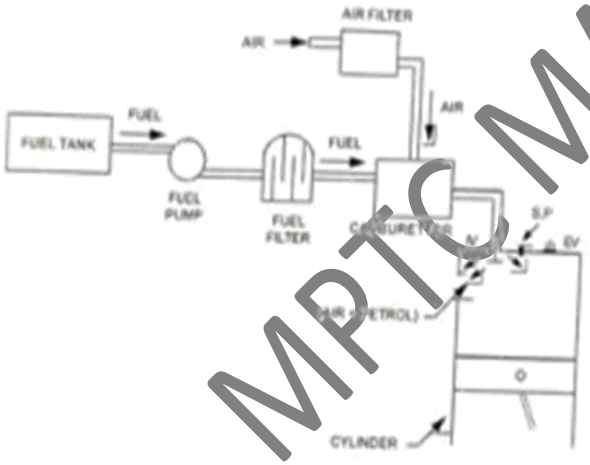
SYSTEMS IN AUTOMOBILE

The Internal combustion engines are basically employed with the following systems

- Fuel systems
- Cooling system.
- Lubrication systems
- Governing system.
- Ignition system

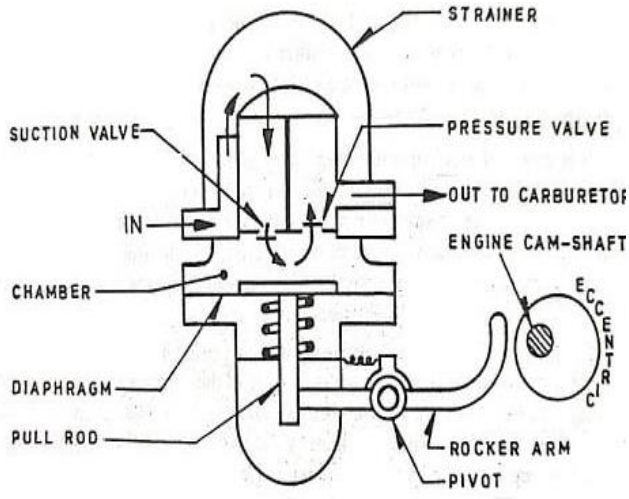
FUEL SYSTEM

FUEL SYSTEM IN SI ENGINE



- The fuel from the fuel tank supplied to carburettor through filter by using fuel feed pump.
- The fuel is mixed with air in the carburettor and supplied to engine cylinder.
- The air is reached in the carburettor through air filter.

FUEL PUMP



- It is a diaphragm type mechanically operated pump actuated with the help of rocker arm and cam.
- One end of rocker arm is connected in cam and other end is pull rod.
- Due to rotation of cam shaft, one end of rocker arm is pushed up; the other end of the arm pulls downwards making the diaphragm to move downwards against the spring action.

- This creates vacuum in the chamber above the diaphragm, which open inlet valve and makes petrol (fuel) to enter into the pump.
- With further rotation of cam, the rocker arm releases the diaphragm, and the spring pushes the diaphragm up, Producing pressure in the chamber.
- Due to this action inlet valve close and at the same time outlet valve opens.
- The fuel under pressure flows through outlet valve to the carburettor.

FUEL FILTER

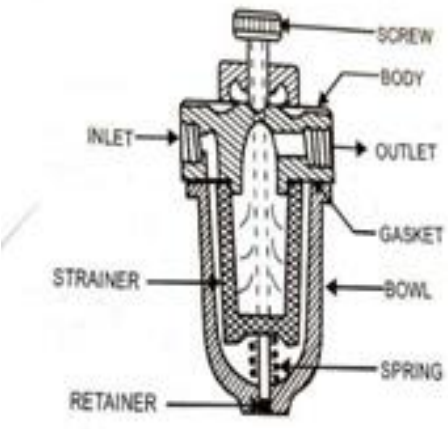


Fig. 2.8 Fuel Filter

- The filter consists of body, bowl and filter element. The filter element or strainer is a fine wire gauge.
- During engine operation, some impurities settle to the bottom of the bowl and the rest are retained by the filter element.

AIR CLEANER

- This prevents the damage of engine surfaces by abrasive action of hard particles.
- The most common types are

1. Dry-type cleaner
2. Viscous-impingement cleaner

- Oil-bath cleaner-It is a most common type of air cleaner.

