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PAPER III

AUTOMOBILE POWER PLANTS

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Mechanical & Automobile Engineering (M & AE)

PAPER III

AUTOMOBILE POWER PLANTS

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AUTOMOBILE POWER PLANTS

UNIT - 1

ENGINE CONSTRUCTION, INLET & EXHAUST SYSTEM

Introduction to Engines:

An engine or motor is a device which is designed to convert one form of energy into another form of energy.

Eg: Heat engines, Electric engines, Electric motors etc.

History of Automobiles:

In 1769, A French engineer, Captain Nicholas Cugnot built the first road vehicle propelled by its own power. In 1880, German and French efforts developed an internal combustion engine vehicle, which was used to carry fruits. In 1985, Benz in Germany built a tricycle propelled by an internal combustion engine. In 1895, Panhard & Levassor named French people made modifications that engine is placed in front of the chassis, hooked up to a sliding gear and incorporate break peddles, clutch and accelerator. In India, the first motor car appeared at Bombay in 1897.

Definition of Automobile:

An automobile is a self-propelled vehicle which is used for the transportation of passengers and cargo on the ground. Automobile or Automotive means one which itself can move. Car, Bus, Truck, Jeep, Tractor, Scooter, Motor cycle etc. are the examples of Automobiles.

Types of Automobiles:

The automobiles are categorized in several ways.

1) Purpose:
   A) Passenger Vehicles - - car, jeep, bus
   B) Goods Vehicles - - truck
2) Capacity :
   A) Light Motor Vehicles - - car, motor cycle, scooter.
   B) Heavy Motor Vehicles - - bus, coach, tractor.

3) Fuel used :
   A) Petrol used Vehicles - - car, jeep, motor cycle, scooter.
   B) Diesel used Vehicles - - truck, bus, tractor, bulldozer.
   C) Electric Cab - - Battery truck, fork lift.
   D) Steam Carriages - - steam road rollers.
4) Number of wheels :
   A) Two wheeler - - Mopeds, scooters, motor cycles.
   B) Three wheeler - - Tempos, Road rollers.
   C) Four Wheeler - - car, bus, Tractor.
   D) Six wheeler - - Truck, tankers, Gun carriage vehicle.
   E) Eight or More wheelers - - car transporting vehicle, rocket transporters.

1.1 Engines:

Engine is a prime mover which works with the help of heat energy obtained from the fuel, which is converted into mechanical energy. Simply, Engine is one which converts heat energy (chemical energy) into mechanical energy.

Types of Engines:

In general the Engines are two types, based on the location of combustion process taking place.

External combustion Engines:

If the process of combustion is taking place outside of the engine, then it is External combustion engines.

Eg : Steam engines, Coal fired power plants , Stirling engines etc.

Internal combustion Engines:

If the process of combustion is taking place inside of the engine, then it is Internal combustion engines.

Eg: Petrol engines, Diesel engines etc.

Engine Parts:

1. Cylinder Block:

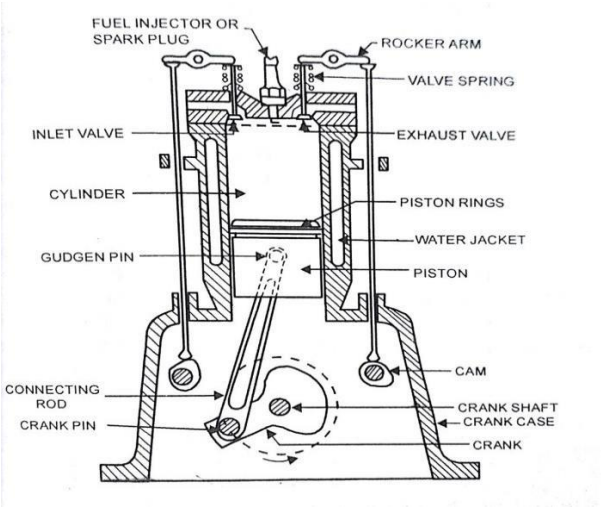

Fig. 1.1 Engine parts (Cross Section)

The basic frame of the engine is formed by cylinder block. It houses the cylinders and pistons. Around the cylinders there are passages for the circulation of cooling water. Cylinder block also carries lubrication oil to various components through drilled passages. At the lower end Crank case is cast integral with the block. At the top of the cylinder block, cylinder head is attached.

2. Cylinder Head:

Cylinder head is attached to the top of the cylinder block by means of studs. The gaskets are used to provide a tight leak proof joint at the interface of the head and the cylinder block. The cylinder head forms a combustion chamber above each cylinder. It also contains holes for spark plug and cooling water jackets. Besides valve openings are provided upon which complete valve operating mechanism is arranged.

3. Cylinder:

The cylinder houses the cylinder liners, piston and connecting rod. The piston moves up and down in the cylinder. When piston is moving in the cylinder, the walls of cylinder, wear. To avoid these cylinder liners are arranged in cylinder. These cylinders are replaced when they are worn out. Two types of cylinder liners are used. One is Dry liner and other is Wet liner.

4. Piston: The functions of the piston are

1. To transmit the pores of explosion to the crank shaft.
2. To form a seal so that high pressure gases in the combustion chamber do not escape into the crank case.
3. To serve as a guide and bearing for small end of the connecting rod.

The top of the piston is called head or crown. It has groves to house the piston rings. Two types of piston rings are used. One is Compression rings and the other is Oil rings. Piston has a piston pin. The small end of the connecting rod is connected to the piston pin.

5. Connecting Rod:

The function of the connecting rod is to convert the reciprocating motion of the piston into rotary motion of the crank shaft. The small end of the connecting rod is connected to the piston pin. The big end of the connecting rod is connected to the crank shaft.

6. Crank Shaft:

Crank shaft receives the power from the connecting rod and supply to the fly-wheel.

7. Crank Case:

The bottom part of the cylinder block is called Crank case. It houses the crank shaft and crank pin. It also acts as a reservoir for lubricating oil.

8. Cam Shaft:

The cam shaft is driven by the crank shaft by means of timing gears. The speed of the cam shaft is half the speed of the crank shaft. It operates inlet valve and outlet valve.

9. Inlet Valve:

The inlet valve is used to suck the charge into the cylinder.

10. Outlet Valve:

The outlet valve is used to send out the hot gases from cylinder to atmosphere through muffler.

11. Fly Wheel:

Fly-wheel is used to store the power at power-stroke and supply the power to other strokes.

12. Piston Rings:

In order to seal the gases in the top of the cylinder and prevent their leaking down the side of the piston, piston rings installed in the grooves turned in the piston crown are used. It is desirable that the ring gap should be as small as possible, and it is equally important that it should never close completely.

Piston Ring failures:

- Insufficient piston ring and groove clearance, which causes the ring to jam in the groove at working temperatures, as a result blow-by occurs and the ring may break.
- Insufficient cylinder lubrication.
- Large amount of wear in cylinder liner.
- Excessive diametrical clearance between the piston and cylinder liner.

Combustion chamber:

Combustion chamber is the space enclosed between the piston head and cylinder head when the piston is the top dead centre position.

Types of combustion chambers:

1. Direct Injection type or Open type
2. Turbulent or swirl type
3. Pre-chamber type.

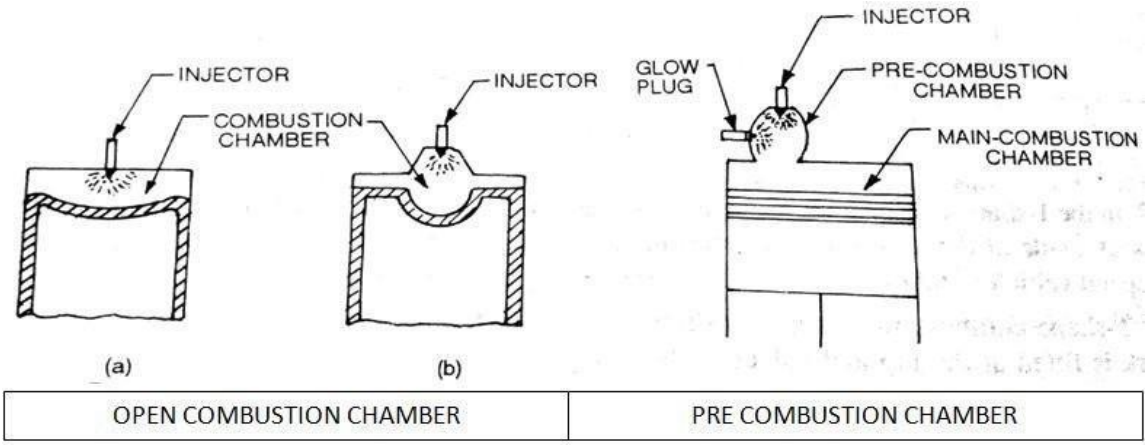

Fig 1.2 Types of Combustion Chambers

Valve Operating Mechanisms:

Side Valve Mechanism:

This mechanism is used in L,T and F type engine heads. The valve stem slides up and down with the help of valve stem guide. The valve spring is fitted between the engine block and spring retainer. It keeps the valve closed tightly on the valve seat. The valve tappet is lifted by the cam.

When the cam is rotated to 90° the tappet is moving up with the help of valve spring and valve stem guide. The valve is open. When the cam is rotated to 0°.The valve tappet moving down. With the help of valve spring , the valve is closed.

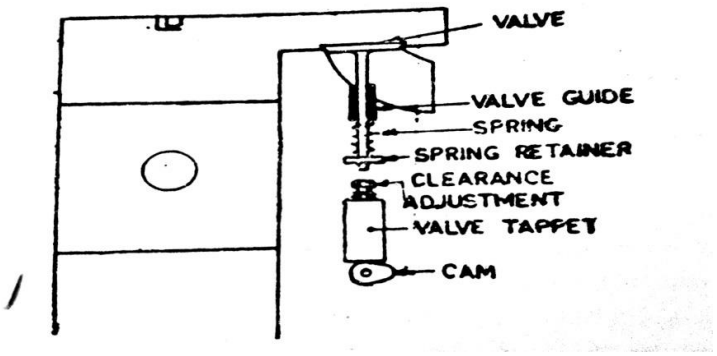

Fig 1.3 Side Valve Mechanism

The valve operating mechanism consists of a cam ring or camshaft equipped with lobes that work against a cam roller or a cam follower. The cam follower pushes a push rod and ball socket, actuating a rocker arm, which in turn opens the valve. Springs, which slip over the stem of the valves and are held in place by the valve-spring retaining washer and stem key, close each valve and push the valve mechanism in the opposite direction.

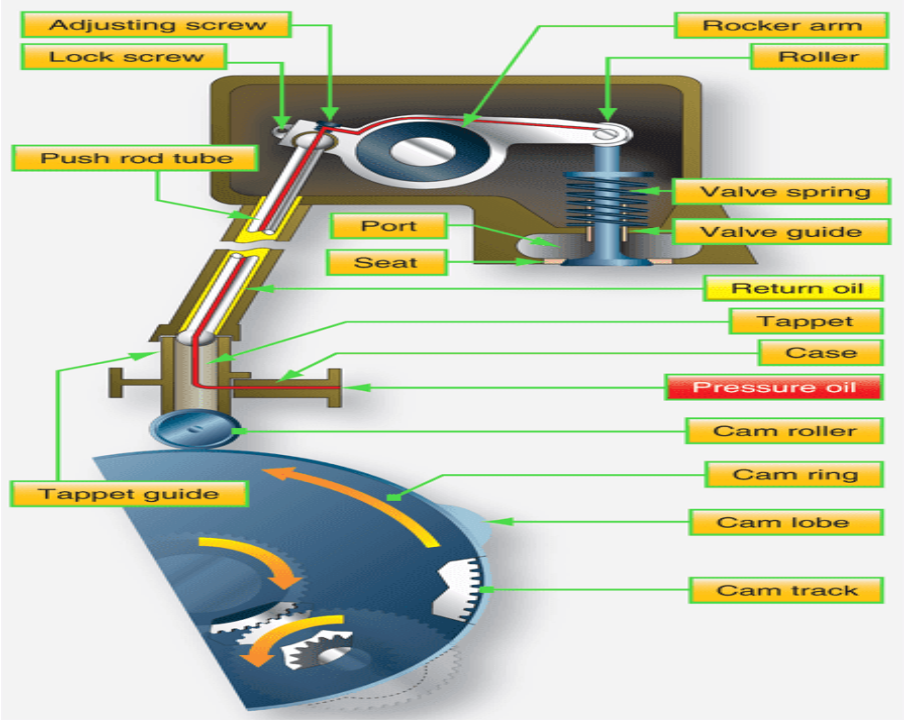

Fig 1.4 Valve Mechanism

Cylinder arrangements:

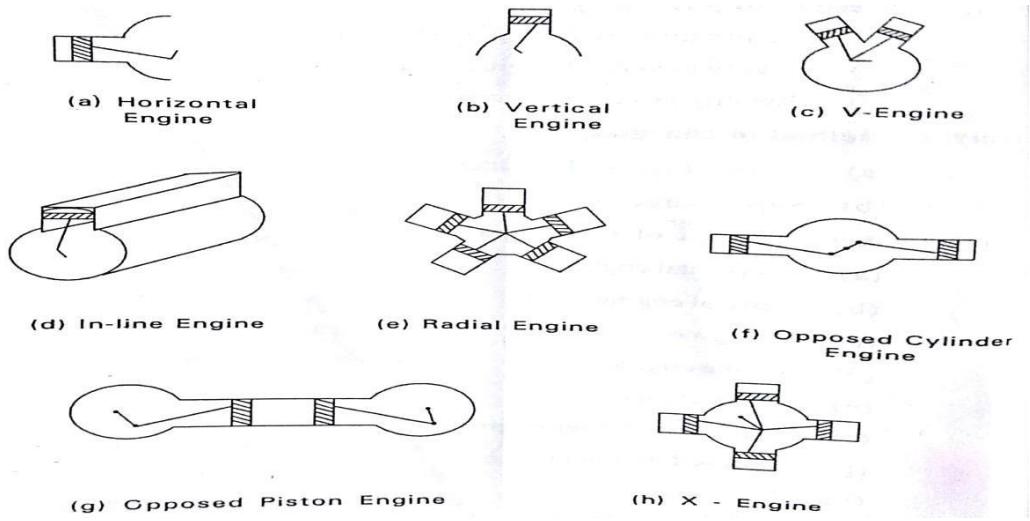

Fig 1.5 Various Cylinder Arrangements

Based on number of cylinders and motion of the piston we have different types of engines used for different types of applications.

Valve Timing Diagram:

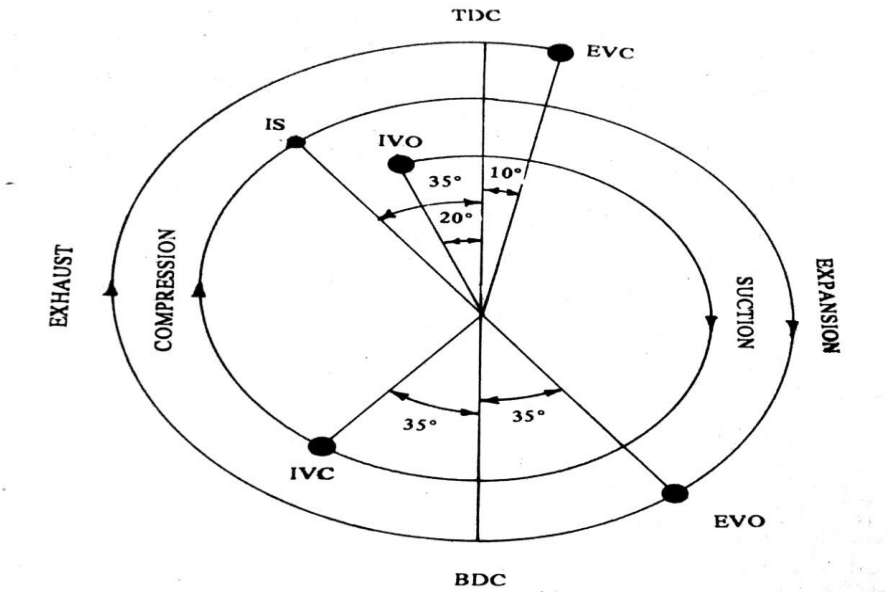

Fig 1.6 Valve Timing Diagram for 4-s Engine

In four-stroke cycle engines and some two-stroke cycle engines, the valve timing is controlled by the camshaft. It can be varied by modifying the camshaft, or it can be varied during engine operation by variable valve timing. An engine will have a period of "valve overlap" at the end of the exhaust stroke, when both the intake and exhaust valves are open. The intake valve is opened before the exhaust gases have completely left the cylinder, and their considerable velocity assists in drawing in the fresh charge.

Engine designers aim to close the exhaust valve just as the fresh charge from the intake valve reaches it, to prevent either loss of fresh charge or unscavenged exhaust gas.

Port Timing Diagram:

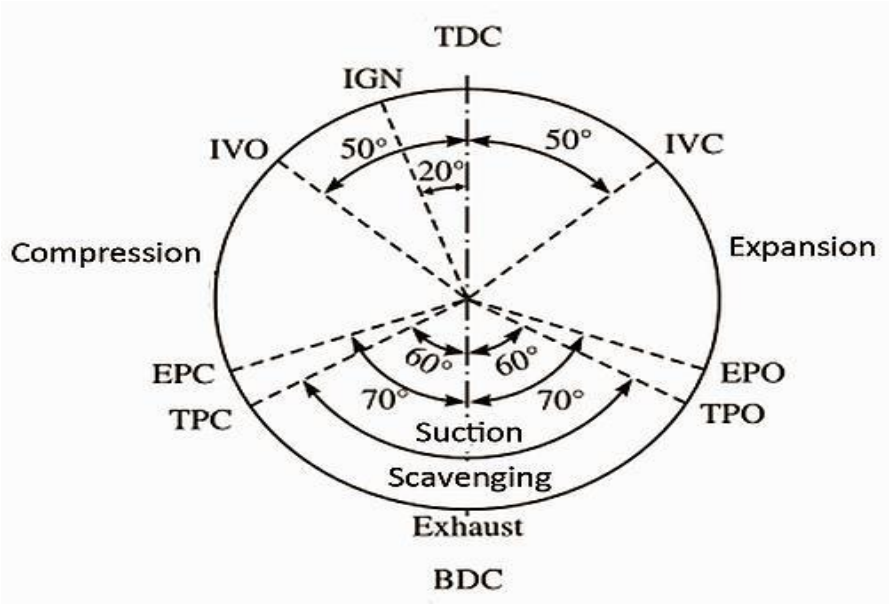

Fig 1.7. Port Timing Diagram

1.5.2 Valve Clearance:

In the case of straight poppet valve, a slight clearance is kept between the valve tappet and the valve stem is called valve clearance. In the case of over-head poppet valve, a slight clearance is kept between rocker arm and valve stem is called valve clearance. This clearance allows for expansion of the valve stem when the engine becomes heated. If sufficient clearance is not given the valve will not seat properly.

1.6 Timing Gears:

The cam shaft rotates at half the crank shaft speed so as to open and close the valves in every two revolutions of crank shaft. The drive from the crank shaft to the cam shaft is done by using timing gears. There are timing marks on the gears of the cam shaft and crank shaft to ensure correct volume timing.

Firing Order:

The sequence in which the power impulses are occurred in an engine is called the "Firing Order" of the engine.

Four Cylinder Engine	:	1-3-4-2 (or) 1-4-3-2.
Six Cylinder Engine	:	1-5-3-6-2-4
V-8 Engine	:	1-5-4-2-6-3-7-8

Introduction to Inlet & Exhaust system

The exhaust system collects the exhaust gases from the cylinders, removes harmful substances, reduces the level of noise and discharges the purified exhaust gases at a suitable point of the vehicle away from its occupants. The exhaust system can consist of one or two channels depending on the engine.

Necessity of manifolds:

The primary function of the intake manifold is to evenly distribute the combustion mixture (or just air in a direct injection engine) to each intake port in the cylinder heads. It may also serve as a mount for the Carburetor, throttle body, fuel injectors and other components of the engine.

The exhaust manifold acts as a funnel and is used to collect all of the engine's emissions (from however many cylinders your vehicle has). Then once they are in one place and completely burnt, the manifold sends the emissions into the rest of the exhaust system.

Types of manifolds:

There are two types of manifolds:

1. Inlet manifold
2. Exhaust manifold.

1. Inlet manifold:

The inlet manifold carries air fuel mixture from the Carburetor to the cylinder. The shape and size of the manifold must be such as to prohibit the formation of fuel droplets without restricting the air flow. On-in-line engines the inlet manifold is usually mounted on the same side of the engine on which exhaust manifold is located. This method is very effective in that the heat transfer takes place as soon as the engine is started.

