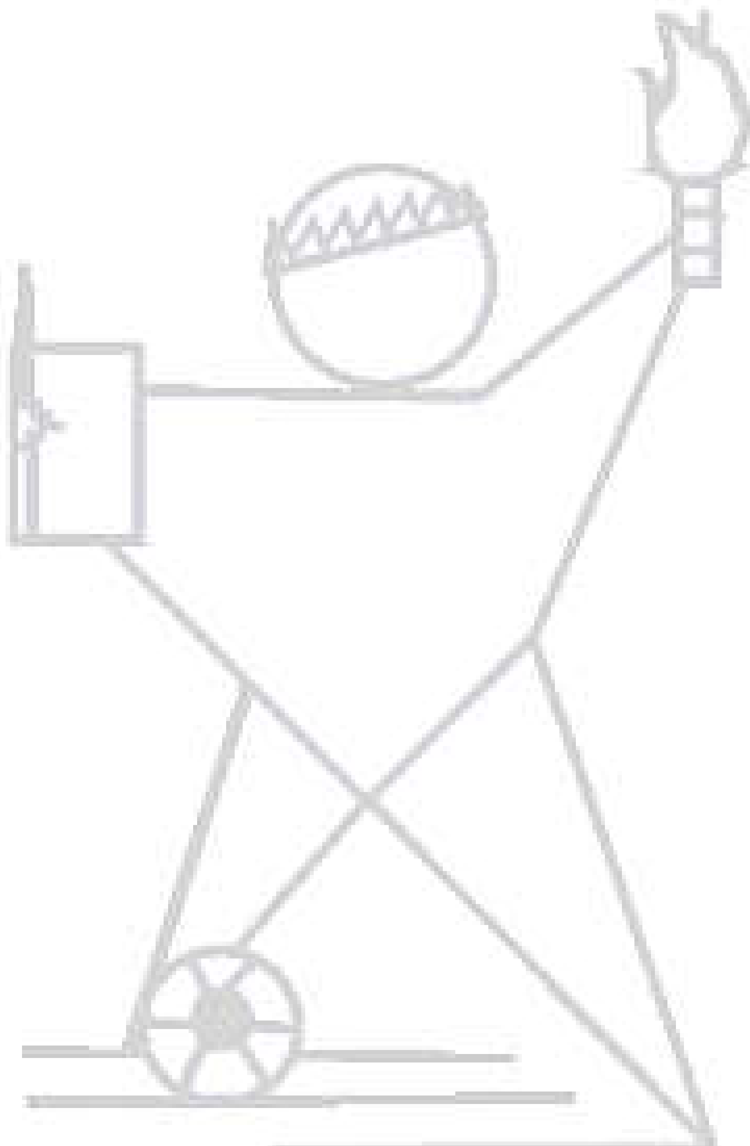

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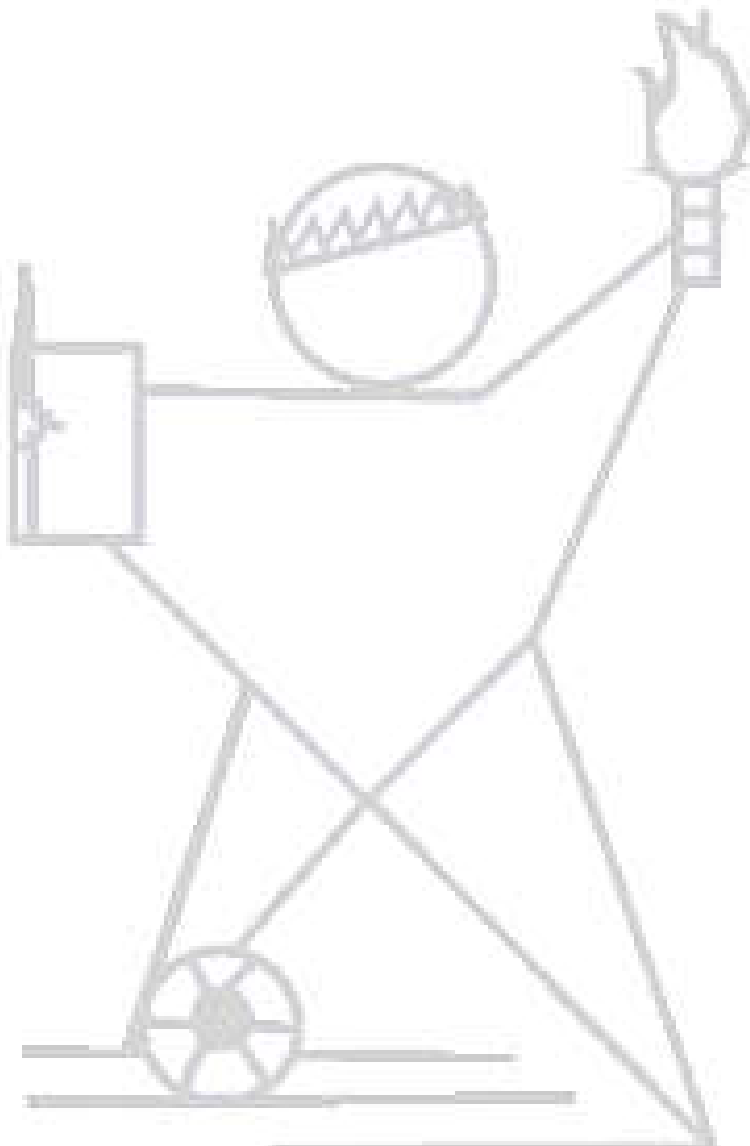

Experiment No. 07

Aim: To study and draw the valve timings diagram Four-Stroke, Single-Cylinder Diesel Engine.

Apparatus Used : Four-Stroke, Single-Cylinder Diesel Engine Test Rig, Sprit Level, Marking Pencil, and Device for measuring crank angle.

Theory: In four- stroke S. I. Engine the opening and closing of the valves, and the ignition of the air fuel mixture do not take place exactly at the dead centre positions. The valve open slightly earlier and close after their respective dead centre positions. The ignition also occurs prior, to the mixture is fully compressed, and the piston reaches the top dead centre position. Similarly in a C. I. Engine both the valves do not open and close exactly at dead centre positions, rather operate at some degree on either side in terms of the crank angles from the dead centre positions. The injection of the fuel is also timed to occur earlier.

Procedure:

1) Fix a plate on the body of the Engine touching the flywheel.
2) Mark the positions of the both the dead centres on the flywheel with the reference to the fixed plate. TDC and BDC in case of vertical Engines, IDC and ODC in case of horizontal Engines.
3) Mark on the flywheel when the inlet and exhaust valves open and close as the flywheel is rotated slowly.
4) Measure the valves (Tappet) Clearance.
5) Mark the spark ignition timing in case of petrol Engine and fuel injection timing in case of Diesel Engine.
6) Measure the angles of the various events and plot the valve timing diagram.

Observation Table:

S. No.	Event	Condition of valves			
		Inlet Valve		Exhaust Valve	
		Open $(^0)$	Close$(^0)$	Open $(^0)$	Close$(^0)$

Valve Timing Diagram:

Result:-Based on observation table valve timing diagram is drawn and compare with the standard valve timing diagram.

Questions:

1. Define valve timing in four stroke petrol engine?
2. What is overlapping?
3. What is inlet valve?
4. What is exhaust valve?
5. What do you mean by ignition?
6. What are the various types of ignition systems that are commonly used?

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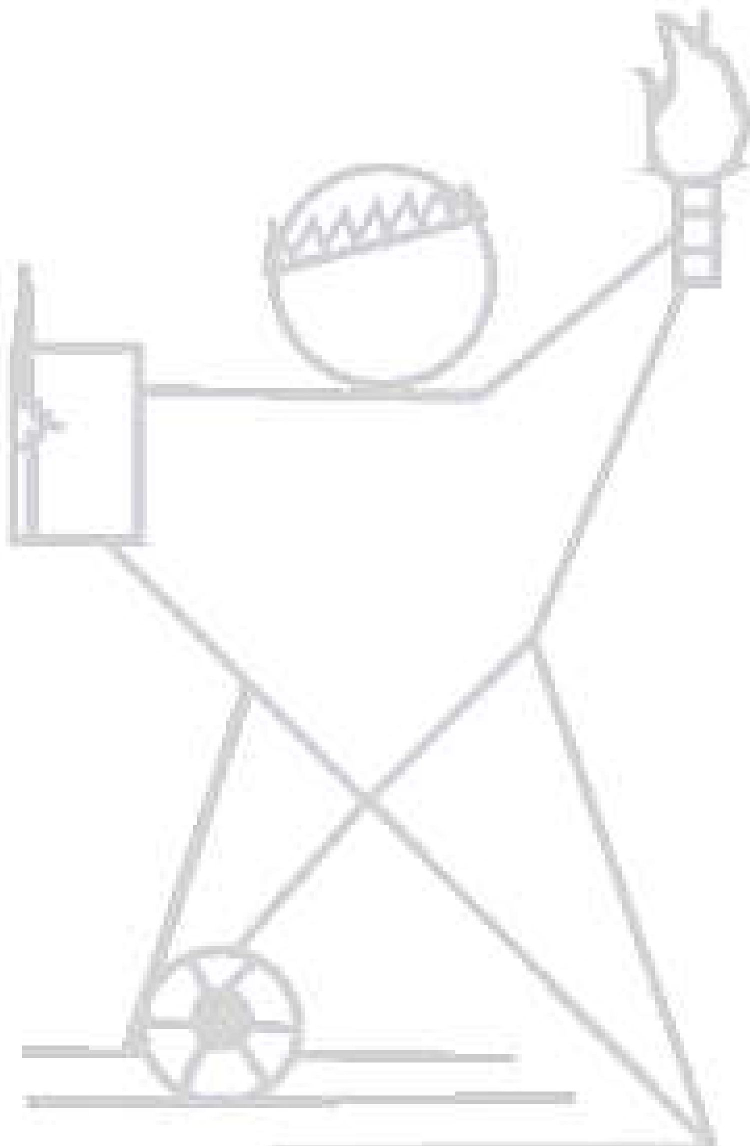