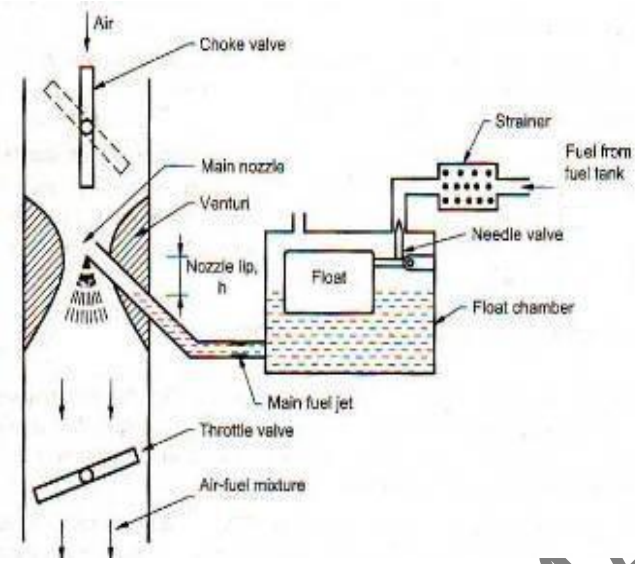
SIMPLE CARBURETTOR

The main functions of carburettor are

- To maintain a small reserve of petrol at a constant level in float chamber

- To atomise the liquid fuel (petrol) and to mix it with air
- To supply air-fuel vapour mixture at correct ratio according to engine requirements.

CONSTRUCTION



- It consists of float chamber, venture (choke) tube, fuel jet and throttle value.
- Fuel jet is placed in the throat (smallest section of venture) at a slightly higher level than the level of the petrol in the float chamber.
- A vent hole is provided on float chamber to maintain atmospheric pressure in the float chamber.
- Fuel is delivered to the float chamber by gravity or by a pump.
- Float and needle valve maintain a constant fuel (petrol) level in thee float chamber.
- As the float chamber is filled with fuel, the float rises and actuates the needle to close the valve.
- When the fuel level drops, the float descends to open the valve, allowing more fuel to enter the float chamber.

WORKING

- During suction stroke, a partial vacuum is created in the engine cylinder and carburettor. Due to this, air flows into the carburettor.
- At the narrow section (throat) of venturi tube velocity of air increases and air pressure is correspondingly reduced.

- A pressure difference is thus produced between float chamber and the venturi, which causes fuel to flow out of fuel jet in the form of spray.
- The fuel delivered by the jet into the air stream is finely atomised, mixed with air and which is admitted to the engine cylinder.

LIMITATIONS

- At low speed, the amount of fuel in air-fuel mixture is very low.
- It gives stoichiometric mixture only at one specific speed and load.
- Fuel economy is very low
- The working of simple carburetor will be affected by the atmospheric pressure and temperature.
- It has no provision to deliver extra fuel i.e., to supply rich mixture during acceleration and over load.

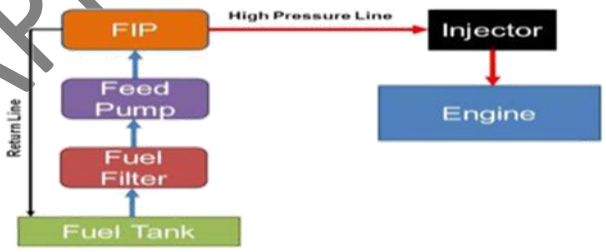
Carburation

- The process of preparing the charge for SI engines is called ***carburetion***.

Air-fuel ratio

- The ratio of mass of air sucked by engine to mass of fuel supplied is air-fuel ratio.

FUEL INJECTION SYSTEM FOR CI ENGINES



Fuel system in CI engines performs the following functions

- To meter (or measure) the correct quantity of fuel to be injected.
- Atomise the fuel into fine particles.
- Time the fuel injection.
- Control the rate of fuel injection.
- Properly distribute the fuel in the combustion chamber.

- During the operation the fuel from the fuel tank is pumped into the fuel injection pump (FIP) by using a fuel feed pump through a fuel filter.
- where all the dust particles are removed from fuel by passing through the filter
- Then the pressure of the fuel is increased and supplied to the injector by using a fuel injection pump.
- The high pressure fuel is supplied to the engine cylinder by using a injector.