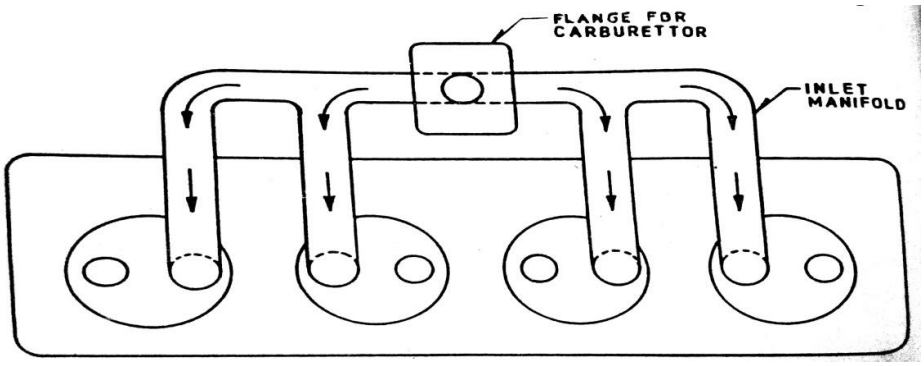

Fig 1.8. Intake Manifold of IC Engine

2. Exhaust Manifold:

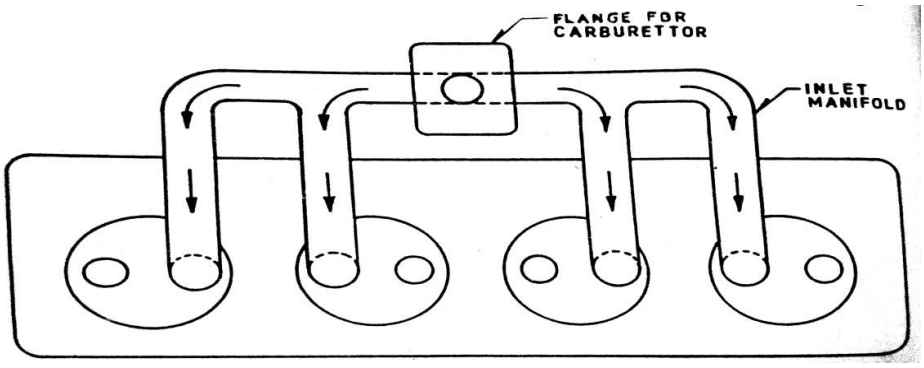

Fig 1.9 Exhaust Manifold of IC Engine

The exhaust manifold is the set of pipes carrying exhaust gases from the cylinder head to the exhaust system. The exhaust manifold is bolted to the side of the cylinder block on L-head engines. In I head engines it is bolted side of the cylinder head. In V-engines manifold is connected to a separate exhaust pipe, muffler and tail pipe.

Consideration for a good manifold design:

The points to be considered for design of manifold:

1. The amount of charge required to the engine cylinder.
2. The amount of charge entering into the cylinder.
3. The fuel should enter into cylinder smoothly and easily.
4. The manifolds with stand high temperature.
5. The material used for manifold should be transfer the exhaust heat to the surroundings.

Muffler:

If the high pressure exhaust gases were allowed to enter atmosphere directly from the exhaust manifold. A load unpleasant noise would be heard like firing of gun. This noise is due to large difference in pressure between the exhaust gases and atmosphere. To avoid this muffler or silencer I used. A muffler is connected between the engine exhaust pipe and the tail or outlet pipe.

The muffler is to reduce the pressure of the exhaust gases sufficiently to permit them to be discharged to the atmosphere silently.

Types of Muffler:

The types of muffler are:

1. Baffle type Muffler
2. Wave cancellation type Muffler
3. Resonance type Muffler
4. Absorber type Muffler
5. Combined resonance and absorber type.

1. Baffle Type Muffler:

It is generally cylindrical in shape with a number of baffles spot welded in side. It has closing in every direction passage for gas.

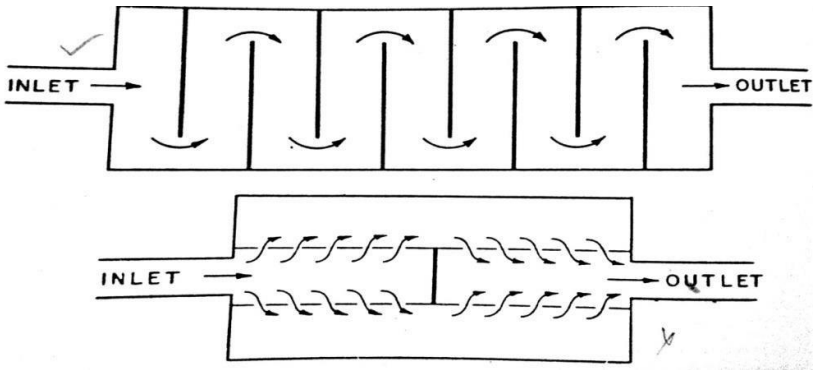

Fig 1.10 Baffle Type Muffler

2. Wave Cancellation Type Muffler:

In this type exhaust gases are divided in to two parts .the lengths of these paths are so adjusted that after they come out of the muffler, the crests of one wave coincide with the troughs of the second wave, thus cancelling each other and reducing the noise to zero.

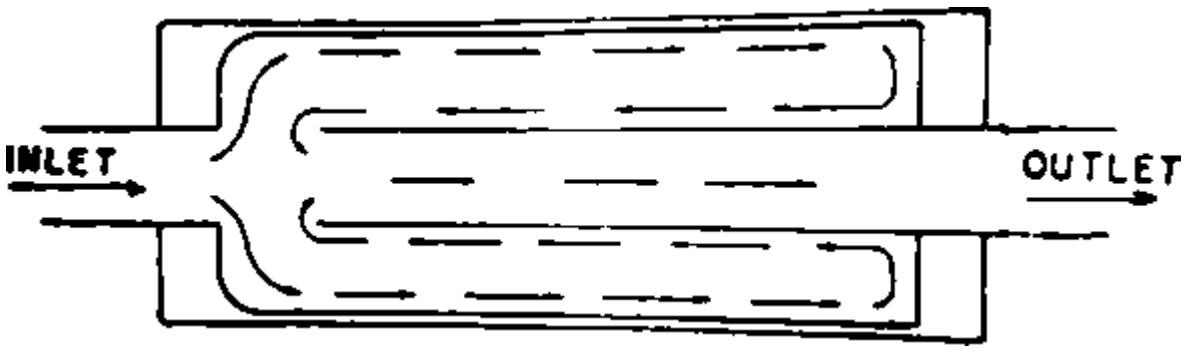

Fig 1.11 Wave Type Muffler

3. Resonance type Muffler:

These are also called Helmohtlz type. It consist a number of resonators in series through which a pipe containing access ports passes . the exhaust gases flow through this type .

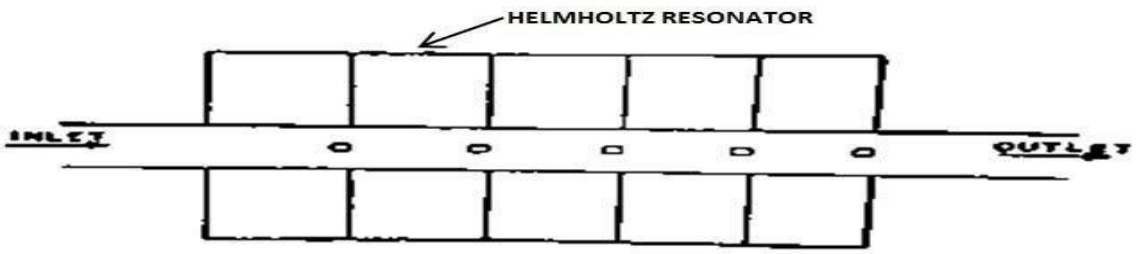

Fig 1.12 Resonance Type Muffler

4. Absorber Type Muffler:

The sound absorbing material usually fibre glass is placed around the perforated tube through which the exhaust gases pass. During the high pressure fluctuation the gases pass through the perforations to the sound absorbing material. These are reducing the noise.

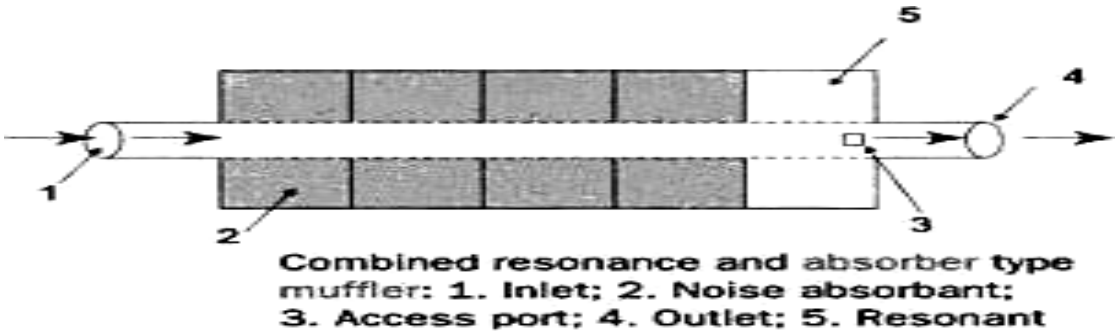

Fig 1.13 Absorber Type Muffler

Air Cleaner:

Air contains dust and dirt. If the air is enter directly to the engine. The dust particles damage the engine. To avoid this problem air cleaner are used. It cleans the air and supplied to the engine cylinder.

Types of Air Cleaner:

Air cleaners are of two types:

1. Light dirty air cleaner
2. Heavy dirty air cleaner

1. Light Duty Air cleaner:

It consists of wire mesh elements and oil reservoir at the bottom. The atmospheric air enters the air cleaner through windows, strikes the oil surface. The heavier impurities are retained by the oil and goes bottom. The air with lighter impurities passes through the wire mesh element, where the impurities are retained. The clean air passed to the engine cylinder.

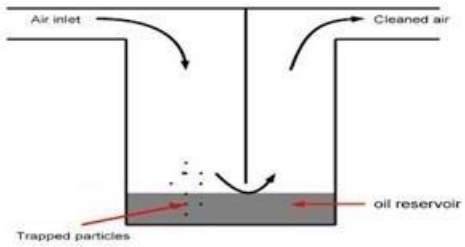

Fig 1.14 Light Duty Air Cleaner

2. Heavy Duty type Air Cleaner:

It consists of a centrifugal pre-cleaner and two filtering elements and oil reservoir. The pre-cleaner gives a whirling motion to the incoming air. The impure particles in the air to be thrown out through the slots. The pre-cleaned air passed on the oil surface. The impurities left on the oil. The air passed through wire-wool mesh. The dirty oil condenses and falls back into the reservoir. The cleaned air then passed through the second wire mesh, which retains any impurities left. The clean air is passed the engine cylinder.

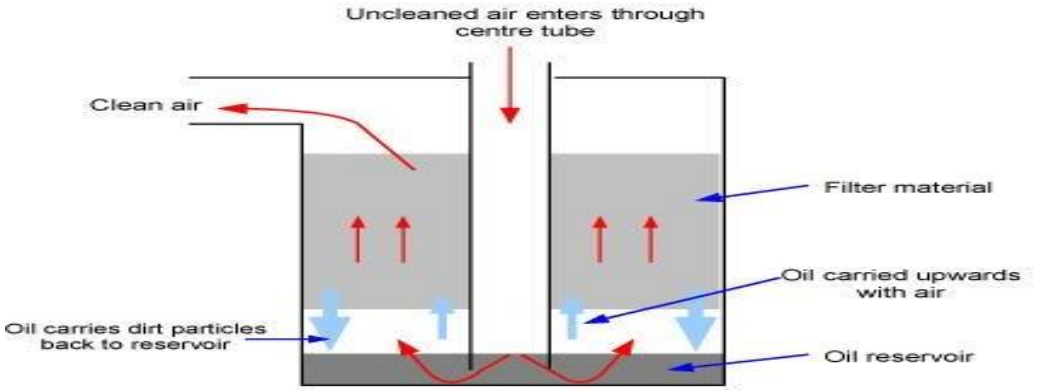

Fig 1.15 Heavy Duty Air Cleaner

Short Answer Questions

1. Write the types of automobiles.
2. Write the types of engines & give examples
3. Explain piston ring failures.
4. Draw the valve-timing diagram.
5. Write the firing order for 4-s,6-s & 8-s engines.
6. Explain the light duty air cleaner.
7. Draw heavy duty air cleaner and label the parts.

Long Answer Questions

1. Explain the parts of the engine with neat sketch.
2. Explain the types of manifolds.
3. Explain the types of mufflers.
4. Draw the types of cylinder arrangements.

UNIT - 2

I.C. ENGINES

2.0. Introduction:

In general heat Engines are defined as a device which transforms the chemical energy of a fuel into thermal energy and utilizes this thermal energy to perform useful work.

Types of Engines:

In general the Engines are two types, based on the location of combustion process taking place.

External combustion Engines:

If the process of combustion is taking place outside of the Engine, then it is External combustion Engines.

Eg : Steam Engines, Coal fired power plants , Stirling Engines etc.

Internal combustion Engines:

If the process of combustion is taking place inside of the Engine, then it is Internal combustion Engines.

Eg: Petrol Engines, Diesel Engines etc.

Classification of IC Engines:

Based on Various aspects the IC Engines are classified into different types.

1. Type of Ignition used :
    A) Spark Ignition (SI) Engine,
    B) Compression Ignition (CI) Engine,
    C) Hot-Spot Ignition Engine.
2. Type of fuel used :
    A) Petrol or Gasoline Engine.
    B) Diesel Engine.
    C) Gas Engine.
3. Number of Stroke per cycle :
    A) Two Stroke Engine,
    B) Four Stroke Engine.

4. Type of Cooling system :
    A) Air Cooled Engine,
    B) Water Cooled Engine,
    C) Evaporative Cooling Engine.
5. Cycle of operation
    A) Otto Cycle Engine,
    B) Diesel Cycle Engine,
    C) Dual Combustion Cycle or Semi Diesel Cycle Engine.
6. Method of Fuel Injection:
    A) Carburetor Engine,
    B) Air injection Engine,
    C) Airless or Solid injection Engine.
7. Arrangement of cylinders :
    A) Vertical Engine,
    B) Horizontal Engine,
    C) Radial Engine,
    D) V- Engine,
    E) Opposed Cylinder Engine.
    F) Opposed Piston Engine.
8. Applications :
    A) Stationary Engine,
    B) Automotive Engine,
    C) Marine Engine,
    D) Aircraft Engine,
    E) Locomotive Engine.
9. Valve location :
    A) Overhead Valve Engine,
    B) Side Valve Engine.
10. Speed :
    A) Low Speed Engine,
    B) High Speed Engine,
    C) Medium Speed Engine.

11. Method of Governing :

A) Hit and Miss Governed Engine,

B) Qualitatively Governed Engine,

C) Quantitatively Governed Engine.

2.3 Two-stroke Petrol Engine:

In two-stroke Petrol Engine, two strokes are present. One is upward stroke and other is downward stroke. In this Engine piston moving two times and crank shaft moving one time. It has inlet port, exhaust port and transfer port.

1. Upward Stroke:

Piston moving from bottom dead center to top dead center. The inlet port open. The air-fuel mixture enter into the crank case. The exhaust port and transfer port are closed. The air-fuel mixture in the cylinder is compressed when the piston moving upwards. When the piston coming to top dead center the compressed air-fuel mixture is ignited by using spark plug. Then the power is generated.

2. Downward Stroke:

When the air-fuel mixture is ignited the hot gases are produced in the cylinder. The hot gases makes pressure on the piston. Then the piston moving downward. The inlet port closed and the exhaust and transfer ports are open. The hot gases goes to the atmosphere through exhaust port. The air-fuel mixture present in the crank case goes to the cylinder through transfer port.

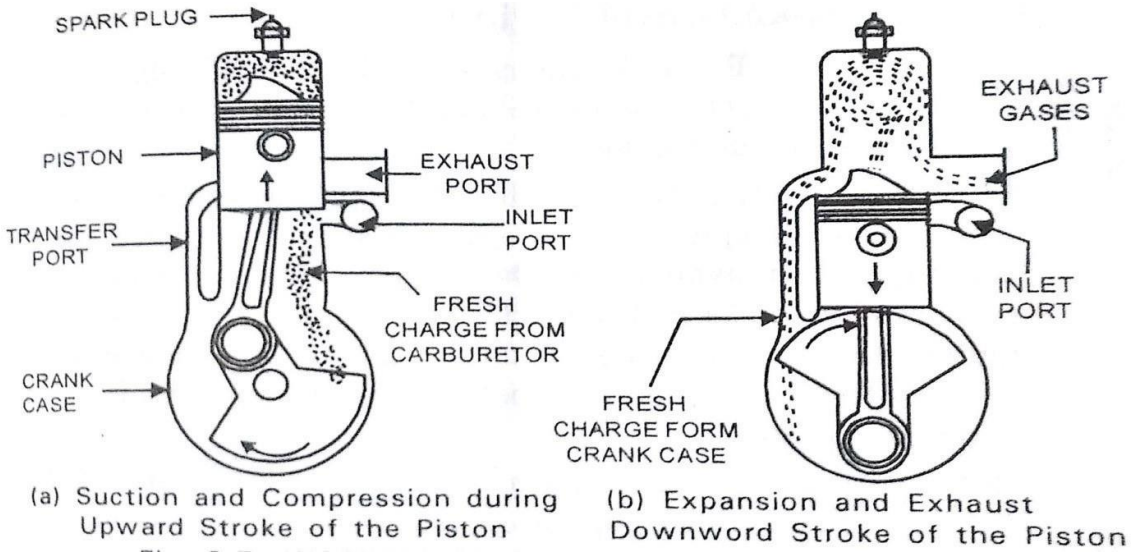

Fig 2.1 Working of 2 Stroke Engine

Four Stroke Petrol Engine:

Petrol Engine is also known as spark ignition Engine. The Engine cycle is completed in two revolutions of crank shaft and piston is moving four times.

The four strokes are

1. Suction Stroke
2. Compression Stroke
3. Power Stroke (or) Expansion Stroke
4. Exhaust Stroke.

1. Suction Stroke:

During the suction stroke inlet valve open and exhaust valve closed. The piston moving downwards and create partial vacuum in the cylinder. Due to pressure difference, The air-fuel mixture is sucked into the Engine cylinder. The crank shaft completes half of the revolution.

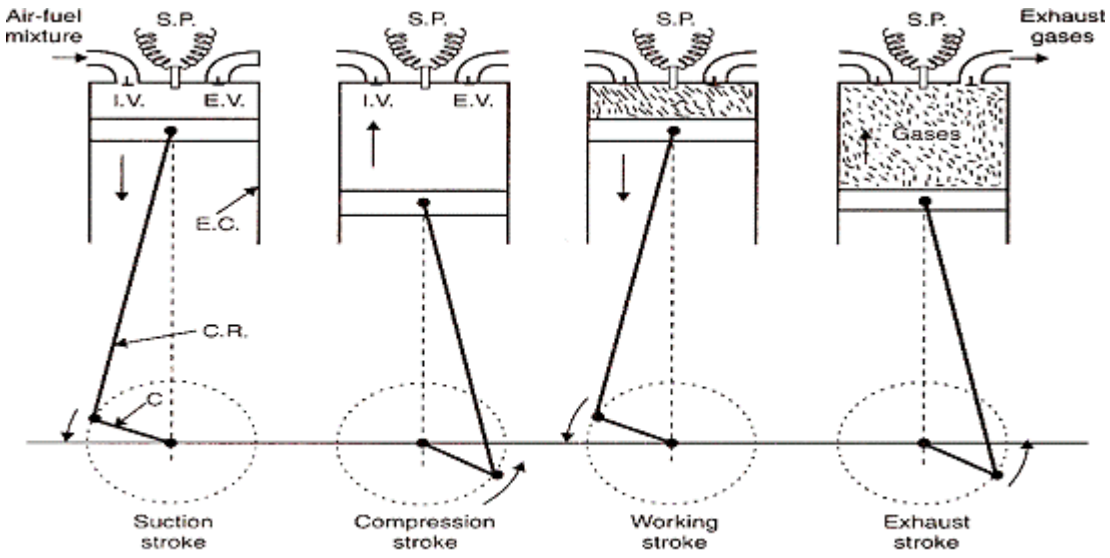

Fig 2.2 Working of 4 Stroke Petrol Engine

2. Compression Stroke:

During compression stroke, the inlet valve and exhaust valves are closed. The piston moving upwards and compress the charge to required pressure and temperature. At the end of the compression stroke, the charge is ignited by spark plug. The crank shaft completes half of the revolution.

3. Power Stroke (or) Expansion stroke:

During power stroke, the inlet valve and exhaust valves are closed. The piston moving downwards, in this stroke power is produced. The crank shaft completes half of the revolution.

4. Exhaust Stroke:

During exhaust stroke, exhaust valve is open and the inlet valve is closed. Piston moving upwards. The hot gases present in the cylinder are goes out through the exhaust valve. The crank shaft completes half of the revolution.

Four Stroke Diesel Engine:

The four stroke Diesel Engine works on Diesel cycle And the process of combustion is compression ignition.