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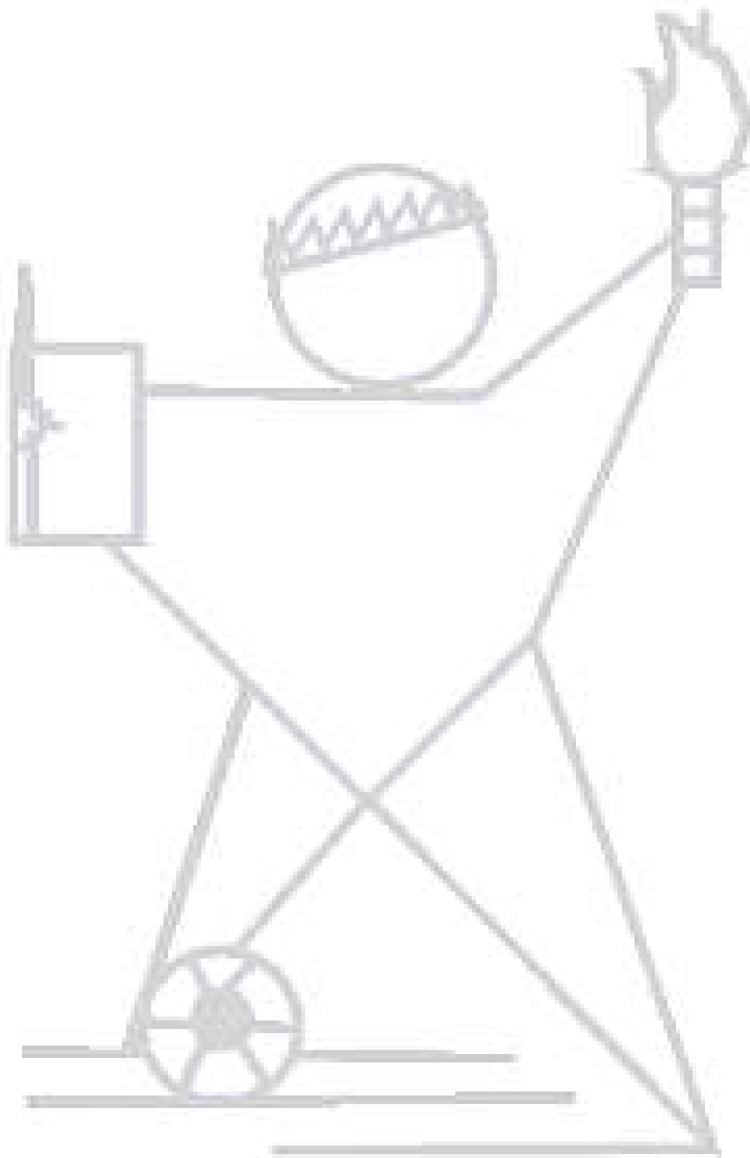

Experiment No. 08

Aim: Study of the lubrication and cooling system in IC ENGINE.

Apparatus Used : Model of lubrication and cooling system of I.C. Engine.

Theory:

1. **Lubrication System:**

Lubrication is an art of admitting a lubricant (oil, grease, etc.) between two surfaces that are in contact and in relative motion. The purpose of lubrication in engine is to perform one or several of the following function:-

1) To reduce friction and wear between the moving parts and thereby the energy loss and to increase the life of engine.
2) To provide selling action e.g. the lubrication oil helps the piston rings to maintain an effective seal against the high pressure gasses in the cylinder from leaking out into the crankcase.
3) To cool the surface by carrying away the heat generated in engine components.
4) To clean the surface by washing away carbon and the metal particles caused by wear.

Of all these function, the first function is considered to be the most important one. In internal combustion engines, the problem of lubrication become more difficult because of the high temperature experienced during the combustion process and by the wide range of temperature encounter throughout the cycle. So the energy losses from the friction between different components of the engine can be minimized by providing proper lubrication.

Lubrication of engine component

In the reciprocating engine there are many surfaces in the contact with each other and therefore they should be lubricated to reduce friction. The principal friction surfaces requiring lubrication in an internal combustion engine are:-

1. Piston and cylinder
2. Crankshaft and their bearings
3. Crank pin and their bearing
4. Wrist-pin and their bearing
5. Valve gear

Type of Lubrication system

The function of lubrication system is to provide sufficient quantity of cool, filtered oil to give positive and adequate lubrication to all the moving parts of an engine. The various systems used for internal combustion engine may be classified as:-

1) Mist lubrication system
2) Wet sump lubrication system
3) Dry sump lubrication system

Mist lubrication system

This system is used where crankcase lubrication is not suitable. In two stroke engine, as the charge is compressed in the crankcase, it is not possible to have the lubrication oil in the sump. Hence mist lubrication is used in practice. In such engine, the lubrication oil is mixed with the fuel, the usual ratio being 3% to 6%. The oil and fuel mixture is inducted through the carburetor. The fuel is vaporized and the oil in the form of mist goes via the crankcase into the cylinder. The oil which strikes the crankcase walls lubricates the main and connecting rod bearings and the rest of oil lubricate the piston, piston rings and the cylinder.

The advantage of this system is its simplicity and low cost as it does not require an oil pump, filter, etc. however there are certain disadvantage which are enumerated are following:

1) It cause heavy exhaust stroke due to burning of lubricating oil partially or fully and also forms deposit on piston crown and exhaust port which are affect engine efficiency.
2) Since the oil come in close contact with acidic vapor produced during the combustion process get contaminant and may result in the corrosion of bearing surfaces.
3) This system call for a thorough mixing if effective lubrication. This requires either separate mixing prior to use or use of some additive to give the oil good mixing characteristics.
4) During closed throttle operation as in the case of vehicle moving down the hill, the engine will suffer from insufficient lubrication as the supply of fuel is less. This is an important limitation of system.

Wet sump lubrication system

In the wet sump lubrication system, the bottom of the crankcase contains an oil pan or sump from which the lubricating oil is pumped to various engine components by a pump. After lubrication these parts, the oil flow back to the sump by gravity. Again it is picked by a pump and recirculated through the engine lubricating system. There are three varieties in the wet sump lubricating system. They are:

1) The splash system
2) The splash and pressure system
3) The pressure feed system

Splash system

This type of lubricating system is used in light duty engine. The lubricating oil is discharge into the bottom of the engine crankcase and maintained at a predetermined level. The oil is drawn by the pump and delivered through a distributing pipe extending the length if the crankcase into the splash trough located under the big end of all the connecting rods. These troughs were provided with overflows and oil in the trough are therefore kept at a constant level. A splashier or dipper is provided under each connecting rod cap which dips into the oil in the trough at every revolution of the crankshaft and the oil is splashed all over the interior of crankcase, into the pistons and onto the exposed portion of cylinder walls. The oil dripping from the cylinder is collected in the sump where it is cooled by the air flowing around. The cooled oil is then recirculated.

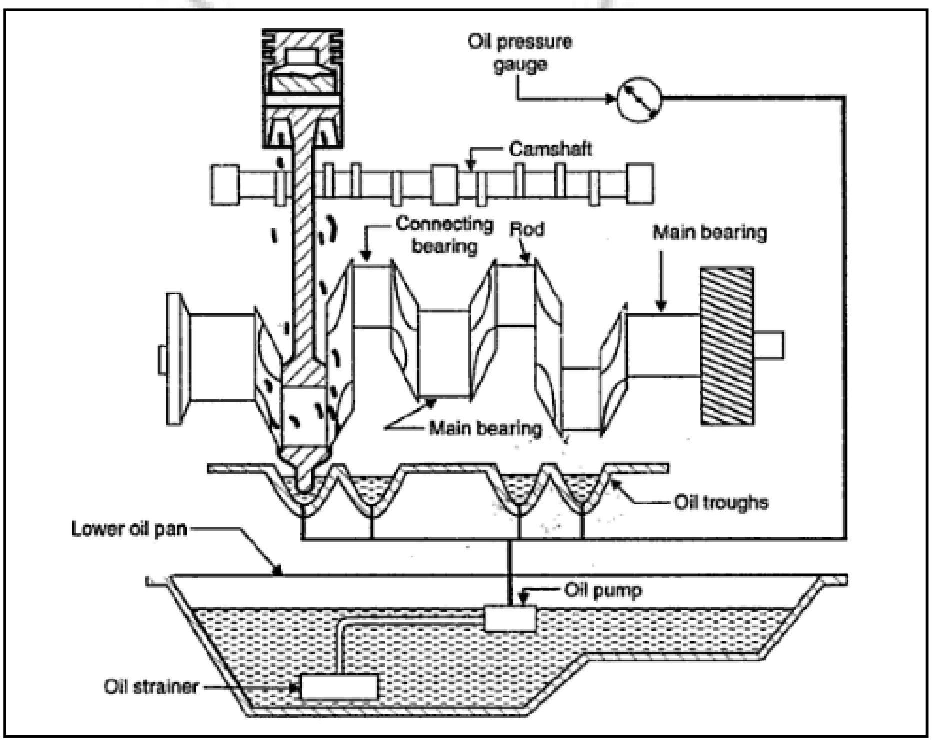

Fig.1 Splash lubrication system

The splash and pressure lubrication system:

In this system, the lubricating oil is supplied under pressure to main and camshaft bearing. Oil is also supplied under pressure to pipes which direct a stream of oil against the dipper on the big end of connecting rod bearing cup and thus the crankpin bearing are lubricated by the splash or spray of oil thrown up by the dipper.

Pressure feed system:

In this system, the oil is drawn in from the sump and forced to all the main bearings of the crankshaft through distributing channels. A pressure relief valve will also be fitted near the delivery point of the pump which open when the pressure in the system attains a predetermine value. An oil hole is drilled in the crankshaft from the center of each crankpin to the centre of an adjacent main journal, through which oil can pass from the main bearing to the crankpin bearing. From the crankpin it reaches piston pin bearing through a hole drilled in the connecting rod. The cylinder wall, tappet roller, piston and piston rings are lubricated by oil spray from around the piston pins and the main and connecting rod bearings. The basic components of the wet sump lubricating system are (1) pump (2) strainer (3) pressure regulator (4) filter (5) breather.