FUEL FEED PUMP

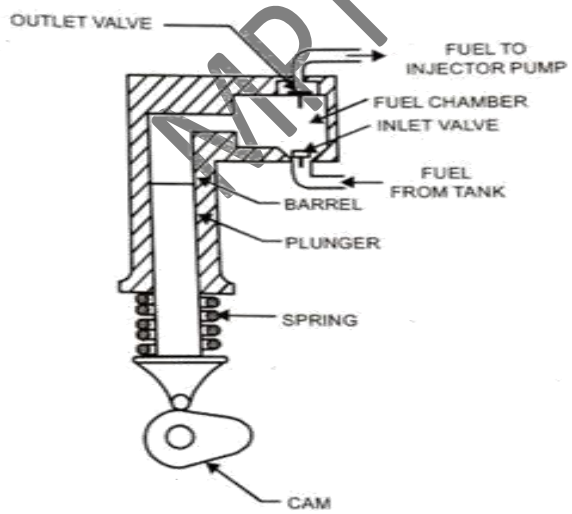
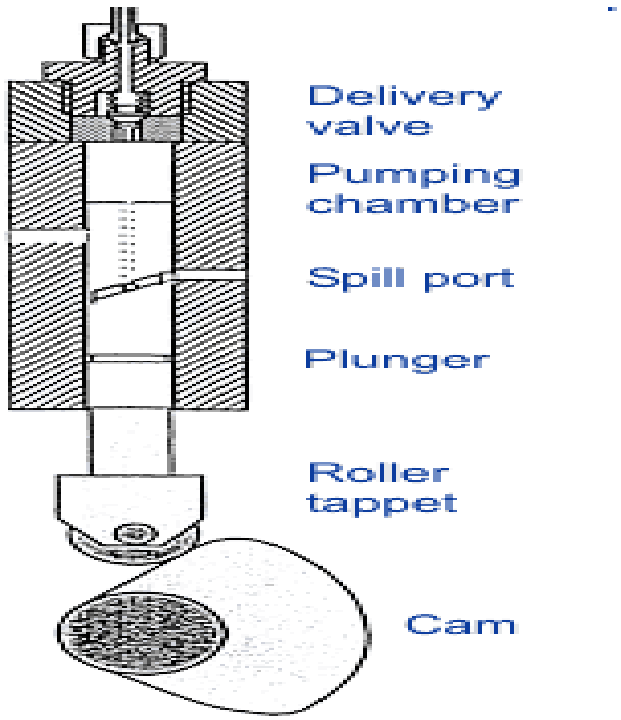


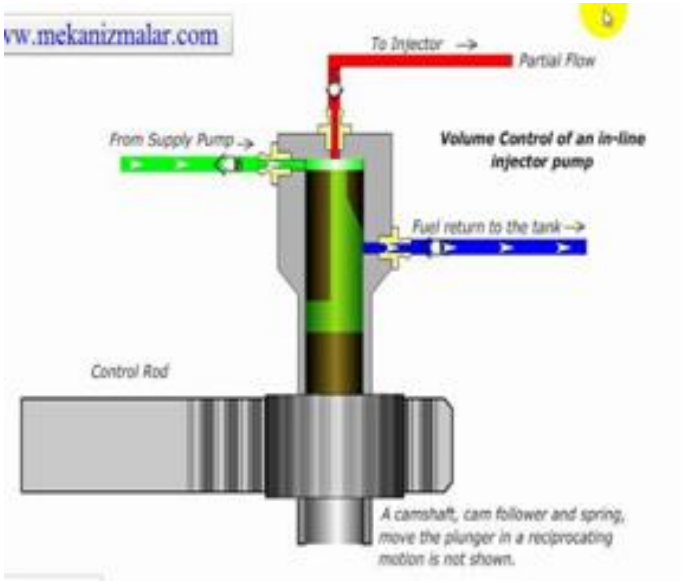
Fig. 2.2 Fuel Feed Pump

- Fuel feed pump deliver fuel to the fuel injection pump.
- It consists of a barrel, a plunger and two valves.
- The plunger is actuated by spring and cam.
- When the plunger to move downwards creates low pressure above the plunger and fuel enters into the pump (chamber) through the open inlet valve.
- As the plunger moves upwards, the pressure above the plunger increases.
- This fuel is delivered to fuel injection pump (FIP) through a opened outlet valve.

FUEL INJECTION PUMP (FIP)



- The fuel injection pump supply high pressure fuel into engine cylinder.



- As the plunger moves up, it closes the inlet port and spill port of the barrel and pressurise the fuel in the barrel.
- The fuel pressure increases causing delivery valve to open and allow the fuel to enter into fuel injector at high pressure.
- With further rise of the plunger, at a certain moment, the spill port is connected to the edge of helical groove.
- As soon as spill port uncovers, the fuel passes through the vertical groove and annular helical groove to the spill port, thus reducing the pressure of the fuel above the plunger.
- The quantity of fuel delivered is controlled by the turning of the plunger.
- Plunger is rotated by using control rod.
- The reciprocating motion of plunger is actuated by cam.

