LAB MANUAL

INTERNAL COMBUSTION ENGINES

(MED 323)

G.S. Mandal’s

MAHARASHTRA INSTITUTE OF TECHNOLOGY, AURANGABAD

DEPARTMENT OF MECHANICAL ENGINEERING

INDEX

Vision: To be a center of excellence in the field of Mechanical Engineering where the best of teaching, learning and research synergize and serve the society through innovation and excellence in teaching.

Mission: To provide world-class under-graduate and graduate education in Mechanical Engineering by imparting quality techno-managerial education and training to meet current and emerging needs of the industry and society at large.

PEOs

PEO-I Graduates will apply the tools and skills acquired during their undergraduate studies either in advanced studies or as employees in engineering industries

PEO-2 Graduates of the program will have successful technical and professional career.

PEO-3 Graduates of the program will continue to learn to adopt constantly evolving technology.

PEO-4 Graduates will demonstrate sensitivity towards societal issues.

POs

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 search 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 modelling 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.

PSOs

PSO-I: Ability to design & analyse components & systems for mechanical performance

PSO-II: Ability to apply and solve the problems of heat power and thermal systems.

PSO-III: Ability to solve real life problems with the exposure to manufacturing industries

Course Objectives & Course Outcomes

Objectives: - To deal effectively with practical engineering situations, including analysis, selection and performance, and design of Internal Combustion Engines and the equipment's Associated with it.

Course Outcomes: -

CO 1- Recall I. C. Engine terminology and different system of I. C. Engines.

CO 2- Understand the various losses, stages of combustion and performance parameters in I.C. Engines

CO 3- Apply knowledge of fundamentals of thermodynamics and physics to measure performance parameters and characteristics of I. c. engines.

CO 4- Compare different technologies to enhance I. C. Engine performance.

CO 5 - Evaluation of engines emission and their effect on environment

CO 6- Discuss alternative solutions for current problems in I. C. Engines.

University Syllabus: -

Dr. Babasaheb Ambedkar Marathwada University, Aurangabad
(Faculty of Science & Technology)
Syllabus of Third Year B. Tech. (Mechanical Engineering) Semester V

Course Code: MED323 Course: Lab: -Internal Combustion Engine **Teaching Scheme:** Practical: 2 Hrs/week		Credits: 0-1-0 Term Work: 25 Marks Practical: 0 Marks
Objective	**:**	1. To deal effectively with practical engineering situations, including analysis, selection and performance, and design of Internal Combustion Engines and the equipment's associated with it.
List of Practical/ Assignments	**:**	1. Trial on Diesel Engine with variable load & constant speed. 2. Trial on Diesel Engine with variable speed & constant load. 3. Trial on Petrol Engine with variable load & constant speed. 4. Trial on Petrol Engine with variable speed & constant load. 5. To draw the actual Valve Timing diagram for a given engine. 6. Dissembling & Assembling of the given Carburetor. 7. Morse Test. 8. Study of different types of fuel injection systems 9. Study of different types of carburetors. 10. Study of Cooling and Lubrication system. 11. Assignment on Exhaust Emission. 12. Study and demonstration on VTEC system.
(Any TEN practical to be performed from the given list)		

The assessment of term work shall be done on the basis of the following.

- Continuous assessment
- Performing the experiments in the laboratory
- Oral examination conducted on the syllabus and term work mentioned above.

<u>Lab Instructions to all:</u>

Please 'Do'

1. Switch off all Electrical Appliances before leaving the lab.
2. Sign on Lab Utilization Register before leaving the lab.
3. Inform the In-charge about any abnormal incidence if any, immediately.

Please 'Do Not'

1. Touch any appliance/equipment without permission.
2. Start or Switch on any Engines without permission.
3. Move out anything from the lab without permission.
4. Disturb anything including furniture without permission.

EXPERIMENT NO. 1

Aim: -Demonstration of an anyone automobile engine with reference to characteristics.

Objectives: - To know different components of I. C. Engines and their function.

Introduction

An IC engine is one in which the heat transfer to the working fluid occurs within the engine itself, usually by the combustion of a fuel with the oxygen of the air. In external combustion engines, heat is transferred to the working fluid from the combustion gases via a heat exchanger. e.g. steam engines; Stirling engines.IC engines include spark ignition (SI) engines using petrol as a fuel, and compression ignition (CI) engines (usually referred to as Diesel engines) using fuel oil,

DERV, etc as a fuel. In these engines there is a sequence of processes:

- Induction
- Compression
- Combustion
- Expansion
- Exhaust

Various Parts of IC engines are as follows:

The main components of the reciprocating internal combustion engine are shown in Figure. Engine parts are made of various materials and perform certain functions, some of which will be explained: cylinder block (g) it is integral with crankcase (m), both are made of cast iron. The piston (e) reciprocates inside the cylinder, which includes the combustion chamber.

The piston is connected to the connecting rod (h) by piston pin (f). This end of the connecting rod is known as the small end. The other end of the connecting rod called the big end is connected to the crank arm by crankpin (I). Camshaft (u) makes the cam (t) to rotate and move up and down the valve rod through the tappet (r). Mainly each cylinder has two valves; one is an admission or suction valve and the other is the exhaust valve. The ignition system consists of a battery, an ignition coil, a distributor with cam and breaker points, and a spark plug for each cylinder. In diesel engines, there is an injection system instead of the ignition system.

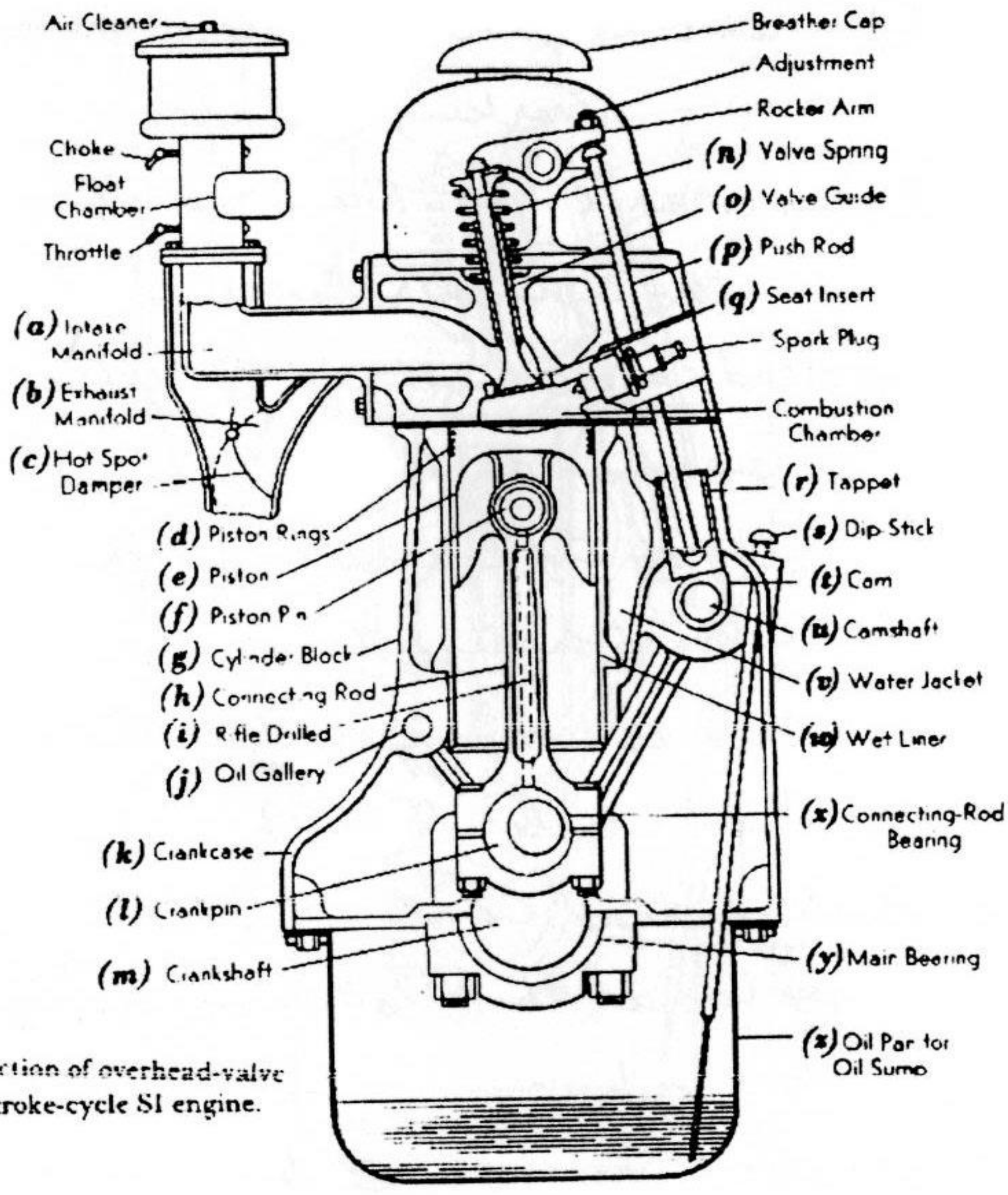


Figure: S.I. engine parts and details (over-head valve)

1) **Cylinder:-** A cylinder is the central working part of a reciprocating engine or pump, the space in which a piston travels. Multiple cylinders are commonly arranged side by side in a bank, or engine block, which is typically cast from aluminum or cast iron before receiving precision machine work. Cylinders may be sleeved (lined with a harder metal) or sleeveless. A cylinder's displacement, or swept volume, can be calculated by multiplying its cross-sectional area (the square of half the bore by pi) and again by the distance the piston travels within the cylinder (the stroke). The engine displacement can be calculated by multiplying the swept volume of one cylinder by the number of cylinders.
2) **Cylinder head:-** In an internal combustion engine, the cylinder head (often informally abbreviated to just head) sits above the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allows the exhaust to escape. The head can also be a place to mount the valves, spark plugs, and fuel injectors.
3) **Piston:** The piston of an internal combustion engine is acted upon by the pressure of the expanding combustion gases in the combustion chamber space at the top of the cylinder. This force then acts downwards through the connecting rod and onto the crankshaft. The connecting rod is attached to the piston by a swiveling gudgeon pin. This pin is mounted within the piston: unlike the steam engine, there is no piston rod or crosshead (except big two-stroke engines).
4) **Piston ring:-** A piston ring is a split ring that fits into a groove on the outer diameter of a piston in a reciprocating engine such as an internal combustion engine or steam engine.

The three main functions of piston rings in reciprocating engines are :

1 Sealing the combustion chamber so that there is no transfer of gases from the combustion chamber to the crank.

2 Supporting heat transfer from the piston to the cylinder wall.

3 Regulating engine oil consumption.

4 The gap in the piston ring compresses to a few thousandths of an inch when inside the cylinder bore.

5 **Gudgeon pin:-** In internal combustion engines, the gudgeon pin connects the piston to the connecting rod and provides a bearing for the connecting rod to pivot upon as the piston moves. In very early engine designs (including those driven by steam and also many very large stationary or marine engines), the gudgeon pin is located in a sliding crosshead that connects to the piston via a rod. Gudgeon is a pivot or journal

6 **Connecting rod**:- In modern automotive internal combustion engines, the connecting rods are most usually made of steel for production engines, but can be made of T6-2024 and T651-7075 aluminum alloys[citation needed] (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of lightness with strength, at higher cost) for high performance engines, or of cast iron for applications such as motor scooters. They are not rigidly fixed at either end so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft. Connecting rods, especially in racing engines, may be called "billet" rods, if they are machined out of a solid billet of metal, rather than being cast or forged.

7 **Crank Shaft:-** The crankshaft, sometimes casually abbreviated to crank, is the part of an engine which translates reciprocating linear piston motion into rotation. To convert the reciprocating motion into rotation, the crankshaft has "crank throws" or "crankpins", additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach. It typically connects to a flywheel, to reduce the pulsation characteristic of the four-stroke cycle, and sometimes a torsional or vibrational damper at the opposite end, to reduce the torsion vibrations often caused along the length of the crankshaft by the cylinders farthest from the output end acting on the torsional elasticity of the metal.

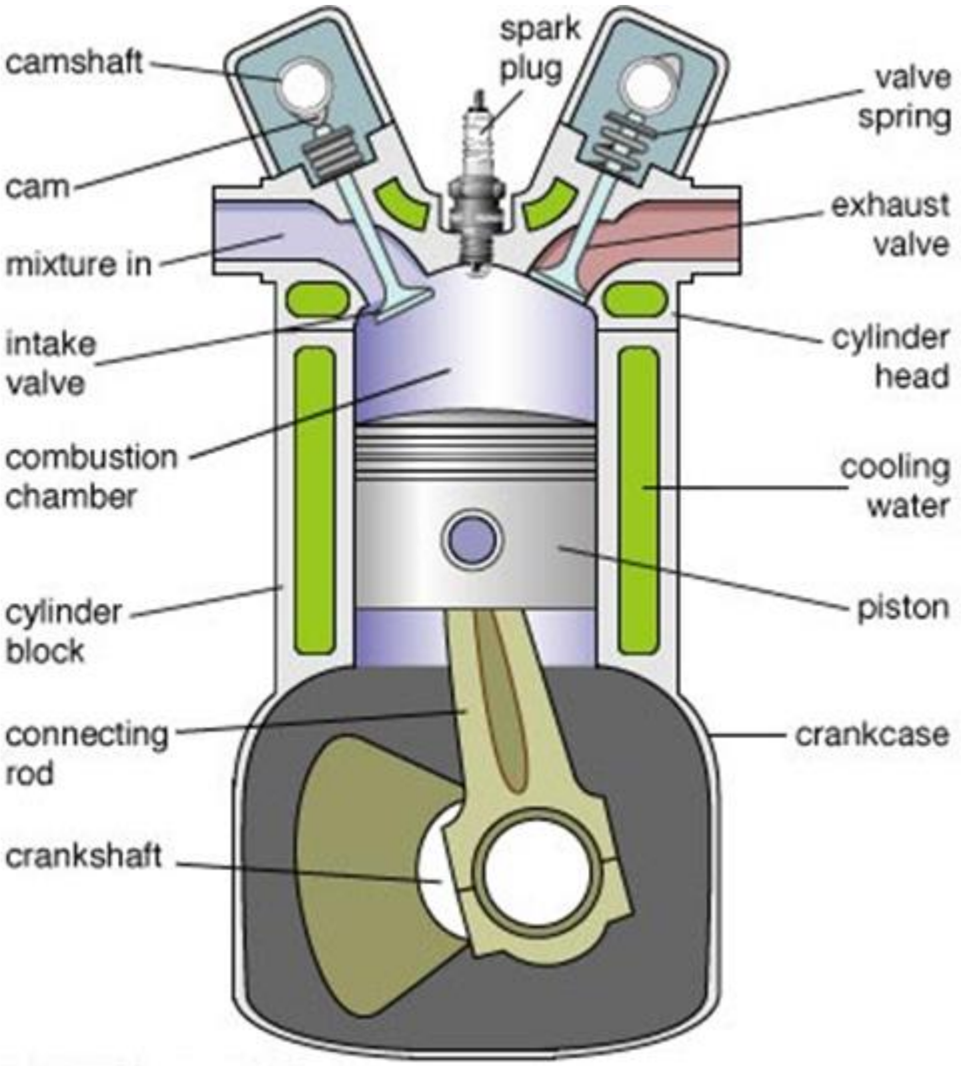
8 **Engine bearing**:-Bearing is a device supporting a mechanical element and providing its movement relative to another element with minimum power loss. The rotating components of internal combustion engines are equipped with sleeve type sliding

bearings. The reciprocating engines are characterized by the cycling loading of their parts including bearings. Such character of the loads is a result of alternating pressure of combustion gases in the cylinders. Rolling bearings, in which a load is transmitted by rolls (balls) to a relatively small area of the ring surface, can not withstand under the loading conditions of internal combustion engines. Only sliding bearings providing a distribution of the applied load over a relatively wide area may work in internal combustion engines.

9 **Crank Case: -** In an internal combustion engine of the reciprocating type, the crankcase is the housing for the crankshaft. The enclosure forms the largest cavity in the engine and is located below the cylinder(s), which in the Maulticylinder engine are usually integrated into one or several cylinder blocks. Crankcases have often been discrete parts, but more often they are integral with the cylinder bank(s), forming an engine block. Nevertheless, the area around the crankshaft is still usually called the crankcase. Crankcases and other basic engine structural components (e.g., cylinders, cylinder blocks, cylinder heads, and integrated combinations thereof) are typically made of cast iron or cast aluminum via sand casting.

10 **Flywheel: -** A flywheel is a rotating mechanical device that is used to store rotational energy. Flywheels have a significant moment of inertia and thus resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to a flywheel by applying torque to it, thereby increasing its rotational speed, and hence its stored energy. Conversely, a flywheel releases stored energy by applying torque to a mechanical load, thereby decreasing its rotational speed.

11 **Governer:-** A governor, or speed limiter, is a device used to measure and regulate the speed of a machine, such as an engine. A classic example is a centrifugal governor, also known as the Watt or fly-ball governor, which uses weights mounted on spring-loaded arms to determine how fast a shaft is spinning, and then uses proportional control to regulate the shaft speed.