The four strokes of Diesel Engine are

1. Suction stroke
2. Compression stroke
3. Power or Expansion stroke
4. Exhaust stroke

The piston moves four times and Crank shaft makes two revolutions.

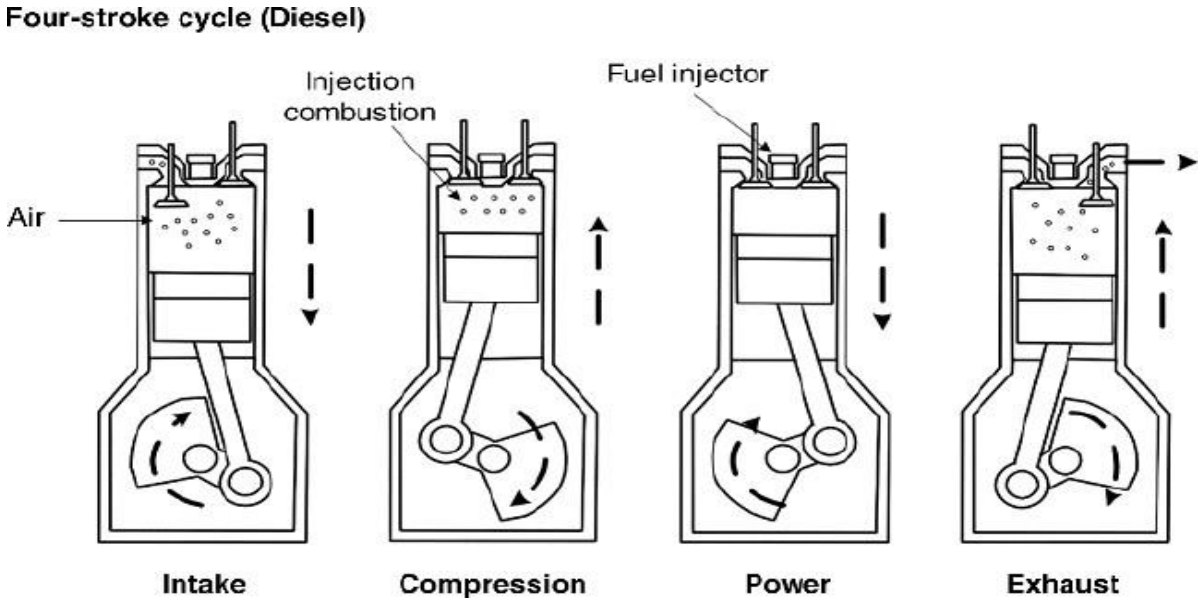

Fig 2.3 Working 4 S Diesel Engine

1. Suction Stroke:

In Suction stroke the piston moving from the top dead center to bottom dead center. The inlet valve open and outlet valve closed. The fresh air enter into the cylinder through inlet valve.

2. Compression Stroke:

In compression stroke, the piston moving from bottom dead center to top dead center. The inlet valve and outlet valves are closed. The air is compressed. At the end of the compression stroke, Fuel is injected into the cylinder by fuel injector. Ignition is taken place.

3. Power or Expansion Stroke:

In this stroke the piston moving from top dead center to bottom dead center. The inlet and outlet valves are closed. The power is generated.

4. Exhaust Stroke:

In Exhaust stroke the piston moving from bottom dead center to top dead center. The inlet valve closed and the outlet valve open. The hot gases go out through the outlet valve.

COMPARISION OF TWO-STROKE AND FOUR STROKE PETROL ENGINE:

S. No	TWO-STROKE PETROL ENGINE	FOUR-STROKE PETROL ENGINE
1.	In this ports are provided. The ports are opened and closed by piston.	In this valves are provided. The valves are operated by cam mechanism.
2.	The charge first enter into the crank case then goes to the cylinder through transfer port.	The charge is directly admitted into the Engine cylinder through inlet valve.
3.	All events are in two-strokes of the piston or one revolution of the crank shaft.	All events are completed in four-strokes of the piston or two revolutions of crank shaft.
4.	Torque is more uniform and requires lighter fly-wheel	Torque is not uniform and require heavy fly-wheel.
5.	Volumetric efficiency is low due to less time for suction.	Volumetric efficiency is mire due to more time for suction.
6.	Elimination of suction and exhaust strokes minimize the frictional loses.	More frictional loses.
7.	Thermal efficiency is lower	Thermal efficiency is higher.
8.	Consumes more lubricating oil.	Consumes less lubricating oil.
9.	More wear and tear and more noisy in operation.	Less wear and tear and les noisy in operation.
10	Generally employed in light duty vehicles such as scooters, motor cycles and hand sprayers.	Generally employed in heavy duty vehicles such as cars, buses, trucks, tractor and power generating units.
11	Engine cost is less.	Engine cost is more.

COMPARISION OF PETROL ENGINE AND DIESEL ENGINE:

S. No	PETROL ENGINE	DIESEL ENGINE
1.	Petrol Engine works on the principle of Otto cycle.	Diesel Engine works on the principle of Diesel cycle.
2.	Petrol and gases fuels are used.	Diesel And heavy oils are used.
3.	Mixture of air and fuel is drawn during suction stroke.	Only air is drawn during suction stroke.
4.	Requires Carburetor.	Requires fuel-injection pump.
5.	Spark plug is used to ignite the charge.	Fuel injector is used for ignition.
6.	Lighter due to low compression ratio.	Heavier due to high compression ratio.
7.	The initial cost is low.	The initial cost is high.
8.	Volumetric efficiency is less.	Volumetric efficiency is low.
9.	Wear and tear is more.	Wear and tear is less.
10	It makes less noise.	It makes more noise.
11.	Throttle is present	Governor is present.

Scavenging of I.C. Engine:

In an internal combustion Engine, scavenging is the process of replacing the exhaust gas in a cylinder with the fresh air/fuel mixture (or fresh air, in the case of direct-injection Engines) for the next cycle. If scavenging is incomplete, the remaining exhaust gases can cause improper combustion for the next cycle, leading to reduced power output.

The three main types of scavenging for two stroke Engines are cross flow, uniflow and loop flow.

Detonation in IC Engine:

Knocking (also knock, detonation, spark knock, pinging or pinking) in spark ignition internal combustion Engines occurs when combustion of some of the air/fuel mixture in the cylinder does not result from propagation of the flame front ignited by the spark plug, but one or more pockets of air/fuel mixture explode outside the envelope of the normal combustion front. The fuel-air charge is meant to be ignited by the spark plug only, and at a precise point in the piston's stroke. Knock occurs when the peak of the combustion process no longer occurs at the optimum moment for the four-stroke cycle. The shock wave

creates the characteristic metallic "pinging" sound, and cylinder pressure increases dramatically. Effects of Engine knocking range from inconsequential to completely destructive**.**

Definition for Bore and Stroke:

The inner diameter of the cylinder is called bore. Stroke is the distance of the piston travelled in the cylinder.

Short Answer Questions

1. Write the classification of IC engines according to the operation.
2. Write the classification of IC engines according to the method of fuel injection.
3. Write the classification of IC engines according to the method of governing.
4. Write the parts of 4-stroke engine.
5. Explain Bore & stroke.
6. Explain scavenging.

Long Answer Questions

1. Write the classification of IC engines.
2. Explain the working of 2-stroke petrol engine with neat sketch.
3. Explain the working of 4-stroke petrol engine with neat sketch.
4. Explain the working of 4-stroke diesel engine with neat sketch.
5. Write the comparison of 2-strole & 4-stroke engine.
6. Write the comparison of petrol & diesel engine.

UNIT - 3

Fuel Supply System

3.0 Introduction:

The fuel system is made up of the fuel tank, pump, filter, and injectors or Carburetor, and is responsible for delivering fuel to the Engine as needed. Each component must perform flawlessly to achieve expected vehicle performance and reliability and To run a Diesel Engine, the fuel from the tank must reach by some means to the Engine cylinder at higher pressures for that purpose a fuel injector incorporated with nozzles and feed pumps will be provided.

Fuel Supply Systems in Petrol Engine:

There are many types of fuel supply system in Petrol Engine. The basic fuel supply system in an automobile Petrol Engine consists of a Fuel Tank, Fuel Lines, Fuel Pump, Fuel Filter, air Cleaner, Carburetor, intake manifold.

The components of fuel supply system:

1. Fuel tank:

The fuel tank holds the fuel for the Engine. It is made of steel or aluminum or synthetic rubber compounds and fiber reinforced plastics which are flame resistant. And these tanks are coated with lead-tin alloy to protect the tank from the corrosion effect.

2. Fuel pump:

The fuel pump is used to deliver the fuel from the fuel tank to the Carburetor. It supplies the high-pressure fuel from tank to the Carburetor.

3. Fuel lines:

These tubes are used to connect the fuel tank with the pump and pump to the Carburetor. Generally, these tubes are made of Copper or Steel.

The two joints of the tubes are made flexible because of the flexible joints help the fuel tank to moves back or front with the body, and also pump is moves according to the body. This joint prevents the loosening of fuel line by front-back movement of the body.

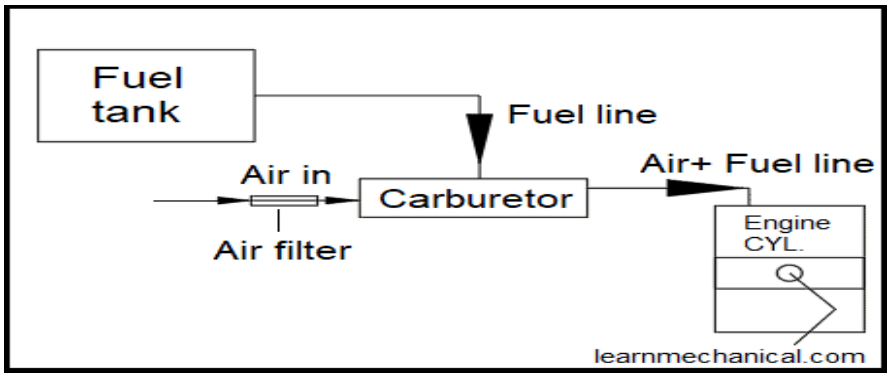

Fig 3.1 Components of Fuel System

4. Air Cleaner:

This is very necessary for an Engine to get fresh air, otherwise, the polluted air causes several damages to the Engine chamber. Particularly Piston, Piston chamber, Piston ring, and Valves. And if the polluted air enters the crankcase where we store Engine oil that can be damaged the lubrication parts like bearings. Therefore we need to install an air filter which purifies the air before entering the Engine cylinder.

Fuel Filters:

A fuel filter is necessary for a vehicle to clean the fuel. It screens off the dirt or foreign matter from the fuel and prevents entry to the pump.

There are 3 types of fuel filters. They are

1. Cartridge type
2. Edge type
3. Centrifugal type

1. Cartridge Type Oil Filter:

It consists of a filtering element placed in the metallic casing. The impure oil pass through the filtering element which takes all the impurities. The oil enters the filter at the top and passes through the filter element. The pure oil then goes to the porous metallic tube from where it goes to the out let for circulation and a drain plug is also provided.

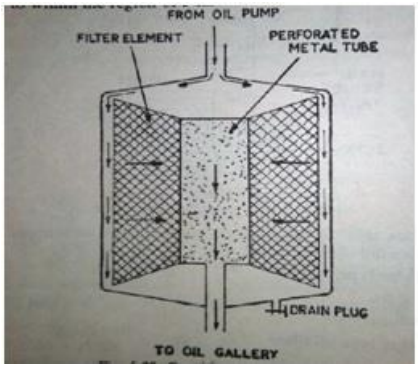

Fig 3.2 Cartridge Type Oil Filter

2. Stack or Edge Type Oil Filter:

In this the oil passes through a number of closely spaced discs. The alternate discs are mounted over a central spindle, while the discs in between these are attached to a separate spindle. The oil is made to flow through the spaces between the discs. The impurities are left on the peripheries. The impurities are removed by operating the central knob.

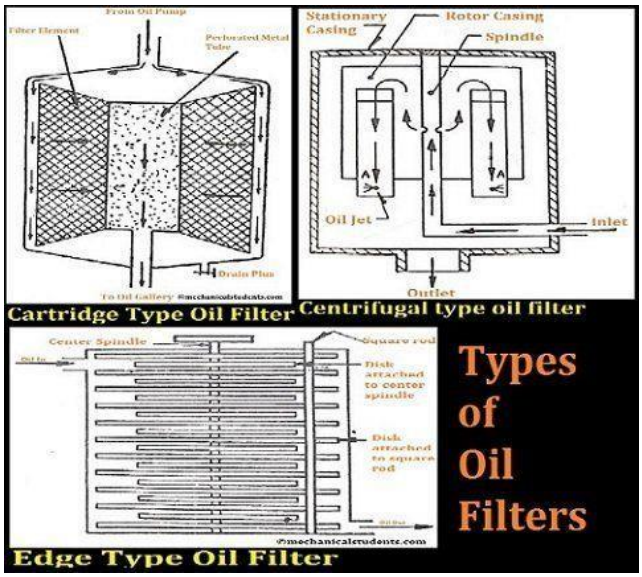

Fig 3.3 Types of Oil Filters

3. Centrifugal Type Oil Filter:

In this the impure oil enters the hollow central spindle having holes around its periphery. The dirty oil comes out of these holes and fills the rotor casing after oil passes down the tubes A at the ends which jets are attached. The oil under pressure passes through these jets, the reaction of which gives the motion to the rotor casing in the opposite direction

so that it starts rotating. The impurities are retained and clean oil falls below from where it is taken out.

Requirements of Carburetion

A perfect air-fuel mixture is necessary for a Petrol Engine to run. So, therefore, the device which performs this operation is called Carburetor. It is the device which controls the air-fuel mixture and mixes with desired proportions. There are two chambers in Carburetor one is float chamber which is used to maintain the fuel level with the help of needle valve and another one is mixing chamber where the mixture of air-fuel takes place.

1. It atomize the fuel and mixed it with the air.
2. It maintains a small reserve of Petrol at a constant head.
3. It prepares a mixture of Petrol and air in correct proportions and makes homogenous mixture.
4. It supplies a fine spray of mixture

Carburetors used in S.I. Engines may be up draught, down draught and side draught. This is based on the direction of air flow in to the Carburetor and air-fuel mixture flow at the Carburetor out let to the inlet manifold.

In down draught Carburetor, the air enters top of the Carburetor and leaves at the bottom In side draught Carburetor, the air enters at the top and leaves at the side. In up draught Carburetor the air enters at the bottom or side of the Carburetor and leaves at the top.

Simple Carburetor:

The main components of simple Carburetor are

A) Float chamber
B) Float
C) Venturing,
D) Nozzle,
E) Choke Valve
F) Throttle Valve.

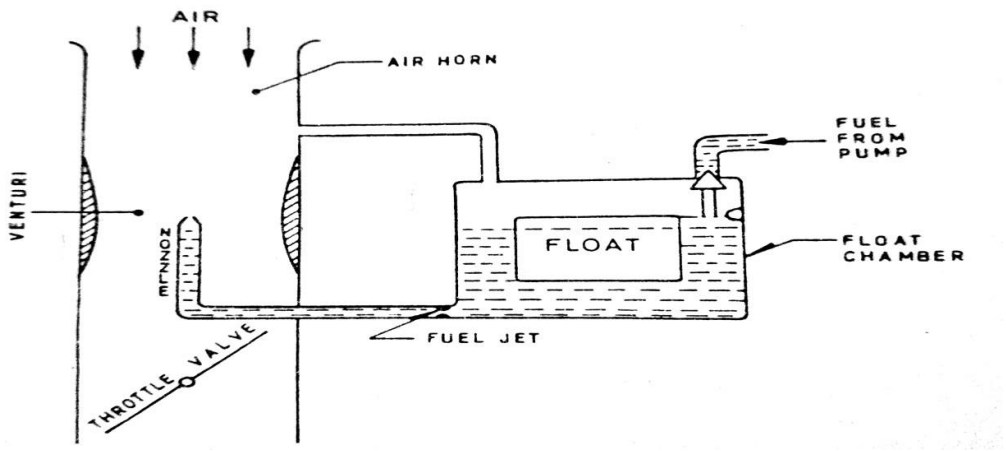

Fig 3.4 Construction of Simple Carburetor

Float Chamber:

In the float chamber, the float and a needle valve helps to maintain a constant level of Petrol. The float chamber is ventilated to atmosphere. This is used to maintain atmospheric pressure inside the chamber.

Float:

The float which is normally a metallic hollow cylinder rises and closes the inlet valve, as the fuel level in the float chamber increases to certain level.

Venturing:

The venture tube is fitted with the inlet manifold. The tube has a narrow opening called venturi.

Nozzle :

A nozzle is provided just below the center of the venture. The venture and the nozzle are kept in the mixing chamber. The mixing chamber has two butterfly valves. One is choke valve and the other is throttle valve.

Choke Valve:

It is a valve which allows air into the mixing chamber.

Throttle Valve:

It is a valve which allows air fuel mixture to the Engine cylinder.

Working:

Vacuum is created inside the cylinder during the suction stroke. Then exist a pressure difference between the cylinder and outside the Carburetor. Therefore the atmospheric air enters into the Carburetor. The air flow through venturi. It increases the velocity of air and reduces the pressure. This provides partial vacuum at the top of the nozzle. Because of this vacuum the fuel comes out from the nozzle in the form of a fine spray. The fuel particles mixed with the incoming air to form air-fuel mixture. Thus it gives homogenous mixture and goes to the Engine cylinder

Solex Carburetor:

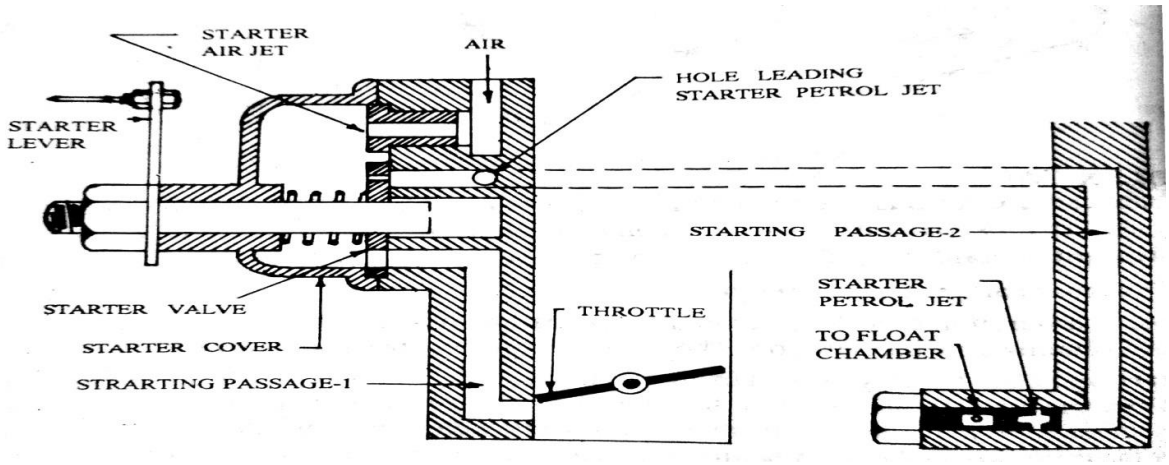

Fig 3.5 Construction of Solex Carburetor

Solex Carburetor is most commonly used down draught type of Carburetor. This Carburetor comes with an additional feature of Bi-starter. This Carburetor can work differently at different conditions known as

1. Cold starting conditions
2. Idling conditions
3. Normal conditions
4. Acceleration conditions

1. Cold Starting Conditions:

It consists of a starter valve in the form of a flat disk having holes of different sizes. These holes connect the Petrol jet and starter jet ides to the passage which opens into the air horn just below the throttle valve. The starter lever is operated by the driver from the dash board. It adjusts the position of the starter valve so that either bigger or small holes come opposite to the passage. At the time of starting bigger holes connect

the passage so that more fuel go to the Engine. The throttle valve being closed, the hole of the Engine suction is applied to the starting passage1. So that the Petrol from the float chamber passes through the starter Petrol jet and rises into passage2. Some of the fuel comes out and mixes with air and entering through the air jet. After the Engine is started the starter lever is brought to the second position. The smaller holes connects to the passage reducing the amount of Petrol. The throttle valve is partly open then the Petrol coming from the main jet. When the Engine reaches the normal running temperature the starter is brought to off position.

2. Idling:

At idling or low speed the throttle valve is almost closed. The Engine suction is applied at the pilot Petrol jet which supplies Petrol. The jet itself draws Petrol from the main jet circuit. The air is drawn from the pilot air jet. The air and Petrol mix in the idle passage. The mixture comes out of the idle port which opens below the throttle valve.

3. Normal Running:

During Normal running the throttle valve is partly opened and the Engine suction is applied at the main jet which supplies the fuel. The air enters directly through the venture and mix with the fuel. The air fuel mixture is governed by the throttle valve.