FUEL INJECT0R

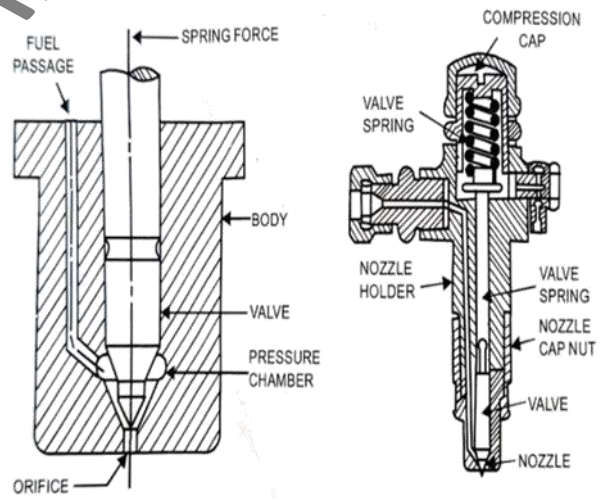


Fig. 2.4 Fuel Injector

- The function of an injector is to spray the high pressure fuel into the engine cylinder.
- The fuel from FIP 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.
- As the pressure of fuel below the valve decreases, the spring retards the nozzle valve and the fuel below the valve is delivered to cylinder at high pressure.

FUEL FILTER

- The function of fuel filter is to clean the fuel by eliminating dirt and abrasive particles from it.

1. Primary (or preliminary) fuel filter
2. Secondary (or fine filter)

Primary (Preliminary) Fuel Filter

- The preliminary fuel filter is located between fuel tank and fuel feed pump.
- It cleans the fuel from coarse dust particles.
- During engine operation the fuel enters the bowl from fuel tank. Then, passes through filter element, and finally leaves to fuel feed pump.

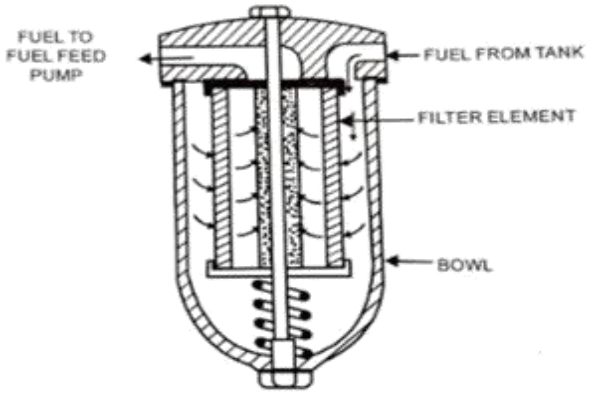


Fig. 2.5 preliminary Fuel Filter

Secondary (or Fine Filter)

- Secondary fuel filter is located between the feed pump and FIP.
- It cleans the fuel from fine dirt particles and water.
- The working principle of secondary filter is same as the preliminary filter except that the secondary fuel filters are provided with fine grade felt as the filter element.
- Fuel passes through secondary filter before it is delivered to fuel injection pump.

IGNITION SYSTEM OF SI ENGINE

1. Battery Ignition System
2. Magneto Ignition System

BATTERY IGNITION SYSTEM

- The majority of SI engines uses battery ignition system.
- The system has a primary circuit and a secondary circuit.
- The primary circuit consists of a battery, ignition switch, primary coil, condenser and breaker points.
- The secondary circuit contains the secondary coil, distributor and spark plug.
- One end of primary winding is connected to the positive terminal of battery through ignition switch and the other end to the contact breaker.
- The contact breaker points are operated by a cam.
- The condenser is connected in parallel with contact breaker.
- When the ignition switch and the breaker points are closed, a low voltage current flow from the battery through the primary circuit and magnetise the core of the coil.
- Due to rapid collapse of the magnetic field in the core induce a very high voltage (5000 to 20,000 V) in the secondary winding.
- This high voltage spark occurs due to discharge of high voltage across the air gap of the spark plug, and the charge is ignited.
- The condenser is used to assist the collapse of the magnetic field and prevents arcing at the breaker points.