Classification of Internal Combustion Engines:

Internal combustion engines can be classified into a large number of types based on several criteria. The classification of IC engines is given below:

I} Based on the fuel used

1)Diesel Engine

2)Petrol Engine (or Gasoline Engine)

II} Based on the type of cycle

1)Otto Cycle Engine

2)Diesel Cycle Engine

3)Dual Cycle Engine

III} Based on the number of strokes per cycle

1)Two-stroke Engine

2)Four-stroke Engine

IV} Based on the number of cylinders

1)Single Cylinder Engine

2)Multi-cylinder Engine

3)Twin Cylinder Engine

4)Three-Cylinder Engine

5)Four-Cylinder Engine

6)Six Cylinder Engine

7)Eight Cylinder Engine

8)Twelve Cylinder Engine

9)Sixteen Cylinder Engine

V} Based on the type of ignition

1)Spark Ignition Engine (S.I. Engine)

2)Compression-Ignition Engine (C.I. Engine)

VI} Based on the lubrication system used

1)Dry sump lubricated the engine

2)Wet sump lubricated Engine

VII} Based on the cooling system used

1)Air-cooled Engine

2)Water-cooled Engine

VIII} Based on the arrangement of valves

1)L-head Engine

2)I-head Engine

3)T-head Engine

4)F-head Engine

IX} Based on the position of cylinders

1)Horizontal Engine

2)Vertical Engine

3)Radial Engine

4)Opposed Piston Engine

5)Opposed Cylinder Engine

6)V Engine

7)W Engine

8)Inline Engine

X} Based on the pressure boost given to the inlet air or air-fuel mixture

1)Naturally aspired Engine

2)Supercharged Engine

3)Turbocharged Engine

4)Crankcase compressed Engine

XI} Based on application

1)Automobile Engine

2)Aircraft Engine

3)Locomotive Engine

4)Marine Engine

5)Stationary Engine

Figure:- Working of CI engine

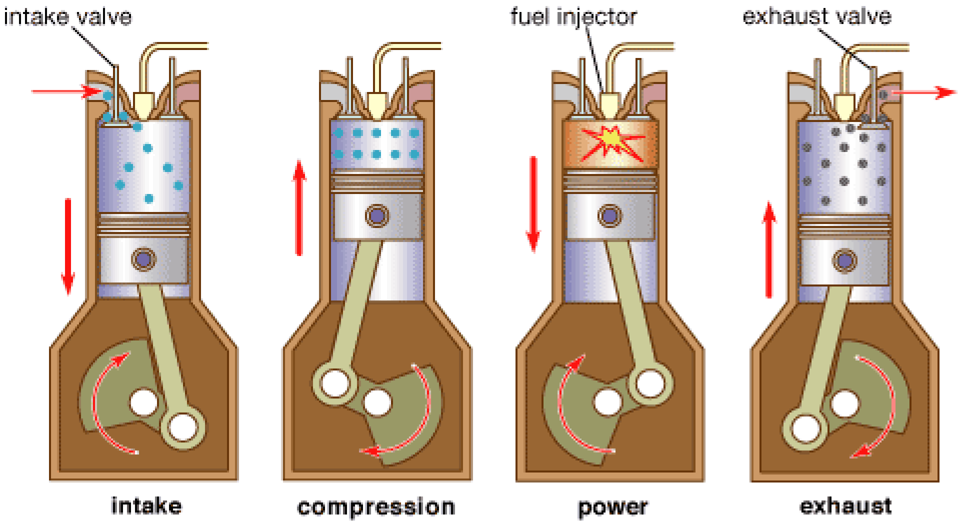
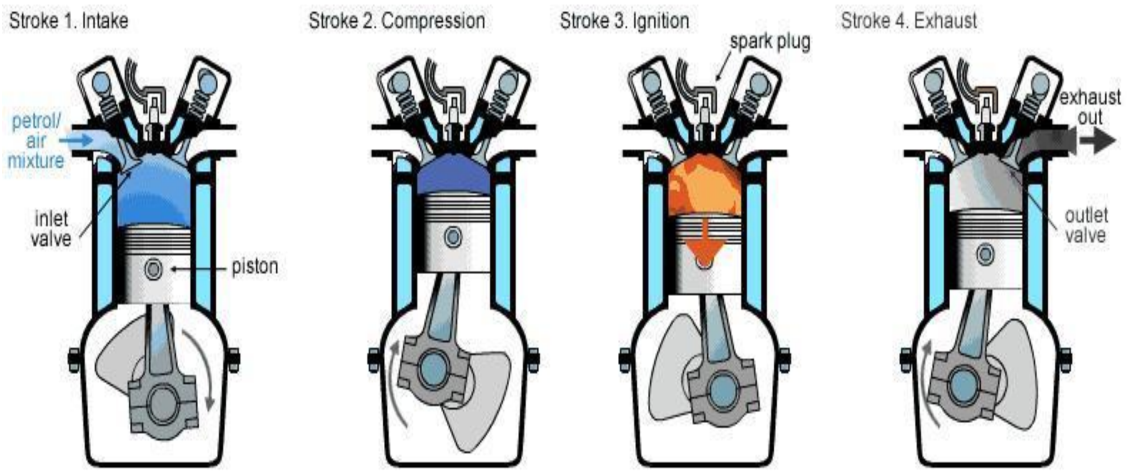


Figure:- Working of SI Engine



Internal Combustion Engines Terminology:

1. Cylinder bore (B): The nominal inner diameter of the working cylinder.

2. Piston area (A): the area of a circle diameter equal to the cylinder bore.

3. Top Dead Center (T.D.C.): the extreme position of the piston at the top of the cylinder. In the case of the horizontal engines, this is known as the outer dead center (O.D.C.).

4. Bottom Dead Center (B.D.C.): the extreme position of the piston at the bottom of the cylinder. In a horizontal engine, this is known as the Inner Dead Center (I.D.C.).

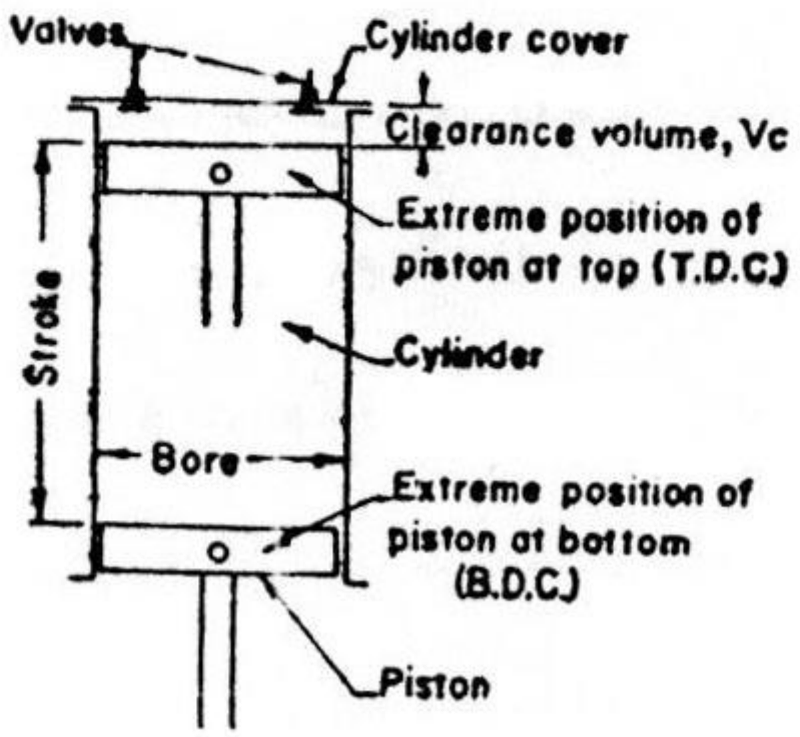
5. Stroke: the distance between TDC and BDC is called the stroke length and is equal to double the crank radius (l).

6. Swept volume: the volume swept through by the piston in moving between TDC and is denoted by Vs:

7. Clearance volume: the space above the piston head at the TDC, and is denoted by Vc: Volume of the cylinder: V = Vc + Vs

8. Compression ratio: it is the ratio of the total volume of the cylinder to the clearance volume, and is denoted by (r)

9. Mean piston speed: the distance traveled by the piston per unit of time:



Modern Developments of I.C.E.:

The modern I.C.E. is a product of research and developments extending over a long period of time many engines were proposed and tested, these include:

1. Stratified charge engine.
2. Dual Fuel and Multi- Fuel engines.
3. Sterling engine.
4. Free Piston engine.
5. Variable compression ratio engine.
6. Combination of reciprocating engine with a gas turbine.

Advantages of I.C.E. over E.C.E.:

1. More mechanical simplicity and lower weight/power ratio.
2. They do not need auxiliary equipment, such as a boiler & condenser.
3. They could be started and stopped in a short time.
4. Their thermal efficiency is higher than other heat engines.
5. Their initial cost is low.

These advantages make I.C.E. more suitable in the transport sector; motor cars, small ships, submarines, and small aircraft.

Conclusion: Students should write the conclusion

Hence demonstration of IC engine is conducted**.**

Questions:

1. What is the I. C. engine? State its applications?
2. How do you classify I. C. Engines?
3. Distinguish between 2- stroke and 4-stroke engine?
4. Enlist different types of piston rings? And state its function?
5. Explain different components of I. C. Engine?

Experiment No:-02

Aim:-To draw the actual Valve Timing diagram for a given engine.

Objectives: - To understand the importance of the valve timing diagram and firing order.

Apparatus Required:

1. Four-stroke cycle diesel engine
2. Measuring tape
3. Chalk
4. Piece of paper

Theory and Description:

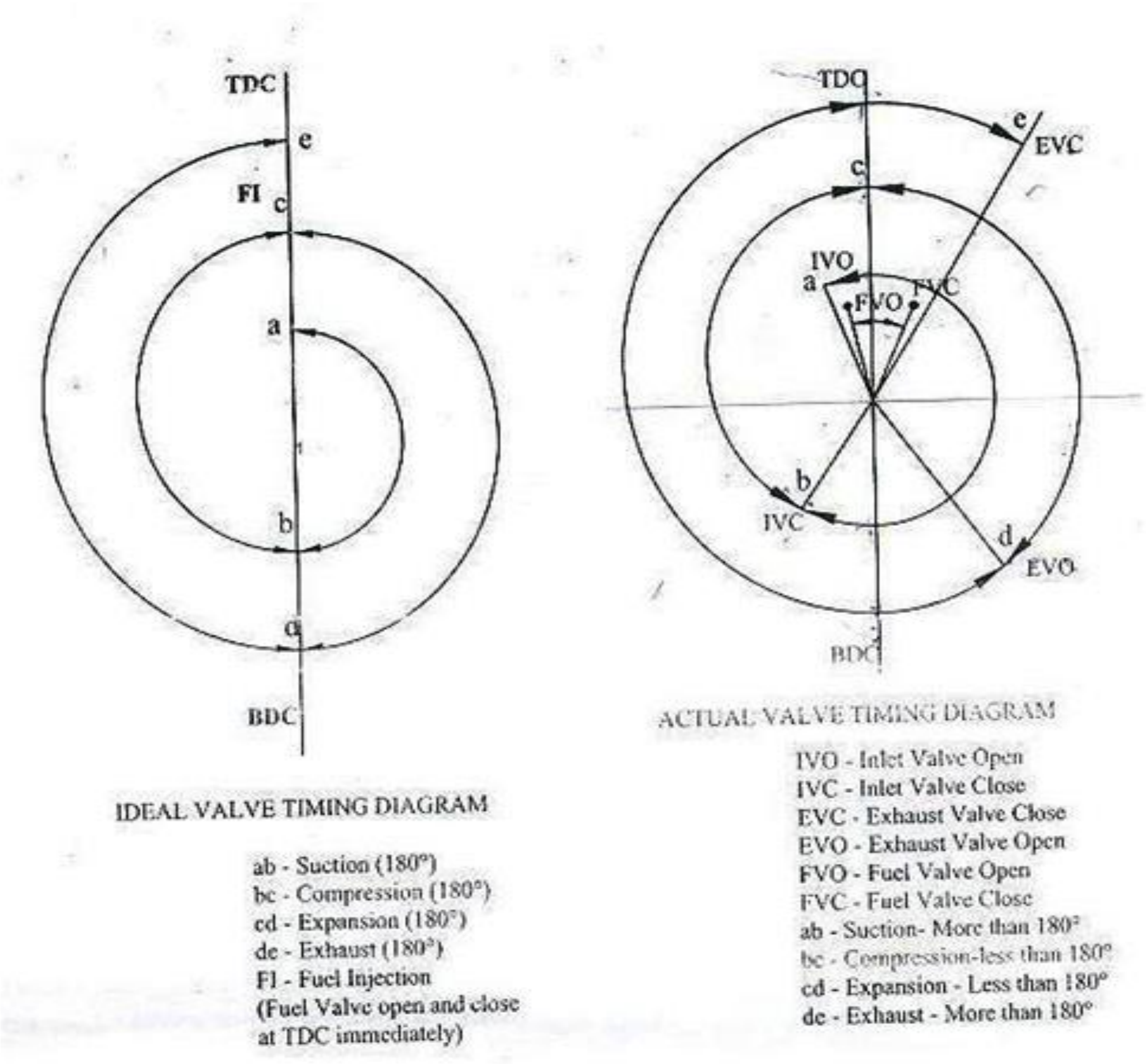
The diagram shows the position of the crank of the four-stroke cycle engine at the beginning and at the end of suction, compression, expansion, and exhaust of the engine are called a Valve Timing Diagram. The extreme position of the bottom of the cylinder is called "Bottom Dead Centre" [BDC].IN the case of the horizontal engine, this is known as "Outer Dead Centre" [ODC]. The position of the piston at the top of the cylinder is called "Top Dead Centre" [TDC].In the case of the horizontal engine, this is known as the "Inner Dead Centre" [TDC]. In the case of horizontal engine this is known as "inner dead center " [IDC] In an ideal engine, the inlet valve opens at TDC and closes at BDC. The exhaust valve opens at BDC and closes at TDC. The fuel is injected into the cylinder when the piston is at TDC and at the end of compression stroke But in actual practice, it will differ.

Inlet Valve opening and closing :

In an actual engine, the inlet valve begins to open 5°C to 20 °C before the piston reaches the TDC during the end of the exhaust stroke. This is necessary to ensure that the valve will be fully open when the piston reaches the TDC. If the inlet valve is allowed to close at BDC, the cylinder would receive less amount of air than its capacity and the pressure at the end of suction will be below the atmospheric pressure. To avoid this the inlet valve is kept open for 25° to 40°after BDC.

Exhaust valve opening and closing

Complete clearing of the burned gases from the cylinder is necessary to take in more air into the cylinder. To achieve this the exhaust valve is opening at 35° to 45° before BDC and closes from 10° to 20° after the TCC. It is clear from the diagram, for a certain period both the inlet valve and exhaust valve remains in open condition. The crank angles for which both valves are open are called an overlapping period. This overlapping is more than the petrol engine.



Observation and Tabulation :

1. Circumference of the flywheel = X Cm

$$\therefore 1 \text{ cm} = \frac{360}{X} \text{ degree}$$

S.No.	Event	Position of crank w.r.to TDC or BDC	Distance in cm	Angle in degrees
1.	IVO	Before TDC		
2.	IVC	After BDC		
3.	EVO	Before BDC		
4.	EVC	After TDC		
5.	FVO	Before TDC		
6.	FVS	After TDC		

Fuel valve opening and closing :

The fuel valve opens at 10° to 15 °before TDC and closes at 15° to 20 ° after TDC. This is because of better evaporation and mixing fuel.

Procedure :

1. Remove the cylinder head cover and identify the inlet valve, exhaust valve and piston of a particular cylinder.
2. Mark the BDC and TDC position of flywheel This is done by Rotating the crank in the usual direction of rotation and observe the position of the flywheel when the piston is moving downwards at which the piston begins to move in the opposite direction. i.e from down to the upward direction. Make the mark on the flywheel with reference to a fixed point on the body of the engine. That point is the BDC for that cylinder.Measure the circumference. That point is TDC and is diametrically opposed to the BDC.
3. Insert the paper in the tappet clearance of both inlet and exhaust valves

4. Slowly rotate the crank until the paper in the tappet clearance of the inlet valve is gripped .make the mark on flywheel against a fixed reference. This position represents the inlet valve open (IVO). Measure the distance from TDC and tabulate the distance.
5. Rotate the crank further, till the paper is just free to move. Make the marking on the flywheel against the fixed reference. This position represents the inlet valve close (IVC). Measure the distance from BDC and tabulate the distance.
6. Rotate the crank further, till the paper in the tappet clearance of exhaust valve is gripped. Make the marking on the flywheel against a fixed reference. This position represents the exhaust valve open (EVO). Measure the distance from BDC and tabulate.
7. Then convert the measured distances into an angle in degrees

Result :

The valve timing diagram for the given four-stroke Diesel engine was drawn.

Questions:

1. What is mean by TDC & BDC positions?
2. Sketch and explain the valve operating mechanism?
3. Distinguish between theoretical and actual valve timing diagram?
4. State the significance of the valve timing diagram?

Experiment No:-03

Aim:-Dissembling & Assembling of the given Carburettor.