4. Acceleration:

For acceleration extra fuel is required by the Engine, which is supplied by membrane pump. The pump lever is connected to the accelerator. When the accelerator peddle is depressed the pump lever presses the membrane forcing the fuel into the main jet. Then the peddle is returned the membrane moves back, sucking the fuel from the float chamber through the ball valve.

Carter Carburetor:

The Carter Carburetor is a down draught type of Carburetor which provides of fine air-fuel mixture for different conditions with the help of more number of venturi sections.

The carter Carburetor consists of following circuits

1. Float circuit
2. Starting circuit
3. Idle and low speed circuit
4. Part throttle circuit
5. Full throttle circuit
6. Acceleration pump circuit

Float Circuit:

The float chamber has a float. A needle valve closes the fuel inlet when the fuel in the float chamber attains a specific level. When the fuel level falls, the needle valve opens the inlet to admit more fuel.

Starting Circuit:

Choke is used for starting. It is mounted eccentrically which facilitates its automatic opening after the Engine has started. As the choke valve is closed the whole of the Engine suction is applied at the main nozzle the fuel delivers.

Idling & Low Speed Circuit:

For idling rich mixture is required in small quantity. The throttle valve is almost closed. The suction is now applied at the idle port, through which the air and fuel are drawn, giving rich mixture. While operating at low speed operation throttle valve is opened. The main nozzle also starts supplying the fuel. At this stage fuel is delivered both by the main venture and low speed port through idle passage.

Part Throttle Circuit:

When the throttle valve partly opened a small amount of air-fuel mixture is giving.

Full Throttle Circuits:

When the throttle is fully open, maximum amount of air is passing through the venture. Thus a higher rate of fuel is drawn.

Acceleration Pump Circuit:

When the acceleration is desired, acceleration pedal is pressed which actuate the pump giving an extra fuel for acceleration.

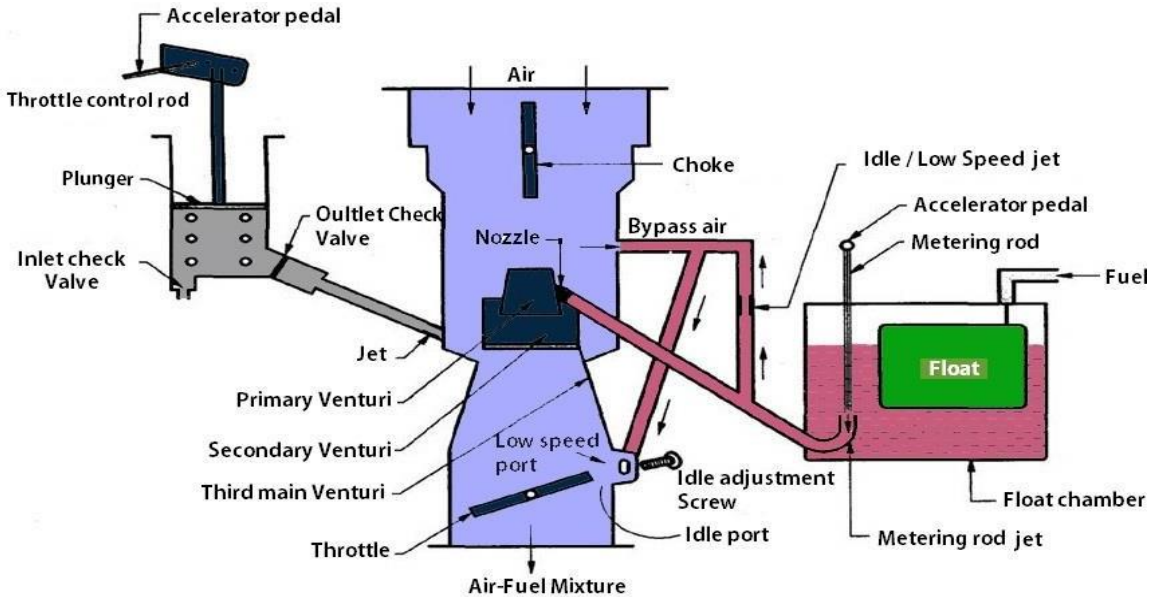

Fig 3.7 Construction of Carter Carburetor

Zenith Carburetor:

The standard model of Zenith Carburetor contains the old type of float chamber. The system is modified in recent years. There are three jets- main jet, compensating jet and idling jet in the Carburetor. This compensating jet is around the main jet. The choke valve is used for starting. For idling and slow speed running, the air enters through the holes A and B, mixes with the fuel in idling passage, and the mixture passes to the idling jet. A separate knob is provide for idle adjustment, which controls the opening B to supply the mixture.

When the throttle valve is widely opened, the main jet comes into action, along with the idling jet. On further opening the throttle valve, the whole suction is applied on the main and compensating jet. The idling jet is cut off. The compensating jet takes care to maintain correct air-fuel ratio at different speeds.

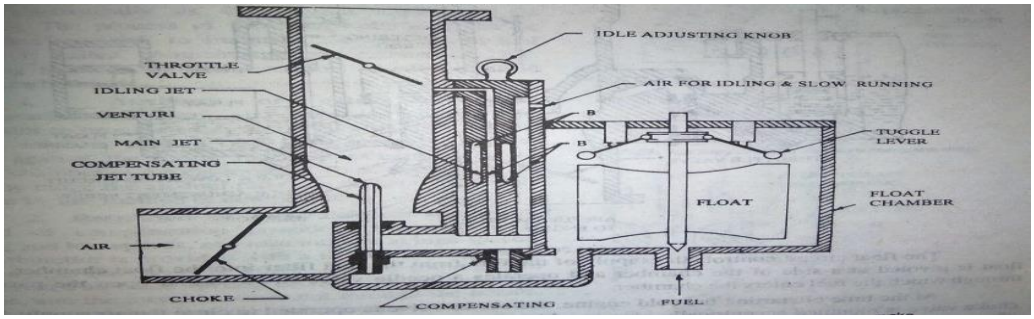

Fig 3.8 Zenith Carburetor

S.U. Carburetor:

It is constant vacuum type Carburetor. It consists of a single jet in which a tapered needle operates. The area of the throat is varied by means of piston which slides up and down. The tapered needle is connected to the accelerator. When the accelerator is operated the piston moves up and down in the throat, controlling the air. The needle moves up and down to the jet controlling the supply of fuel. When the piston moves down throat area decreases the annular area in the jet to pass less fuel. The piston and tapered needle are designed that they maintain correct air fuel mixture at different opening conditions.

The upper side of the piston is connected to the throttle passage through a slot cut in the piston. The lower side is covered to the atmospheric pressure. The piston at any instant depends up on the balance of its own weight against the vacuum force. As the weight of the piston is constant, the vacuum also constant. The jet can move broadly up and down with respect to the tapered needle by an adjusting screw fitted at the bottom of the screw. This is done for adjusting the mixture strength.

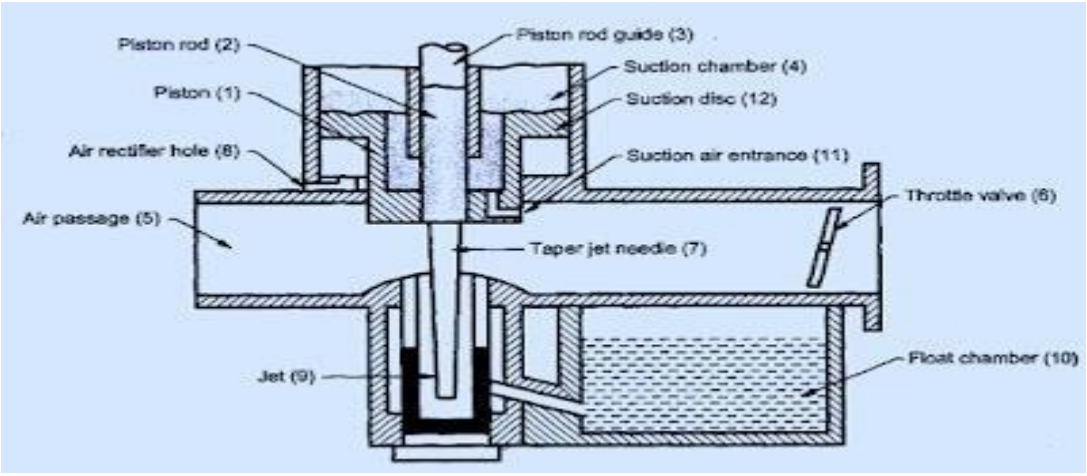

Fig 3.9 S.U Carburetor

3.5. Spark Plug:

Spark plug is a device for delivering electric current from an ignition system to the combustion chamber of a spark-ignition Engine to ignite the compressed fuel/air mixture by an electric spark, while containing combustion pressure within the Engine. A spark plug has a metal threaded shell, electrically isolated from a central electrode by a porcelain insulator. The central electrode, which may contain a resistor, is connected by a heavily insulated wire to the output terminal of an ignition coil or magneto. The spark plug's metal shell is screwed into the Engine's cylinder head and thus electrically grounded. The central electrode protrudes through the porcelain insulator into the

combustion chamber, forming one or more spark gaps between the inner end of the central electrode and usually one or more protuberances or structures attached to the inner end of the threaded shell and designated the side, earth, or ground electrode(s).

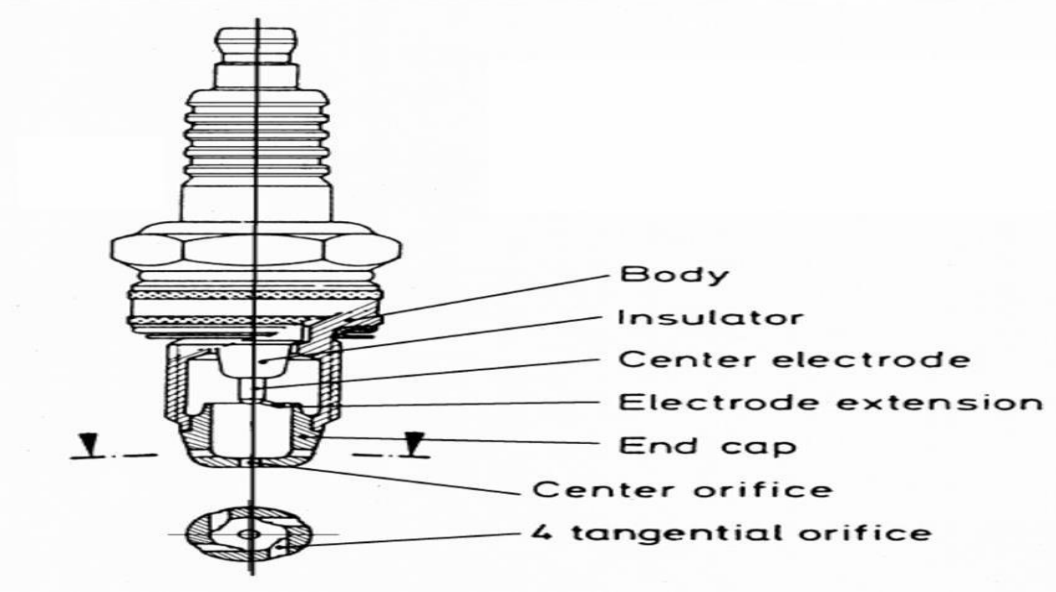

Fig 3.10 Spark Plug Construction

Super Charging:

The process of supplying the air fuel mixture to the Engine above the atmospheric pressure is called super charging. A super charger is used to increase the pressure of air fuel mixture from the Carburetor before it enters the Engine.

Types of Super Chargers:

1. Centrifugal type Super Charger.
2. Vane type Super Charger.
3. Roots Blower type Super Charger.

Scavenging:

The process of driving exhaust gases out of the cylinder and replacing it with fresh air is called scavenging. The methods of scavenging are A) Loop scavenging, B) Uni- flow scavenging.

3.8. Petrol Injection System in Modern vehicles:

This system is used in modern cars where a single Carburetor is used to deliver air fuel mixture into multi cylinder Engine. Some of the cylinders may not get regular supply of the mixture. It ensures unrestricted fuel supply and controls it at all times of

the Engine operation. Petrol injection gives both higher power and low specific fuel consumption.

3.9 Line diagram of a Diesel Engine Fuel System:

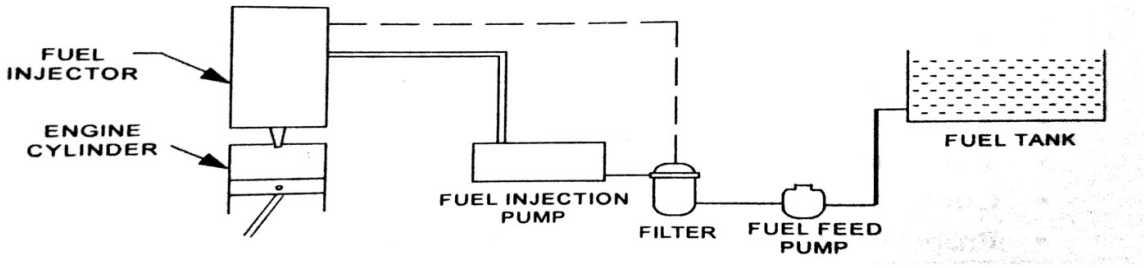

Fig 3.11Line Diagram of Diesel Engine Fuel System

Requirements of Fuel Injection System:

1. To meter or measure the correct quantity of fuel to be injected.
2. Atomized the fuel into fine particles.
3. The timing of fuel injected into the cylinder during Engine starting, full load and high speed.
4. Control the rate of fuel injection.
5. Properly distribute the fuel to the combustion chambers.

Fuel Feed Pump

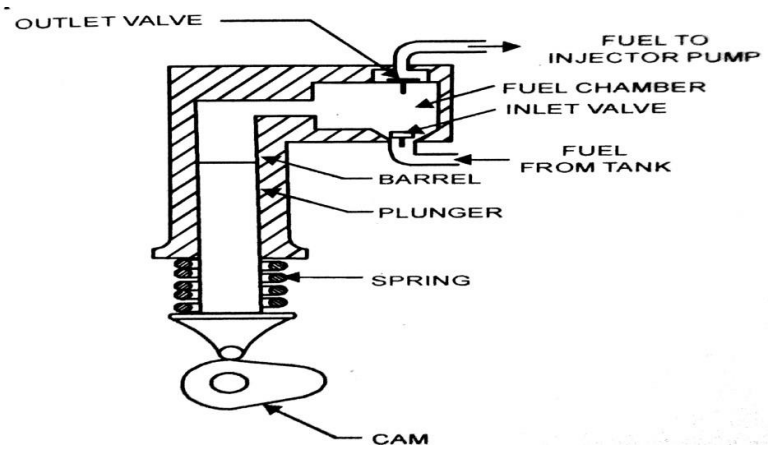

Fig 3.12 Fuel Feed Pump in Diesel Engine

Fuel Feed Pump serves to deliver fuel to the fuel injection pump. The fuel field pump deliver adequate amount of fuel to the fuel injection pump at a pressure of 1.2 bar.

The fuel feed pump consists a barrel, plunger and two valves. The plunger is activated by a spring and a cam. Plunger requires two strokes to deliver fuel to the injection pump. Due to rotation of the cam, the plunger moves upwards against the spring action. At the same time its inlet valve is closed and fuel is forced through outlet valve. At the initial lift position of the cam, the spring forces the plunger to move downwards. The downward movement of the piston creates low pressure above the plunger and fuel enters into pump. As the cam continues to rotate, the plunger moves upwards and the pressure above the plunger increases. This pressure causes the inlet valve close and outlet valve to open and fuel comes out from the pump.

Fuel Injection Pump:

The fuel injection pump serves the supply of metered quantity of fuel into Engine cylinder. It has plunger reciprocating in a barrel. Barrel is a cylindrical one with two opposite ports, one is inlet port and other is spill port. Inlet port serves to fill the barrel space above the plunger with fuel. The upper portion of plunger is provided with by a vertical groove. Fuel injection pump is connected to its fuel injector through delivery valve.

As the plunger moves up, it closes the inlet port and pill port of the barrel. The fuel pressure increases causes delivery valve to open and allow the fuel to enter into the fuel injector at high pressure. With further rise of the plunger, At a certain movement, the spill port is connected to the edge of helical groove. As soon as spill port uncovers the fuel passes through the vertical groove. The delivery valve is closed by spring action.

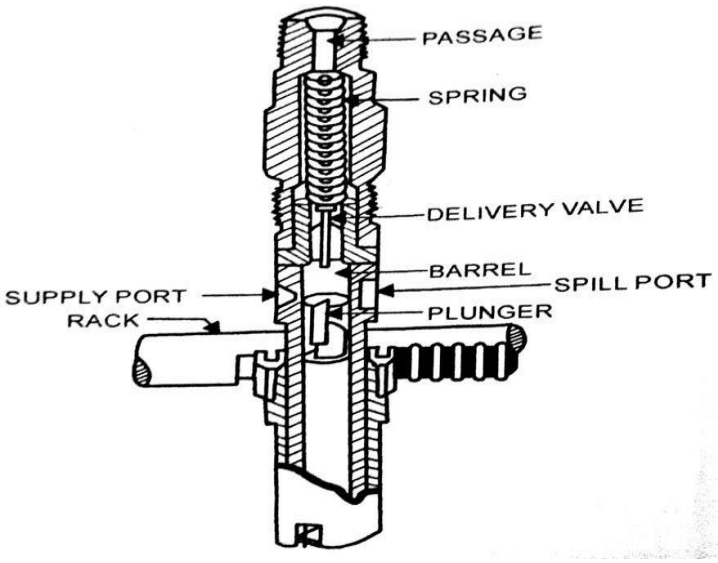

Fig 3.13 Fuel Injection Pump

Fuel Injector (Atomizer):

The friction of an injector is to spray the high pressure fuel into the Engine cylinder. It is basically, a spring loaded valve which opens by oil pressure. The fuel from injector pump enters through fuel inlet and is directed down to a space below the nozzle valve. Due to high pressure of fuel, the valve is lifted against the spring pressure. The fuel is then sprayed through nozzle into the Engine cylinder. Any leakage of excess fuel is taken off through the leak of pipe. The valve is again closed by spring pressure.

Fuel Injection Types:

The function of a fuel injection system is to inject proper quantity of fuel into the Engine cylinder at the correct time and at a predetermined rate.

There are two types of fuel injection systems.

Common Rail Fuel Injection System:

In this a single injection pump with injector is employed on each cylinder. The unit injectors are operated by rocker arms and springs. The fuel is taken from the fuel tank by the feed pump. It is supplied at low pressure through a filter to all the unit injectors. Any excess fuel from the relief valve is returned to the fuel tank.

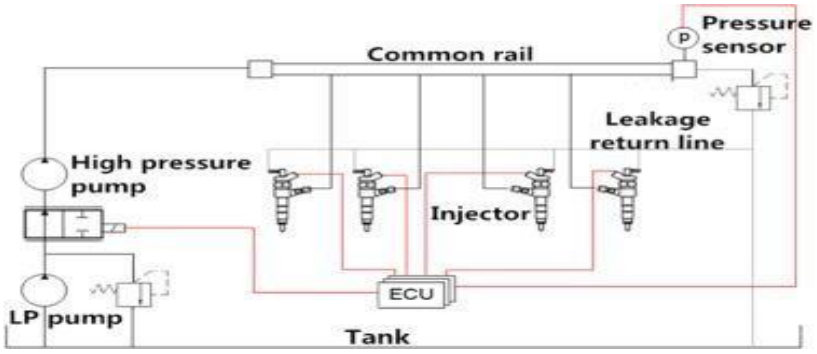

Fig 3.14 Common Rail Fuel Injection System

Individual Pump Fuel Injection System:

This system using in-line injection pump. The plunger type or the diaphragm type of fuel feed pumps are used. The pump I provided with hand pumping lever o that Diesel oil can be forced into the system. The fuel is then passed through a filter and to the fuel injection pump. The fuel injection pump, inject definite quantity of fuel into individual cylinder according to firing order.

Governors:

A typical governor regulates an Engine's speed according to its load by varying the rate at which fuel is furnished to it.

There are three types of governors.

1. Mechanical or Centrifugal Governors
2. Pneumatic Governor
3. Hydraulic Governor

1. Mechanical Governor:

Mechanical governors are fitted to large Engines on an extension of the pump cam shaft. When the Engine starts, the weights take up a position to maintain a stable idling speed, as the accelerator pedal is depressed against the spring, the weights move inwards. The weights are linked to the control rod. Then the fuel delivery is increased so the Engine speed increases. The increased Engine speed causes the pump cam shaft to rotate faster, then the weights are moves outwards. Then fuel delivery decreases. Thus the accelerator does not increase delivery directly but delays the action of governor.