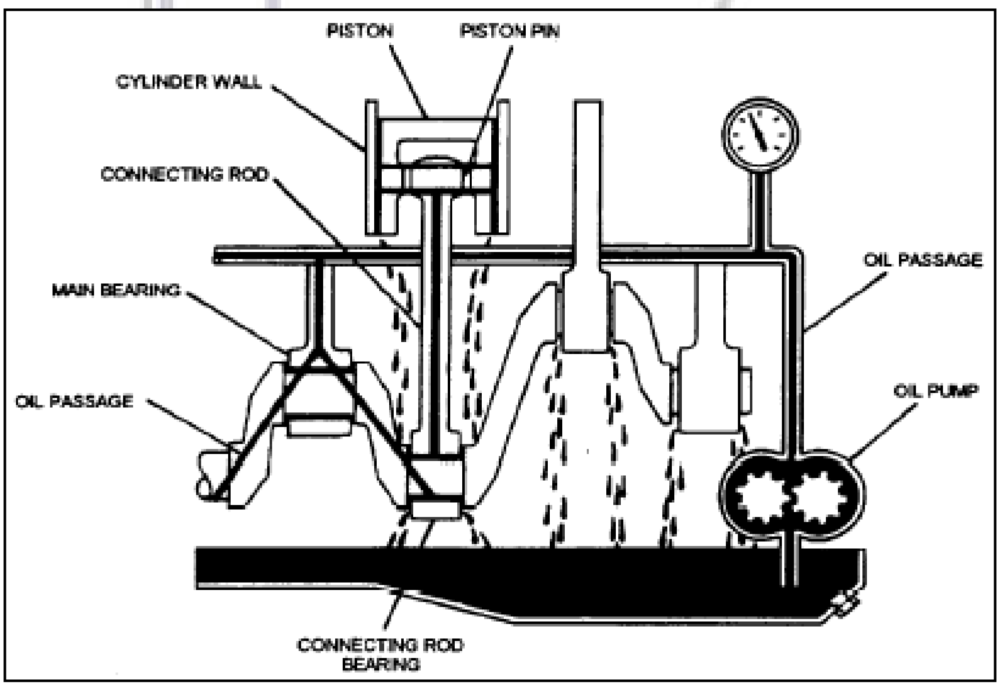

Fig: 2 pressures feed lubrication system

Oil is drawn from the sump by a gear or rotor type of oil pump through an oil strainer. The strainer is a fine mesh screen which prevents foreign particles from entering the oil circulating system. A pressure relief valve is provided which automatically keep the delivery pressure constant and can b set to any value. When the oil pressure exceed that for which the valve is set, the valve open and allow some of the oil to return to the sump thereby reliving the oil pressure in the system.

Dry sump lubrication system

In this system, the supply of oil is carried in an external tank. An oil pump draws oil from the supply tank and circulates it under pressure to the various bearing of the engine. Oil dripping from the cylinder and bearing into the sump is removed by the scavenging pump which in turn the oil is pass through a filter, and is fed back to the supply tank. Thus oil is prevented from accumulating in the base of engine. The capacity of the scavenging pump is always greater than the oil pump. In this system a filter with a bypass valve is placed in between the scavenging pump and the supply tank. If a filter is clogged, the pressure relief valve opens permitting oil to bypass the filter and reaches the supply tank. A separate oil cooler with either water or air as the cooling medium, is usually provided in the dry sump system to remove the heat from the oil.

Properties of lubricants

The duties of the lubricant in an engine are many and varied in a scope. The lubricant is called upon to limit and control the following:

1) Friction between the component and metal to metal contact
2) Overheating of the component
3) Wear of component
4) Corrosion
5) Deposit

To accomplish the above function, the lubricant should have

1) Suitable viscosity
2) Oiliness to ensure adherence to the bearing, and for less friction and wear when the lubrication is in the boundary region , and as a protective covering against corrosion
3) High strength to prevent the metal to metal contact and seizure under heavy load
4) Should not react with the lubricating surface
5) A low pour point to allow floe of the lubricant at low temperature to the oil pump
6) No tendency to form deposit by reacting with air, water, fuel or the product of combustion
7) Cleaning ability
8) Non foaming characteristics
9) Non toxic and non inflammable

Additives for lubricants

The modern lubrication for heavy duty engines are highly refined which otherwise may produce sludge or suffer a progressive increase in viscosity. For these reasons the lubricant are seasoned by the additive of certain oil soluble organic compound containing inorganic elements such as phosphorus, sulphur, amine additive. Thus oil soluble organic compound added to the present day lubricant to impart one or more of the following characteristics.

1) Anti oxidant and anti-corrosive agent
2) Detergent dispersant
3) Extreme pressure additives
4) Pour point depressor
5) Viscosity index improver
6) Antifoam agent
7) Oiliness and film strength agent

2. Cooling system

Need for cooling system

During the process of converting thermal energy to mechanical energy high temp are produced in the cylinder of the engine as a result of the combustion process. A large portion of the heat is transferred to the cylinder head and walls, piston and valves. Unless this excess heat is carried away and these parts are adequate cooled, the engine will be damaged. A cooling system must be preventing damages to vital parts of the engine, but the temperature of these components must be maintained within certain limits in the order to obtain maximum performance from the engine. Hence a cooling system is needed to keep the engine from not getting so hot as to cause problems and yet to permit it to run hot enough to ensure maximum efficiency of the engine. The duty of cooling system, in other word, is to keep the engine from getting not too hot and at the same time not to keep it too cool either.

Characteristics of efficient cooling system

The following are the two main characteristics desired of an efficient cooling system

1) It should be capable of removing about 30% of heat generated in the combustion chamber while maintain the optimum temp of the engine under all operating conditions of engine.
2) It should remove heat at a faster rate when engine is hot. However during starting of the engine the cooling should be minimum, so that the working parts of engine reach their operating temperature in short time.

Type of cooling system

In order to cool the engine a cooling medium is required. This can be either air or a liquid accordingly there are two type of systems in general use for cooling the IC engine. They are

1) Liquid or indirect cooling system
2) Air or direct cooling system

Liquid cooled systems

In this system mainly water is used and made to circulate through the jackets provided around the cylinder, cylinder-head, valve ports and seats where it extracts most of the heat.

It consists of a long flat, thin-walled tube with an opening, facing the water pump outlet and a number of small openings along its length that directs the water against the exhaust valves. The fits in the water jacket and can be removed from the front end of the block.

The heat is transferred from the cylinder walls and other parts by convection and conduction. The liquid becomes heated in its passage through the jackets and is in turn cooled by means of an air-cooled radiator system. The heat from liquid in turn is transferred to air. Hence it is called the indirect cooling system. Water cooling can be carried out by any of the following five methods

1) Direct or non-return system
2) Thermosyphon system
3) Forced circulation cooling system
4) Evaporative cooling system
5) Pressure cooling system

Direct or non-return system

This system is useful for large installation where plenty of water is available. The water from a storage tank is directly supplied through the inlet valve to the engine cooling jacket. The hot water in not cooled for reuse but simply discharged.

Thermosyphon system

The basic principle of thermosyphon can be explained with respect to fig. heat is supplied to the fluid in the tank A. because of relative lower density, the hot fluid travel up, its place is being taken by comparatively cold fluid from the tank B through pipe p2. The hot fluid flow through the pipe p1 to the tank B where it get cooled. Thus the fluid circulates through the system in the form of convective current.

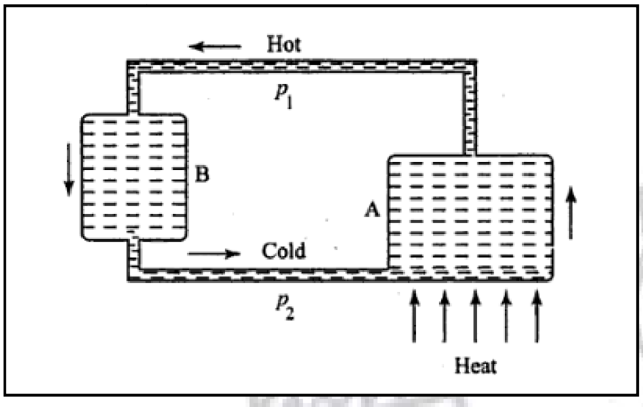

Fig.3 Principal of thermosyphon system

For engine application the tank a represent the cylinder jacket while tank B represent a radiator and water act as a circulating fluid. The main advantage of this system is its simplicity and automatic circulating of the cooling water.

Forced circulating cooling system

This system is used in large number of auto-mobile like cars, buses and even heavy trucks. Here, flow of water from radiators to water jacket is by convection assisted by pump.

The main principle of this system is explained with the help of block diagram as shown.