Objectives: - To understand the working of different components of the carburetor

Functions of a carburetor

The main functions which a carburetor is required to perform are

1 To keep a small reserve of fuel at a constant head

2 To vaporize the fuel to prepare a homogeneous air-fuel mixture

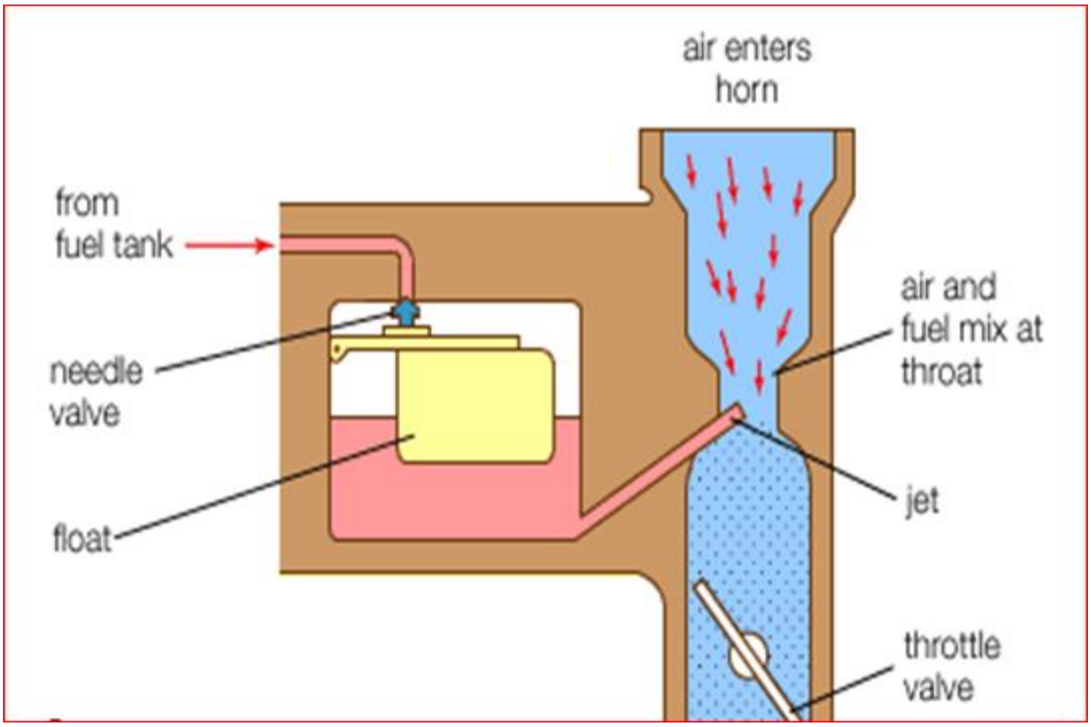
3 To supply the correct amount or the air-fuel mixture at the correct strength under all conditions of load and speed of the engine

Simple carburetor

To understand the principle on which a carburetor works, consider a simple carburetor as shown in fig. The main parts are a float chamber, fuel jet, venturi, nozzle, and a throttle valve. The float in the float chamber is made of deep-drawn brass sheet and is kept hollow for lightness. Such floats have a tendency to leak along the joint seams. Due to this reason floats are now made of nylon plastic or expanded synthetic rubber. The needle valve attached to the float lever serves to close or open the fuel inlet to the float chamber depending upon the requirements.

The needle valve consists of a cylindrical stem with a conical tip made of steel or else a solid steel stem with a rubber seat tip. Alternatively, there may be a three-piece valve with a rubber seat tip and a spring-loaded ball in the body of the stem. The latter two types maintain the liquid-tight seal during vibrations, which is not possible with an ordinary single piece needle valve. When the fuel level falls below a definite predetermined value, the float also falls along with fuel level, thus opening the passage for the fuel supply.

The fuel starts flowing in and the float rises gradually till the fuel level reaches the desired value. At this time, the float needle closes the fuel inlet passage. Thus a constant head of fuel is maintained in the float chamber. This constant level of fuel is slightly below the nozzle outlet, so that the fuel may not drop all the time from the nozzle, even when the engine is not working. This provision also prevents the fuel from spilling out when the car is tilted on account of a hilly or highly cambered road. In practice, the fuel level in the float chamber is maintained about 5mm below the nozzle outlet. A small vent in the float chamber keeps the pressure inside the atmospheric. In modern practice, it is preferred to vent the float chamber to the air intake of the carburetor. Such an arrangement prevents dust particles from mixing with the petrol through the vent as there is always an air cleaner on the intake side of the carburetor which filters the incoming air.



Write Construction, working, and a sketch of the carburettor which you have Dissembled & Assembled in the Practical session.

Conclusion: Hence we have studied dissembling & Assembling of the given Carburettor

Questions:

1. Classify carburetor? And state its function?
2. What is the correct air-fuel mixture?
3. What is the function of the main metering system in carburetors?

EXPERIMENT NO:-04

Aim:-Study of different types of carburetors.

Objectives: - To know the different types of carburetors used in modern vehicles and their components.

Functions of a carburetor

The main functions which a carburetor is required to perform are

1 To keep a small reserve of fuel at a constant head

2 To vaporize the fuel to prepare a homogeneous air-fuel mixture

3 To supply the correct amount or the air-fuel mixture at the correct strength under all conditions of load and speed of the engine

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To understand the principle on which a carburetor works, consider a simple carburetor as shown in fig. The main parts are a float chamber, fuel jet, venturi, nozzle, and a throttle valve. The float in the float chamber is made of deep-drawn brass sheet and is kept hollow for lightness. Such floats have a tendency to leak along the joint seams. Due to this reason floats are now made of nylon plastic or expanded synthetic rubber. The needle valve attached to the float lever serves to close or open the fuel inlet to the float chamber depending upon the requirements.

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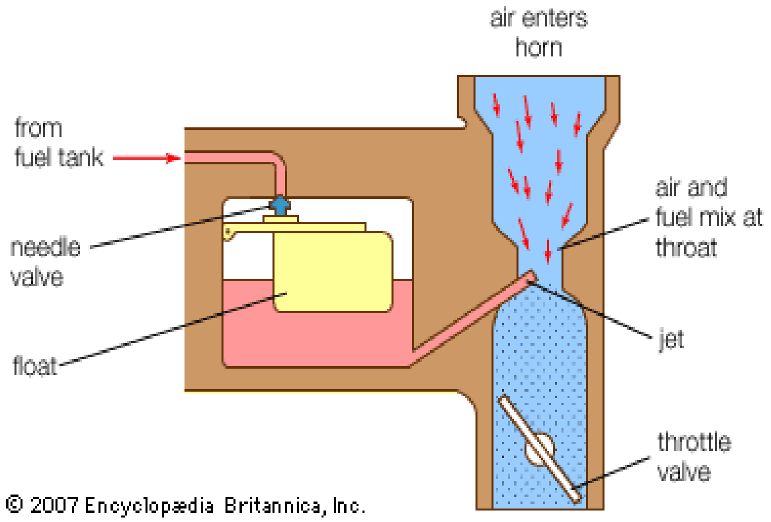


Types of Carburetors

- Natural or side draft
- Updraft
- Downdraft

Natural Draft Carburetor

This carburetor is used where there is little space on top of the engine. The air horizontally into the manifold

Updraft Carburetors

This type is placed low on the engine and uses a gravity fed-fuel supply. In other words, the tank is above the carburetor and the fuel falls to it

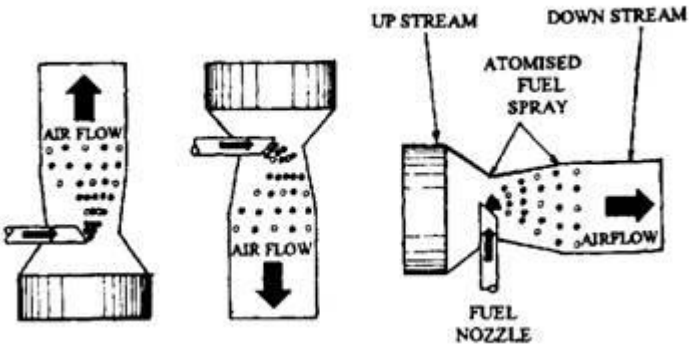
Updraft Carburetors

Even this carburetor uses gravity to receive the fuel from the tank, the air-fuel mixture must be forced upward into the engine.

Downdraft Carburetors

This carburetor operates with lower air velocities and larger passages. This is because gravity assists the air-fuel mixture flow to the cylinder.

The downdraft carburetor can provide large volumes of fuel when needed for high speed and high power output.



In an up-draught carburetor, the air-fuel mixture flows upward. This arrangement is convenient for the gravity flow of fuel with a low overall height. Horizontal carburetor gives higher charge efficiency, because of shorter connections to the intake manifold. It is not suitable for the installation of an air filter. The down draught carburetor has a flow of the air-fuel mixture in the downward direction. This type of carburetor is most accessible and air filters can be attached easily. Further, there is less chance of the settling out of the heavier fractions of the fuel, because Liquid particles flow in the direction of gravity. **Carburetors' are usually classified by the number of barrels or venturies used.**

One-barrel.

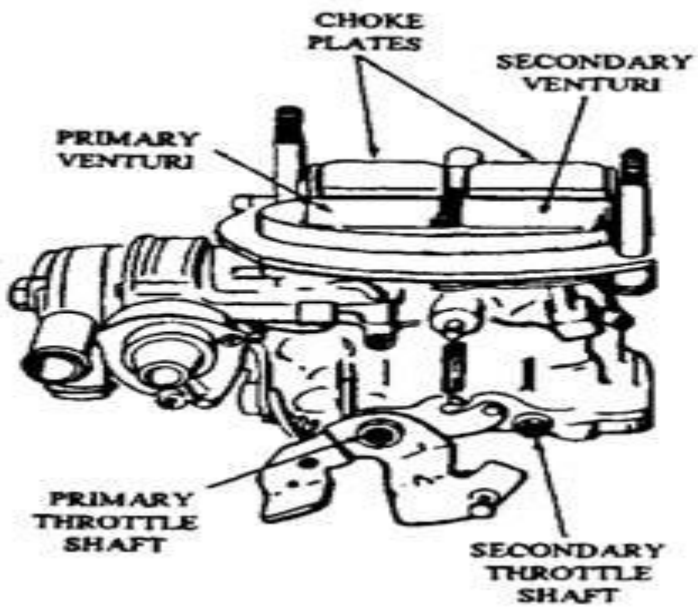
The one-barrel carburetor has a single outlet through which all the systems feed to the intake manifold. This type of carburetor is also known as a single-venturi design. These carburetors are generally used on 4-cylinder and 6-cylinder engines.

Single-stage Two-barrel.

This carburetor has two barrels and two throttles, which operate together. Since the various fuel-discharge passages in each barrel operate at the same time, it can be considered as two numbers of single-barrel carburetors sharing the same body having one air horn. The two throttle plates are mounted on the same shaft and operate together. The two barrels share a common float, choke, power system, and acceleration pump. Single-stage two-barrel carburetors as used on many 6-cylinder and 8-cylinder engines.

Two-stage Two-barrel.

This carburetor is relatively a latter development brought about by emission control requirements. It differs from the single-stage two-barrel design in that it's two throttle plates operate independently. The primary barrel is generally smaller than the secondary and handles engine needs at low-to-moderate speeds and loads. The larger secondary barrel opens whenever necessary to meet higher load requirements. The primary stage usually includes the

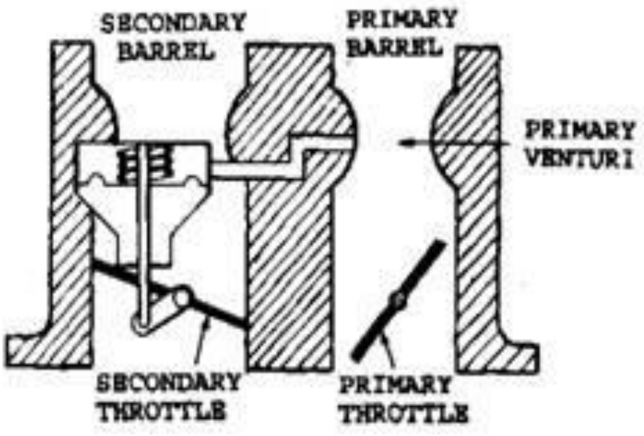


Two-stage two-barrel carburetor.

idle, the accelerator pump, the low speed, the main metering, and power systems. The secondary stage usually has a transfer, the main metering, and a power system. Both stages draw fuel from the same fuel bowl. Some designs use a common choke for both barrels.

In others, only the primary stage is choked. The secondary system supplies large quantities of the rich fuel mixture for high engine power. In moderate driving at legal speed limits, the secondary system normally does not come into operation. The secondary portion comes into operation under approximately the same operating conditions as the primary, but it begins to operate when the primary throttle is opened about 60% and throttle plate, in this case, opens very rapidly so that both secondary and primary throttle plates reach the fully open position at the same time.

Many carburetors incorporate a mechanical linkage to operate secondary throttles. In this case, an air valve, somewhat like a choke plate, is installed in the air horn which keeps the secondary air passage closed at full throttle low-speed conditions when the operation of secondary fuel discharge nozzle is not necessary. In other designs, the secondary throttle is operated through a spring-loaded diaphragm and linkage, which holds the secondary throttle closed at low speeds. A passage from the narrow portion of the primary venturi senses the venturi vacuum produced by high primary airflow velocity, and this venturi vacuum pulls the diaphragm against the spring, which opens the secondary throttle plate and provides the engine with required quantity of mixture to meet the power demand. Vacuum operated secondary



Vacuum operated the secondary throttle.

the throttle is illustrated in A two-stage two-barrel carburetor that is used primarily on 4-cylinder and 6-cylinder engines and few V-8 engines. A sticking or leaking piston or diaphragm gives problems in the secondary system requiring replacement.

Four-barrel.

The 4-barrel, or quad, carburetor uses two primary barrels and two secondary barrels in a single body. The two primaries operate single-stage two-barrel at low-to-moderate engine speeds and loads. The secondary barrels open about half to three-quarter throttle to provide the increased fuel and airflow required for high-speed operation. The primary barrels contain the choke, the idle, the low speed, the high-speed, an accelerator pump and a power system. The secondary barrels have their own high speed and power system and may use their own acceleration system.

Airflow through the secondary barrels can be provided either by venturi action or air velocity valves. Air velocity valves look like large choke plates located in the secondary barrels. They are opened by the low pressure created in the secondary barrels when the throttles are opened. Four-barrel carburetor is used on V-8 engines. The primary barrel meets the requirement of all eight cylinders during low-to-moderate speeds and loads. The secondary barrels provide additional fuel and airflow for high speeds and heavy loads.

Conclusion: Students should write the conclusion

Hence we have studied different types of carburetors.

Questions:

1. State the Functions of the carburetor?
2. Enlist and explain different types of Carburetors?
3. What is the complete carburetor?

Experiment No:-05

Aim:-Study of different types of fuel injection systems.

Objectives:-To understand the different types of fuel injection systems used in I. C. engines.

Fuel Injection System

The function of a fuel injection system is to inject the proper quantity of fuel into the engine cylinders at the correct time and at a predetermined rate. The fuel injection systems may be broadly classified into the solid injection system and the air injection system. In the solid injection system, only the liquid fuel is injected, whereas in the injection system liquid fuel is injected along with compressed air. The air injection system is less reliable, less efficient and requires an air compressor for supplying air at 7 Mpa or higher pressures (which consumes up to 10% of the power output of the engine) due to which reasons it has become obsolete. The solid injection system will, therefore, be discussed here in detail.

Two types of solid injection systems are in use:

1. common rail fuel injection system
2. individual pump fuel injection system

The layout of a common rail fuel injection system is shown in fig. This type of fuel supply system is used in the Detroit diesel engine, commonly known as Jimmy diesel. In this, a single injection pump with an injector, called as the unit injector is employed on each cylinder. The unit injectors are operated by rocker arms and springs similar to the engine valves. A linkage connects the control racks of all the unit injectors, so that fuel injection in all the cylinders may be equal and simultaneously controlled.

The fuel is taken from the fuel tank by the feed pump and is supplied at low pressure through a filter, to all the unit injectors. This avoids the high-pressure fuel lines necessary in the individual pump system. Any excess fuel from the relief valve is returned to the fuel tank.