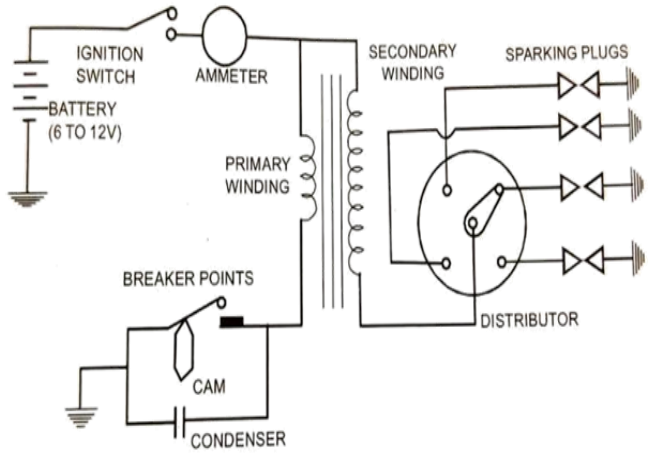


Fig. 2.13 Battery" coil Ignition System

Advantages

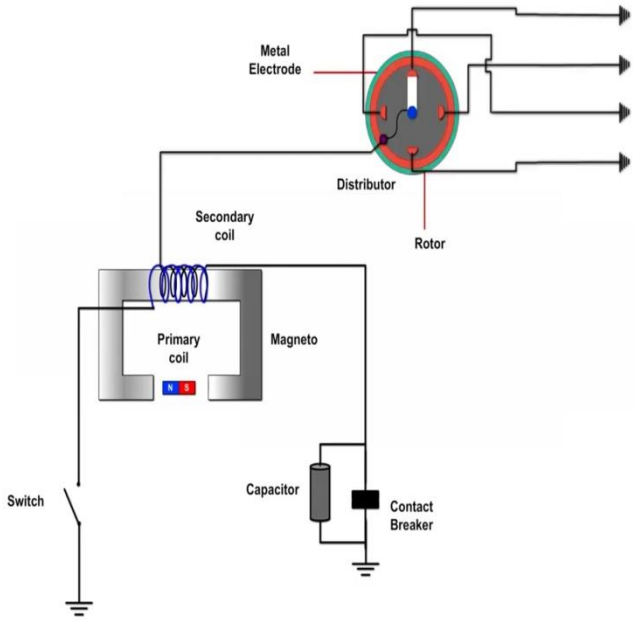
- Initial cost is low as compared with magnetic system.

- It provides better sparks at low speeds.
- Simple in design, and
- The maintenance cost in low.

Limitations

- The engine cannot be started if the battery is weak.
- The system is not used in aero engines due to high weight of battery.
- The sparking voltage drops as the speed increases.
- The breaker points are continuously subjected to wear.

MAGNETO IGNITION SYSTEM



- The magneto ignition system consists of magneto, ignition switch, breaker points, condenser, distributor and spark plug.
- It is similar in principle to the battery system except that the battery of battery ignition system is replaced by a rotating permanent magnet.
- It has a stationary coil which carries primary and secondary windings.
- When the breaker points are opened by the cam, the condenser is charged.
- This is followed by rapid discharge of the condenser which causes very rapid break down of magnetic flux.
- This induces a high voltage in the secondary winding which is led to the spark plug by the distributor.

Advantages

- No battery is required and as such no maintenance problems.

- Compact and occupy less space.
- Efficiency improves as the engine speed increases.

Limitations

- During starting, quality of spark is poor due to low speed.
- Suitable only for small capacity engines.

Battery	Magneto
Difficult to start the engine when battery is discharged.	No battery needed, no problem of battery discharge.
Maintenance problems are more due to battery	Maintenance problem is less
Current for primary circuit is obtained from battery.	Required electric current is generated by the magneto coil
Good spark Is available even at low speed	Quality of spark is poor due to low speed
Occupies more space	Less space is enough
Used in light commercial vehicles	Mainly used in racing cars

COOLING SYSTEM

- The cooling system is used to remove the heat from the engine cylinder.
- it maintains the engine operating temperature where it works most efficiently
- It brings the engine up to the right operating temperature as quickly as possible.

Methods of Cooling

- Air cooling, and
- Water cooling.

Air cooling

- In air cooling system the removal of heat is affected 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.
- The air cooling system is employed for scooters, motor cycles and aircrafts.

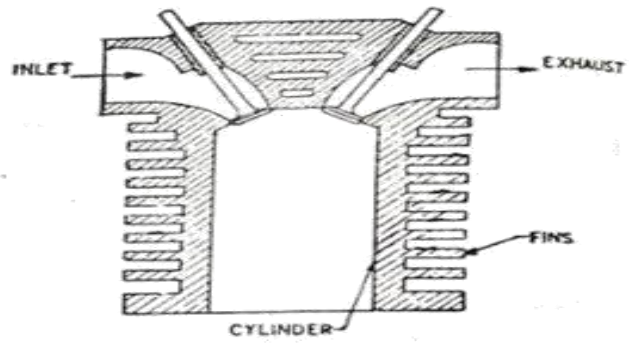


Fig. 5.1. Cylinder with cast fins.

Advantages

- Simple design
- Less maintenance
- No danger of leakage and freezing of water in cold climate.
- Weight per given output is less.

Limitation

- Cooling is not uniform, and suitable only for small and medium size engines.

Water Cooling

- In water cooling system, the heat removed by water circulating around the cylinder.