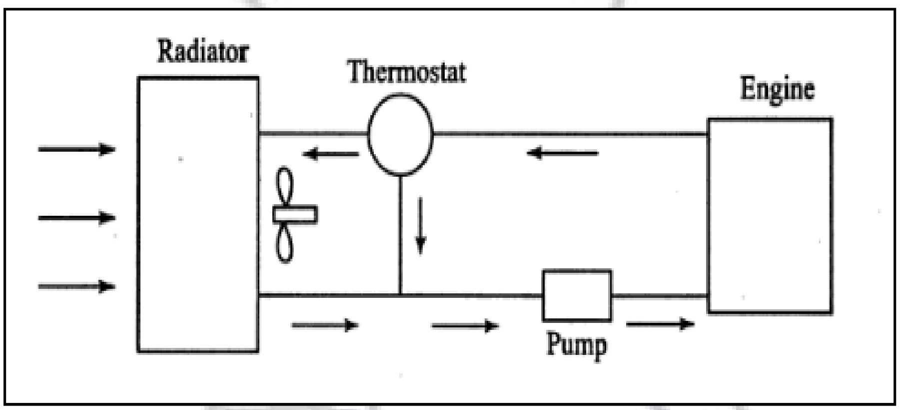

Fig.4 Principal of forced circulation cooling system using thermostat

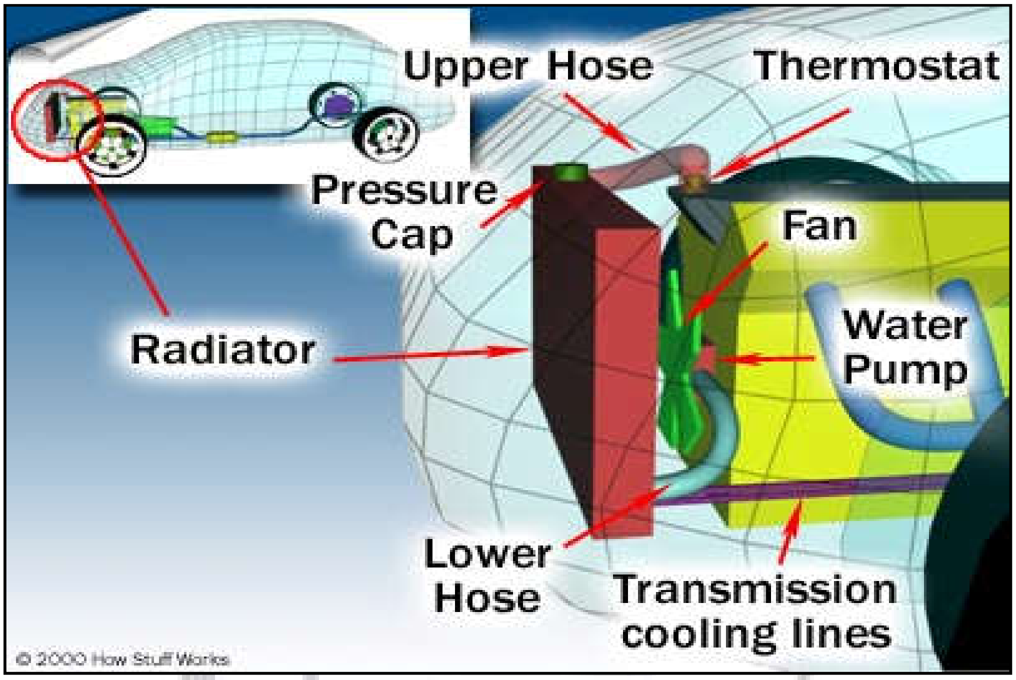

Fig.5 cooling of an auto mobile

The water or coolant is circulated through jacket around the part of engine to be cooled, and is kept in motion by a centrifugal pump which is driven by the engine. The water is passed through the radiator where it is cooled by the air drawn through the radiator by a fan and by the air draft to the forward motion of the vehicle. A thermostat is used to control the water temperature required for cooling. It consist mainly four component radiator, fan water pump and a thermostat.

Evaporative cooling system

This is predominately used in stationary engine. In this the engine will be cooled because of the evaporation the water in the cylinder jackets into the steam. Here the advantage is taken from the high latent heat of vaporizing of the water by allowing evaporating in the cylinder jackets. If the steam is formed at a pressure above atmospheric the temperature will be above the normal permissible temperature.

In fig. below evaporative cooling with air cooled condenser. In this case water is circulated by the pump A and when delivered to the overhead tank B part of it boils out. The tank has portion C. The vapors rise above the portion C and because of the condensing action of the radiator tube D, condensate flow into the lower tank E from which it is picked up and return to the tank B by the small pump F. the vertical pipe G is in communication with the outside atmosphere to prevent the collapsing of the tank B and E when the pressure inside them due to condensation fall below the atmosphere

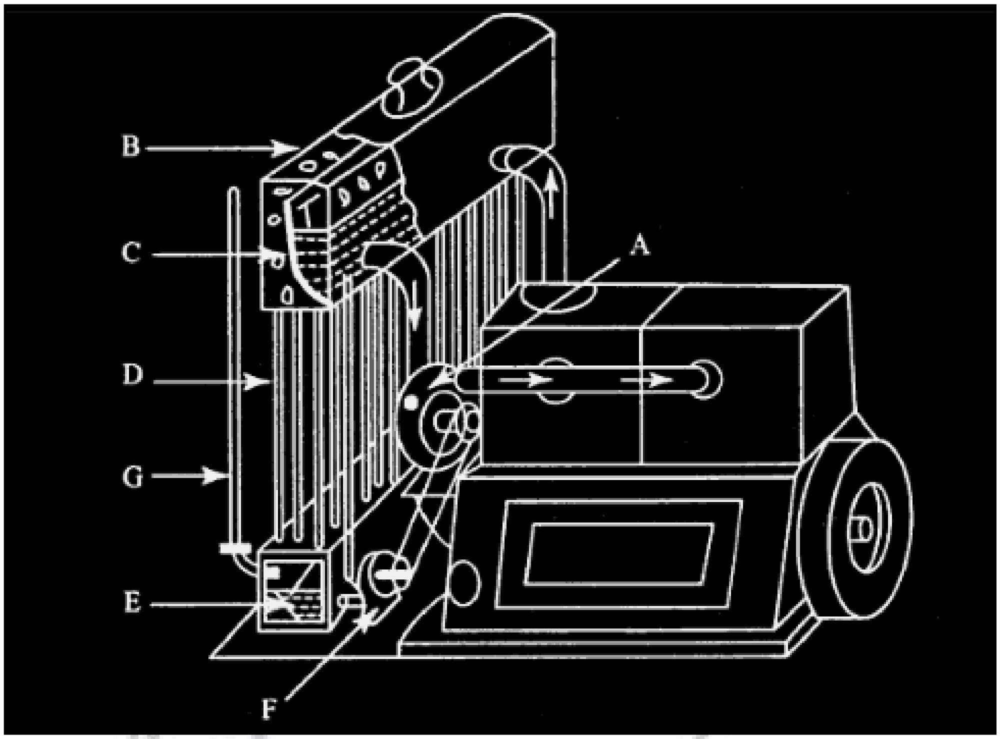

Fig.6 Evaporative cooling with air cooled condenser

Pressure cooling system

In pressure cooling system moderate pressure, say up to 2 bar, are commonly used. As shown in fig a cap is fitted with two valves which are loaded by a compression spring and a vacuum valve. When the coolant is cold both valve are shut but as the engine warm up the coolant temperature rises until it reaches a certain pre-set value corresponding to the desired pressure when the safety valve open. But if the coolant temperature falls during the engine operation the valve will close again until the temperature rises to equivalent pressure value. When the engine is switched off and the coolant cool down vacuum being to form in the cooling system but when the internal pressure fall below atmosphere the vacuum valve is opened by the higher outside pressure and the cooling system then attains atmosphere pressure.

Air cooled system

In the air cooled system a current of air is made to flow past the outside of the cylinder barrel, outer surface area of which has been considerably increased by providing cooling fin as shown in fig. this method will increased the rate of cooling. This method is mainly applicable to the engine in the motorcycles, small cars, airplanes and combat tank where motion of the vehicle gives a good velocity to cool the engine. The value of heat transfer coefficient between metal and air is appreciably low. As a result of this the cylinder wall temperature of the air cooled cylinder are considerably higher than those of water cooled type.

Fig.7 Cooling fins

Comparison of liquid and air cooling system:

In view of the wide spread use of these two alternative cooling system for petrol as well as diesel engine it is of interest to summarize the respective advantage and limitation of these system.

Advantage of liquid cooling system

(1) Compact design of engine with appreciably smaller frontal area is possible.

(2) The fuel consumption of high compression liquid cooled engine is rather lower than for air cooled ones.

(3) Because of the even cooling of the cylinder barrel and due to jacketing makes it possible to reduce the cylinder head and valve seat temperature.

(4) In case of water cooled engines, installation is not necessarily at the front of the mobile vehicle, aircraft etc. as the cooling system can be conveniently located wherever required. This is not possible in case of air cooled system.

(5) The size of engine does not involve serious problem as far as the design of the cooling system is concerned. In case of air cooled engines particularly in high horsepower range difficulty is encounter in the circulation of requisite quantity of air for the cooling purpose.

Limitation

(1) This is a dependent system in which water circulation in the jackets is to be ensured by additional.

(2) Power absorbed by the pump for water circulation is considerable and this affects the power output of the engine.

(3) In the event of failure of the cooling system serious damage may be caused to the engine.

(4) Cost of the system is considerably high.

(5) System requires considerable maintenance of its various parts.

Advantage of Air-cooling System

- The design of the engine becomes simpler as no water jackets are required. The cylinder can have identical dimensions and be individually detachable and therefore cheaper to renew in case of accident etc.
- Absence of cooling pipes, radiator, etc. makes the cooling system thereby minimum maintenance problems.
- No danger of cooling leakage etc.
- The engine is subjected to freezing troubles etc., usually encountered in case of water coolant engines.
- The weight of the air-cooled engine is less than that of water-cooled engine, i.e., power to weight ratio is improved.
- In this case, the engine is rather a self-contained unit as it requires no external components like radiator, header, tank etc.
- Insulation of air-cooled engines is easier.

Limitations

(1) Can be applied only to small and medium sized engines.

(2) In places where ambient temperature are lower.

(3) Cooling is not uniform.

(4) Higher working temperature compared to water-cooling.

(5) Produce more aerodynamic noise.

(6) Specific fuel consumption is slightly higher.

(7) Lower maximum allowable compression ratios.

(8) The fan, if used absorbs as much as 5% of the power developed by the engine.

Question:

Q.1 what do you understand by the cooling system of IC engine.