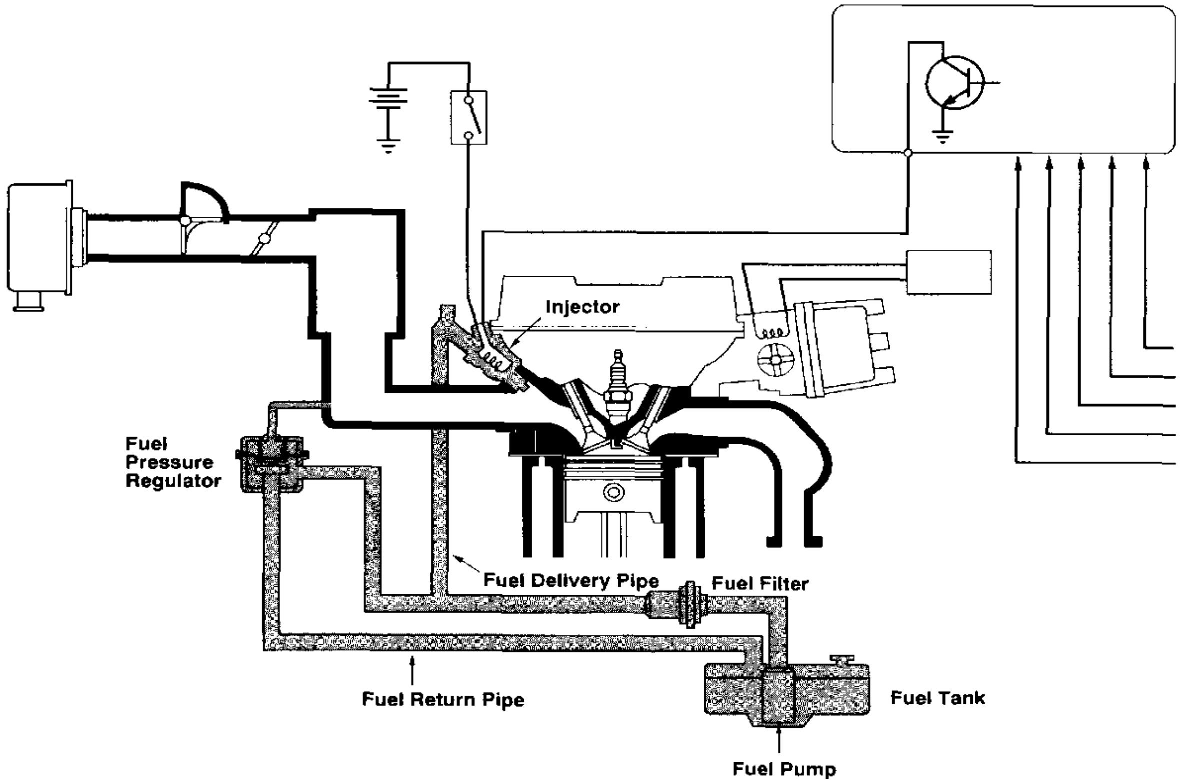
The individual pump fuel injection system using the inline injection pump is shown in fig. Fuel is drawn from the fuel tank by means of a fuel feed pump which is operated from the injection pump camshaft. Generally, the plunger-type or the diaphragm type of fuel feed pumps are employed in automobiles. The pump is provided with a hand priming lever so that the diesel oil can be forced into the system and the air bled out without turning the engine.

The fuel is then passed through a filter and thence to the fuel injection pump. Without the filter or with a poor quality filter, the abrasive matter would reach the fuel injection pump and injectors, resulting in poor starting, irregular idling and deterioration in performance due to decreased fuel delivery from the injection pump. The abrasive matter would also cause faulty spraying and leakage in the injectors thus resulting in increased fuel consumption and heavy exhaust smoke.

Electronic Fuel Injection Overview

How Electronic Fuel Injection Works

Electronic Fuel injection works on some very basic principles. The following discussion broadly outlines how a basic or **Convention Electronic Fuel Injection (EFI)** system operates. The Electronic Fuel Injection system can be divided into three: basic sub-systems. These are the fuel delivery system, air induction system, and the electronic control system.

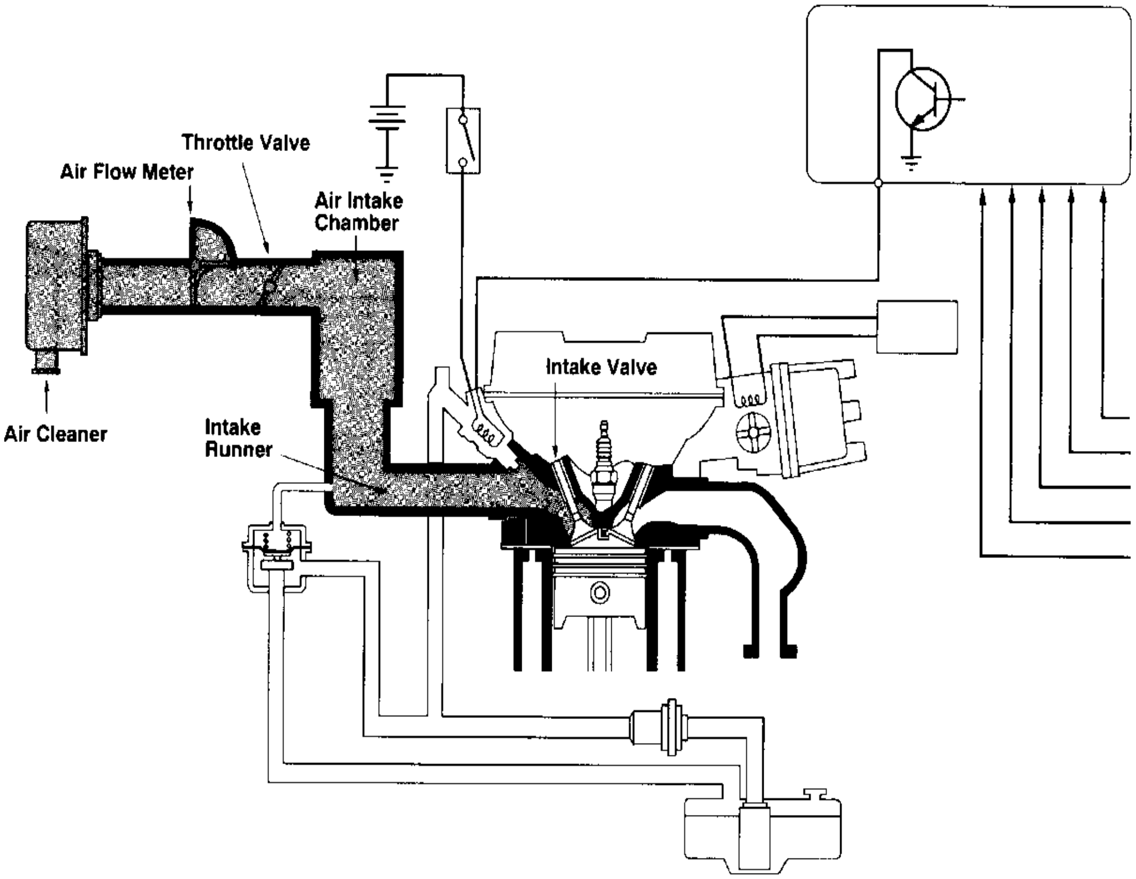


The Fuel Delivery System

The fuel delivery system consists of the fuel tank, fuel pump, fuel filter, fuel delivery pipe (fuel rail), fuel injector, fuel pressure regulator, and fuel return pipe. Fuel is delivered from the tank to the injector by means of an electric fuel pump. The pump is typically located in or near the fuel tank. Contaminants are filtered out by a high capacity inline fuel filter. Fuel is maintained at a constant pressure by means of a fuel pressure regulator. Any fuel which is not delivered to the intake manifold by the injector is returned to the tank through a fuel return pipe.

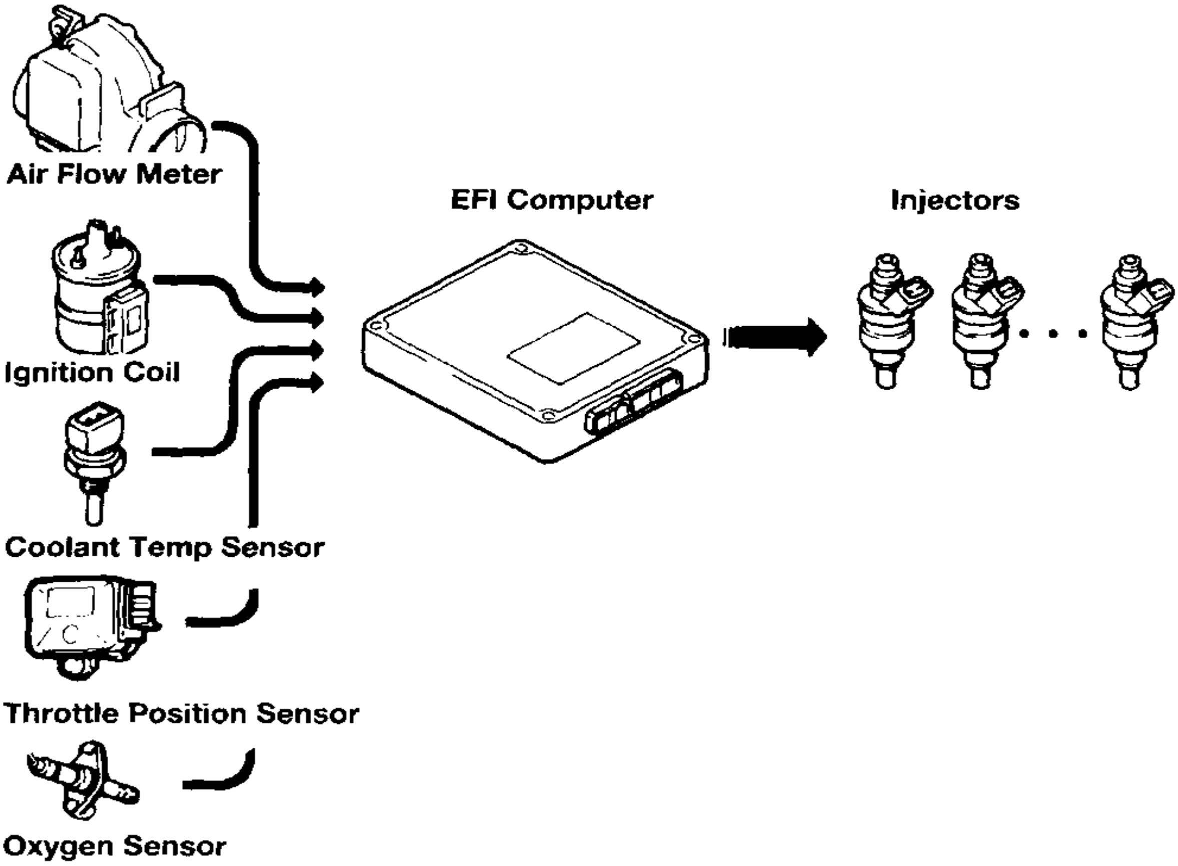
The Air Induction System

The air induction system consists of the air cleaner, airflow meter, throttle valve, air intake chamber, intake manifold runner, and intake valve. When the throttle valve is opened, air flows through the air cleaner, through the airflow meter (on L type systems), past the throttle valve, and through a well-tuned intake manifold runner to the intake valve. Air delivered to the engine is a function of driver demand. As the throttle valve is opened further, more air is allowed to enter the engine cylinders. Toyota engines use two different methods to measure intake air volume. The L type EFI system measures airflow directly by using an airflow meter. The D type EFI system measures airflow indirectly by monitoring the pressure in the intake manifold.



Electronic Control System

The electronic control system consists of various engine sensors, Electronic Control Unit (ECU), fuel injector assemblies, and related wiring. The ECU determines precisely how much fuel needs to be delivered by the injector by monitoring the engine sensors. The ECU turns the injectors on for a precise amount of time, referred to as injection pulse width or injection duration, to deliver the proper air/fuel ratio to the engine.



Basic System Operation

Air enters the engine through the air induction system where it is measured by the airflow meter. As the air flows into the cylinder, fuel is mixed into the air by the fuel injector. Fuel injectors are arranged in the intake manifold behind each intake valve. The injectors are electrical solenoids that are operated by the ECU. The ECU pulses the injector by switching the injector ground circuit on and off. When the injector is turned on, it opens, spraying atomized fuel at the backside of the intake valve.

As fuel is sprayed into the intake airstream, it mixes with the incoming air and vaporizes due to the low pressures in the intake manifold. The ECU signals the injector to deliver just enough fuel to achieve an ideal air/fuel ratio of 14.7:1, often referred to as stoichiometry. The precise amount of fuel delivered to the engine is a function of ECU control. The ECU determines the basic injection quantity based upon measured intake air volume and engine rpm. Depending on engine operating conditions, the injection quantity will vary. The ECU monitors variables such as coolant temperature, engine speed, throttle angle, and exhaust oxygen content and makes injection corrections that determine the final injection quantity.

Advantages of EFI

1 Uniform Air/Fuel Mixture Distribution

2 Excellent Fuel Economy With Improved Emissions Control

3 Highly Accurate Air/Fuel Ratio Control Throughout All Engine Operating Conditions

4 Superior Throttle Response and Power

5 Improved Cold Engine Startability and Operation

6 Simpler Mechanics, Reduced Adjustment Sensitivity

Conclusion: Students should write the conclusion

Hence we have study different fuel injection systems.

Questions:-

1. What is the function of the Fuel Injection System?
2. Classify fuel injection systems?
3. Enlist and discuss fuel injection systems used in two-wheelers and four-wheelers?

Experiment No:-06

Aim: Study of Lubrication and cooling system of I. C. Engines

Objectives:-To understand construction and working the different types of Lubrication and cooling systems used in I. C. Engines.

Introduction:-

In the engine, frictional forces cause wear and tear of rubbing parts of the engine and thereby the life of the engine is reduced. So the rubbing part requires that some substances should be introduced between the rubbing surfaces in order to decrease the frictional force between them. Such a substance is called lubricant.

The lubricant forms a thin film between the rubbing surfaces. And lubricant prevents metal to- metal contact. So we can say "Lubrication is the admission of oil between two surfaces having relative motion".

The main function of a lubricant is to,

1. To reduce friction and wear between the parts having a relative motion by minimizing the force of friction and ensures the smooth running of parts.
2. To seal a space adjoining the surfaces such as piston rings and cylinder liner.
3. To clean the surface by carrying away the carbon and metal particles caused by wear.
4. To absorb shock between bearings and other parts and consequently reduce noise.
5. To cool the surfaces by carrying away heat generated due to friction.
6. It helps the piston ring to seal the gases in the cylinder.
7. It removes the heat generated due to friction and keeps the parts cool.

The cooling water used in the engine may be used for cooling the lubricant. Nearly 2.5% of the heat of fuel is dissipated as heat, which is removed by the lubricating oil.

The various lubricants used in engines are of three types:

1. Liquid Lubricants or Wet sump lubrication system.
2. Solid Lubricants or Dry sump lubrication system.
3. Semi-solid Lubricants or Mist lubrication system.

Liquid oil lubricants are most commonly used. Liquid lubricants are of two types:

(a) Mineral oils

(b) Fatty oils.

(c) Graphite, white lead, and mica are the solid lubricants.

(d) Semi-solid lubricants or greases as they are often called are made from mineral oils and fatty-oils.

LIQUID LUBRICANTS OR WET SUMP LUBRICATION SYSTEM

These systems employ a large capacity oil sump at the base of the crank chamber, from which the oil is drawn by a low-pressure oil pump and delivered to various parts. The oil then gradually returns back to the sump after serving the purpose.

(a) Splash system.

This system is used on some small four strokes, stationary engines. In this case, the caps on the big ends bearings of connecting rods are provided with scoops which, when the connecting rod is in the lowest position, just dip into oil troughs and thus directs the oil through holes in the caps to the big end bearings. Due to the splash of oil, it reaches the lower portion of the cylinder walls, crankshaft and other parts requiring lubrication. Surplus oil eventually flows back to the oil sump. Oil level in the troughs is maintained by means of an oil pump which takes oil from sump, through a filter. Splash system is suitable for low and medium-speed engines having moderate bearing load pressures. For high-performance engines, which normally operate at high bearing pressures and rubbing speeds this system does not serve the purpose.

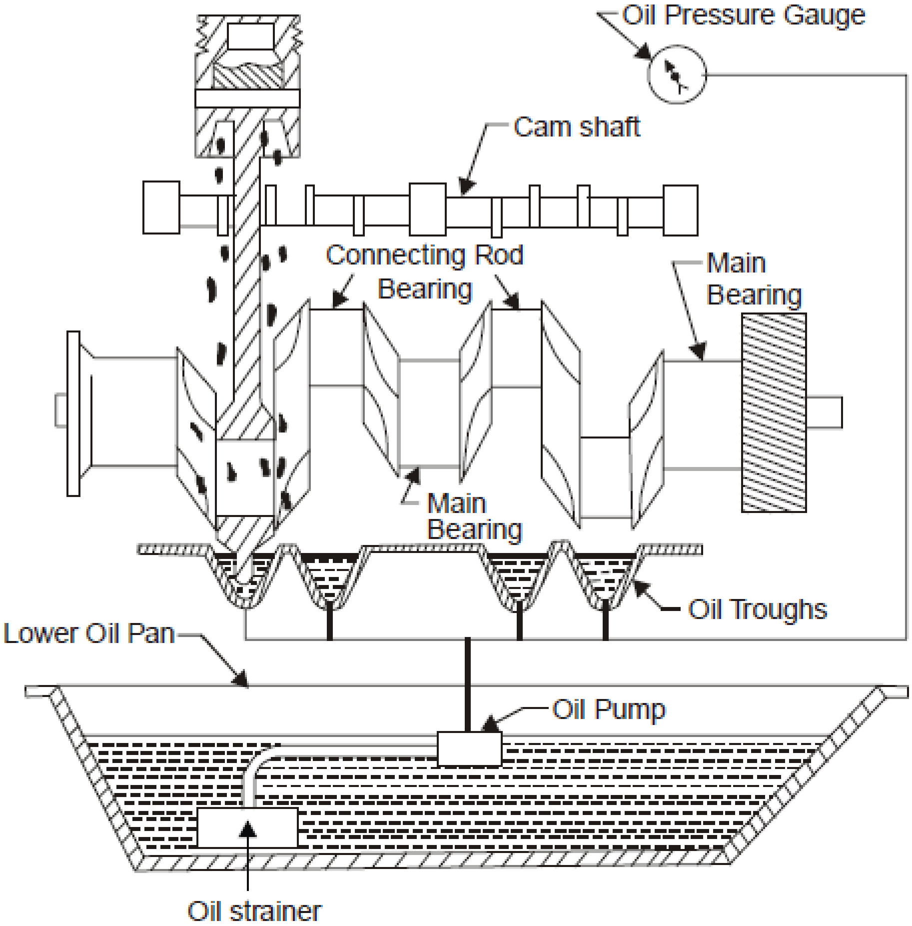


Figure: Splash Lubrication System

(b) Semi-pressure system.