1. Thermo syphon (Gravity circulation) system.
2. Forced circulation system (Pump circulation system)

Thermo syphon (Gravity circulation) system

- In this system circulation of water is due to difference between the density of hot water and cold water.
- While the cold water circulating in the jacket, it absorbs heat from the engine and hot water comes out at the top.
- Hot water flows down the radiator where it is cooled by the atmospheric air.
- Atmospheric air is drawn through radiator by a fan which is driven by engine.
- This system is simple and needs no pump to maintain circulation of water.
- Rate of circulation is slow and insufficient.
- It needs a bigger radiator to cool the circulating water.
- It is used for small engines.

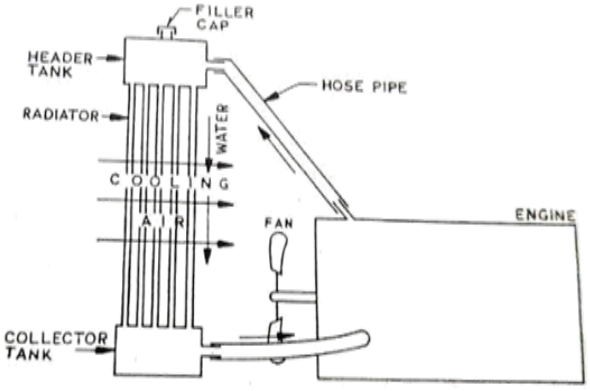
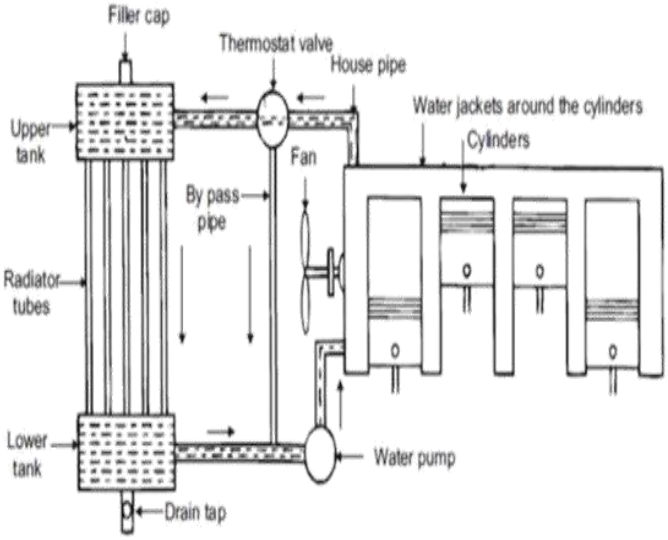


Fig. 5.4. Thermosyphon system of cooling

Forced circulation system (Pump circulation system)

- In this system water circulation is maintained by a pump operated by the engine itself.
- The hot water comes out from the top and passes into the radiator where it is cooled and then return to the jacket.
- The hot water is cooled while it passing through the radiator by air.
- Atmospheric air is drawn through radiator by a fan which is driven by engine.
- The cold water from the radiator lower tank is again pumped to the water jackets.
- A thermostat valve is used to maintain the engine at working temperature at the time of starting.
- Thermostat valve opens when engine it reaches operating temperature (80^0 c to 100^0 c)



Radiator

- The radiator is a device used to cool the hot water coming from the engine with the help of atmospheric air.
- The ***upper tank*** is connected to the water outlet or outlets from the engine jacket by a hose pipe, and
- The ***lower tank*** is connected to the jacket inlet through the water pump.
- The ***core*** is a radiating element, which cools the water.

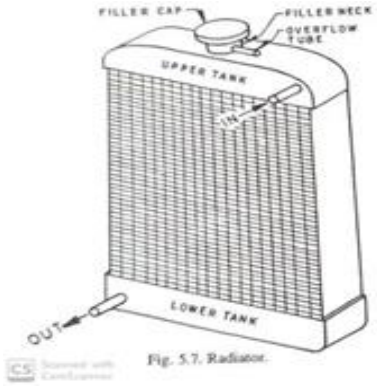


Fig. 5.7. Radiator.