Q.2 Explain following

- Air-cooling System
- Anti oxidant and anti-corrosive agent
- Detergent dispersant
- Extreme pressure additives

Q.3 explain following

- Mist lubrication system
- Wet sump lubrication system
- Dry sump lubrication system

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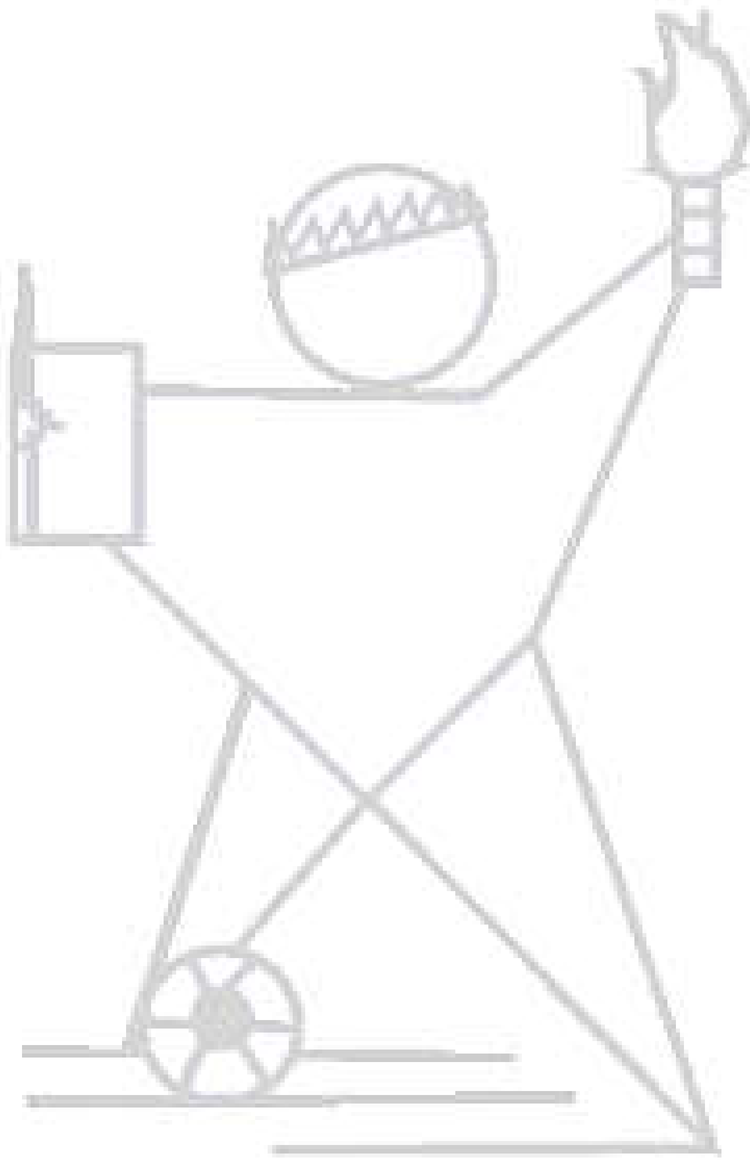

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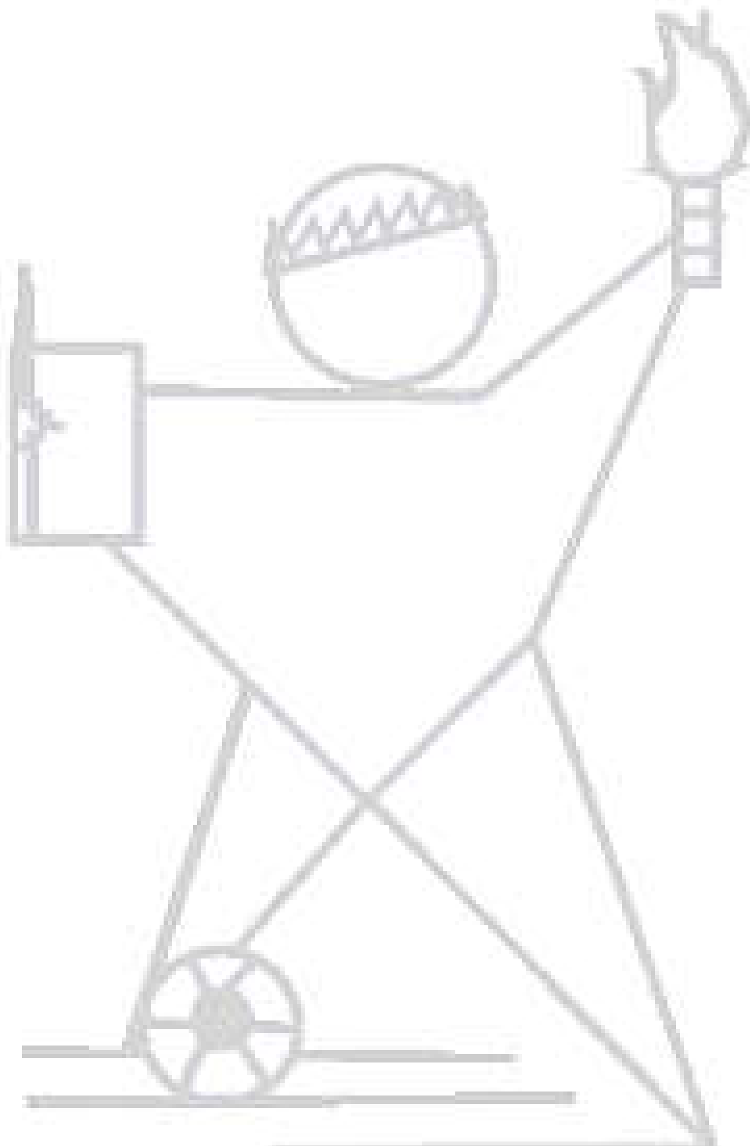


Experiment No. 09

Aim: Study of carburetor.

Apparatus Used: Model of Carburetor.

Theory:

Principles:

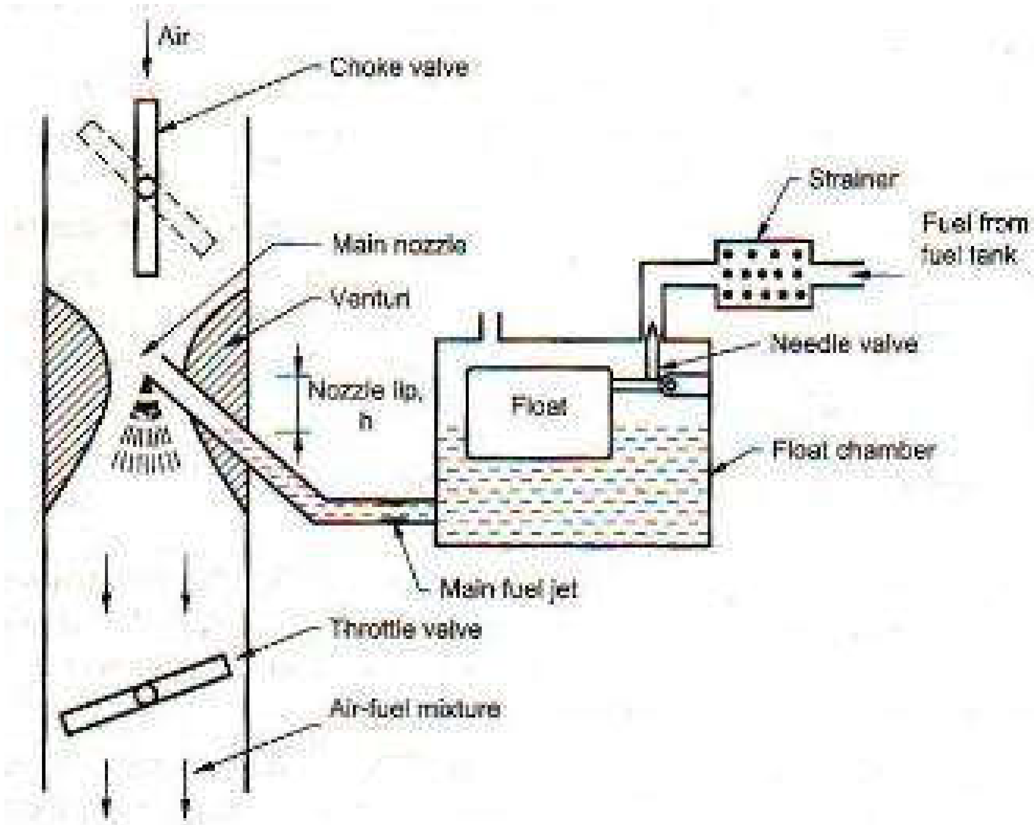
The carburettor works on Bernoulli's principle the faster air moves, the lower its static pressure and the higher its dynamic pressure. The throttle (accelerator) linkage does not directly control the flow of liquid fuel. Instead, it actuates carburettor mechanisms which meter the flow of air being pulled into the engine. The speed of this flow, and therefore its pressure, determines the amount of fuel drawn into the air-stream.

When carburettors are used in aircraft with piston engines, special designs and features are needed to prevent fuel starvation during inverted flight. Later engines used an early form of fuel injection known as pressure carburettors.

Most production **carburetted** (as opposed to fuel-injected) engines have a single carburettor and a matching intake manifold that divides and transports the air fuel mixture to the intake valves. though some engines (like motorcycle engines) use multiple carburettors on split heads. Multiple carburettor engines were also common enhancements for modifying engines in the USA from the 1950s to mid-1960s, as well as during the following decade of high-performance muscle cars fuelling different chambers of the engine's intake manifold.

Older engines used up-draft carburettors, where the air enters from below the carburettor and exits through the top. This had the advantage of never flooding the engine, as any liquid fuel droplets would fall out of the carburettor instead of into the intake manifold; it also lent itself to use of an oil bath air cleaner where a pool of oil below a mesh element below the carburettor is sucked up into the mesh and the air is drawn through the oil-covered mesh; this was an effective system in a time when paper air filters did not exist.

Beginning in the late 1930s, down draft carburettors were the most popular type for automotive use in the united state. In Europe, the side draft carburettors replaced downdraft as free space in the engine bay decreased and the use of the SU-type carburettor (and similar units from other manufacturers) increased. Some small propeller-driven aircraft engines still use the updraft carburettor design. carburettors are typically side draft, because they must be stacked one on top of the other in order to feed the cylinders in a vertically oriented cylinder block.



1979 Evinrude Type I marine side draft carburettor The main disadvantage of basing a carburettor's operation on Bernoulli's principle is that, being a fluid dynamic device, the pressure reduction in a venturi tends to be proportional to the square of the intake air speed. The fuel jets are much smaller and limited mainly by viscosity, so that the fuel flow tends to be proportional to the pressure difference. So jets sized for full power tend to starve the engine at lower speed and part throttle. Most commonly this has been corrected by using multiple jets. In SU and other movable jet carburettors, it was corrected by varying the jet size. For cold starting, a different principle was used in multi-jet carburettors. A flow resisting valve called a choke, similar to the throttle valve, was placed upstream of the main jet to reduce the intake pressure and suck additional fuel out of the jets.

Question:

Q.1 Write the name of any three volatile fuels used in IC engines.