This method is a combination of splash and pressure systems. It incorporates the advantages of both. In this case, the main supply of oil is located in the base of the crank chamber. Oil is drawn from the lower portion of the sump through a filter and is delivered by 6 means of a gear pump at a pressure of about 1 bar to the main bearings. The big end bearings are lubricated by means of a spray through nozzles. Thus oil also lubricates the cams, crankshaft bearings, cylinder walls, and timing gears. An oil pressure gauge is provided to indicate satisfactory oil supply. The system is less costly to install as compared to a pressure system. It enables higher bearing loads and engine speeds to be employed as compared to the splash system.

(c) **Full pressure system.**

In this system, oil from oil sump is pumped under pressure to the various parts requiring lubrication. Refer Fig. The oil is drawn from the sump through the filter and pumped by means of a gear pump. The pressure pump at pressure ranging delivers oil from 1.5 to 4 bar. The oil under pressure is supplied to the main bearings of crankshaft and camshaft. Holes drilled through the main crankshafts bearing journals, communicate oil to the big end bearings and also small end bearings through holes drilled in connecting rods. A pressure gauge is provided to confirm the circulation of oil to the various parts. A pressure-regulating valve is also provided on the delivery side of this pump to prevent excessive pressure. This system finds favors from most of the engine manufacturers as it allows high bearing pressure and rubbing speeds. The general arrangement of the wet-sump lubrication system is shown in Fig. In this case, oil is always contained in the sump that is drawn by the pump through a strain

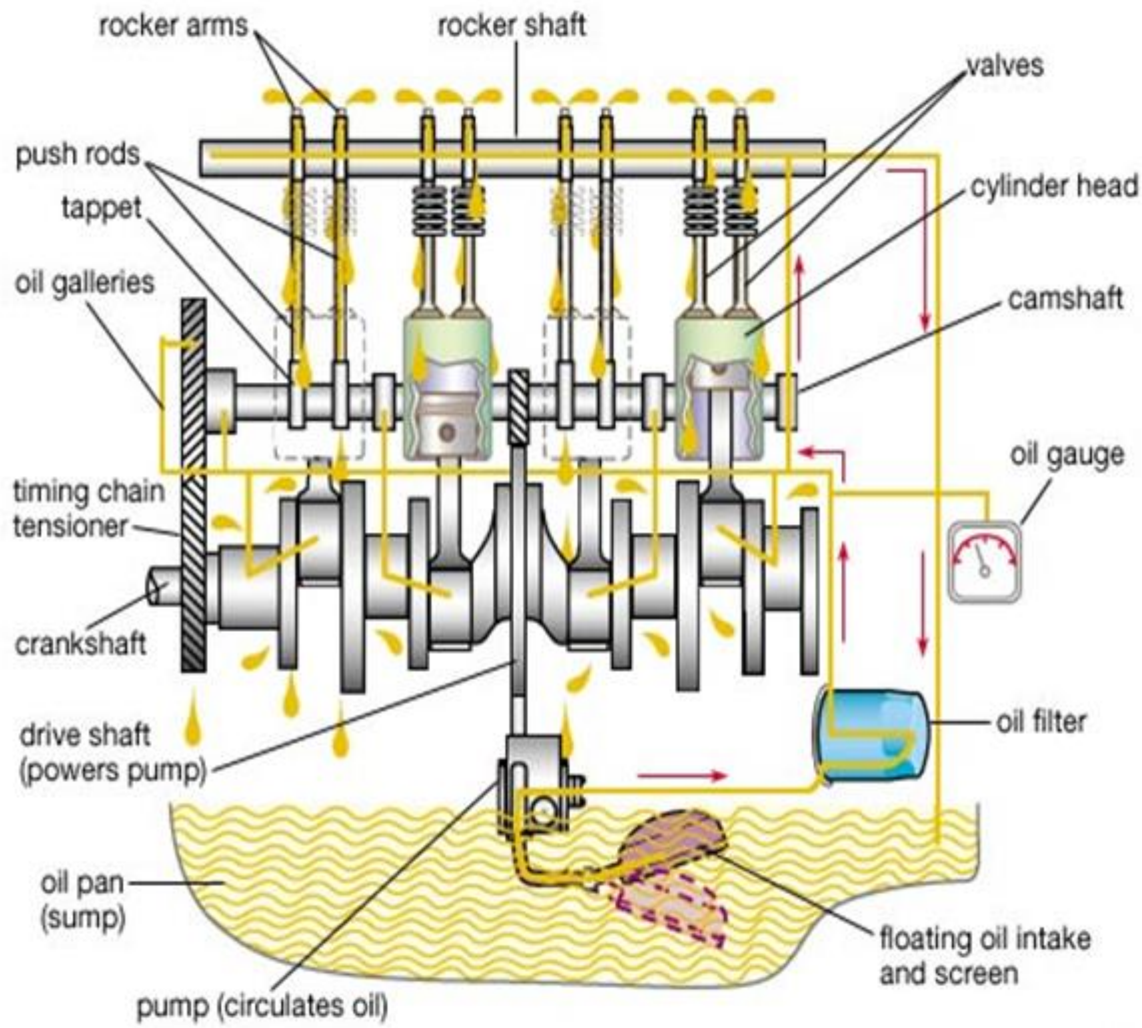


Figure: Full Pressure Lubrication system

SOLID LUBRICANTS OR DRY-SUMP LUBRICATION SYSTEM

In this system, the oil from the sump is carried to a separate storage tank outside the engine cylinder block. The oil from the sump is pumped by means of a sump pump through filters to the storage tank. Oil from the storage tank is pumped to the engine cylinder through the oil cooler. Oil pressure may vary from 3 to 8 kgf/cm^2. The dry-sump lubrication system is generally adopted for high capacity engines.

MIST LUBRICATION SYSTEM

This system is used for two-stroke cycle engines. Most of these engines are crank charged, i.e. they employ crankcase compression and thus, are not suitable for crankcase lubrication. These engines are lubricated by adding 2 to 3 percent lubricating oil in the fuel tank. The oil and fuel mixture is induced through the carburetor. The gasoline is vaporized, and the oil in the form of mist goes via a crankcase into the cylinder. The oil that impinges on the crankcase walls lubricates the main and connecting rod bearings, and the rest of the oil that passes on the cylinder during charging and scavenging periods, lubricates the piston, piston rings, and the cylinder.

Cooling system:-

Methods of cooling

Various methods used for cooling of automobile engines are

1 Air cooling

2 Water cooling

Air cooling

The basic principle involved in this method is to have current of air flowing continuously over the heated metal surface from where the heat is to be removed. The heat dissipated depends upon following factors;

a) The surface area of metal into contact with air

b) The mass flow rate of air

c) The temperature difference between the heated surface and air

d) Conductivity of metal

Advantages

1. Air-cooled engines are lighter because of the absence of the radiator, the cooling jackets, and the coolant
2. They can be operated in extreme climates where the water may freeze.

3. In certain areas where there is a scarcity of cooling water, the air-cooled engine is an advantage.
4. Maintenance is easier because the problem of leakage is not there.
5. Air-cooled engines get warmed up earlier than the water-cooled engine

Disadvantages

1. It is not easy to maintain even cooling all around the cylinder so that the distortion of the cylinders takes place. This defect has been remedied sometimes by using fins parallel to the cylinder axis. This is also helpful where a number of cylinders in a row are to be cooled. However, this increases the overall engine length.
2. As the coefficient of heat transfer for air is less than that for water, there is less efficient cooling in this case and as a result, the highest useful compression ratio is lesser in the case of air-cooled engines than in the water-cooled ones.
3. The fan used is very bulky and absorbs a considerable portion of the engine power (about 5%) to drive it.
4. Air-cooled engines are more noisy, because of the absence of cooling water which acts as a sound insulator.
5. Some engine components may become inaccessible easily due to the guiding baffles and cooling which makes the maintenance difficult.

Water cooling

In the water cooling system, the cooling medium used is water. In this, the engine cylinders are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into the water which goes to the radiator where it loses its heat to the air. Usually, some antifreeze is added to the cooling water, due to which it is often referred to as coolant. Both these terms have been used in this chapter, often meaning the same unless the context requires otherwise.

Water cooling systems are of two types;

1. Thermosyphon system
2. Pump circulation system

Advantages

1. As the circulation of coolant is maintained by natural convention only, the cooling is rather slow. Therefore, to have adequate cooling, the capacity of the system has to be large.
2. Due to the quantity of coolant being large, it takes, more time for the engine to reach the operating temperature.
3. The radiator header tank must be located higher than the top of the cylinder coolant jackets, which is no more possible with the modern body styles.
4. Certain minimum levels of coolant water must be maintained in the system. If the coolant falls below that level, continuity of flow would break and the system would consequently fail.

Conclusion: Students should write the conclusion

Hence, Construction and Working of different types of Lubrication systems and cooling systems have been studied.

Questions:-

Q1. What is the necessity of a cooling system in I. C. Engines?

Q2. Why the lubrication system is required in I. C. Engines?

Q3. Classify the cooling and the lubrication system?

Q4. Enlist and discuss the cooling system used in the modern vehicle?

Q5. Enlist and discuss the Lubrication system used in the modern vehicle?

Experiment No:-07

Aim:-Assignment on Exhaust emission.

Objectives:-To study the different Exhaust emissions of I.C. Engines

Introduction

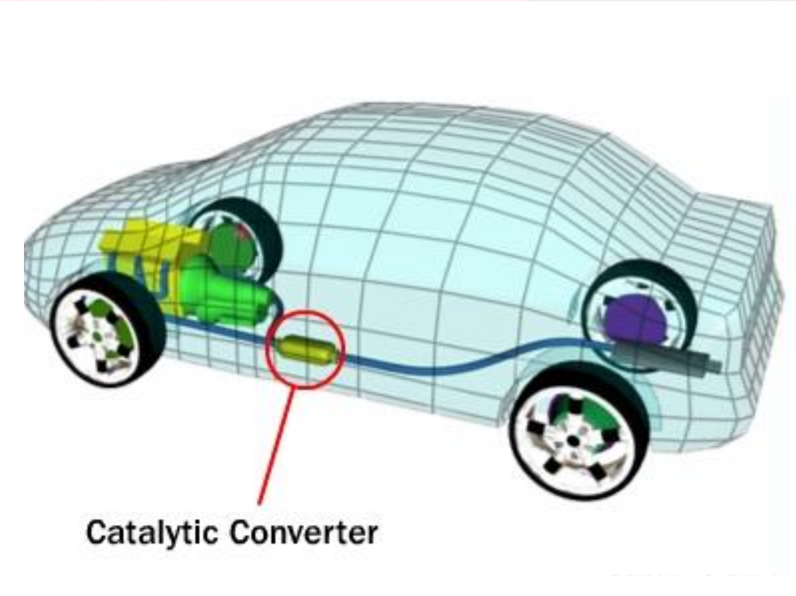
With the latest innovations in technology, more and more cars are produced to cope with the changes in the lifestyle of the modern generation. There are millions of cars on the road all over the world, and each one is potentially a source of air pollution. Especially in large cities, the amount of pollution that all cars produce together can create big problems.

To solve those problems, cities, states and the federal government creates clean-air laws, and many laws have been enacted that restrict the amount of pollution that cars can produce. To keep up with these laws, automakers have made many refinements to car engines and fuel systems. To help reduce the emissions further, they have developed an interesting device called a catalytic converter, which treats the exhaust before it leaves the car and removes a lot of the pollution. Catalytic converters contain a catalyst made from a noble metal such as platinum, palladium or rhodium. A catalyst is defined as anything that induces or accelerates a change.

Figure: Catalytic Convertor in a car

In-car design Catalytic Converter is fitted in between exhaust outlet of Engine and Silencer, so that pollutant gases will pass-through catalytic converter before released in the environment.

Generally, this catalytic converter is mounted on the underbody of the car with the help of rubber hangers.



Pollutants Produced by a Car Engine

In order to reduce emissions, modern car engines carefully control the amount of fuel they burn. They try to keep the air-to-fuel ratio very close to the stoichiometric point, which is the calculated ideal ratio of air to fuel. Theoretically, at this ratio, all of the fuel will be burned using all of the oxygen in the air. For gasoline, the stoichiometric ratio is about 14.7:1, meaning that for each pound of gasoline, 14.7 pounds of air will be burned. The fuel mixture actually varies from the ideal ratio quite a bit during driving. Sometimes the mixture can be lean (an air-to-fuel ratio higher than 14.7), and other times the mixture can be rich (an air-to-fuel ratio lower than 14.7).

The main emissions of a car engine are:

- **Nitrogen gas** (N_2) - Air is 78-percent nitrogen gas, and most of this passes right through the car engine.
- **Carbon dioxide** (CO_2) - This is one product of combustion. The carbon in the fuel bonds with the oxygen in the air.

- **Water vapor** (H_2O) - This is another product of combustion. The hydrogen in the fuel bonds with the oxygen in the air.

These emissions are mostly benign (although carbon dioxide emissions are believed to contribute to global warming). But because the combustion process is never perfect, some smaller amounts of more harmful emissions are also produced in car engines:

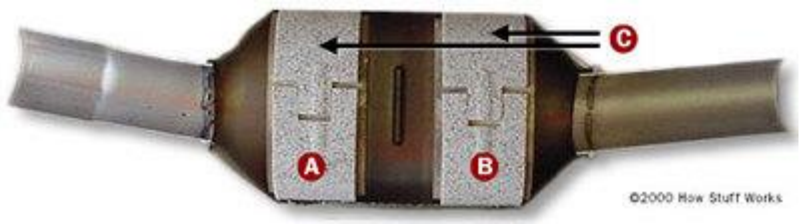
- **Carbon monoxide** (CO) - a poisonous gas that is colorless and odorless
- **Hydrocarbons** or **volatile organic compounds** (VOCs) - produced mostly from unburned fuel that evaporates

  Sunlight breaks these down to form oxidants, which react with oxides of nitrogen to cause ground-level ozone (O_3), a major component of smog.
- **Nitrogen oxides** (NO and NO_2, together called NO_x) - contribute to smog and acid rain, and also causes irritation to human mucous membranes

These are the three main regulated emissions, and also the ones that catalytic converters are designed to reduction

How Catalytic Converters Reduce Pollution

Most modern cars are equipped with three-way catalytic converters. "Three-way" refers to the three regulated emissions it helps to reduce -- carbon monoxide, VOCs and NO_x molecules. The converter uses two different types of catalysts, a reduction catalyst, and an oxidation catalyst. Both types consist of a ceramic structure coated with a metal catalyst, usually platinum, rhodium and/or palladium. The idea is to create a structure that exposes the maximum surface area of catalyst to the exhaust stream, while also minimizing the amount of catalyst required (they are very expensive).



A Reduction catalyst
B Oxidation catalyst
C Honeycomb

A three-way catalytic converter: Note the two separate catalysts.

There are two main types of structures used in catalytic converters honeycomb and ceramic beads. Most cars today use a honeycomb structure.