Types of Radiator

There are two basic types of radiator

1. Tubular type
2. Cellular type

Tubular Type Core

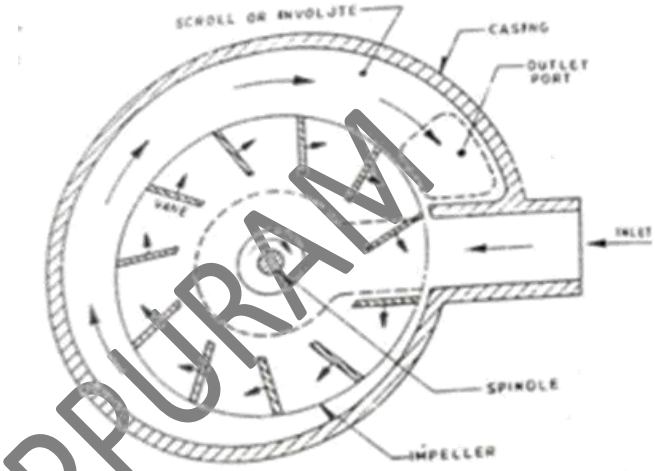
- In tubular type core, the water passes through the tube. Fins are placed around the tubes to improve heat transfer.

Cellular Type Core

- In cellular type core, air passes through the tubes and the water flows in the spaces between them.

WATER PUMP

- Water pump is a simple centrifugal pump driven by a belt connected to the crankshaft of the engine.
- The rotation of impeller creates a vacuum pressure in the casing, that causes the fluid to enter in the pump and it is delivered by centrifugal force



Types of coolant used

- Water
- Glycerine
- Ethylene glycol

THERMOSTAT

- The function of thermostat is to control the flow of coolant to the radiator until the engine has warmed up.
- When the engine is cold, the thermostat valve is closed and no fluid flows to the radiator.

- Once the engine reaches its operating temperature, the thermostat opens and the coolant starts to flow into the radiator.

Two types of thermostats are used in automobiles:

1. Bellows or aneroid type
2. Wax or hydrostatic type

Bellows type thermostat

- It consists of metallic bellows particularly filled with some volatile liquid like acetone, alcohol or ether which boils between 70-85°C.
- A valve is attached to one end of the bellows, while to the other end is attached a frame which fits into the cooling passage.
- The thermostat is fitted in the coolant hose pipe at the engine outlet.
- The coolant temperature reaches a predetermined value, (about 80°C) the liquid inside the thermostat is converted into vapour which exerts a pressure on the valve, which begins to open, so that the water circulation through the radiator starts.

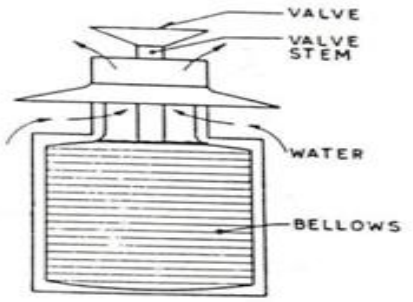


Fig. 5.12. Bellows type Thermostat

Wax Thermostat

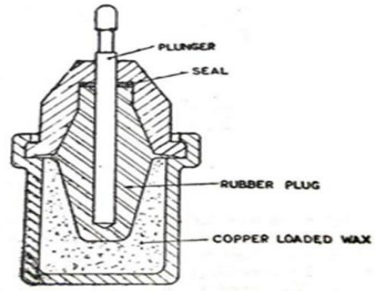


Fig. 5.14. Dole Thermostat.

- As the coolant is heated, it transmits its heat to the copper-loaded wax having high coefficient of volumetric thermal expansion which expands so that the rubber plug contracts against the plunger and exerts a force on it upwards so that it moves vertically.
- This movement of the plunger opens a valve in the thermostat

(not shown) to allow coolant to flow through the radiator.

TEMPERATURE GAUGES

- Temperature gauge is used to indicate engine coolant temperature.

1. Bourdon tube type.
2. Electrically operated type.

Bourdon tube type

- As the temperature of cooling water increases, the liquid in the element evaporates and exerts its pressure in the capillary, which is further transmitted to the Bourdon tube.
- Due to this pressure, the Bourdon tube tries to straighten outward thus moves a pointer attached to it, to show higher temperature on the dash board

Electrically operated type

- This contains an element made of such a material that its electrical resistance decreases with increase of temperature.
- The element is connected to the coils inside the dash unit
- The gauge element is inserted into the coolant at some appropriate place.
- As the cooling water temperature in-creases, the resistance of element decreases, which causes more current to flow in the coil, thus increasing the e.m.f. built up there.
- The pull of the coil on the armature carrying indicator pointer, therefore, increases and the pointer moves to show the higher temperature.