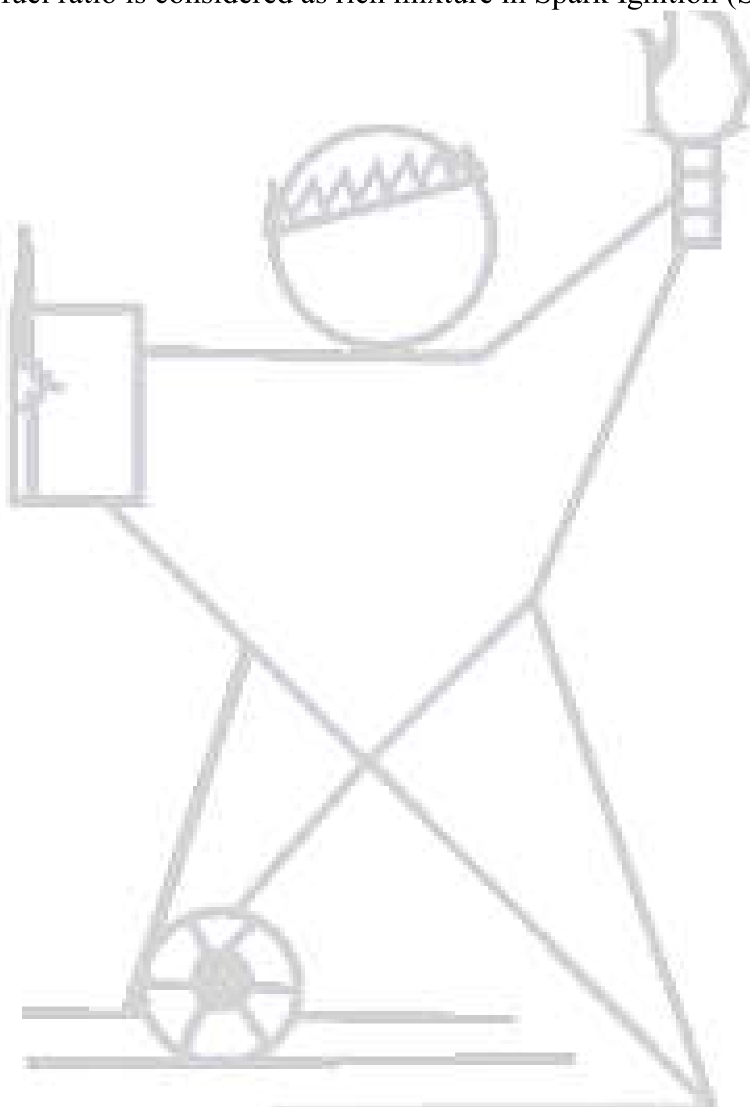
Q.2 What is the function of induction system of Spark Ignition (SI) engine

Q.3 What is carburetor.

Q.4 Explain the function of carburetor.

Q.5 Write the name of factors affecting the process of carburetion.

Q.6 Write the Air-fuel ratio is considered as rich mixture in Spark Ignition (SI) engine?



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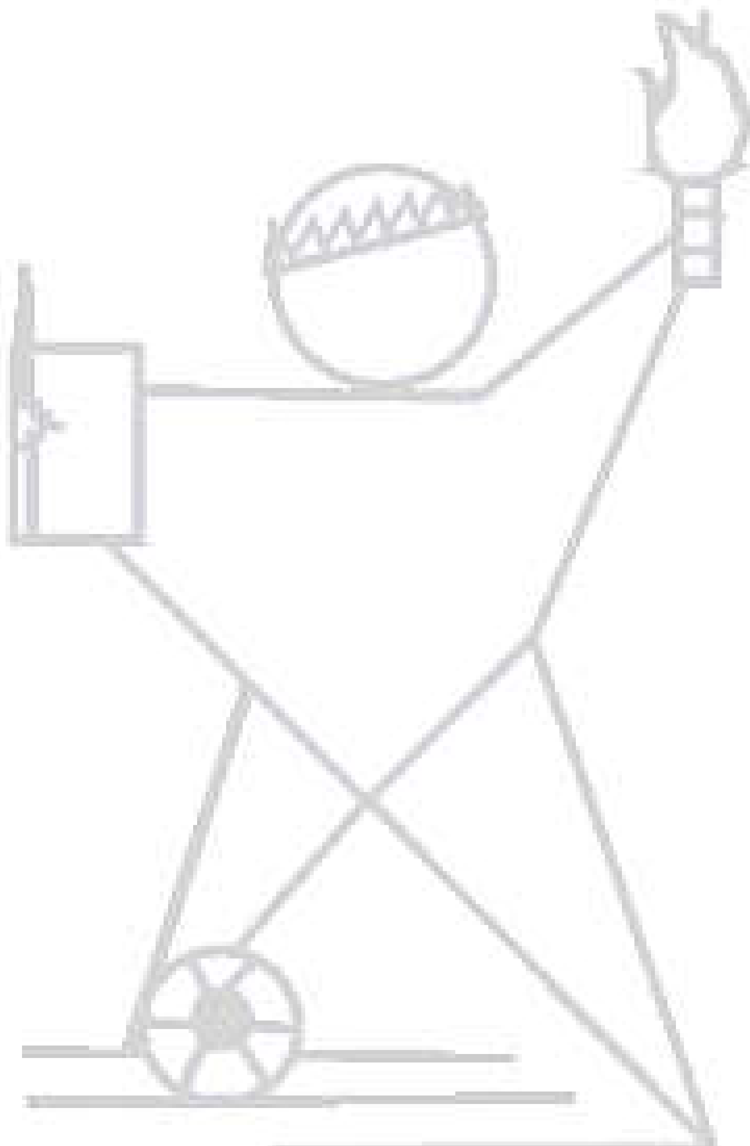

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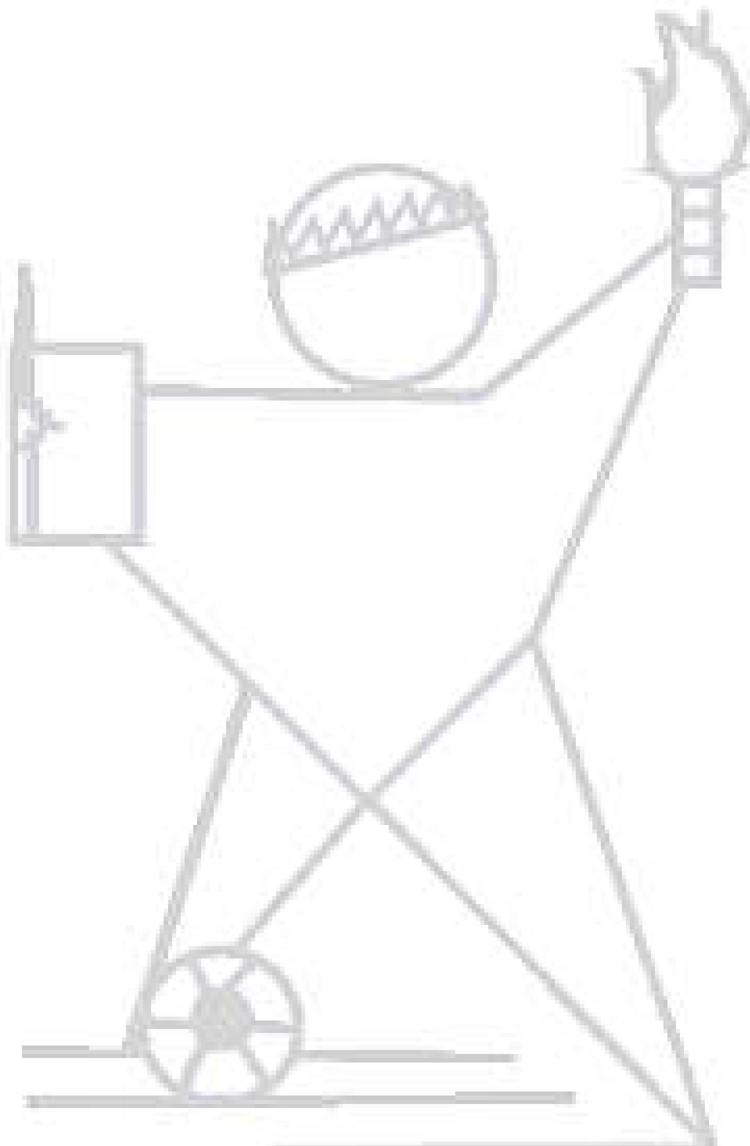


Experiment: - 10

Aim: Study of ignition system.

Apparatus Used: Model of ignition system.

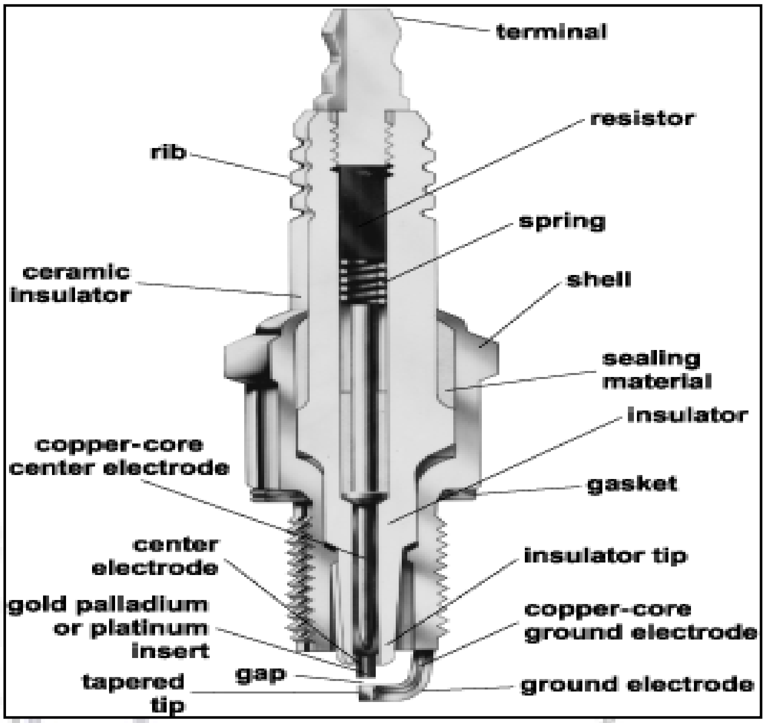
Theory:

Ignition system

Introduction:

We know that in case of Internal Combustion (IC) engines, combustion of air and fuel takes place inside the engine cylinder and the products of combustion expand to produce reciprocating motion of the piston. This reciprocating motion of the piston is in turn converted into rotary motion of the crank shaft through connecting rod and crank. This rotary motion of the crank shaft is in turn used to drive the generators for generating power. We also know that there are 4-cycles of operations viz.: suction; compression; power generation and exhaust. These operations are performed either during the 2-strokes of piston or during 4-strokes of the piston and accordingly they are called as 2-stroke cycle engines and 4-stroke cycle engines. In case of petrol engines during suction operation, charge of air and petrol fuel will be taken in. During compression this charge is compressed by the upward moving piston. And just before the end of compression, the charge of air and petrol fuel will be ignited by means of the spark produced by means of for spark plug. And the ignition system does the function of producing the spark in case of spark ignition engines.