The ceramic honeycomb catalyst structure

The Reduction Catalyst

The reduction catalyst is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce NOx emissions. When a NO or NO_2 molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O_2. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N_2. For example:

$2NO \Rightarrow N_2 + O_2$ or **$2NO_2 \Rightarrow N_2 + 2O_2$**

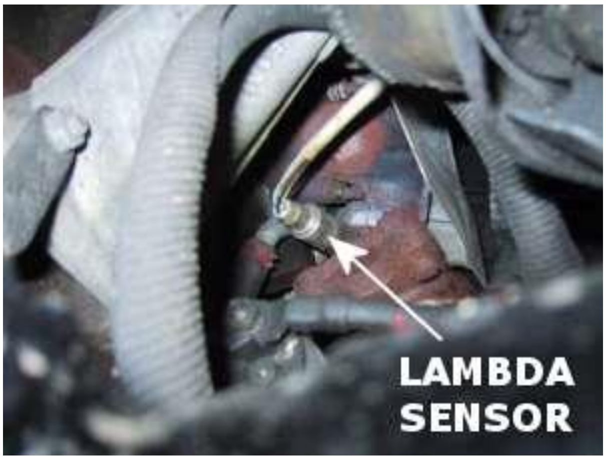
The Oxidization Catalyst

The oxidation catalyst is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas. For example:

$2CO + O_2 \Rightarrow 2CO_2$

But where did this oxygen come from? The Control System The third stage is a control system that monitors the exhaust stream and uses this information to control the fuel injection system. There is an oxygen sensor mounted upstream of the catalytic converter, meaning it is closer to the engine than the converter is. This sensor tells the engine computer how much oxygen is in the exhaust. The engine computer can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. This control scheme allows the engine computer to make sure that the engine is running at close to the stoichiometric point, and also to make sure that there is enough oxygen in the exhaust to allow the oxidization catalyst to burn the unburned hydrocarbons and CO. Other Ways to Reduce Pollution

The catalytic converter does a great job of reducing pollution, but it can still be improved substantially. One of its biggest shortcomings is that it only works at a fairly high temperature. When you start your car cold, the catalytic converter does almost nothing to reduce the pollution in your exhaust. One simple solution to this problem is to move the catalytic converter closer to the engine. This means that hotter exhaust gases reach the converter and it heats up faster, but this may also reduce the life of the converter by exposing it to extremely high temperatures. Most carmakers position the converter under the front passenger seat, far enough from the engine to keep the temperature down to levels that will not harm it. Preheating the catalytic converter is a good way to reduce emissions. The easiest way to preheat the converter is to use electric resistance heaters. Unfortunately, the 12-volt electrical systems on most cars don't provide enough energy or power to heat the catalytic converter fast enough. Most people would not wait several minutes for the catalytic converter to heat up before starting their car. Hybrid cars that have big, high-voltage battery packs can provide enough power to heat up the catalytic converter very quickly.



Questions

1. What is mean by Exhaust emission?
2. What are the constituents/elements of I. C. Engines exhaust?
3. Enlist and explain the effect of I. C. Engines' exhaust on human health?
4. State and explain the different methods to reduce the harmful exhaust emission of I. C. Engines?

Experiment No:-08

Aim:-Trial on Single- Cylinder 4 – Stroke Petrol Engine

Objectives:-To calculate the performance parameters of an I. C. Engine.

Introduction:-

Petrol Engine is very widely used as a source of mechanical power and their application ranges from a prime mover to drive a centrifugal pump or a flour mill and automotive engines of trucks and buses to a diesel generating set as a standard by the unit in industries. The diesel engines can range from few H.P.s to thousand of H.P.s. vertical and horizontal single-cylinder engines are very popular in farms and other stationary applications.

- The petrol engines are tested for performance calculations. The testing is carried out at various loads from no load to rated full load conditions.
- The tests are conducted at constant speed conditions. The governor of the engines will adjust the engine speed nearly equal to the rated rpm of the engine.

Specification:-

Engines specification:-

1) Rated power output:- 408 H.P. at 3600 rpm-163 CC
2) Rated RPM:- 2500 RPM (10.3 N-m)
3) Stroke:- 45 mm
4) Bore:- 68 Φ mm.
5) Loading:- Rope brake dynamometer with a spring balance and loading screw with a handwheel . 25 Kg:1 no/ 10 Kg:1 no
6) Pulley radius:- 0.100 m
7) Orifice dia. : 14 mm
8) Manometer: Inclined ,15 mm

Procedure:-

- Stare the water supply for engines jacket and exhaust gas calorimeter.
- Ensure zero loads on spring balance and pointer at 0 reading of spring balance
- ON petrol tank valve and both valves at the bottom of the burette.

- Fill the burette with petrol, remove air if any
- Check temperature indicator reading, all channel should read approx the same reading as ambient temperature
- Check the manometer fluid level, the level must be near to 0 reading.
- Fill the burette on the fuel supply line and measure the time required for 25 cc and thee we can calculate with the help of measuring flask and stopwatch.
- Record the speed and repeat the same for 0,3,6,9,12 Kg load (T1-T2).

Observations:-

Sr No	**Particulars**	**Load (T1-T2) Kg**				
		0	**3**	**6**	**9**	**12**
1	**Spring Balance, W1 in Kg**					
	W2 in Kg					
2	**Speed**					
3	**Sp. Fuel Consumption** Time for 25 cc fuel in sec					
4	**Calorimeter Section** Exhaust Gas inlet to calorimeter temperature, T3 ^{O}c					
5	Exhaust Gas Outlet from calorimeter temperature, T4 ^{O}c					
6	Water inlet to calorimeter temperature, T1 ^{O}c					
7	Water inlet to calorimeter temperature, T2 ^{O}c,					
8	Water flow rate through calorimeter in LPH					
9	Manometer Reading in mm					

Calculations

1) Brake Power = (2πNT)/ 4500 × 0.746 in KW
2) Fuel consumption
3) Brake specific fuel consumption

4) Indicated Power
5) Heat supplied by fuel
6) From Heat Balance of Calorimeter
7) Mechanical Efficiency
8) Thermal Efficiency
    a) Brake thermal efficiency
    b) Indicated thermal efficiency

9) Volumetric efficiency

HEAT BALANCE

Credit			Debit		
	KJ/hr	%		KJ/hr	%
1) Heat supplied by fuel			1) Heat equivalent of brake power 2)Heat carried by exhaust gases 3) Heat unaccounted		

Observation table (sample reading and calculation)

Sr.No.	Particulars	load		
		0	2.5	9.5
01	Spring Balance W1 in kg W2 in kg	0 0	3.5 1	15.5 6.3
02	Speed in R P M	2510	2500	2520
03	Sp. Fuel consumption time for 25cc fuel consumption in sec	251	197	67
04	Calorimeter section Ex. Gas inlet to Calorimeter (T3)	 219	 250	 322

	Ex. Gas outlet to Calorimeter(T4)	41	42	47
05	Water inlet to calorimeter (T1) Water outlet to calorimeter (T2)	40 45	35 44	28 44
06	Water how rate (L P H)	1200	1200	1200
07	Manometer reading in (mm)	1.8	2.8	14

Observation .

1) Brake power = $\frac{2\pi HT}{4500} \times 0.746\ in\ kw$

$= \frac{2\pi \times 2510 \times (0)}{4500} \times 0.746 \ldots$

2) Fuel consummation:-

25 cc drop in level in burette

Let time required for this drop be 't' second

F.C = $\frac{25\times16\sqrt{-3\times3600\times0.737}}{t} \ldots$

$= \frac{25\times16\sqrt{-3\times3600\times0.737}}{251}$

$= \frac{66.33}{251} = 0.216$ kg/hr.

3) Brake Sp. fuel consummation:-

$\frac{F.c.}{B.P.} = \frac{0.261}{0} = 0\,kg/kw.hr$

4) Indicated power

I.P=B.P +FP.

Form graph F.P=

I.P=0+0.65

=0.65 kg

5) Heat supplied by fuel

= C.V × fuel consummation

= 48,000 × 0.261

= 12528 kg/hr

6) Form heat balance of calorimeter :-

The heat required by water = heat lost by exhaust gases

Mw × Lw × $\Delta T = mag \times$ c pag × Δteg

Where

Mw = mass flow rate & water through calorimeter in kg /hr

Cw = Sp. Heat of water 4.18 kj / kg°C

$\Delta t = temp.rise\ of\ water\ through\ calorimeter$

$= (T2 - T1)$

Meg = mass how rate of exhaust gases =(T3-T4)

(meg ×c peg)$\frac{Mw\times cw\times \Delta t}{\Delta Teg}$

Meg ×c peg = $\frac{1200\times 4.18\times(45-40)}{(219-4)}$ = 140-89 kj/hr

Heat carried away by exhaust gases in kj/hr

=meg ×c peg ×(Tin -Tout)

=146.898× (219-41)

= 25080 kj/ hr

4) Mechanical efficiency = $\frac{B.P}{I.P}\times 100$

=0 ×100

= 0

5)thermal efficiency

1} Brake thermal efficiency = heat equivalent to B.P in kj/hr

=heat supplied by fuel kg/hr

$$\frac{0}{0.261\times 48{,}000} = 0$$

2} volumetric efficiency =

Actual vol. of air valued at NTP /min

= piston displacement /min

How actual volume of air suede at RTP

V rtp = a× $\sqrt{2gh}$ × 60×0.64 m^3/min

Where

A = area of m^2

G=accretion due to gravity = 9.8

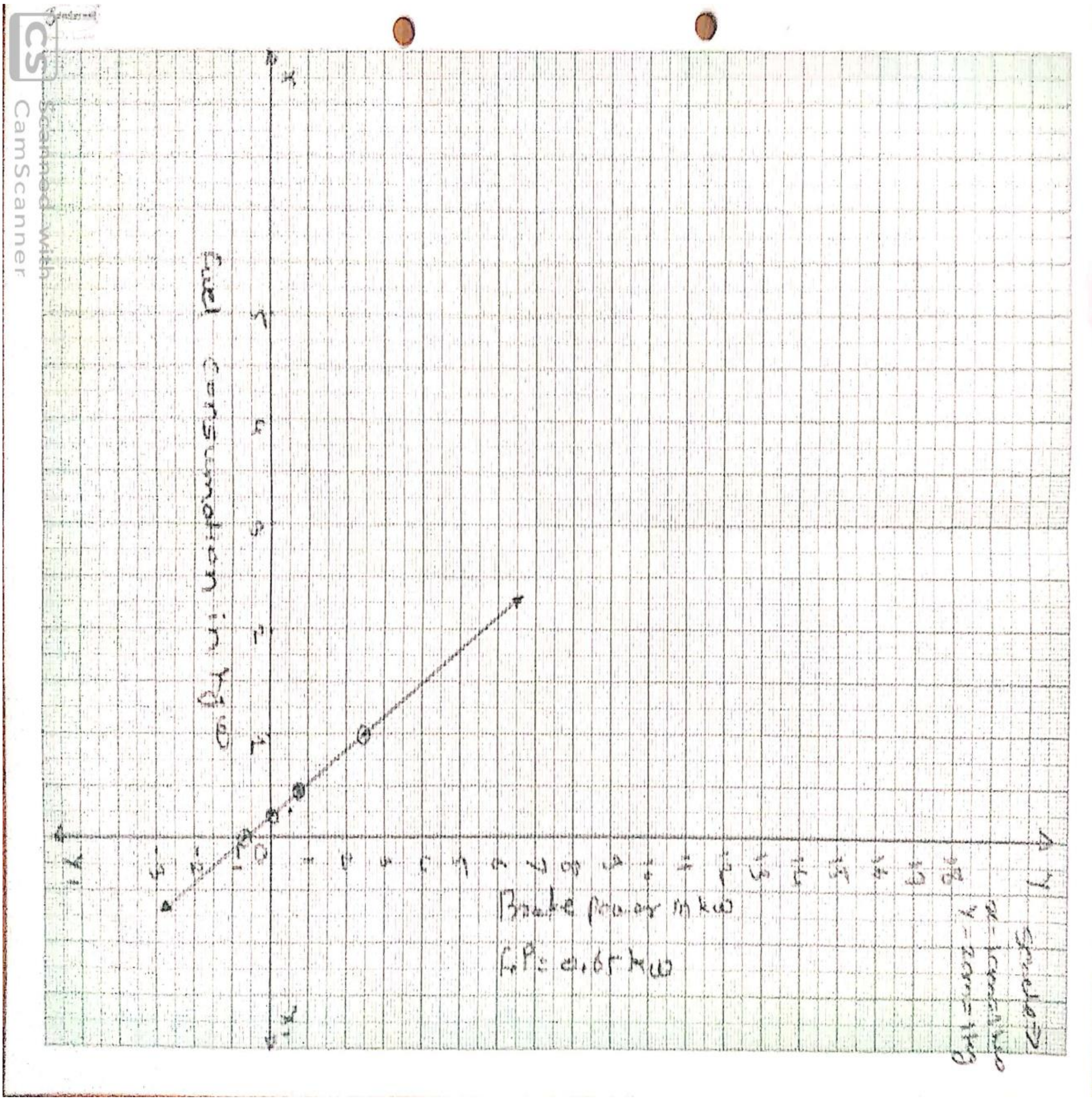
H = a head causing flow in m/r

=water heat × density of water

Density of air at RTP

Water need =0.0018 m/r

Density of water =1000 kg/m^3



Density of air at KTP = $\frac{1.293 \times 273}{(273+Tat)}$

$= \frac{1.293 \times 273}{(273+33)} = 1.153$

H=0.0018× = $\frac{1000}{1.153}$

= 1.56 in m/r

How

V KPT =1.539 $\times\ 10^{-4}\ \sqrt[\times]{2 \times 9.81 \times 1.56} \times 60 \times 0.04$

= 0.0327 m^3 /min

The volume of air at N. T. P.

V ntp = V ntp $\times \frac{273}{273+tat}$

=0.0327 ×$\frac{273}{273+33}$

=0.0291 m^3 /min

5) Piston displace men +

Vp=speed × swept +vol.

= H ×(3.14/4×D^3×L)

=2510×$\frac{\pi}{4}$ $(0.063)^2 \times 0.045)m^3$ /min ...

= 0.410m^3/min

Volumetric efficiency = $\frac{\text{V ntp}}{\text{vp}}$

= $\frac{0.410}{0.0291}$

=14.096%

RESULT:-

1. Indicated Power =
2. Brake power =

3. Mechanical efficiency =

4. Thermal efficiency =

5. Volumetric efficiency **=**

Questions

1. Distinguish between the single-cylinder and multi-cylinder engines?
2. State the use of Single-cylinder engines?
3. Distinguish between indicated power and brake power?
4. What is the mean by the thermal efficiency of engines?
5. Define volumetric efficiency?

Experiment No:-09

Aim:- To conduct a performance test on a four-cylinder four-stroke petrol engine

Objectives:-To calculate the performance parameters of an I. C. Engine.

INTRODUCTION:

ENGINE: -

Petrol Engines are widely used now a days as a source of mechanical power. Due to their less weight to power ratio, they are popularly used for two-wheelers and light vehicles like cars. Their output varies from few horsepowers to hundreds of horsepower. Both two-stroke and four-stroke engines are used. The present test rig. Incorporates a Villiers Four Stroke Petrol Engine.

HYDRAULIC DYNAMOMETER: -

The Hydraulic Dynamometer is designed to meet the demand for the power testing purposes of the engine, electrical motors & other prime movers. They are compact & are capable of measuring large outputs at normal speeds. The power absorbing capacity of the unit increases very rapidly as the speed increases and are most suitable for testing I.C. Engines

The principle operation of the unit is similar to fluid couplings, but the reaction of the casting is measured by a suitable mechanism, consisting of the lever arm, spring balance loading weights, etc. cooling water is used to carry away the heat generator during the process of power absorption.

Constructional specification: -

Casing: - It is made of close-grained cast iron rugged in construction with integral bearing housing of gunmetal with semi-elliptical pockets formed in the opposite direction to that of the stator.

Stator: - It is made of gunmetal with semi-elliptical pockets and cooling water inlet.

Shaft: - It is made of stainless steel ground and finished to close limits and fitted with a shaft sleeve where it enters the stuffing box. Sliding gates Of gunmetal designed for smooth operation

Ball Bearing: It is of deep groove, single row type in the casing for the shaft, and double row, Self-slinging type in the pedestal for the casing to swing.

Load measuring device: -

Consists of a lever arm, a spring balance with provision for adjustments mounted on a flat form, cast iron dead weights in metric units, all designed to measure the torque in the shaft conveniently and accurately.

Damping Device: -

A large capacity dashpot is provided to damp the vibration of the casing if any thus giving a steady reading of the balance pointer.

Cooling water arrangement: provision of cooling water supply is made in the unit consisting of a flexible hose inlet with the G.M. Control valve, outlet pipe with a control valve, wastewater outlet bowl, etc.

Base plate: of cast iron with box type ribbed construction providing rigid support for the main unit and for the load-measuring device.

CONSTRUCTION OF DYNAMOMETER: -

The Dynamometer rotor consists of a series of semi-elliptical pockets or blades on both the faces rotating within a casing containing the stator that is also having similar semi-elliptical pockets formed in the opposite direction. The rotor is rigidly fixed to the shaft by keys and runs on ball bearing. In between the rotor and stator, a pair of sliding gates are provided which is provided by means of a handwheel to control the power absorbed by the dynamometer.

A dashpot is provided to damp the vibration, which should be always filed completely removing the air with a good quality machine oil of suitable viscosity having anti-wear, and restless properties. By means of the spiral nut, the dashpot can be kept out of action for checking the static balance, and by adjusting the nut the degree of the damping effect of the dashpot can be varied.

POWER CONTROL: -

The method of power control is very simple, two sluice gate provided inside the casing, which can move to and for, varies the amount and water communication in between the rotor and stator. As the hydraulic resistance between the rotor and stator varies with respect to the position of the sluice gates the power absorbed by the dynamometer also varies.

By rotating the handwheel clockwise the sluice gates are closed reducing the power absorbing capacity. Rotating the handwheel in the anti-clockwise direction increases the power. Thus the power absorbed by the dynamometer can be easily and quickly adjusted even while the dynamometer is working.

Water Supply: -

The temperature of the cooling water leaving the dynamometer should not exceed a certain value. The quantity of water required must be sufficient to carry away all the heat generated by the absorbing of power. Each BHP metric absorbed generated about 10.5 kilocalories of heat per minute (23.2 CHU per minute) & 25 to 30 liters of water per minute would be required for each kilowatt-hour absorbed
(22 to 26 liters per bhp hour). It is in the interest of the buyer to use reasonably clear water free from foreign matter and mechanical impurities to prolong the working life of the dynamometer elements. The water should not be acidic in nature. the PG value shall be between 7.5 & 8.5. Water pressure inside the dynamometer should be above 1kg/cm^2.