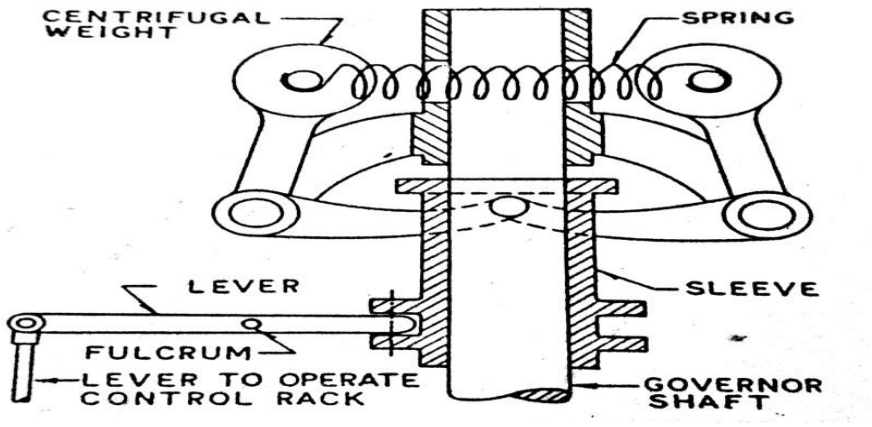

Fig 3.14 Centrifugal Governor

2. Pneumatic Governor:

A Pneumatic Governor consist two main parts, The Venturi unit and the Diaphragm unit. The Venturi unit is connected to the Engine inlet manifold and the diaphragm unit is fitted on the fuel injection pump. The two units are connected by a vacuum pipe.

Accelerator pedal controls the position of the butterfly valve in the Venturi unit. Hence vacuum from the manifold is applied to the diaphragm via vacuum pipe. The diaphragm is connected to the fuel pump control rack. The rack is operated left or right depending upon the amount of vacuum applied. Thus the position of the accelerator pedal determines the position of the pump control rack. Hence the amount of fuel injected. These Governors are used in small and medium sized Engines.

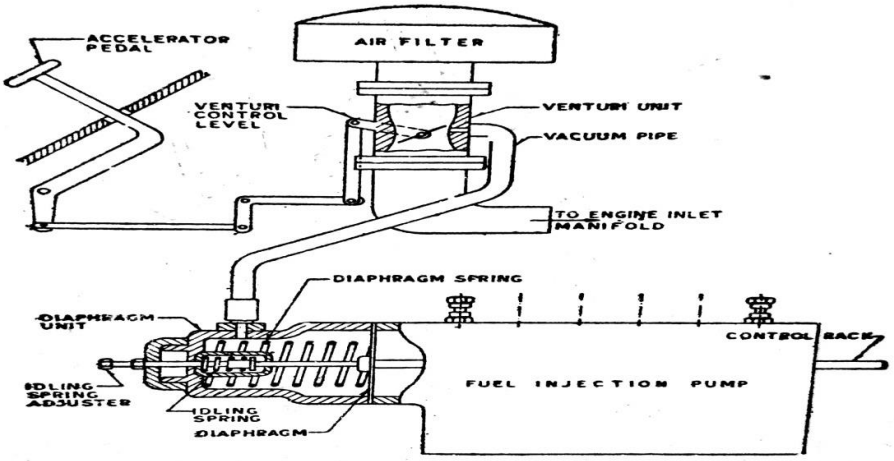

Fig 3.14 Pneumatic governer

3. Hydraulic Governor:

Hydraulic governors have more moving parts and are generally more expensive than mechanical governors, they are used in many applications because they are more sensitive, have greater power to move the fuel control mechanism of the Engine, and can be timed for identical speed for all loads.

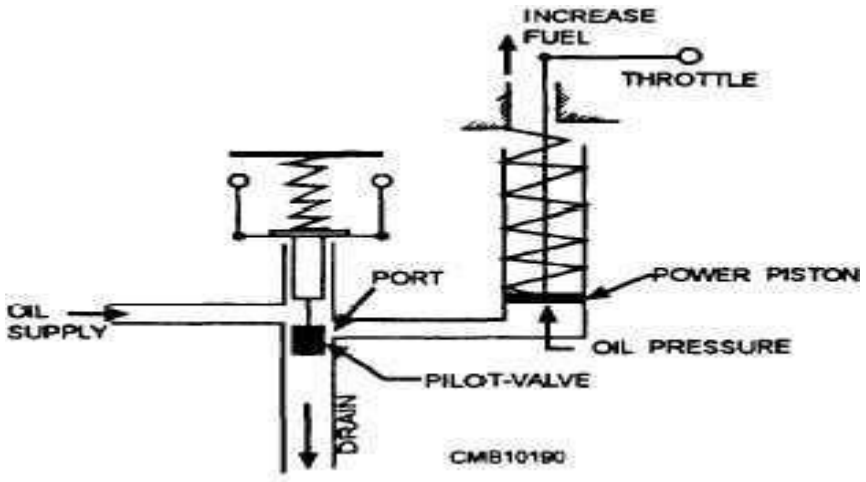

Fig 3.15 Hydraulic Governor

When the governor speed rises due to a decrease of Engine load, the flyweights move out and the pilot valve moves up. This opens the port from the power piston to the drain into the sump. The spring above the power piston forces the power piston down, thus decreasing the speed.

The simple hydraulic governor has a serious defect, which prevents its practical use. It is inherently unstable. It keeps moving continually, making unnecessary corrective actions. In other words it hunts. The cause of this hunting is the unavoidable time lag between the moment the governor acts and the moment the Engine responds. The Engine cannot come back to the speed called for by the governor.

Most hydraulic governors use a speed droop to obtain stability. Speed droop gives stability because the Engine throttle can take only one position for any speed. Therefore, when a load change causes a speed change, the resulting governor action ceases at a particular point that gives the amount of fuel needed for a new load. In this way speed droop prevents unnecessary governor movement and overcorrection (hunting).

Fuel Injection Nozzles:

The modern high speed oil Engines depends on the proper functioning of its fuel injection system. A nozzle is held in position in its cylinder head by the nozzle holder. A complete nozzle consists two parts. The nozzle value and nozzle body. The inner end of the nozzle valve is reduced in diameter to produce a stem upon which value face is formed. The out end is provided with a stalk. Fuel is fed to the mouth of the nozzle through small holes drilled vertically in the nozzle body. The nozzle value is raised from its seating in the nozzle body. Thus the fuel is forced through the hole or holes in the nozzle. In the form of spray the fuel is injected in the Engine combustion chamber.

Type of nozzles:

1. Single hole Nozzle
2. Multi hole Nozzle
3. Long stem Nozzle
4. Pintle Nozzle
5. Delay Nozzle
6. Pintaux Nozzle.

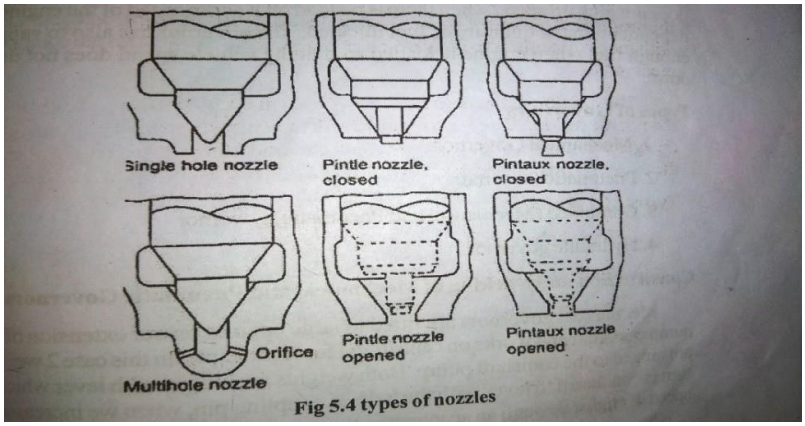

Fig 3.16 Types of Nozzles

1. Single Hole Nozzle:

It has one hole drilled centrally through its body which is closed by the nozzle valve. The hole can be of any diameter from 0.2mm onwards. The single hole is bored at an angle to the vertical center line of the valve as required.

2. Multi Hole Nozzle:

This nozzle can have a varying number of holes drilled in the bulbous end under the valve seating. Their actual number, size and disposition being dependent upon the requirements of the Engine.

3. Long Stem Nozzle:

For direct injection Engines where owing to limited space between the valves in the cylinder head . It is not possible to provide adequate cooling for the standard short stem nozzle. An alternate form of nozzle with a small diameter extension has been developed.

4. Pintle Nozzle:

It is used in the Engine combustion chambers of the cell, swirl or pre combustion type chambers. The valve stem is extended to a pin or pintle which produces through the mouth of the nozzle body.

5. Pintaux Nozzle:

A pintle-type Diesel fuel injector nozzle with a hole in the side through which a very small amount of fuel is sprayed when the needle valve is partly opened at low pressure, before the main hole comes into use.

6. Delay Nozzle:

It has an auxiliary spray hole to assist easy starting under cold condition. At Engine starting speeds the nozzle valve is not lifted sufficiently to clear the pin hole and the fuel is discharged through auxiliary hole.

Turbocharger:

Turbochargers are used to increase Engine power by compressing the unit that goes into the Engine combustion chambers. The Turbocharger is located to one side of the Engine close to the exhaust manifold. When exhaust pipe runs between the Engine exhaust manifold and the turbine housing to carry the exhaust flow to the turbine wheel. Another pipe connects the compressor housing intake to an injector throttle body or Carburetor.

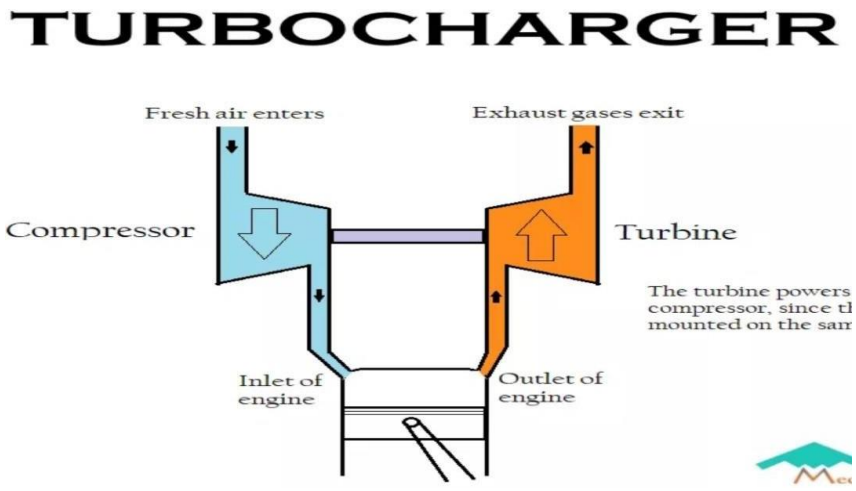

Fig 3.17 Turbocharger

Working:

The turbo charger is bolted to the exhaust manifold of the Engine. The exhaust from the cylinders spins the turbine. The turbine is connected by a shaft to the compressor, which is located between the air filter and the intake manifold. The compressor pressurizes the air going into the piston. The exhaust from the cylinders passes through the turbine blades causing the turbine to spin. The more the exhaust that goes through the blades the faster the spin. On the other end of the shaft the turbine is attached, the compressor pumps air into the cylinders. It draws air into the center of its blades and flings it outward as it spins. In order to handle speeds up to 150,000rpm the turbine shaft has to be made of costlier metals like duraluminum.

Short Answer Questions

1. Write the additional features of solex carburetor.
2. Write about the special circuit features of carter carburetor.
3. Write the parts of spark plug.
4. Draw the line diagram of diesel engine fuel supply system.
5. Explain the functions of turbo charger.

Long Answer Questions

1. Draw the line diagram of fuel supply system and give brief explanation on its components.
2. Explain any two types of filters with neat sketch.
3. Explain the construction and the working of simple carburetor.
4. With a neat sketch, explain the working of fuel injection system.
5. Write a note on governors and explain any two of them with neat diagram.

UNIT - 4

LUBRICATION SYSTEMS

4.0 Introduction:

In order to ensure of smooth running of the Engine, various Engine parts are to be lubricated to reduce friction. It provides a film of oil between the moving parts and their bearing surfaces. It avoids direct friction by keeping the parts of floating upon oil film. This enables the parts to work longer time resulting in longer.

Types of Lubricants:

The lubricants are three types.

1. Solid Lubricants : Graphite, Mica, Soap stone or Steatite.

2. Semi-Solid Lubricants : Grease.

3. Liquid Lubricants : Mineral oil, Vegetable oil, Animal oil etc.

Properties of Lubricants:

Viscosity:

Viscosity is the resistance of lubricating oil to flow. The viscosity of the lubricating oil should be sufficient to ensure hydrodynamic lubrication.

Physical Stability:

The lubricating oil must be stable physically at the lowest and highest temperatures.

Chemical Stability:

At higher temperatures oil should remain chemically stable. It should not have any tendency for oxide formation. It should not form carbon.

Resistant against Corrosion:

The oil should not have any tendency to corrode the pipe lines, crank case and other Engine parts.

Pour Point:

The minimum temperature at which the oil will pour is called pour point.

Flash Point:

The flash point of the oil should be sufficient high so as to avoid flashing of oil vapours at temperatures occurring in common use.

Cleanliness:

The oil should be clean and stable itself so that crank case and oil liners are kept clean.

Resistance against extreme pressure:

In modern automobile Engines, lubricating oil is with stand to very high pressures, particularly in bearings and value activating mechanism.

Dilution:

During the combustion, Petrol vapour may escape from piston rings. If the rings are broken to dilute the oil crank case oil is mixed with it.

Oiliness:

Any liquid is said to be oil when it has oiliness. Then property is highly desirable in helping the lubricant to adhere to the cylinder walls.

Requirements of Lubricants for Automobiles:

1. To reduce friction between moving parts.
2. To reduce wear of the moving parts.
3. To provide cooling effect.
4. To provide cushioning effect.
5. To provide cleaning action.
6. To provide sealing action.

SAE Number:

The Society of Automotive Engineers has recommended SAE Viscosity Number for Lubricating Oil.

5 Watts, 10 Watts and 20 Watts:

SAE number lubricating oil are used for winter.

20 Watts, 30 Watts and 40 Watts:

SAE number lubricating oil are used for summer.

Lubrication Systems:

The various systems adopted for the lubrication of automobile Engines are

1. Petrol system
2. Splash system
3. Pressure system
4. Dry-sump system

1. Petrol System:

This is used for small two stroke Engines like scooters and motor cycle Engines. It is the simplest of all types of Engine lubrication systems. Certain amount of lubricating oil is mixed with the Petrol. The used ratio is 2% to 3% of oil. If it is less, there is a danger of oil starvation or insufficient lubrication causing damage to the Engine. If it is more, excessive carbon deposits in the cylinder head and Engine will give dark smoke.

2. Splash Lubrication System:

This was employed for the Engines of early motor cycles. It is one of the cheapest method of Engine lubrication. A scoop is made in the lowest part of the connecting rod and the oil is stored in the oil through. It is pumped from the crank case oil jump. When the Engine runs, the scoop causes the oil to splash on the cylinder walls. Thus affects the lubrication of Engine walls, gudgeon pin, main crank shaft bearings, big end bearings.

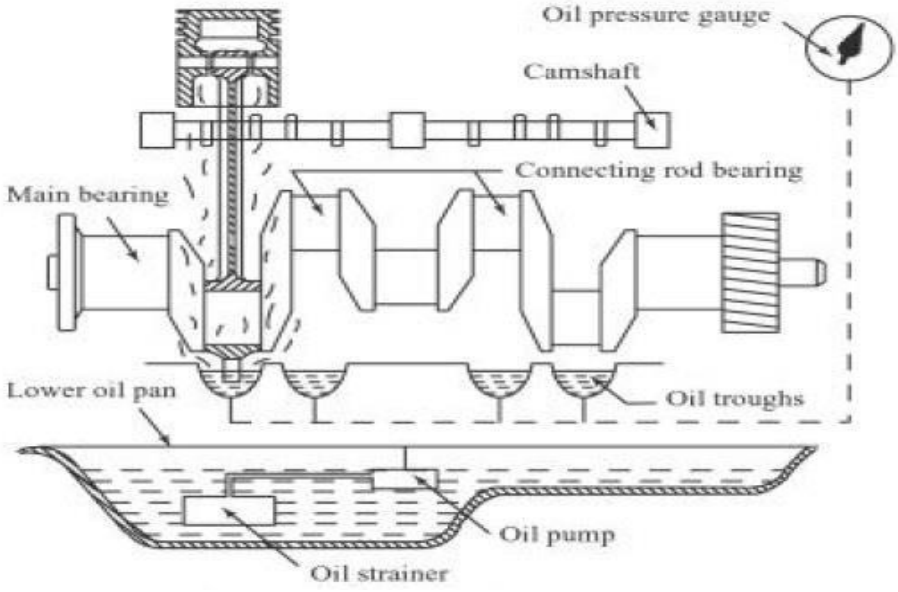

Fig 4.1 Splash Lubricating System

3. Pressure (or) Forced feed Lubrication System:

This system is used almost universally in modern car Engines In this system car oil pump takes the oil from the wet pump through a strainer and deliver through a filter to the main oil gallery. The oil pressure is controlled by means of pressure-relief valve. There is one main gallery in case of inline Engines. Whereas V-Engines use two main galleries or one main gallery and value tappet galleries.

From the main gallery, the oil goes through the drilled passages to the main bearings. Some of the oil after lubricating the main bearings falls back to the pump. Some is splashed to lubricate cylinder walls. The oil goes through a hole to the crank pins and connecting rod web and to the gudgeon pin and to the ring lubrication. The oil then falls on the cylinder walls and drains back into the oil pan. For camshaft and timing gears, lubricating oil is lead through separate oil lines from the oil gallery. The valve tappets are lubricated by connecting the main oil gallery to the tappet guide surface through drilled holes. During its circulation, the oil gains heat from various Engine parts, which is given out to the pump walls.

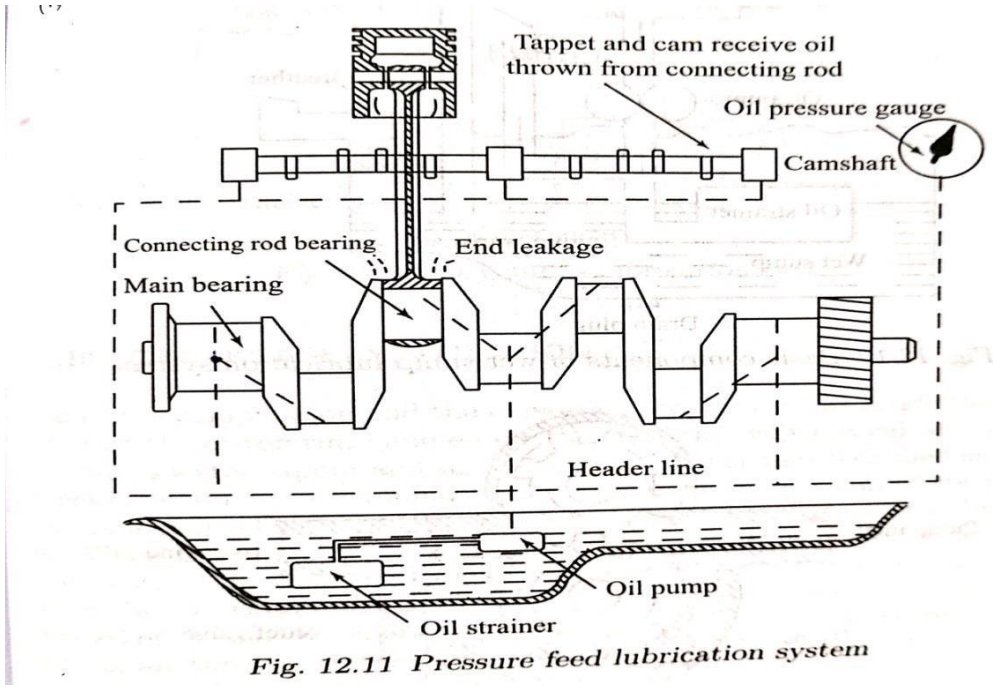

Fig. 12.11 Pressure feed lubrication system

Fig 4.2 Pressure Feed Lubricating System

4. Dry Sump System:

This system is employed in some racing car Engines. In dry sump lubrication system two pumps are used. The scavenge pump is installed in the crank case portion which is the lowest. It pumps oil to a separate reservoir, from where the pressure pump. The pump send the oil to filter. Then goes to the cylinder bearings. The oil pressure is maintained at

400-500kpa for main and big end bearings about 50-100kpa pressure is used for timing gears and cam shaft bearings.

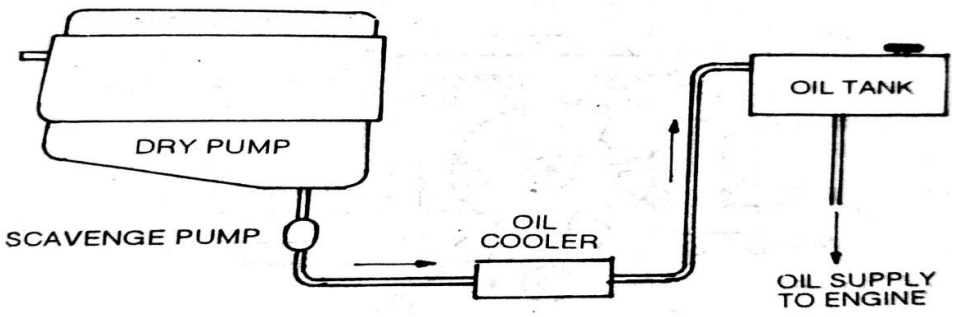

Fig 4.3 Dry Sump System

Oil Filters:

Oil filters used in Engine lubricating system to filter out the dirt particles from the oil.