Figure shows a typical spark plug used with petrol engines. It mainly consists of a central electrode and metal tongue. Central electrode is covered by means of porcelain insulating material. Through the metal screw the spark plug is fitted in the cylinder head plug. When the high tension voltage of the order of 30000 volts is applied across the spark electrodes, current jumps from one electrode to another producing a spark. Whereas in case of diesel (Compression Ignition-CI) engines only air is taken in during suction operation and in compressed during compression operation and just before the end of compression, when diesel fuel is injected, it gets ignited due to heat of compression of air. Once the charge is ignited, combustion starts and products of combustion expand, i.e. they force the piston to move downwards i.e. they produce power and after producing the power the gases are exhausted during exhaust operation.



Types of Ignition System

Basically Convectional Ignition systems are of 2 types :

(a) Battery or Coil Ignition System

(b) Magneto Ignition System.

Both these conventional, ignition systems work on mutual electromagnetic induction principle. Battery ignition system was generally used in 4-wheeler, but now-a-days it is more commonly used in 2-wheelers also (i.e. Button start, 2-wheeler like Pulsar, Kinetic Honda; Honda-Activa, Scooty, Fiero, etc.). In this case 6 V or 12 V batteries will supply necessary current in the primary winding. Magneto ignition system is mainly used in 2-wheeler, kick start engines. (Example, Bajaj Scooters, Boxer, Victor, Splendor, Passion, etc.). In this case magneto will produce and supply current to the primary winding. So in magneto ignition system magneto replaces the battery.

Battery or Coil Ignition System

Figure shows line diagram of battery ignition system for a 4-cylinder petrol engine. It mainly consists of a 6 or 12 volt battery, ammeter, ignition switch, auto-transformer (step up transformer), contact breaker, capacitor, distributor rotor, distributor contact points, spark plugs, etc. Note that the Figure 4.1 shows the ignition system for 4-cylinder petrol engine, here there are 4-spark plugs and contact breaker cam has 4-corners. (If it is for 6-cylinder engine it will have 6-spark plugs and contact breaker cam will be a perfect hexagon).

The ignition system is divided into 2-circuits:

(i) **Primary Circuit :** It consists of 6 or 12 V battery, ammeter, ignition switch, primary winding it has 200-300 turns of 20 SWG (Sharps Wire Gauge) gauge wire, contact breaker, capacitor.

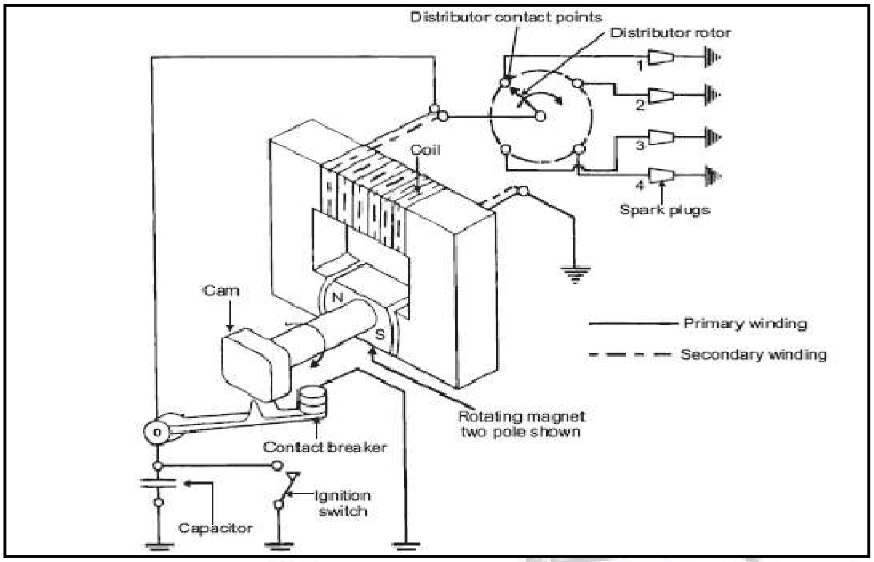
(ii) **Secondary Circuit:** It consists of secondary winding. Secondary Ignition Systems winding consists of about 21000 turns of 40 (S WG) gauge wire. Bottom end of which is connected to bottom end of primary and top end of secondary winding is connected to centre of distributor rotor. Distributor rotors rotate and make contacts with contact points and are connected to spark plugs which are fitted in cylinder heads (engine earth).

(iii) **Working:** When the ignition switch is closed and engine in cranked, as soon as the contact breaker closes, a low voltage current will flow through the primary winding. It is also to be noted that the contact beaker cam opens and closes the circuit 4-times (for 4 cylinders) in one revolution. When the contact breaker opens the contact, the magnetic field begins to collapse. Because of this collapsing magnetic field, current will be induced in the secondary winding. And because of more turns (@ 21000 turns) of secondary, voltage goes unto 28000-30000 volts.

This high voltage current is brought to centre of the distributor rotor. Distributor rotor rotates and supplies this high voltage current to proper stark plug depending upon the engine firing order. When the high voltage current jumps the spark plug gap, it produces the spark and the charge is ignited-combustion starts-products of combustion expand and produce power.

Note: (a) The Function of the capacitor is to reduce arcing at the contact breaker (CB) points. Also when the CB opens the magnetic field in the primary winding begins to collapse. When the magnetic field is collapsing capacitor gets fully charged and then it starts discharging and helps in building up of voltage in secondary winding.

(b) Contact breaker cam and distributor rotor are mounted on the same shaft. In 2-stroke cycle engines these are motored at the same engine speed. And in 4-stroke cycle engines they are motored at half the engine speed.

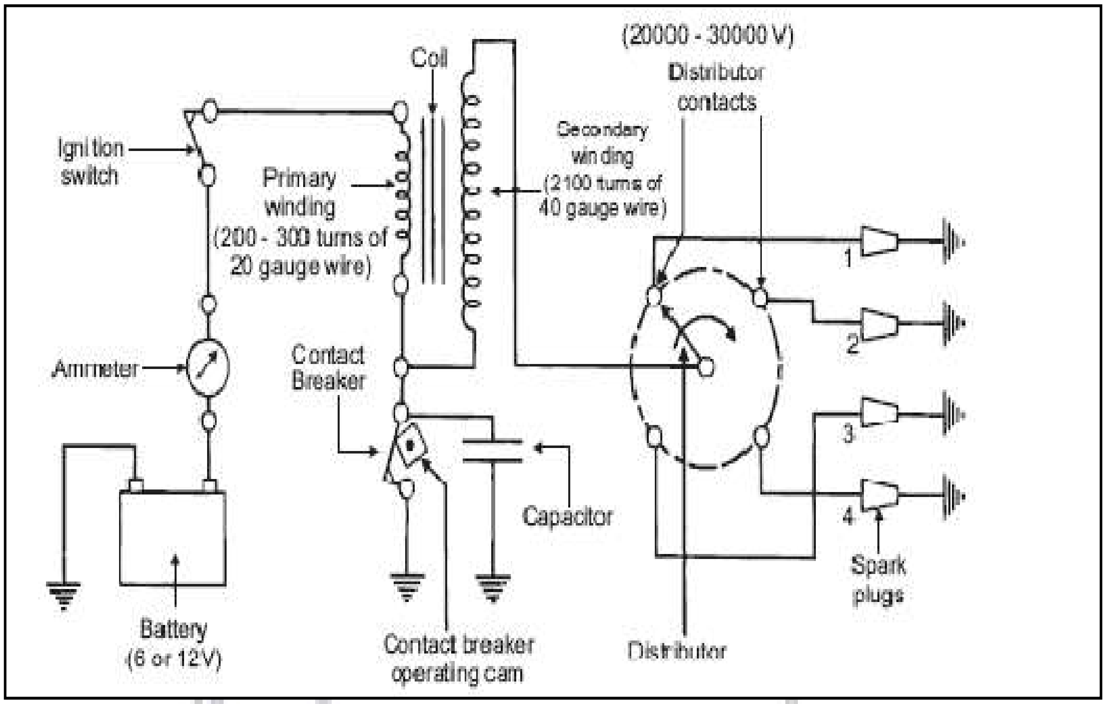


Magneto Ignition System

In this case magneto will produce and supply the required current to the primary winding. In this case as shown, we can have rotating magneto with fixed coil or rotating coil with fixed magneto for producing and supplying current to primary, remaining arrangement is same as that of a battery ignition system.

Comparison Between Battery And Magneto Ignition System

Battery Ignition	**Magneto Ignition**
Battery is a must	No battery needed.
Battery supplies current in primary circuit.	Magneto produces the required current for primary circuit.
A good spark is available at low speed also.	During starting the quality of spark is poor due to slow speed.
Occupies more space.	Very much compact.
Recharging is a must in case battery gets discharged.	No such arrangement required.
Mostly employed in car and bus for which it is required to crank the engine.	Used on motorcycles, scooters, etc.
Battery maintenance is required.	No battery maintenance problems.



Drawbacks (Disadvantages) Of Conventional Ignition Systems

Following are the advantages of electronic ignition system:

(a) Moving parts are absent-so no maintenance.

(b) Contact breaker points are absent-so no arcing.

(c) Spark plug life increases by 50% and they can be used for about 60000 km without any problem.

(d) Better combustion in combustion chamber, about 90-95% of air fuel mixture is burnt compared with 70-75% with conventional ignition system.