Drain: -

Provision must be made to dispose of the outlet cooling water from the dynamometer, and the leakage water from the glands to the nearest pump or drain.

The direction of rotation: -

The DUI Hydraulic dynamometer is of a non-reversible type. An arrow fixed the casting. As such the dynamometer should be coupled to the prime mover such that the direction of rotation of the prime mover is the same as that marked on the casing marks the correct direction of rotation.

NEVER RUN THE DYNAMOMETER IN REVERSE DIRECTION OF ROTATION.

SPECIFICATIONS:

ENGINE : 1 No.

1) Rated Power Output : 37 B.H.P.
2) Rated RPM : 3000 rpm.
3) Stroke : 72 mm.
4) Bore : 68.5 mm.

5) Make : MARUTI

6) Compression ratio : 8.8: 1 normal

HYDRAULIC DYNAMOMETER : 1 No.

1) Type : Hydraulic dynamometer DUI IV
2) Speed : up to 4000 rpm
3) Torque arm length : 37.5 cm
4) Pressure required : 1.5 kg/cm^2.
5) Load cell : 100 Kg S type.

WATER FLOW METER : 1 No.

1) Type : Rotameter-variable area type
2) Connection : 1" BSP
3) Range : 250-2500 LPH

AIR TANK : 1 No.

1) Tank Size : 500 x 500 x 500 mm
2) Orifice size : 25 mm
3) Air pipe : 2" flexible pipe.

TEMPERATURE SENSOR : 6 Nos.

1) Type : CR-AL
2) Location : Engine cooling water inlet / outlet

Calorimeter cooling water inlet/outlet

Exhaust gas outlet and after calorimete

FUEL CONSUMPTION : 1 No.

1) Type : Load type.
2) Tank Size : 280 x 220 x 220
3) Capacity : 13.55 liters.
3) Load sensor : Weighing Scale– 20 kg

CONTROL PANEL : 1 No.

1) Temperature Indicator: 1 No.

Type : CR-AL

Channel : 6

Resolution : 1 ^{0}C

Temp. Range : 0 – 600 ^{0} C

Interfacing o/p : RS – 232

2) Load Indicator : 1 No.

Range : 0 to 100 Kg

Resolution : 0.1 Kg

Input : from load cell connected to the Torque arm of dynamometer.

4) Speed Indicator : 1 No.

Range : 0 - 4000 rpm

Resolution : 1 rpm

Input : NPN/NO M12 proximity

7) Switches

Mains On/ Off : 1 No.

Pump On/Off : 1 No.

8) MCB : 1 Nos.

Instrumentation : 2 Pole / 6 Amp.

8) Morse Test :

Using a switch box for each cylinder, which will cut the injector supply.

9) Pump : 2 nos.

For engine cooling water and exhaust gas cooling water flow rate measurement.

PROCEDURE FOR OPERATING 4 CYLINDER PETROL ENGINE TEST RIG WITH HYDRAULIC DYNAMOMETER.

INITIAL PREPARATION: -

1.ON power supply to control panel.

2.ON mcb on the control panel.

3. Check & adjust the water supply.

4. Check the ball valve for Exhaust gas calorimeter/engine cooling water.

5. Keep the valve position as follows,
   a. Engine Cooling water supply ball valve partly open. Keep the flow rate 350-400 LPH approx.
   b. Exhaust gas calorimeter water supply ball valve partly open.

   Keep the water flow rate unto 300-400lph approx.
6. check the fuel in the tank.
7. Now the system is ready to operate.
8. Operate following switches on the control panel
   a. ON Mains switch
   b. ON pump switch
   c. ON instrumentation Switch
9. Observe the water flow rate for engine & calorimeter.
10. Start the engine with the help of a starter.

OBSERVATION TABLE:

Sr. no	QUANTITY	Torque Force Kg.mtr				
		T	**T**	**T**	**T**	**T**
	BRAKE POWER SECTION					
1	SPEED (N)					
	SP. FUEL CONSUMPTION					
2	Time for 50gm drop in fuel weight					
	ENGINE SIDE					
3	Engine cooling water inlet temperature (t1)					

4	Engine cooling water outlet temperature (t2)					
5	Water flow rate through engine					
	CALORIMETER SECTION					
1	Ex. Gas calorimeter cooling Water inlet (t3)					
2	Ex. Gas calorimeter cooling Water outlet (t4)					
3	The water flow rate through calorimeter.					
	EXHAUST GAS SECTION					
1	Exhaust gas temp. at the outlet from the engine (t5)					
2	Exhaust gas temp. at calorimeter outlet (t6)					
	AIR TANK					
1	Manometer reading					

Where,

T = initial torque force 0 kg.mtr.

(For No load condition water supply to the dynamometer is stopped using ball valve provided on the motor.)

Calorific Value of Fuel : 48,000 kj / kg. (Theoretical).

Density of Fuel = f : 737 kg/m^3

SPECIMEN CALCULATIONS:

Brake Power (BP): -

$$\text{Brake Power} = \frac{\text{Torque x Speed}}{} \text{ H.P.}$$

60000

Where, Load = Indicated on Digital Indicator, in kg.

Torque = 0.375 x load in kg x 9.81 N.m

Speed = rpm.

Indicated Power (IP): -

F**rictional Power (FP) + Brake Power (BP)**

FP from the graph of fuel consumption Vs Brake Power.

Fuel Consumption:

Time for fuel consumption of 50 gm in sec (m_f)

∴ Fuel consumed by the engine

$$= \frac{0.050}{t} \text{ Kg / sec}$$

= X 3600 kg / hr

Brake specific fuel consumption (BSFC).

$$= \frac{\text{Fuel consumption in kg/sec}}{\text{Brake power in KJ/sec.}} \text{ Kg / BHP. Hr.}$$

Brake Specific Energy Consumption (BSEC)

BSEC = Calorific value of fuel x BSFC

= KJ/ kW - hr

m_a Mass flow Rate of Air (m_a)

m_a = [Cd x ∏ /4 x d^2 x (√ {2 g (h/1000) x (ρw / ρa)} x 1.16] x 3600 in Kg/Hr.

Where,

g = Acceleration due to gravity =9.81 m/s^2.

h = Air pressure in mmWC

ρw = Density of water = 1000 kg/ m^3.

ρa = Density of Air = 1.16 kg/ m^3.

Do =orifice Diameter in a meter.

Cd= Coefficient of discharge = 0.68

Mechanical Efficiency (η mech): -

$$\eta_{mech} = \frac{B.P.}{I.P} \times 100\%$$

Where,

BP = Brake Power in kW

IP = Indicated Power in kW

Thermal Efficiency:

Brake Thermal Efficiency (ηTB): -

$$\eta_{TB} = \frac{B.P}{m_f \times C_v} \times 100\%$$

Where,

BP = Brake Power in kW

m_f = Mass of fuel in Kg/sec.

C_v = Calorific Value in Kj/kg.

Indicated Thermal Efficiency (ηTI): -

I.P

η_{TI} = --------------------- x 100%

m_f x C_v

Where,

IP = Indicated Power in kW

m_f = Mass of fuel in Kg/sec.

C_v = Calorific Value in Kj/kg

Heat Added / hr in Kj/hr: -

Heat Added / hr in Kj/hr = (Mass of fuel in Kg/hr) x Calorific Value in Kj/kg

= m_f x C_v

Volumetric Efficiency (η_v): -

$$\eta_v = \frac{m_a}{[\Pi/4 \times d^2 \times L \times N \times \text{no. of cylinder} \times \rho a \times 60] / n} \times 100\%$$

Where,

d= Bore diameter in meter.

L= Length of stroke in meter.

N =Engine Speed in rpm.

ρa = Density of Air in kg/m^3.

n = 2 for 4 stroke engine.

To find ma:

ma = Air flow / 3600 in kg/sec.

HEAT BALANCE CALCULATIONS: -

Heat Carried away by Jacket Cooling Water (Hjcw):

= $m\omega$ x $Cp\omega$ x Δ T

= KJ / hr.

Where,

$m\omega$ = Mass flow rate of jacket cooling water kg / hr.

$c\omega$ = Specific heat of water = 4.18kJ/kg.^{0}c.

Δ T = Rise in temp. Of water.

Heat carried away by exhaust gases (Hexg)

$$= \frac{(T5 - T7)}{(T5 - T6)} \times Cpw \times Mwc \times (T4 - T3)$$

Where,

T_3 = Ex. Gas calorimeter cooling water inlet.

T_4 = Ex. Gas calorimeter cooling water outlet.

T_5 = exhaust gas inlet to the calorimeter

T_6 = Temperature drop of exhaust gases through calorimeter.

T_7 = Ambient Temp.

M_W = Calorimeter Cooling water flow rate

$C\pi_W$ = Specific heat of exhaust gases. = 1.05 kJ/kg.

Heat Supplied by Fuel (Hsf)

= (Mass of fuel in Kg/hr) x Calorific Value in Kj/kg

= $m_f \times C_v$ in Kj/hr

Heat Equivalent of BP (Hbp)

= BP x 3600 Kj/hr.

Heat Equivalent of FP (Hfp)

= FP x 3600 Kj/hr.

Heat Carried away by cooling water from the exhaust gas

(H_{ex} cooling water)= Mw x cw x ΔT

Heat Unaccounted =

= Hsf – (Hjcw + Hexg + Hbp + Hfp)

HEAT BALANCE

The heat balance is computed on hourly of minute basic as given below for one or all loads.

Credit			**Debit**		
	Kcal/min	%		Kcal/min	%
1] Heat Supplied by Fuel.			1]Heat equivalent Of brake power 2] Heat carried Jacket water. 3] Heat carried by Exhaust gages. 4] Heat Unaccounted		

Normally, heat in B.P. is about 25-30%., heat carried by jacket water about 30% heat carried by exhaust gages about 30% and heat an accounted about 10-20% the actual values may vary due to assumed calorific value of fuel which may be less because of availability of commercial oil.

FOLLOWING RESULTS CAN BE OBTAINED: -

1] Indicated Power.
2] Brake Power.
3] Brake Specific Fuel Consumption.
4] Mechanical and Thermal Efficiency.
5] Heat Balance sheet.

Also, the following characteristics can be studied: -

1] Load Vs. B.S.F.C.
2] Load Vs. Thermal efficiency.
3] Speed Vs. Brake Power.

PRECAUTIONS: -

1. Before starting the engine, ensure that –
   a. The water supply is sufficient.
   b. All nut-bolts and electrical connections are tight.
   c. Battery is charged
   d. Water is being supplied to a dynamometer, at the pressure of 1- 1.5 Kg/cm^2 and also to the calorimeter.
   e. Dynamometer sluice gates are in a fully closed condition.
   f. Coupling between the dynamometer and engine is matched and in good condition.
   g. All spark plug switches are 'ON'.
2. While taking the reading –
   a. Never put 'OFF' more than one cylinder at a time.
   b. Operate the controls gently.
3. While putting 'OFF' the engine –
   a. Firstly remove the load and reduce the speed of the engine.
   b. Now put 'OFF' the engine.
   c. Put 'OFF' water supply to a dynamometer.
   d. Drain all the water from the dynamometer.

4-

Cylinder 4-Stroke Petrol engine setup

Observation Table (sample reading and calculation)

Particulars	T.F	T.F	T.F	T.F	T.F
Load (kg.m)	0	1.5	3.5	5.5	7.5
Brake power section 1} Speed (W) RPM	2000	2030	2015	2004	2000
1} SP. Fuel consumption The time required for 50g drop in fuel wt. in sec	133	125	94	70	41
Engine side 1} Engine cooling water inlet pump (T1) °C 2} Engine cooling water outlet pump (T2) °C 3} water flow rate through the engine (LPH)	37 39 1150	38 40 1150	39 41 1150	42 43 1150	43 44 1150
Calorimeter section 1} exhaust gas calorimeter water inlet temp. (T3) °C 2} exhaust gas calorimeter water outlet temp. (T4)°C 3} water flow rate through colorimeter (liters per hours)	37 38 750	38 39 250	59 40 750	42 42 750	45 48 750
Exhaust gas section 1} Exhaust gas temp. at outlet form engine (T5) in °C	260	206	384	482	528

2} Exhaust gas temp. at calorimeter outlet (T6) in °C	45	47	63	55	67
Diff in limb g manometer reading (mm)	20	28	58	106	106

{1} Specimen calculation

Brake power

a) Observation (1)

B. P = $\frac{2\pi NT}{60}$ ...

T=T.F ×r ×9.81
T=0 NM
B.P=0

B) observation 2)

B.P= $\frac{2\pi NT}{60}$ ...

T=T.F × r ×9.81 = 1.5 ×0.375 ×9.81

= 5.518 nm B.P= $\frac{2\pi \times 2030 \times 5.518}{60}$ ...

= 1173.02watts

=1.1730 kw

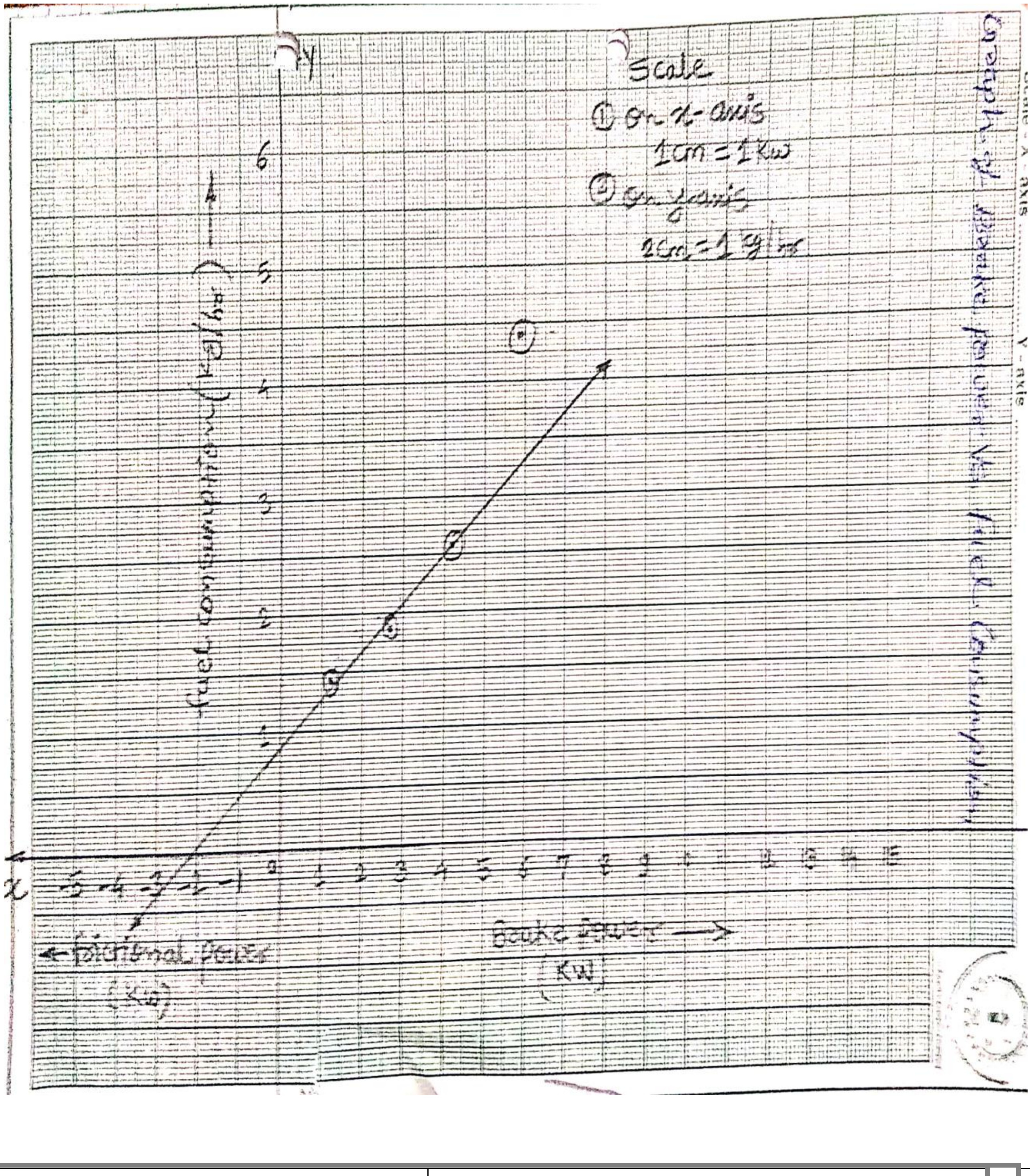
c) Observation 3)

B.P= = $\frac{2\pi NT}{60}$ ...