Types of Oil Filtering Systems:

a) By-pass system

b) Full flow system.

a. By-pass System:

In by-pass system the whole of the oil does not pass through the filter at the same time. Most of the oil without being filtered goes to the bearings where as the rest passing through the filter is cleaned out and is returned to the sump.

b. Full-flow System:

In this system all the oil which goes to the bearings must pass through the filter first. If any time filter is blocked in the system, the bearings would be starved. To avoid this a spring loaded relief valve is incorporated in the filter. It by pass the unfiltered oil to the bearings to saving from starvation.

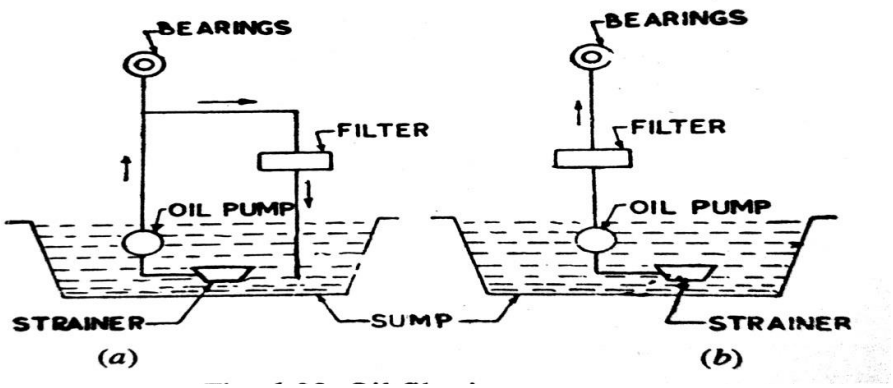

Fig 4.4 Oil Filter

Types of Oil Filters:

1. Cartridge type oil filter:

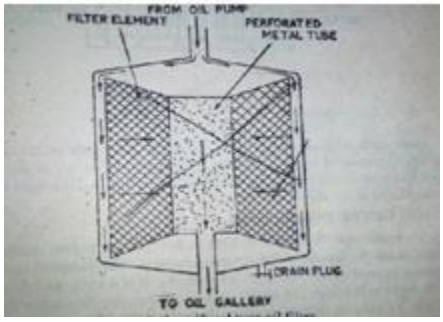

Fig 4.5 Catridge Type Oil Filter

It consists a filtering element placed in the metallic casing. The impure oil pass through the filtering element which takes all the impurities. The oil enters the filter at the top and passes through the filter element. The pure oil then goes to the porous metallic tube from where it goes to the out let for circulation. A drain plug is also provided.

2. Stack or Edge type oil filter:

In this the oil is pass through a number of closely spaced discs. The alternate discs are mounted over a central spindle, while the discs in between these are attached to a separate spindle. The oil is made to flow through the spaces between the discs. The impurities are left on the peripheries. The impurities are removed by operating the central knob.

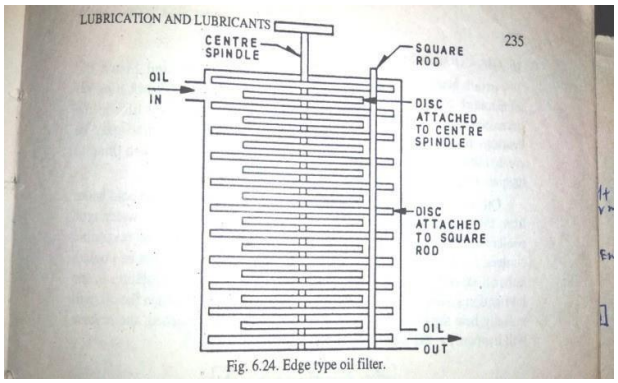

Fig 4.5 Edge type Oil Filter

3. Centrifugal type Oil Filter:

In this the impure oil enters the hollow central spindle having holes around its periphery. The dirty oil comes out of these holes and fills the rotor casing. After oil passes down the tubes A at the ends which jets are attached. The oil under pressure passes through these jets, the reaction of which gives the motion to the rotor casing in the opposite direction so that it starts rotating. The impurities are retained and clean oil falls below from where it is taken out.

Positive Crank Case Ventilation:

During combustion, fuel and water particles from the combustion chamber into the crank chamber which dilute the lubricating oil. The oil loses its viscosity. The water particles causes rusting of Engine parts. In order to save the Engine from the harmful effects of fuel, water and sulpher particles must removed out of Engine. Crank case ventilation removes these particles from the Engine.

Air from the atmosphere enters the crank chamber through air cleaner and goes out through the outlet passage carrying along with fuel, water and sulpher particles. In order to make the best utility of the Petrol and oil particles. Positive crank case ventilation outlet is connected with the Engine manifold. So that useful gases may go into the combustion chamber along with fresh charge.

Sludge formation Effect:

Sludge is a thick, creamy and block substance. It is a mixture of oil water and combustion products. It clogs the oil lines and galleries. It is caused by the condensation of water in the Engine crank case. A vehicle which runs mostly in traffic, running slow and stopping intermittently are the causes for sludge formation. This can be remedied by adjusting its cooling system so that the Engine remains at a reasonable high temperature.

Short Answer Questions

1. Write the necessity of providing a lubrication system.
2. Explain various types of lubricants.
3. Write various types of lubricating systems.
4. Draw the line diagram of dry sump lubrication system.

Long Answer Questions

1. What is lubricant & explain the properties of lubricants.
2. With a neat sketch, explain splash lubrication system.
3. Explain pressure or forced feed lubricating system with a neat sketch.

UNIT - 5

COOLING SYSTEMS

Introduction:

When the fuel is burnt in the cylinder, only about one-third of heat energy liberated is converted to mechanical energy. The rest of the heat goes to exhaust gases and heating the combustion chamber. This chamber consists of cylinder head, cylinder and piston.

The Necessity of providing Cooling system:

The cooling system is necessary to remove the unwanted heat from the cylinder so as to present:

a. Burning of lubricating oil so as to minimize the wear of the parts.
b. Seizure of the piston because of excessive expansion.
c. Overheating of spark plug and cylinder walls which leads to pre-ignition.
d. Excessive stress in the parts due to unequal temperature.
e. To increase the life of the parts by controlling the temperature.

Disadvantages of Overcooling and Under Cooling:

Engine should be cooled within a particular temperature limits. It should not be too cooled or too heated up. Getting the Engine too much cooled is called overcooling. And if the Engine is over heated it is to under cool. Both under cooling and over cooling have individual disadvantages. Over cooling results in the increase of viscosity of the lubricating oil, which in turn result in the increase of friction between the moving parts.

If the Engine gets warmed up excessively, it should be cooled so as to keep the correct alignment of the Engine. Under cooling also keeps the Engine in correct position and increase the life of the Engine. Evaporation of lubricating oil that lubricates the piston and cylinder wall is also another reason of under cooling. This will result in metal to metal contact of the piston and cylinder wall leading to piston crown. Burning of and warping of exhaust valves setting up of thermal stresses in the cylinder, cylinder head and piston. This may lead to cracking of them.

Methods of Cooling:

There are three methods used for cooling of automobile Engines.

1. Air Cooling
2. Water Cooling

1. Air Cooling System:

In sir cooling system the removal of heat is effected by inducing air to flow around the cylinders and their heads. To increase the surface heat transfer area, metallic fins are cast on the outer surface of cylinder and head. Small capacity Engines obtain adequate circulation of the cooling air by convection. But high capacity Engines require a forced circulation. Forced circulation of air around the Engine is provided by a rotary blower. Revolving with a high speed, the rotor forces the cooling air and remove the heat of Engine. The air cooling system is employed for scooters, motorcycles and aircrafts.

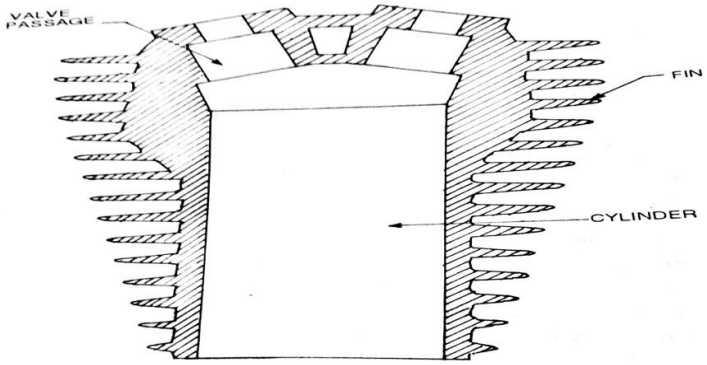

Fig 5.1 Air Cooling System

Advantages & Disadvantages:

1. Design of Engine is simple and no water jackets are required.
2. Absence of radiation makes the system simple.
3. No danger of leakage and freezing of water is cold climate
4. Insufficient cooling effect.

2. Water Cooling System:

In water cooling system, the Engine cylinders are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water which goes to the radiator where it loses its heat to the air.

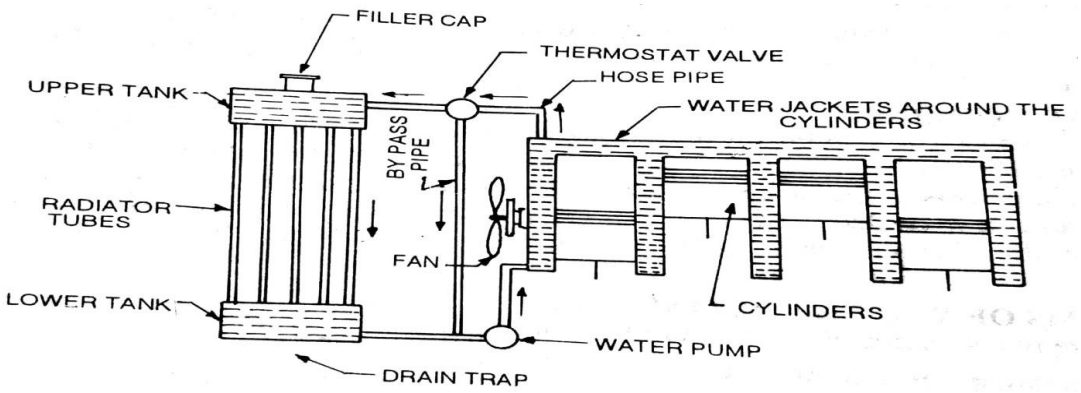

Fig 5.2 Water Cooling System

The system consists a radiator connected to the Engine through flexible hoses. In this system circulation of water is obtained from the differences in densities of hot and cold regions of cooling water. The circulation of water gets heat from the Engine cylinders, thereby cooling the same. The same heat in the water is then dissipated into the atmosphere through the radiator by mainly conduction and convection. The circulating water becomes cold by the time it reaches the collector tank of the radiator. The same water is then circulated through the Engine to collect heat from the cylinders.

In some systems the pump is used for the circulation of cooling water and the most of it is employed to control the air flow.

3. Thermo Syphon Cooling System:

In this system the circulation of water is obtained due to the difference in densities of hot and cold regions of the cooling water. There is no pump. The hot water from the Engine jacket being lighter, rises up in the hose pipe and goes in the radiator from the top side. It is cooled there and goes down at the bottom of the radiator. In this cooling is slow. To maintain continuity of water flow the water must be maintain minimum level. If not cooling system will fail. To avoid this, a thermostat valve is used. It maintain the normal temperature of the Engine parts. When the Engine started from cold, the thermostat valve prevents the flow of water from Engine to radiator so that the Engine readily reaches to its normal working temperature, after which it automatically comes into action. Generally the thermostat valve does not permit the water below 70^0C. There are two types of thermostats used in automobiles. They are bellow type and pellet type thermostat.

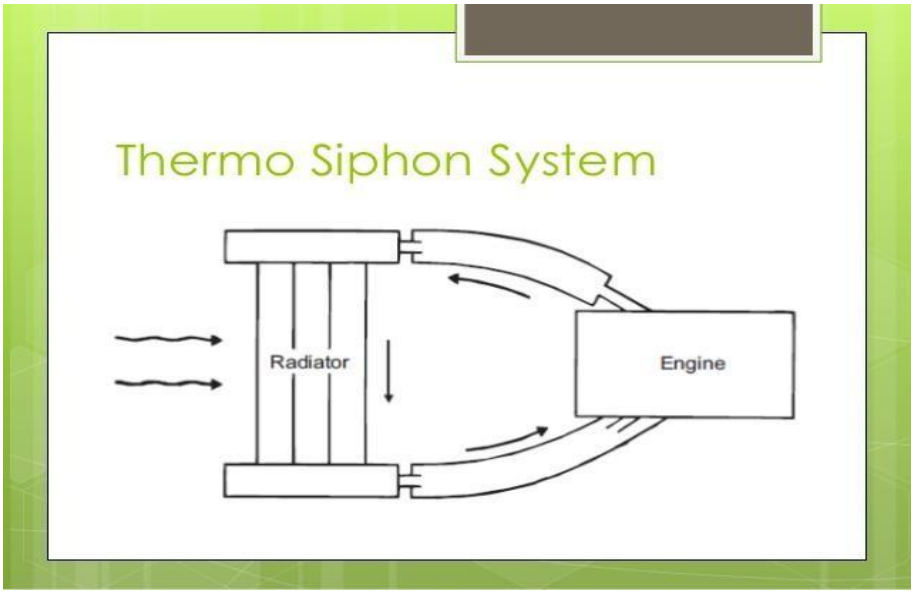

Fig 5.3 Thermo Syphon Cooling System

Radiator:

The function of the radiator is to ensure close contact of the hot water coming out of the Engine with outside air, so as to ensure high rates of heat transfer from the water to air. The radiator consist upper tank or header, core and lower tank or collector. Besides overflow pipe, header tank and drain pipe in lower tank. Filler neck is attached to the upper tank.

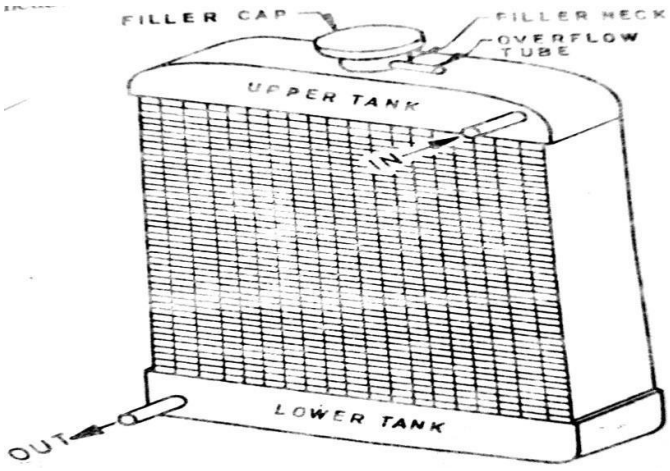

Fig 5.4 Radiator

Hot water from the Engine enters the radiator at the upper tank and is cooled by cross flow air which flowing down the radiator. The cooled water collects in the lower tank. There are two types of cores are used one is tuber type and other is cellular type.

Water Pump

A water pump is necessary for the forced circulation type of Engine cooling system. The pump is mounted at the front end of the Engine and is driven from the crank shaft by means of v-belt. The main parts of the pump are causing shaft mounted impeller having number of vanes and bearings.

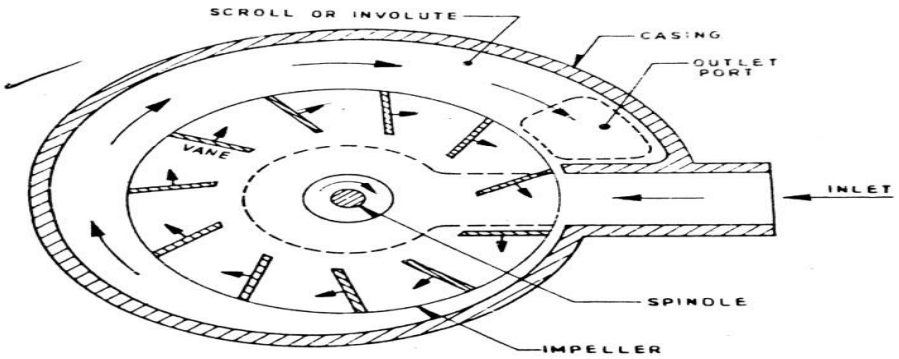

Fig 5.6 Construction of Water Pump

When the impeller rotates the water between the vanes is thrown outward due to centrifugal force. The water forced on periphery of impeller. This water leaving the periphery of the impeller tangentially and having maximum kinetic energy. Then enters the involute or scroll. The enlarging scroll converts the kinetic energy of water to pressure energies. In the way water pressure is created at the pump outlet that forces the coolant through the cooling system.

Anti-freeze solutions & Anti rusting Solutions:

In cold climates there is always a danger that the water in the cooling system may get frozen. Due to this bursting of the radiator core and the cylinder jackets. To avoid this some additives are used. These additives are called anti-freezers and solutions are called antifreeze solutions. The anti-freezers commonly used are wood, alcohol, methyl alcohol, ethyl alcohol, glycerine, ethylene glycol.

Comparison of Air Cooling & Water Cooling System:

S. No	Air Cooling System	Water Cooling System
1.	Due to direct transfer of heat from Engine to air, no water jacket, radiator and water pump are required. Therefore weight is reduced.	Need for pump and radiator increases weight and air resistance of vehicle.
2	Engine is smaller in size and its design much simpler.	Engine has larger dimensions and its design is more complex.
3	Warm-up performance of air-cooled Engine is better. This results in low wear to cylinders.	Warm-up performance is poor and results in greater cylinder wear.
4	Air cooled Engine can take up some degree of damage. A broken fin does not affect the Engine much.	Water cooling system requires more maintenance. A slight leakage of radiator may result in Engine breakdown.
5	Air cooled Engine is less sensitive to climatic conditions. Anti-freeze solution is not needed.	Engine performance is more sensitive to climatic conditions. Cold weather starting requires use of anti-freeze solutions.
6	Air fan is an additional source of noise.	Presence of water passage attenuates the combustion noise.
7	Control of cooling system is much easier.	Control of cooling system is comparatively difficult.

5.8 Thermostat :

A thermostat basically switches the heating system on and off accordingly. It detects by sensing the air temperature, switches on when the heating of air temperature falls below the thermostat setting and switches off when the set temperature has reached.

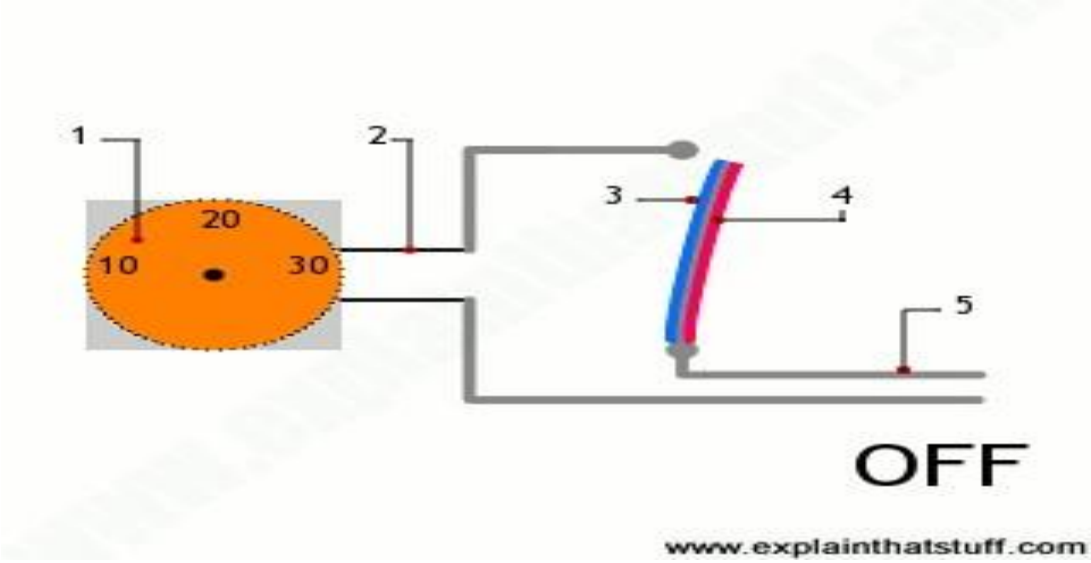

Fig 5.7 Thermostat

Construction & Working:

1. An outer dial enables you to set the temperature at which the thermostat switches on and off.
2. The dial is connected through a circuit to the temperature sensor (a bimetal strip, shown here colored red and blue), which switches an electrical circuit on and off by bending more or less.
3. The bimetal ("two metal") strip is made of two separate metal strips fastened together: a piece of brass (blue) bolted to a piece of iron (red).
4. Iron expands less than brass as it gets hotter, so the bimetal strip curves inward as the temperature rises.
5. The bimetal strip forms part of an electrical circuit (gray path). When the strip is cool, it's straight, so it acts as a bridge through which electricity can flow. The circuit is on and so is the heating. When the strip is hotter, it bends and breaks the circuit, so no electricity can flow. Now the circuit is off.