(e) More power output.

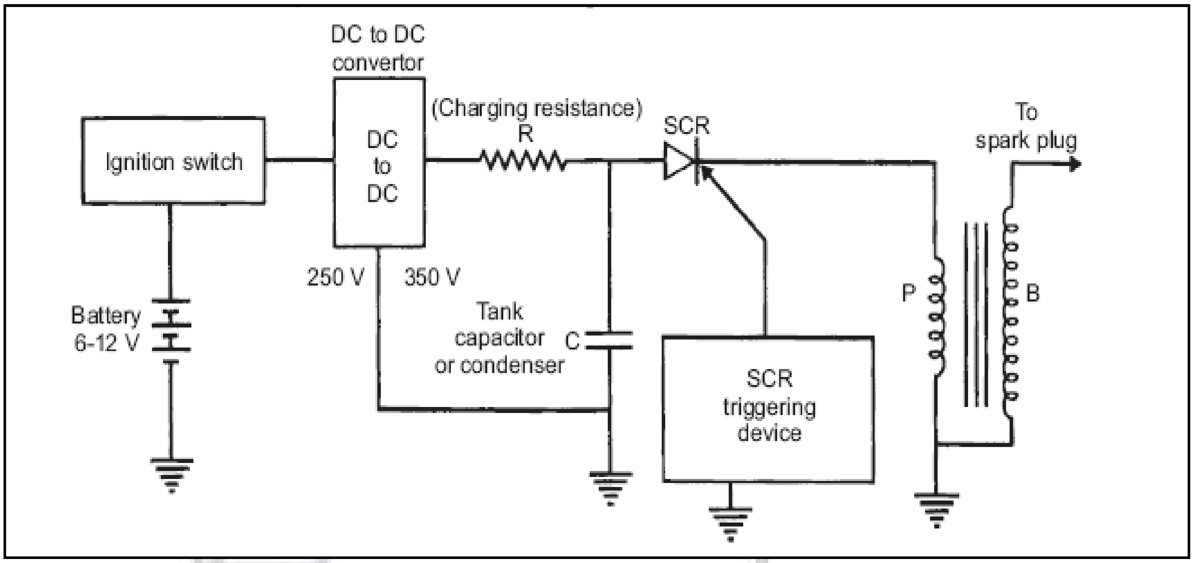
(f) More fuel efficiency.

Types Of Electronic Ignition System

Electronic Ignition System is as follow:

- Capacitance Discharge Ignition system
- Transistorized system
- Piezoelectric Ignition system
- The Texaco Ignition system

Capacitance Discharge Ignition System:



It mainly consists of 6-12 V battery, ignition switch, DC to DC converter, charging resistance, tank capacitor, Silicon Controlled Rectifier (SCR), Triggering device, step up transformer, spark plugs. A 6-12 volt battery is connected to DC to DC converter i.e. power circuit through the ignition switch, which is designed to give or increase the voltage to 250-350 volts. This high voltage is used to charge the tank capacitor (or condenser) to this voltage through the charging resistance. The charging resistance is also so designed that it controls the required current in the SCR. Depending upon the engine firing order, whenever the SCR triggering device, sends a pulse, then the current flowing through the primary winding is stopped. And the magnetic field begins to collapse. This collapsing magnetic field will induce or step up high voltage current in the secondary, which while jumping the spark plug gap produces the spark, and the charge of air fuel mixture is ignited**.**

Transistorized Assisted Contact (TAC) Ignition System

Advantages

(a) The low breaker-current ensures longer life.

(b) The smaller gap and lighter point assembly increase dwell time minimize contact bouncing and improve repeatability of secondary voltage.

(c) The low primary inductance reduces primary inductance reduces primary current drop-off at high speeds.

Disadvantages

(a) As in the conventional system, mechanical breaker points are necessary for timing the spark.

(b) The cost of the ignition system is increased.

(c) The voltage rise-time at the spark plug is about the same as before.

Piezoelectric Ignition System: - The development of synthetic piezo-electric materials producing about 22 kV by mechanical loading of a small crystal resulted in some ignition systems for single cylinder engines. But due to difficulties of high mechanical loading need of the order of 500 kg timely control and ability to produce sufficient voltage, these systems have not been able to come up.

The Texaco Ignition System:-Due to the increased emphasis on exhaust emission control, there has been a sudden interest in exhaust gas recirculation systems and lean fuel-air mixtures. To avoid the problems of burning of lean mixtures, the Texaco Ignition system has been developed. It provides a spark of controlled duration which means that the spark duration in crank angle degrees can be made constant at all engine speeds. It is a AC system. This system consists of three basic units, a power unit, a control unit and a distributor sensor.

This system can give stable ignition up to A/F ratios as high as 24: 1.

Firing Order: - The order or sequence in which the firing takes place, in different cylinders of a multi-cylinder engine is called Firing Order. In case of SI engines the distributor connects the spark plugs of different cylinders according to Engine Firing Order.

Advantages

(a) A proper firing order reduces engine vibrations.

(b) Maintains engine balancing.

(c) Secures an even flow of power.

Firing order differs from engine-to-engine. Probable firing orders for different engines are :

3 Cylinders Engine	= 1-3-2
4 cylinder engine (in-line)	= 1-3-4-2 1-2-4-3
4 cylinder horizontal opposed engine (Volkswagen engine)	= 1-4-3-2
6-cylinder in line engine (Cranks in 3 pairs)	= 1-5-3-6-2-4 1-4-2-6-3-5 1-3-2-6-4-5 1-2-4-6-5-3
8 cylinder in line engine	= 1-6-2-5-8-3-7-4 1-4-7-3-8-5-2-6
8 cylinder V type	= 1-5-4-8-6-3-7-2 1-5-4-2-6-3-7-8 1-6-2-5-8-3-7-4 1-8-4-3-6-5-7-2

Importance Of Ignition Timing And Ignition Advance

Ignition timing is very important, since the charge is to be ignited just before (few degrees before TDC) the end of compression, since when the charge is ignited, it will take some time to come to the required rate of burning.

Ignition Advance

The purpose of spark advance mechanism is to assure that under every condition of engine operation, ignition takes place at the most favorable instant in time i.e. most favorable from a standpoint of engine power, fuel economy and minimum exhaust dilution. By means of these mechanisms the advance angle is accurately set so that ignition occurs before TDC point of the piston. The engine speed and the engine load are the control quantities required for the automatic adjustment of the ignition timing. Most of the engines are fitted with mechanisms which are integral with the distributor and automatically regulate the optimum spark advance to account for change of speed and load. The two mechanisms used are:

(a) Centrifugal advance mechanism.

(b) Vacuum advance mechanism.

In SI engines, the combustion process is initiated by a spark between the two electrodes of spark plug. This occurs just before the end of compression stroke. Ignition is only a pre-requisite of combustion. In this unit, we have learnt in detail the different types of ignition systems. The difference between battery and magneto ignition systems lies only in the source of electrical energy. Battery ignition system uses a battery, magneto ignition system uses a magneto to supply low voltages all other system components being similar. The order or sequence in which the firing takes place, in different cylinders of a multi-cylinder engine is called firing order.

Questions:

(a) What do you understand by ‘ignition’? How is it related to ‘combustion’?

(b) What are the requirements of an ignition system for an IC engines?

(c) Differentiate between battery and magneto ignition system.

(d) Explain in brief the drawbacks of conventional ignition system.

(e) What is the difference between ‘ignition timing’ and ‘firing order’?

(f) List the various electronic ignition systems in use.

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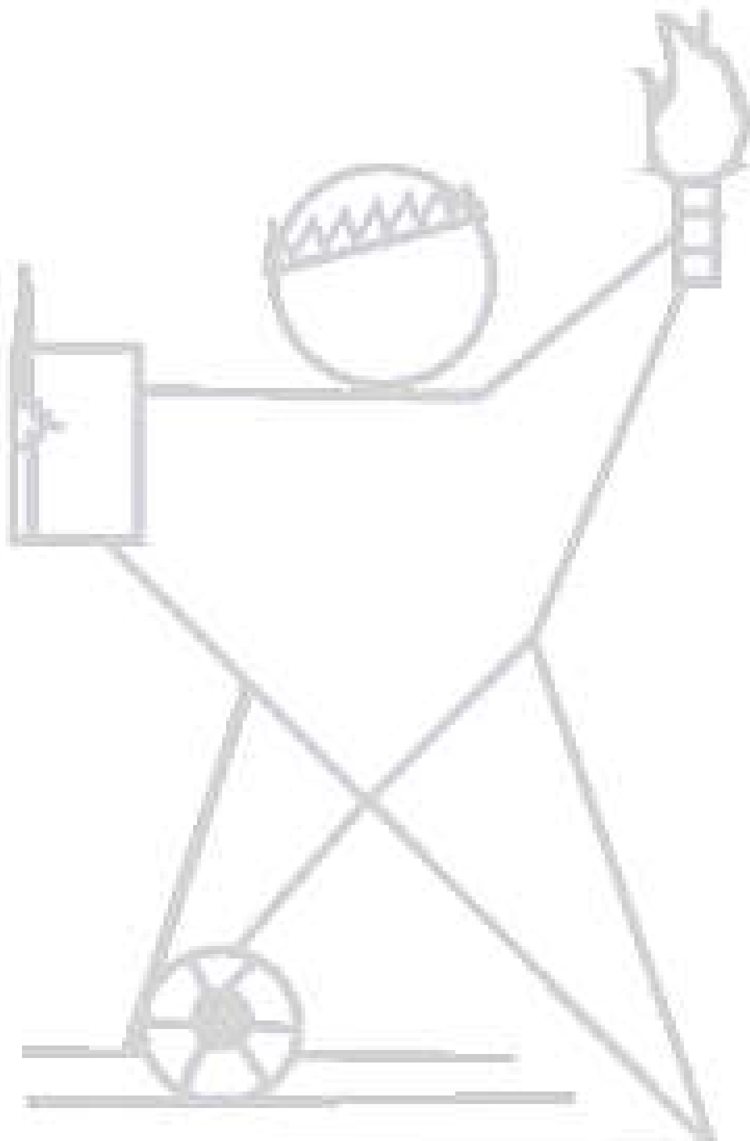

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