T=3.5× 0.375 ×9.81 = 12.87NM

= B.P=$\frac{2\pi \times 2015 \times 12.87}{60}$=2715.70 watts

$= 2.715\times10^{3}\,kw$



{2}Fuel consumption

1) Observation (1)

f.c = $\frac{50\times 10^{-3}}{t}$ kg/sec

= $\frac{50\times 10^{-3}}{133}$ =3.759× 10^{-4}kg/sec

= 1.353kg/hr

{3} Thermal efficiency

= $\frac{B.P}{MF \times \mathrm{CV}}$ = $\frac{5.78}{1.219\times 10^{-3\times 44000}}$= CV =44,000 kj/kg

=0.1077 I, E, 10.77%

= $\frac{I,P}{MF \times \mathrm{CV}}$= $\frac{8.03}{1.219\times 10^{-3\times 44000}}$

=0.1497 I, E, 14.97%

{4} Heat balance sheet calculation on min.

1) input heat energy =mf × c.v

=1.2195 ×10^{-3} (kg/s)×44,000

=1.2195 ×10^{-3} ×60×44,000

=3219.48 kj/min =100%

RESULT:-

1. Indicated Power =
2. Brake power =
3. Mechanical efficiency =
4. Thermal efficiency =
5. Volumetric efficiency **=**

Questions

1. Define a multi-cylinder engine?
2. State the use of multi-cylinder engines?
3. Distinguish between indicated power and brake power?
4. What is the thermal efficiency of engines?
5. Define the volumetric efficiency of an IC engine?

Experiment No:-10

Aim:- Calculate the indicated power, friction power and mechanical efficiency of a four-stroke four-cylinder petrol engine at full load and rated speed by Morse test.

Objectives:-To calculate the performance parameters of an I. C. Engine.

MORSE TEST: -

Morse test is carried out on multi-cylinder petrol engines to determine the indicated power of the engine. Putting OFF the ignition for a cylinder carries out this test. For this test, the desired speed is adjusted & the engine is loaded. The load & speed are noted down. Then one of the cylinders is put off. Then load on the engine is reduced & engine speed is adjusted to previous speed. The accelerator position is not disturbed. The load indicated on the dial is noted down after coinciding with the pointer & the same procedure is followed for rest cylinders.

Experimental setup

Procedure for operating a petrol engine test rig with a hydraulic dynamometer for MORSE TEST.

1. Morse test switch panel is provided with 4 switches like cyl1, cyl2, cyl3, and cyl4.
2. Initially, all switches are in the ON position. Switch OFF the cylinders, with the help Of the switches provided which are not required for performing the test.
3. Repeat the same procedure of the 4-cylinder petrol engine as mentioned above.

SPECIFICATIONS:

ENGINE	:	1 No.
10) Rated Power Output	:	37 B.H.P.
11) Rated RPM	:	3000 rpm.
12) Stroke	:	72 mm.
13) Bore	:	68.5 mm.
14) Make	:	MARUTI
15) Compression ratio	:	8.8: 1 normal
HYDRAULIC DYNAMOMETER	:	1 No.
6) Type	:	Hydraulic dynamometer DUI IV
7) Speed	:	up to 4000 rpm
8) Torque arm length	:	37.5 cm
9) Pressure required	:	1.5 kg/cm^2.
10) Load cell	:	100 Kg S type.
WATER FLOW METER:		1 No.
1) Type	:	Rotameter-variable area type
2) Connection	:	1" BSP
3) Range	:	250-2500 LPH
AIR TANK	:	1 No.
1) Tank Size	:	500 x 500 x 500 mm
2) Orifice size	:	25 mm

3)	Air pipe	:	2" flexible pipe.
TEMPERATURE SENSOR		:	6 Nos.
1)	Type	:	CR-AL
2)	Location	:	Engine cooling water inlet / outlet Calorimeter cooling water inlet/outlet Exhaust gas outlet and after calorimeter
FUEL CONSUMPTION		:	1 No.
1)	Type	:	Load type.
2)	Tank Size	:	280 x 220 x 220
3)	Capacity	:	13.55 liters.
3)	Load sensor	:	Weighing Scale– 20 kg
CONTROL PANEL		:	1 No.
1)	Temperature Indicator:		1 No.
	Type	:	CR-AL
	Channel	:	6
	Resolution	:	1 ^{0}C
	Temp. Range	:	0 – 600 ^{0} C
	Interfacing o/p	:	RS – 232
2)	Load Indicator	:	1 No.
	Range	:	0 to 100 Kg
	Resolution	:	0.1 Kg
	Input	:	from load cell connected to the Torque arm of dynamometer.
4)	Speed Indicator	:	1 No.

Range : 0 - 4000 rpm

Resolution : 1 rpm

Input : NPN/NO M12 proximity

16) Switches

Mains On/ Off : 1 No.

Pump On/Off : 1 No.

8) MCB : 1 Nos.

Instrumentation : 2 Pole / 6 Amp.

17) Morse Test :

Using a switch box for each cylinder, which will cut the injector supply.

18) Pump : 2 nos.

For engine cooling water and exhaust gas cooling water flow rate measurement.

OBSERVATION Table:-

Sr no	Cylinder working	Dynamometer Reading(KW)	Brake power BP (kW)	IP Of the cut off cylinder
			BP_T	
			BP_{234}	IP_1
			BP_{134}	IP_2
			BP_{124}	IP_3
			BP_{123}	Ip_4

CALCULATIONS:-

i) Brake Power (BP): -

$$\text{Brake Power} = \frac{\text{Torque x Speed}}{60000} \text{ H.P.}$$

Where, Load = Indicated on Digital Indicator, in kg.

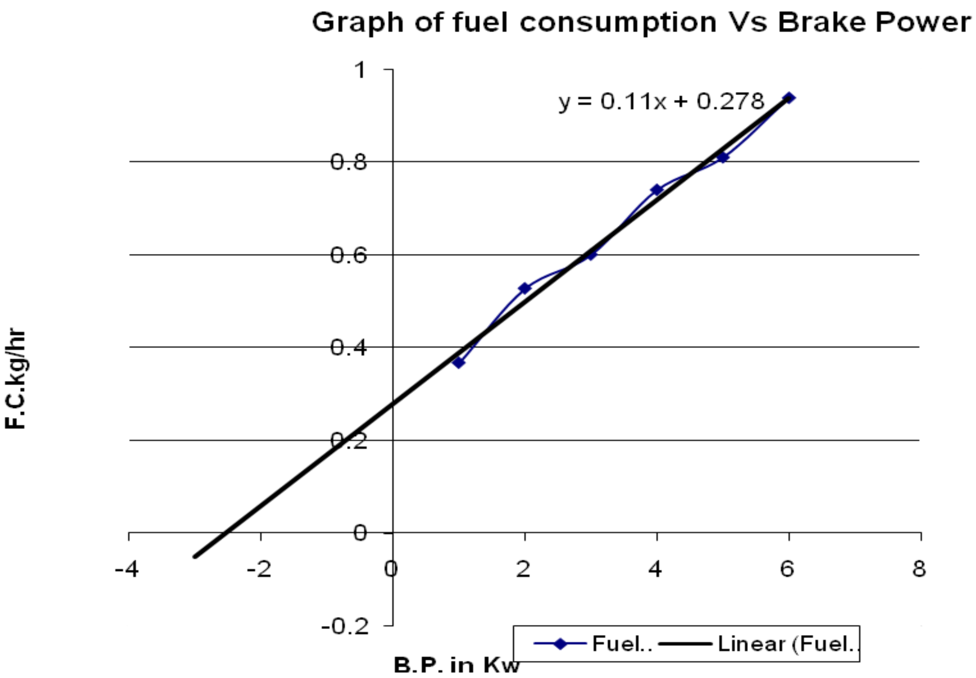
Torque = 0.375 x load in kg x 9.81 N.m

Speed = rpm.

ii) Indicated Power (IP): -

Frictional Power (FP) + Brake Power (BP)

iii) FP from the graph of fuel consumption Vs Brake Power.



Indicated Power (IP) of each Cylinders:

IP1 = (BPT - BP2,3,4) KW

IP2 = (BPT - BP1,3,4) KW

IP3 = (BPT - BP1,2,4) KW

IP4 = (BPT - BP1,2,3) KW

(iv) Total IP of the Engine,

IPT = (IP1 + IP2 + IP3 + IP4) KW

(v) Mechanical Efficiency, **mechanical** = BPT / IPT

OBSERVATIONS:-

Engine Speed, N = rpm

No. of Cylinders, n = Four

Calorific Value of Fuel, C.V. = 42,000 KJ/Kg

RESULT:- Total IP of the Multi-Cylinder Petrol Engine by Morse Test,

IP_T = KW

Questions:-

Q1. State the importance of Morse Test?

Q2. Why Morse Test is Conducted?

Experiment No:-11

Aim:- Trial on single-cylinder four-stroke diesel engine (5 hp) test rig with rope brake dynamometer

Objectives:-To calculate the performance parameters of an I. C. Engine.

INTRODUCTION:-

Diesel Engines are very widely used as a source of mechanical power and their application ranges from a prime mover to drive a centrifugal pump or a flour mill and automotive engines of trucks and buses to a diesel generating set as a stand by the unit in Industries. The diesel engine can range from a few H.P.s to thousand of H.P.s.

Vertical and horizontal single-cylinder diesel engines are very popular in farms and other stationary applications.

- The diesel engine is tested for performance calculations. The testing is carried out at various loads starting from no-load conditions to-rated full load conditions.
- The tests are conducted at constant speed conditions. The governor of the engine will adjust the engine speed nearly equal to the rated rpm of the engine.

SPACIFICATION:-

Engine specification :-

1) Rated power output : 5 H.P.
2) Rated RPM : 1500RPM.
3) Stroke : 110 mm.
4) Bore : 80 ϕ mm.
5) Loading : Rope brake dynamometer with spring balance and loading screw with hand wheel.
6) Pulley radius : 0.150 m

- Main Switch : 2Pole, 2Position,6Amp. Qty: 1 No.
  - Calorific value of fuel : 41800 kJ/ kg. (Diesel)
  - Sp. Gravity of fuel : 0.855 kg/m^3.

- Burette : 50 cc
- Orifice dia. : ϕ20 mm

- Temp. Indicator : Type–Input-CR-Al(K-Type),
  Range – 0^0C to 1000^0C,
  Supply – 230VAC,50Hz,
  Channel – 06,
  Qty : 1No.

  Proximity switch : M-12, PNP/NO,
  max load – 250 mA, 8 mm,
  5-30 VDC,
  Qty : 1 No.
- Thermocouples : Type – k simplex, 3mmϕX40mmL,
  Wire Length – 2mtrs,
  Qty : 6 No.
- Manometer : U – Tube,+/-100,
  Qty : 1 No.
- Specific heat of Water = Cw : 4.18 KJ/Kg^{0}C.
- Density of water : 1000 kg/m^3

PROCEDURE: -

1. Start the water supply for engine jacket cooling and exhaust gas calorimeter.
2. Ensure zero loads on spring balance and pointer at 0 reading of spring balance.
3. Switch ON diesel tank valve and valves at bottom of the burette.
4. Fill the burette with diesel, remove air if any.
5. Check temperature indicator readings, all channels should read approx. same reading as ambient temperature.
6. Check the manometer water level, the water level must be near to 0 reading.
7. Initially with no load on the engine, it is started by hand cranking.

8. Fill the burette on the fuel supply line and measure the time required for 25 cc and from this, we can calculate the fuel flow rate in cc/sec.
9. Record all temperatures, quantity of water through the cooling jacket and through calorimeter with the help of measuring flask and stopwatch.
10. Record the speed and repeat the same for 0, 3, 6, 9, 12 Kg load (T1-T2) and calculate brake power, indicated power, mechanical efficiency, brake thermal efficiency and prepare a heat balance sheet.
11. After a change in load, wait for the system to stabilize, which can be checked on the temperature indicator.
12. Put the engine off after all test is over, cut fuel supply, OFF water supply after 2-3 minutes

OBSERVATIONS:-

Sr.No	Particulars	LOAD (T1-T2) Kg				
		0	3	6	9	12
1	Spring balance, W1 in Kg					
	W2 in Kg					
2	Speed in rpm					
II) 1	<u>SP. FUEL CONSUMPTION</u> Time for 10 CC fuel in sec					
2	Water inlet temperature to Engine jacket, T5 ^{0}C					
3	Water outlet from engine jacket temperature, T6 ^{0}C					
4	Time for circulating 5 lit. water through jacket in sec.					
III) 1	<u>CALORIMETER SECTION</u> Water inlet temperature to Exhaust gas calorimeter ,T3 ^{0}C					
2	Water outlet Temperature from Exhaust gas calorimeter temperature, T4 ^{0}C					

3	Exhaust Gas inlet Temperature , T1 ^{0}C					
4	Exhaust Gas outlet Temperature, T2 ^{0}C					
5	Time for circulating 5 lit. water through calorimeter in sec.					

CALCULATIONS: -

1] Brake Power = ((2 Π N T)/ 4500) x 0.746 in kW.

Where, N = Speed of Engine in RPM,

T = Torque in kgm,

T = Spring balance reading difference X Pulley radius in the meter.

2] Fuel consumption: -

25 CC drop in level in the burette.

let time required for this drop be ' t ' seconds.

$$\text{Then F.C.} = \frac{25 \times 10^{-3} \times 3600 \times 0.855}{t} \text{ in kg/hr}$$

$$= \frac{76.95}{t} \text{ in kg/hr}$$

3] Brake Specific fuel consumption: -

$$= \frac{\text{Fuel Consumption}}{\text{Brake power}} \text{ Kg / kw hr.}$$

4] Indicated Power:-

Plot Willian's line, (i.e. graph of fuel consumption Vs Break power)

From graph find out F. P.

I.P. = B.P. + F.P.

5] Heat supplied by fuel :-

= (Calorific value of fuel X Fuel consumption) KJ/hr.

6] Heat carried away by Jacket Cooling Water:-

= mw X Cw X ΔT in KJ/hr

Where,

mw = Mass flow rate of jacket cooling water kg/hr.

Cw = Specific heat of water = 4.18 KJ/Kg^{0}C.

ΔT = Rise in temp. of water = (T2 – T1).

7] From the heat balance of calorimeter:-

Heat gained by Water = Heat lost by exhaust gases.

M'w X Cw X ΔT' = meg X Cpeg X ΔTeg.

Where,

M'w = Mass flow rate of water through calorimeter in Kg/hr.

Cw = Specific heat of Water = 4.18 KJ/Kg^{0}C.

ΔT' = Temperature rise of water through Calorimeter = (T2 – T1).

meg = Mass flow rate of exhaust gases.

Cpeg = Specific heat of exhaust gases.

ΔTeg = Temperature drop of exhaust = (T3 – T4).

$$(meg \times Cpeg) = \frac{M'w \times Cw \times \Delta T'}{\Delta Teg}$$

Heat carried away by exhaust gases in KJ/hr ,

= (meg X Cpeg) X (Tin – Tat)

Where,

Tin = Temperature of exhaust gases inlet to the calorimeter,

Tat = Ambient temperature.

8] Mechanical efficiency = $\frac{BP}{IP} \times 100$ %

9] Thermal efficiency:-

b] Brake Thermal efficiency = $\frac{\text{Heat Equivalent of B.P. / hr}}{\text{Heat Supplied by fuel/hr}}$

c] Indicated Thermal efficiency = $\frac{\text{Heat Equivalent of I.P. / hr}}{\text{Heat Supplied by fuel/hr}}$

d] Volumetric Efficiency = $\frac{\text{Actual Volume of air sucked at N.T.P. / min}}{\text{Piston displacement / min}}$

Now, the actual volume of air sucked at R. T. P.

VRTP = a X (√ (2gH)) X 60 X 0.64 m^3/min

Where,

a = area of orifice m^2

g = acceleration due to gravity = 9.81 m/sec^2

H = Air head causing flow, in mtr.

= Water head X $\frac{\text{Density of water}}{\text{The density of air at RTP}}$

Water head = Manometer difference, in meter.

Density of water = 1000 kg/m^3

$$\text{Density of air at RTP} = \frac{1.293 \times 273}{(273 + T_{at})}$$

Volume of air at N.T.P. ,

$$VNTP = VRTP \times \frac{273}{(273 + T_{at})}$$

and, piston displacement/min,

VD = Speed (in RPM) X Swept Volume

$= N \times (3.14/4 \times D^2 \times L)\ m^3/\text{min}.$

$$\text{Volumetric efficiency} = \frac{VNTP}{VD}$$

HEAT BALANCE: -

Credit			Debit		
	KJ / hr.	%		KJ/ hr.	%
1] Heat supplied by fuel.			1] Heat equivalent of brake power. 2] Heat carried jacket water 3] Heat carried by exhaust gases.		

			4] Heat unaccounted		

Normally, heat in B.P. is about 25 – 30%, heat carried by jacket water about 30%, heat carried by exhaust gases about 30% and heat unaccounted about 10 – 20 %. The actual values may vary due to the assumed calorific value of fuel, which may be less because of the availability of commercial oil.

Indicated power calculation requires the Indicator, which is normally not available. Hence, indicated power is calculated by plotting William's line.

From cylinder size and speed, brake or indicated mean effective pressure can be calculated.

PRECAUTIONS

1] Check that there is sufficient lubricating oil in the engine before starting.

2] Never start the engine before starting the water supply to the engine.

3] Check that all bolts and nuts are tightened before starting.

RESULT: -

1. Indicated Power =
2. Brake power =
3. Mechanical efficiency =
4. Thermal efficiency =

Questions

1. Distinguish between indicated power and brake power?
2. What is the mean by the thermal efficiency of engines?
3. Define volumetric efficiency?