5.8.1 Types of Thermostats:

There are two types of thermostats usually used in automobiles.

1. Bellows type thermostat
2. Wax pellet type thermostat.

1. Bellows Type Thermostat:

As the liquid in the bellows becomes heated, it will begin to turn to vapour. Because the boiling point of the liquid is lower than that of water, this will happen at less than 100oC, usually somewhere between 80-90^{o}C.

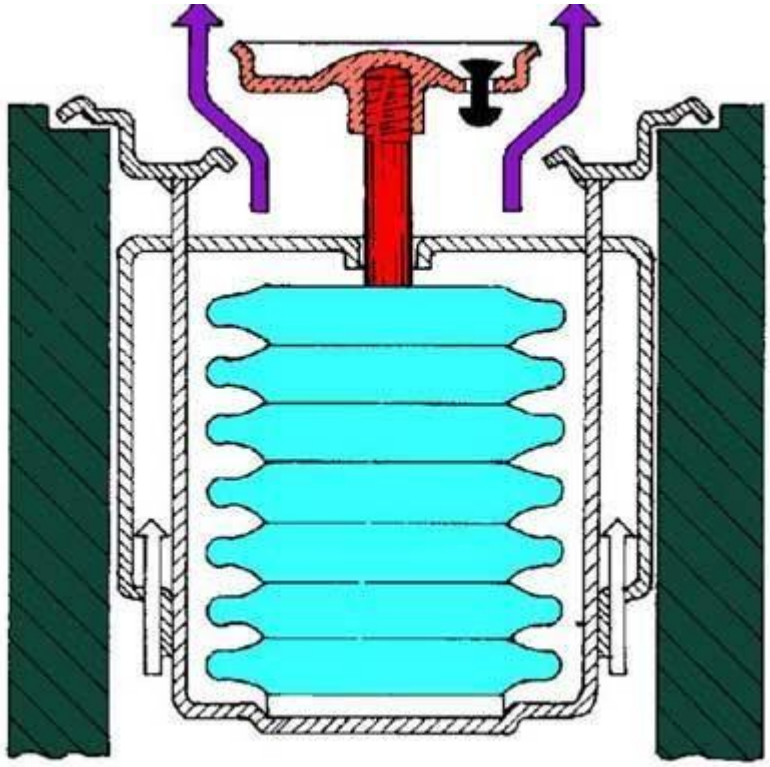

Fig 5.8 Bellow type of thermostat

When this happens, the pressure inside the bellows becomes greater than the pressure outside it. This causes the bellows to expand, thus opening the valve and allowing the hot coolant through and on to the radiator. If the temperature of the coolant drops (say when the engine is running under light load), the pressure in the bellows also drops, causing the thermostat to close. This makes sure the engine is not over-cooled.

2. Wax Pellet Type Thermostat:

The core of the wax thermostat is the motor. Unlike the bellows thermostat, which used an expandable metal bellows filled with alcohol, the wax thermostat uses a rigid brass or copper cup filled with solid wax. Waxes can be blended with any desired temperature range and the motor sized to produce any needed level of force, opening point, and hysteresis. When heated, the wax melts and rapidly expands, acting against a rubber diaphragm, which in turn transmits force to the pin. The pin is pushed out of the cup and reacts against the pin retainer, forcing the entire wax motor backwards. Wax motors in automotive thermostats typically have a stroke of 8mm.

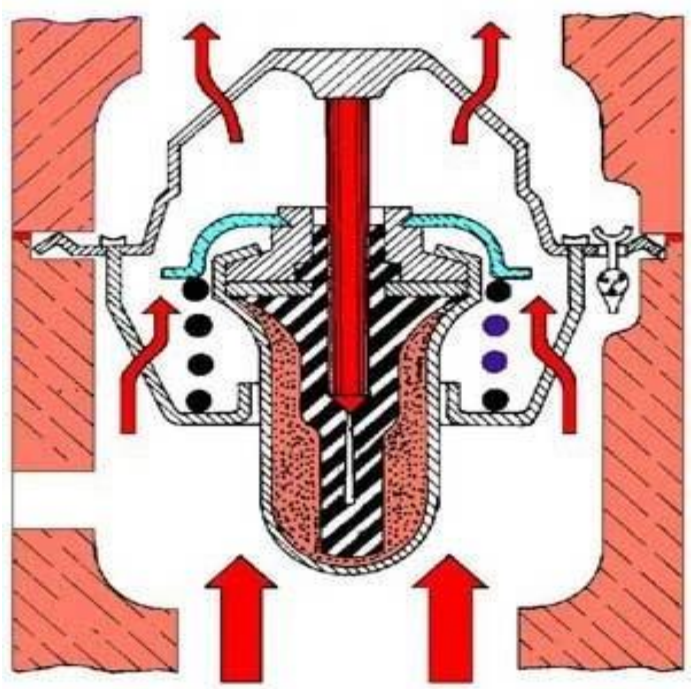

Fig 5.9 Wax Pellet Type Thermostat

Short Answer Questions

1. Write the necessity of providing cooling system for an automobile.
2. Write disadvantages of over cooling & under cooling.
3. Write the advantages and disadvantages of air cooling system.
4. What is the need of anti- freeze & anti- rusting solutions are used for an automobile.

Long Answer Questions

1. Explain the water cooling system with a neat sketch.
2. Explain the thermo syphon cooling system with neat sketch.
3. Explain the below parts used in cooling system.
    a. Radiator.
    b. Water pump
4. Write the comparison between air cooling & water cooling system.

UNIT - 6

AIR CONDITIONING SYSTEM

Introduction:

Air conditioning is the process of removing heat and moisture from the interior of an occupied space to improve the comfort of occupants. Air conditioning can be used in both domestic and commercial environments. This process is most commonly used to achieve a more comfortable interior environment for humans in vast range of applications.

Since humans perspire to provide natural cooling by the evaporation of perspiration from the skin, reducing relative humidity can promote occupant comfort. An air conditioner designed for an occupied space typically will create a 30% to 60% relative humidity in the occupied space to balance comfort, microbial growth, and other indoor air quality factors.

Factors effecting Comfort Air Conditioning:

Following are the Factors affecting Comfort Air conditioning:

1. Temperature
2. Humidity
3. Air movement
4. Air Purity.

1. Temperature:

Convection Heat transfer depends upon the temperature difference. So an adequate difference between body temperature and ambient temperature would ensure the convection heat transfer. Temperature difference would cause chilling effect as in winter. Preferred temperature is in between 20- 25 Degree.

2. Humidity:

At higher ambient temperature convection heat transfer is either not adequate or is in reverse direction. The evaporation of perspiration by body heat is the only means of heat dissipation. Ambient air contains some water vapour in it and water evaporation depends upon vapour pressure difference. So we can say that higher humidity would reduce evaporation of sweat from out body. Even at low temperature water vapour is given out through body pores due to vapour pressure difference. So in dry climate excessive loss of moisture leads to drying of skin and blister on the skin. So humidity maintain in between 30 to 70 %.

3. Air Movement:

Convection heat transfer depends upon air movement and evaporation rate also can be maintained by constantly carrying away the vapour from evaporation surface. So it would be helpful for giving comfort and heat dissipation takes place properly .If the air movement is high it would cause the noise discomfort. Similarly we maintained higher air movement of fan in summer and slow air movement in winter for better comfort. The limited air velocity ranging is in between 8–15 m/min.

4. Air Purity:

The air conditioner supplies conditioning air for comfort. Atmospheric air has many impurities in it. The range of impurities like dust, pollen, and other carbon particles is in microns i e. Nearly 180 micron and for virus and bacteria size rang is 0.05 micron. At some point odorous gases makes you feel discomfort. So air conditioner needs to remove unwanted impurities as per requirement.

Classification of Air Conditioning Systems:

The air-conditioning systems are classified as

1. According to the purpose
    (a) Comfort air-conditioning system
    (b) Industrial air conditioning system
2. According to the season of the year
    (a) Winter air conditioning system
    (b) Summer air conditioning system
    (c) Year round air conditioning system
3. According to the arrangement of equipment
    (a) Unitary air conditioning system
    (b)Central air conditioning system

Terminology of Air Conditioning System:

The basic terminology with which we often specify the most important functions of an air conditioning system are Psychrometry & Psychrometric terms.

6.3.1. Psychrometry & Psychrometric Terms:

Psychrometry is a science dealing with behaviour of water vapour present in atmospheric air. The device which measures the relative humidity in the atmosphere through the use of two thermometers is called Psychrometer.

Psychrometric Terms:

1. Dry Air:

The dry air is considered as a mixture of Nitrogen, Oxygen and neglecting the percentage of other gases.

2. Moist Air:

It is also called atmospheric air. The moist air considered as a mixture of dry air and water vapour. The quantity of water vapour present in air depends upon the temperature of the air. When water vapour contains dry air it becomes cold. Moist air is heavier than the dry air.

3. Saturated Air:

Saturated air is air that holds water vapour at its highest level. Air is composed of moisture or water vapour, regardless of the amount of pressure and temperature levels. Adding more moisture to the air at a specific temperature and in an enclosed area causes the air to absorb the moisture. It is visible as fog or condensation on the cold surfaces.

4. Degree of Saturation:

Degree of Saturation is the ratio of the humidity ratio of moist air - to the humidity ratio of saturated moist air at the same temperature and pressure. The Degree of Saturation can be expressed as. $\mu = x / xs$.

5. Humidity:

Humidity is the concentration of water vapour present in the air. Water vapour, the gaseous state of water, is generally invisible to the human eye. Humidity indicates the likelihood for precipitation, dew, or fog to be present.

If the water vapour present in the 1kg of dry air is known as humidity ratio or specific humidity.

6. Absolute Humidity:

Absolute humidity is the measure of water vapour (moisture) in the air, regardless of temperature. It is the mass of water vapour present in the 1 m^3 of dry air. It is expressed as grams of moisture per cubic meter of air (g/m^3).

7. Relative Humidity:

Relative humidity is the ratio of the partial pressure of water vapour to the equilibrium vapour pressure of water at a given temperature. Relative humidity depends on

temperature and the pressure of the system of interest. The same amount of water vapour results in higher relative humidity in cool air than warm air.

8. Dry Bulb Temperature (DBT):

When there is no moisture in the air, it is dry air and human does not feel comfort. Dry air contains dust also. Its temperature is dry bulb temperature and is recorded by an ordinary thermometer. This temperature increases and decreases according to the dryness of the air. The DBT for human comfort is 25^0C.

9. Wet Bulb Temperature (WBT):

Wet bulb temperature is temperature at which liquid or solid water by evaporating into the air can bring the air to saturation at the same temperature. Wet bulb temperature is measured by an ordinary thermometer then whose glass bulb is covered with wet cloth.

10. Dew Point Temperature (DPT):

The quantity of moisture contained in air having a relative humidity is less than 100%, the maximum possible at some lower temperature. This lower temperature is the dew point and if the air is cooled to a temperature slightly below the dew point moisture will to condense. Dew point temperature is the saturation temperature corresponding to existing humidity ratio and barrow metric pressure.

11. Wet Bulb Depression:

It is the difference between dry bulb temperature and wet bulb temperature at any given point. This difference indicates relative humidity.

12. Dew Point Depression:

It is the difference between dry bulb and dew point temperatures of air.

Equipment Used in Air conditioning System:

1. Fans & Blowers.
2. Ducts.
3. Supply air outlets.
4. Return air outlets.
5. Filter and dust collectors.
6. Heating and cooling coils.

Fans & Blowers:

Fans and Blowers are used for circulation of air in Air- Conditioning plants which create positive pressure in the air and maintained desired speed and rate in the desired space or room. The fan is used to handle small quantity of air where as the blower is used to handle large quantity of air.

Fans may be classified according to the direction of air flow as

1. Axial fan- In this air moves parallel to the impeller shaft.
2. Centrifugal fan – In this air moves radial direction or perpendicular to the impeller shaft.

Ducts:

The duct system convey the conditioned air from the air-conditioning system to the space being conditioned and carry the return air from rooms or conditioned space to the air conditioning equipment for reconditioning and recirculation. Like any other fluid passing through a pipe, air in passing through a duct suffers a pressure drop due to friction. Larger quantity of air passing through a given cross sectional area of the duct, greater will be the frictional loss and pressure drop.

Ducts are defined as the passage way provided for conveying the conditioned air to specified location in order to provide comfort conditions. Smooth surface are desirable for ducts as they offer minimum resistance to the flow of air. The system should also be air tight so that the conditioned air does not leave out to the space not being conditioned

Ducts may be classified as

1. **Supply Air Duct:** Supply air duct carry the conditioned air from equipment to the space or room to be conditioned.
2. **Return Air Duct:** Return duct carry the return air from the space or room to the equipment for reconditioning or recirculation.
3. **Fresh Air Duct:** Fresh air duct carries the atmospheric air in to the air-conditioned equipment.
4. **Low Pressure Duct:** In this, the static pressure is less than 50 mm of water gauge.
5. **Medium Pressure Duct:** In this, the static pressure is from 50mm to 150 mm water gauge.

6. **High Pressure Duct:** In this, the static pressure is from 150mm to 250 mm of water gauge.
7. **Low Velocity Duct:** In this , the velocity of air less than 600 m/min
8. **High Velocity Duct:** In this, the velocity of air is more than 600 m/min.

Supply Air Outlet

The conditioned air enters the conditioned space through supply air outlets. These are designed to distribute air uniformly and prevent noise.

According to their design and construction, they may be classified as

1. Grill outlets
2. Slot diffuser outlets
3. Ceiling diffuser outlets
4. Perforated ceiling panels.

Return Air Outlets:

Return air outlets are the openings in a room space which allow the exhaust air to enter the return duct. Return duct may be connected to air conditioning equipment if recirculation is necessary to the atmosphere if the system is designed for 100 percent fresh air. They can be mounted on ceiling, walls or floor. The selection of outlets depends on the size of the room, quantity of air required and discharge velocity of air.

Filters & Dust Collectors:

Filters

The basic requirement of air conditioned system is that the conditioned air must be free from dust, dirt, smoke, bad odour etc. One of the major functions of an air conditioning system is to clean and purify the air. As the heating and cooling coils are used for controlling the temperature and humidity of the air similarly various cleaning devices are used for controlling the dust, pollen, odour and smoke. Filters and dust collectors are installed in air conditioning system to clean the contaminated air. Air used in an air conditioning system must be filtered to clean the contaminated air, outside air contains always contaminants such as bacteria, pollens, insects, soot, ash, dust, and dirt. The return air contains contaminants such as dust, lint, soot ash etc.

The various types of filters are commonly used in air conditioning system as follows

1. Dry filters
2. Viscous filters
3. Wet filters
4. Electronic filters

Dust Collectors

Sucking dust and water drops. When cleaning A/C fins, can use this machine to such the dust on the fins before water flushing. Also can absorb dust or water drops on the ground after finish cleaning work.

Heating and Cooling Coils:

These are used to increase and decrease the temperature of air respectively. Heating and Cooling of air without changing its moisture content is termed as sensible heating and sensible cooling respectively. Sensible cooling of air takes place when it flows over cooling coil whose surface temperature is lower than the temperature of air. The cooling medium may be chilled water or brine as the secondary refrigerant.

Auto Air Conditioning System:

Automotive air conditioning is the process by which the air is cooled and cleaned, the humidity lowered and the air circulated. The manifold and hand valves allow the system to be purged of refrigerant, evacuated of air and moisture, and recharged with new refrigerant.

Necessity of automobile Air Conditioning System:

The purpose of the vehicle air conditioning system is to cool the air entering the passenger compartment and remove the moisture from the air so it feels more comfortable in the vehicle. In many vehicles, air conditioning also cycles during the defrost setting, pulling the humidity from the windshield to improve visibility.

Construction & Working of AC in an Automobile:

The most common components which make up these automotive systems are the following:

1. Compressor
2. Condenser
3. Evaporator
4. Orifice tube
5. Thermal expansion valve
6. Receiver-drier
7. Accumulator

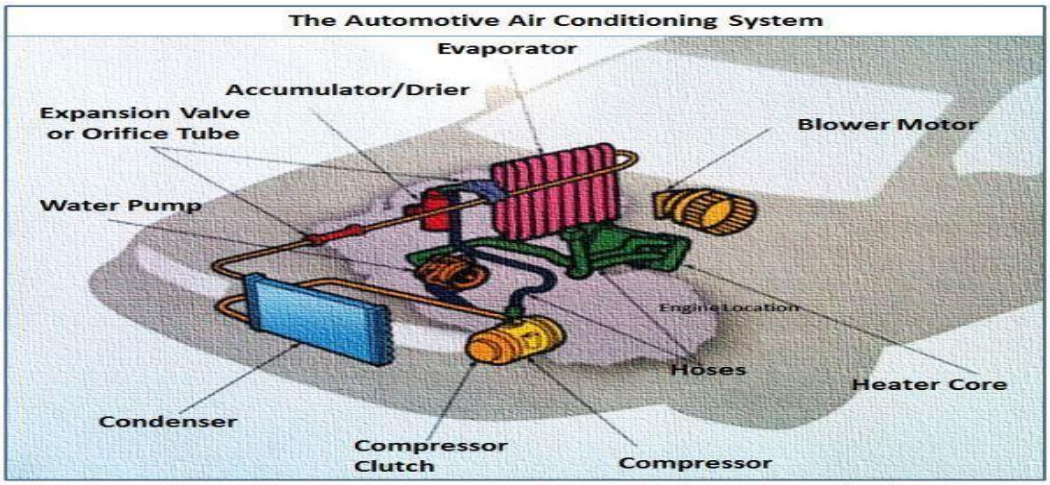

Fig 6.1 Air Conditioning in Automobile

Compressor:

Commonly referred to as the heart of the system, the compressor is a belt driven pump that is fastened to the engine. It is responsible for compressing and transferring refrigerant gas.

The A/C system is split into two sides, a high pressure side and a low pressure side; defined as discharge and suction. Since the compressor is basically a pump, it must have an intake side and a discharge side. The intake, or suction side, draws in refrigerant gas from the outlet of the evaporator. In some cases it does this via the accumulator.

Once the refrigerant is drawn into the suction side, it is compressed and sent to the condenser, where it can then transfer the heat that is absorbed from the inside of the vehicle.

Condenser:

As hot compressed gasses are introduced into the top of the condenser, they are cooled off. As the gas cools, it condenses and exits the bottom of the condenser as a high pressure liquid.

Evaporator:

The evaporator serves as the heat absorption component. As the refrigerant begins to boil, it can absorb large amounts of heat. This heat is then carried off with the refrigerant to the outside of the vehicle.

Orifice tube:

It is located in the inlet tube of the evaporator, or in the liquid line, somewhere between the outlet of the condenser and the inlet of the evaporator.

Thermal expansion valve:

This type of valve can sense both temperature and pressure, and is very efficient at regulating refrigerant flow to the evaporator. Several variations of this valve are commonly found. Another example of a thermal expansion valve is Chrysler's "H block" type. This type of valve is usually located at the firewall, between the evaporator inlet and outlet tubes and the liquid and suction lines. These types of valves, although efficient, have some disadvantages over orifice tube systems. Like orifice tubes these valves can become clogged with debris, but also have small moving parts that may stick and malfunction due to corrosion.

Receiver Drier:

The receiver-drier is used on the high side of systems that use a thermal expansion valve. This type of metering valve requires liquid refrigerant. To ensure that the valve gets liquid refrigerant, a receiver is used.

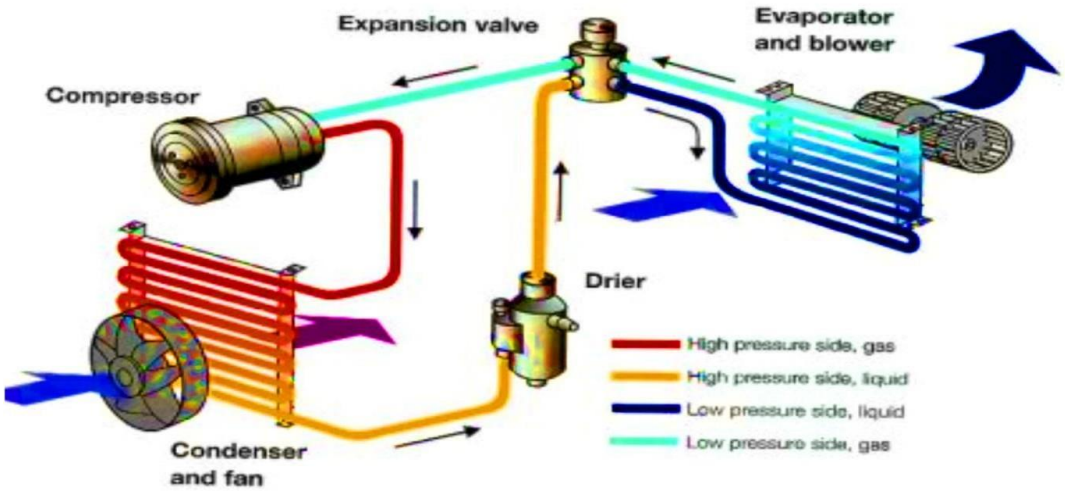

Fig 6.2 View of Air Conditioning System in Car

Receiver Drier:

The receiver-drier is used on the high side of systems that use a thermal expansion valve. This type of metering valve requires liquid refrigerant. To ensure that the valve gets liquid refrigerant, a receiver is used. The primary function of the receiver-drier is to separate gas and liquid. The secondary purpose is to remove moisture and filter out dirt. The receiver-drier usually has a sight glass in the top. This sight glass is often used to charge the system. Under normal operating conditions, vapour bubbles should not be visible in the sight glass.

Accumulator:

Accumulators are used on systems that accommodate an orifice tube to meter refrigerants into the evaporator. It is connected directly to the evaporator outlet and stores excess liquid refrigerant. Introduction of liquid refrigerant into a compressor can do serious damage. Compressors are designed to compress gas not liquid. The chief role of the accumulator is to isolate the compressor from any damaging liquid refrigerant. Accumulators, like receiver-driers, also remove debris and moisture from a system. It is a good idea to replace the accumulator each time the system is opened up for major repair and anytime moisture and/or debris is of concern.

Working:

The whole working starts with the Compressor. It compresses or pressurizes the refrigerant and converts it into the liquid from its gaseous state. The compressed liquid refrigerant has to pass through certain tubes located in the condenser. Here, the fresh air

from outside comes in the contact with liquid refrigerant. The condenser contains a high-temperature liquid and that's why there is a temperature incline between liquid and fresh air. Later, the heat moves from the liquid and mix with air.

Then, the refrigerant moves into the receiver drier or accumulator. The desiccant removes the moisture from the air and refrigerant that leads to the creation of a cooler refrigerant while maintaining the system.

The refrigerant, which is already in the cool liquid state, flows into the expansion valve or orifice tube. This process reduces overall fluid pressure and allows it to move to the evaporator (another component of AC).The converted refrigerant will then move to the evaporator. The air from the car will be drawn into the evaporator and go inside the evaporator core. Till now, the refrigerant temperature is cooler and it can convert the outside heat into the cold air.

Fans near the passenger seat help in blowing the cold air through vents and make the car's temperature cool. This process also removes moisture from the air and allows you to enjoy the fresh and dry air. (During this process, the collection and draining of the condensate also takes place). As the liquid refrigerant in the AC system becomes hotter after working, it again turns into a gaseous state.

This hot and low-pressure gaseous refrigerant again circulates and goes back to the compressor. This is how the new cycle takes place and you get the cool, dry and fresh air.

Short Answer Questions

1. What are the factors effecting the comfort air conditioning system.
2. Write the classification of air conditioning system
3. Explain the heating & cooling coils in air conditioning system.
4. Write importance of air conditioning system for an automobile.

Long Answer Questions

1. Write about the equipment used in air conditioning system.
2. Explain the construction and working of air conditioning system in passenger car with a neat sketch.

UNIT - 7

PERFORMANCE OF IC ENGINES

7.0 Introduction:

The performance of an Engine is an indication of the degree of success with which the conversion of chemical energy contained in the fuel is done into useful mechanical work.

Performance Parameters of an IC Engine:

An internal combustion Engine generally operates at high speeds. Some Engines are made to run at fixed speed by means of a speed governor which is its rated speed. At each speed within the useful range the variations in the power output may differ.

While evaluating the performance of an IC Engine few factors have to be considered.

1. Max power available at each speed within the useful range of speed.
2. The range of power output at constant speed for stable operation is needed.
3. The different speeds should be selected at definite and equal intervals within the range of operation.

Here are listed few performance parameters of the Engine.

1. Compression ratio
2. Swept volume
3. Clearance volume
4. Indicated power
5. Brake power
6. Friction power
7. Indicated thermal efficiency
8. Brake thermal efficiency
9. Mechanical efficiency
10. Indicated & brake mean effective pressure
11. Specific fuel consumption
12. Volumetric efficiency
13. Heat balance sheet.

1. Compression Ratio (r):

It is the ratio of total cylindrical volume (V_T) to the clearance volume (V_C) of the cylinder.

Compression Ratio(r) = V_T/V_C

$V_T = V_s + V_C$

Where **V_T** = Total volume, **V_s** = Swept volume, **V_C** = Clearance volume.

2. Swept Volume (V_s):

The nominal volume swept by the working piston between two dead centers is known as swept volume.

3. Clearance Volume (V_C):

The nominal volume of the cylinder above the piston, when the piston is at top dead center.

4. Indicated Power (IP):

The power actually produced inside the Engine cylinder is called indicated power.

$IP= (P_m*L*A*n*K) / 60$ kwatts

P_m = Indicated Mean effective pressure

L = Length of stroke.

A = Area of the piston

n = N- for 2-s, n=N/2 for 4-s Engines

K = No of cylinders.

For four-stroke Engine speed = N/2. For two-stroke Engine speed = N.

5. Brake Power (BP):

The power output at the crank shaft is called brake power.

$BP= (2*\pi*N*T) / 60$ kwatts

Where N = Speed in RPM

T= Torque developed in N-m

6. Friction Power (FP):

The difference between the indicated horse power and brake horse power is called Friction Horse Power. This power is wasted due to Friction.

$$\mathbf{FP = IP - BP}$$

7. Indicated Thermal Efficiency ($\eta_{\text{Indicated Thermal}}$):

It is the ratio of indicated power obtained to the energy supplied by fuel.

$$\eta_{\text{Indicated Thermal}} = ((IP)/ (\dot{m}_f * CV))*100$$

where $\dot{m}_f$ = Fuel Consumption Kg/hr

CV = Calorific Value

8. Brake Thermal Efficiency ($\eta_{\text{Brake Thermal}}$):

It is the ratio of brake or shaft work obtained to the energy supplied by fuel.

$$\eta_{\text{Brake Thermal}} = ((BP)/ (\dot{m}_f * CV))*100$$

where $\dot{m}_f$ = Fuel Consumption Kg/hr

CV= Calorific Value

9. Mechanical Efficiency ($\eta_{\text{mechanical}}$):

It is the ratio of power obtained at shaft to the indicated power.

$$\eta_{\text{mechanical}} = (BP/IP)* 100$$

10. Indicated & Brake mean effective pressure:

It is the algebraic sum of the mean pressures on the face of the piston during each stroke over one complete cycle.

$$P_m = (a/l)*s \text{ kg/cm}^2$$

Where p = Mean effective pressure in kg/cm^2

a = Area of the indicator diagram in cm^2

l = Length of the indicator diagram in cm

s = Spring number or spring strength in $kg/cm^2/cm$

11. Specific fuel consumption:

It is defined as the amount of fuel consumed per unit of power developed per hour

$$\text{Specific Fuel Consumption} = \frac{\text{Fuel Consumption in Kg/h}}{\text{Power Developed}}$$

12. Volumetric efficiency:

The volumetric efficiency is defined as the ratio of actual volume flow rate of air into the cylinder to the swept volume of the cylinder.

13. Heat Balance Sheet:

S. No	Item	KW	Percentage
1	Heat supplied by Fuel	X	100%
2	Heat absorbed in IP	$a=m_f {}^{*}C_v$	a/x*100
3	Heat taken away by Cooling Water	$b=m_w C_{pw}(t_2-t_1)$	b/x*100
4	Heat carried away by Exhaust Gases	$c=m_g C_{pg} (t_e-t_r)$	c/x*100
5	Heat uncountable for	X-(a+b+c)	{x-(a+b+c)}/X*100

7.2 Sankey Diagram:

Sankey diagrams are named after Irish Captain Matthew Henry Phineas Riall Sankey, who used this type of diagram in 1898 in a classic figure ,showing the energy efficiency of a steam Engine.

Sankey diagrams are a type of flow diagram in which the width of the arrows is proportional to the flow rate. The illustration shows a Sankey diagram that represents all the primary energy flows into a factory. The widths of the bands are linearly proportional to energy production, utilization and loss.

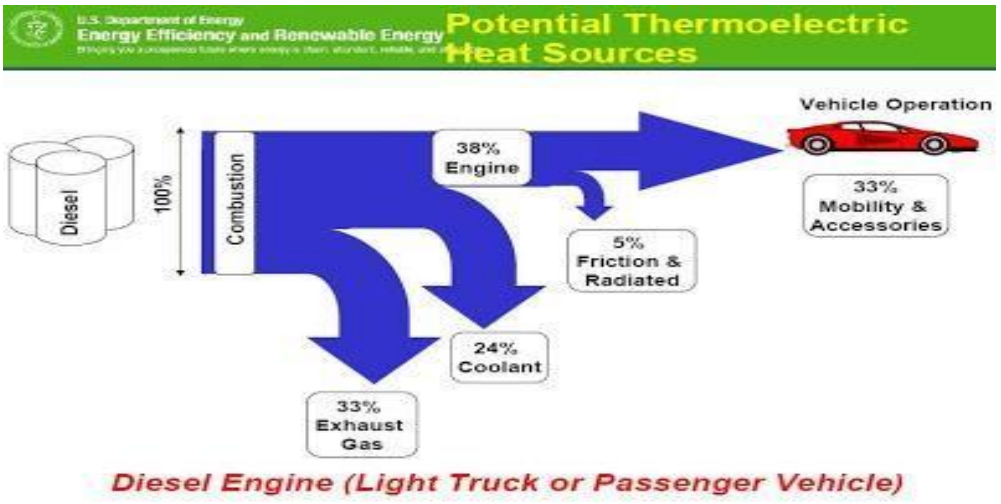

Fig 7.1 Sankey Diagram for a Diesel Engine

7.3. Performance Curves:

The word performance for an Engine is generally used for designating the relationship between power, speed and fuel consumption. For variable speed Engines the rated horse power at a certain speed does not given enough information. The performance curve helps to obtain necessary information.

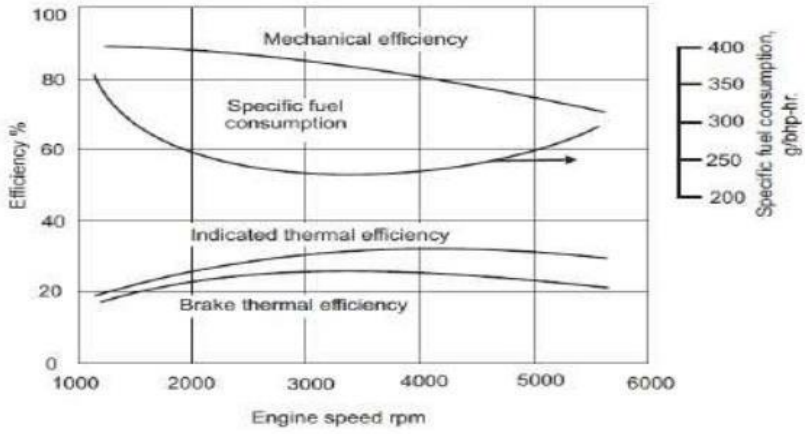

Fig 7.2 Performance Curves

Methods to improve the Performance of an IC Engine:

1. Increasing the compression ratios.
2. Providing better lubricating system.
3. Providing the low friction causing mechanism
4. By maintaining moderate running speeds.
5. By maintaining perfect spark timing.
6. By preventing the excessive heat losses.

Sources of Automobile Emissions:

1. Hydrocarbons:

In automobile of burned or partially burned fuel, hydrocarbons are toxins and are a major contributor to smog, which can be a major problem in urban areas.

2. Carbon Monoxide (CO):

A product of incomplete combustion, carbon monoxide reduces the blood's ability to carry oxygen.

3. Nitrogen Oxides (NOx):

Generated when nitrogen in the air reacts with oxygen at the high temperature and pressure inside the engine.

4. Particulate Matter:

Soot or smoke made up of particles in micrometers size range

5. Sulfur Oxide (SOx):

A general term for oxides of sulphur, which are emitted from motor vehicles burning fuel containing a high concentration of sulphur**.**

Effect of Automobile Pollutants:

1. Prolonged exposure to hydrocarbons contributes to asthma, liver disease, and cancer, overexposure of carbon monoxide poisoning may be fatal.
2. NOx is a precursor to smog and acid rain. NOx is a mixture of NO and NO2. NO2 destroys resistance to respiratory infection.

3. Particulate matter causes negative health effects, including but not limited to respiratory disease.

4. Oil, petroleum products and other toxins from automobiles kill fish, plants, aquatic life and even people. One quart of oil will contaminate thousands of gallons of water because it doesn't dissolve. These toxins as well as trace metals and degreasing agents used on automobiles contaminate drinking water and can cause major illness. Some of these toxins and metals are absorbed in various sea life and cause medical problems to people when eaten.

Control of Automobile Pollution:

1. Engine efficiency has been steadily improved with improved engine design.

2. One of the first-developed exhaust emission control systems is secondary air injection. Originally, this system was used to inject air into the engine's exhaust ports to provide oxygen so unburned and partially-burned hydrocarbons in the exhaust would finish burning.

3. Air injection is now used to support the catalytic converters oxidation reaction, and to reduce emissions when an engine is started from cold. After a cold start, an engine needs a fuel-air mixture richer than what it needs at operating temperature, and the catalytic converter does not function efficiently until it has reached its own operating temperature.

The air injected upstream of the converter supports combustion in the exhaust head pipe, which speeds catalyst warm up and reduces the amount of unburned hydrocarbon emitted from the tailpipe.

4. Converter does not function efficiently until it has reached its own operating temperature. The air injected upstream of the converter supports combustion in the exhaust head pipe, which speeds catalyst warm up and reduces the amount of unburned hydrocarbon emitted from the tailpipe.

SI Engine Emissions:

The gaseous and particulate pollutants to which motor vehicles contribute include carbon monoxide (CO), ozone through its atmospheric precursors volatile organic compounds and nitrogen oxides [NOx], fine particulate matter PM10 and PM2.

CI Engine Emissions:

The four main pollutant emissions from diesel engines (carbon monoxide-CO, hydrocarbons-HC, particulate matter-PM and nitrogen oxides-NOx) and control systems for these emissions.

Emission Standards:

Emission standards are the legal requirements governing air pollutants released into the atmosphere. These emission standards set quantitative limits on the permissible amount of specific air pollutants that may be released from specific sources over specific timeframes. These emission norms gives detailed information of modifications to be done to every automobile before it is released into environment.

7.10.1 Bharat Stage Emission Standards (BSEC):

These are the standards set up by the Indian government which specify the amount of air pollutants from internal combustion engines, including those that vehicles can emit. If these emit more pollutants than the prescribed limit, they don't get a clearance to be sold in an open market. Bharat Stage Emission Standards have been instituted by the Central Pollution Control Board (CPCB), instituted within the Ministry of Environment Forests and Climate Change.

History of BSES:

The first emission norms were introduced in India in 1991 for petroleum distillate, and 1992 for diesel vehicles. These were followed by making the Catalytic converter mandatory for petrol vehicles and the introduction of unleaded petrol in the market.

On 29 April 1999, the Supreme Court of India ruled that all vehicles in India have to meet Euro I or India 2000 norms by 1 June 1999 and Euro II will be imperative in the Delhi by 1 April 2000. Car makers were not prepared for this transition and in a subsequent judgement the implementation date for Euro II was not enforced.

In 2002, the Indian government proposed a road map for the roll-out of Euro based emission norms for India. Based on the recommendations of the committee, the National Auto Fuel policy was announced officially in 2003.

Present BSES:

To regulate the pollution emitted by cars and two-wheelers, the government of Asian nation has placed forth regulations known as Bharat Stage Emission Standards (BSES). The Central government has mandated that every vehicle manufacturer, each two-wheels and four-wheels, ought to manufacture, sell and register solely BS6 (BSVI) vehicles from 1 April 2020.

Both BSIV and BSVI area unit emission norms that set the most permissible levels for pollutants emitting from a automotive or a two-wheeler exhaust. Compared to the BS4, BS6 emission standards area unit stricter, whereas makers use this variation to update their

vehicles with new options and safety standards, the largest or the numerous modifications comes within the type of stricter permissible emission norms.

Permissible Limits of BSES VI &IV for Automobiles:

Fuel Type	Pollutant Gases	BS - VI	BS - IV
Gasoline Vehicle	Nitrogen Oxide Limit (NO_x)	60 mg	80 mg
	Particulate Matter (PM)	4.5 mg/km	
Diesel Vehicle	Nitrogen Oxide Limit (NO_x)	80 mg	250 mg
	Particulate Matter (PM)	4.5 mg/km	25 mg
	HC+ NOx	170 mg/km	300 mg

European Emission Standards (EURO):

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and European Economic Area(EEA) member states. The emission standards are defined in a series of European Union directives staging the progressive introduction of increasingly stringent standards.

In the European Union, emissions of nitrogen oxides (NOx), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) are regulated for most vehicle types, including cars, trucks (lorries), locomotives, tractors and similar machinery, barges, but excluding seagoing ships and aeroplanes. For each vehicle type, different standards apply. Compliance is determined by running the engine at a standardised test cycle. Non-compliant vehicles cannot be sold in the EU, but new standards do not apply to vehicles already on the roads. No use of specific technologies is mandated to meet the standards, though available technology is considered when setting the standards.

Diesel Cars					
Standards	**Date of approval**	**CO**	**NOx**	**HC+NOx**	**PM**
Euro 1	July 1992	2.73	-	0.97	0.14
Euro 2	January 1996	1.0	-	0.7	0.08
Euro 3	January 2000	0.64	0.50	0.56	0.05
Euro 4	January 2005	0.50	0.25	0.30	0.025
Euro 5	September 2009	0.50	0.18	0.230	0.005
Euro 6	September 2014	0.50	0.80	0.170	0.005
Euro 6D	January 2020	0.50	0.80	0.170	0.005
Petrol Cars					
Standards	**Date of Approval**	**CO**	**NOx**	**HC+NOx**	**PM**
Euro 1	July 1992	2.72	-	0.97	-
Euro 2	January 1996	2.2	-	0.5	-
Euro 3	January 2000	2.3	-	-	-
Euro 4	January 2005	1.0	-	-	-
Euro 5	September 2009	1.0	0.068	-	0.005
Euro 6	September 2014	1.0	0.068	-	0.005
Euro 6D	January 2020	1.0	0.068		0.045

Pollution Under Control Certificate (PUC):

A Pollution Under Control Certificate is an approval that emission from your vehicle is under control and as per the pollution norms. It is an official document issued by the government after the thorough verification of the vehicle's emission levels.

As per the Motor Vehicle Act, like a motor insurance policy, registration certificate, and driving license, a PUC certificate is now mandatory to carry while driving.

The Non Polluting Vehicle mark is a mandatory certification mark required on all new motor vehicles sold in India. The mark certifies that the motor vehicle conforms to the relevant version of the Bharat Stage emission standards. This certification for a brand new vehicle has a limited validity of 6 months from the date of sale of the vehicle. After this, the vehicle has to be tested afresh. The vehicle is tested in the car companies' garage during the

year's maintenance and a renewed certificate has to be obtained. The certificate thus issued on a used vehicle is the Pollution under Control certificate.

PUC Certificate Validity:

By now the importance of getting a PUC test is crucial. The person who is supposed to be driving the vehicle must carry the certificate either in soft or hard copy while driving..

The validity of the PUC Certificate for the new car or a bike is 1 year. The certificate will be renewed at regular intervals. The validity of the renewed certificate is 6 months for both cars and bikes. In case, the reading is adverse, the validity of the certificate will depend on the reading.

The cost to obtain the Pollution Under Control Certificate varies from Rs.60/- to Rs.100/-. The cost also depends on the fuel type.

Penalties for not obtaining a PUC Certificate:

According to motor insurance policy, people will have to pay a fine for not carrying a PUC Certificate. And under section 190 (2) of the Motor Vehicle Act, you will be liable for prosecution.

Other than this, a fine of Rs.1000/- will be charged for the first time offence. If it is repeated a fine of Rs.2000/- is to be paid.

Short Answer Questions

1. How do we measure the performance of an engine?
2. What are the performance parameters of an IC engine?
3. Write the sources of auto emissions.
4. Why an automobile is causes air pollution.
5. With a neat diagram explain sankey diagram.
6. What is PUC certificate?

Long Answer Questions

1. Explain the following terms.
    a. Indicated power.
    b. Brake power
    c. Friction power
2. Write the methods to the performance of an IC engine.
3. Explain BS & EURO standards of vehicle emissions.
4. Explain the following.
    a. Mechanical efficiency
    b. Indicated thermal efficiency
    c. Brake thermal efficiency
    d. Volumetric efficiency.