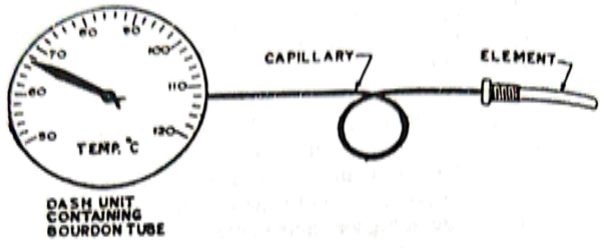
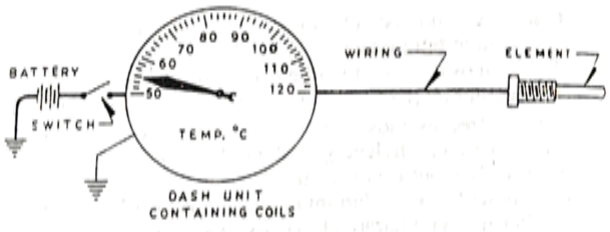


Fig. 5.24. Bourdon tube type temperature gauge.



Air Cooling System	Water Cooling System
The design of this system is simple and less costly.	The design of this system is complicated and more costly.
The weight of the cooling system (per B.H.P. of the engine) is very less.	The weight of the cooling system (per B.H.P. the engine) in much more.
The fuel consumption is more.	The fuel consumption is less.
Its installation and maintenance are very easy and less costly.	Its installation and maintenance in difficult and more costly.
There is no danger of leakage or freezing of the coolant.	There is a danger of leakage or freezing of the coolant.
It works smoothly and continuously. Moreover, it does not depend on any coolant.	If the system fails, it may cause serious damage to the engine within a short time.
Air cooling system is not suitable for multi cylinder engines	This system can be employed in multi cylinder engines satisfactorily

LUBRICATING SYSTEM

The functions of lubrications are

- To reduce the friction between moving parts.
- To reduce the wear between rubbing and bearing surfaces.
- To clean the surface by washing away carbon and metal particles caused by wear.
- To prevent the flow of gases through a space between piston rings and cylinder walls.
- To reduce the noise.

Types of Lubrication system

1. Petroil system.
2. Splash system.
3. Pressure system.
4. Wet sump system.
5. Dry sump system.

Petroil (Mist) Lubrication.

- This system of lubrication is generally adopted in two stroke petrol engines, like scooters and motorcycles.
- The lubricating oil is mixed into the petrol itself while filling in the petrol tank of the vehicle, in a specified ratio (2 to 6 %).
- When the fuel goes into the crank chamber during the engine operation, the oil particles go deep into the bearing surfaces, piston ring, cylinder walls, piston pin are lubricated.

Splash Lubrication

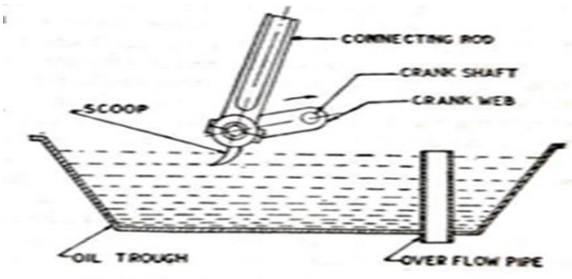


Fig. 6.8. Splash system lubrication.

- In this system of lubrication, the lubricating oil is stored in an oil trough or sump.
- A scoop or dipper is made in the lowest part of connecting rod.
- When the engine runs, the dipper dips in the oil once in every revolution of the crankshaft and causes the oil to splash on the cylinder walls.

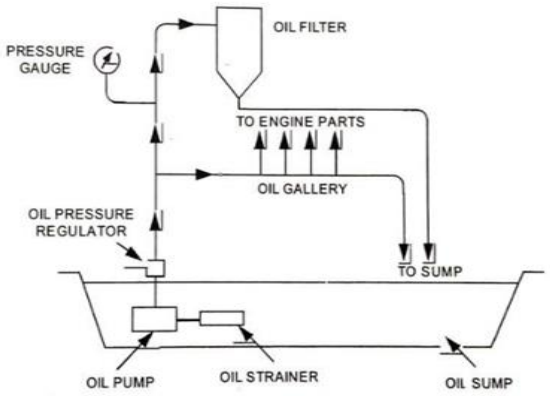


Fig. 2.18 Components of Lubricating System

Pressure Lubrication

- In this system uses a pump to force oil under pressure to the engine parts.
- The oil pump is usually submerged and driven by camshaft.
- To prevent excessive pressure building up in system, an oil pressure relief valve is incorporated, which permits excess oil to by-pass the system.

Properties of Lubricating Oil

- **Viscosity:** Viscosity is a measure of the flow ability of oil under a particular temperature and pressure
- **Physical stability:** The lubricating oil must be stable physically stable at lowest and highest temperatures.
- **Chemical stability:** At higher temperature the oil should remain chemically stable.
- **Resistance against corrosion:** The oil should not have any tendency to corrode the pipe line , crank case and other engine parts with which comes in contact.
- **Pour point:** The minimum temperature at which oil will pour is called pour points.
- **Cleanliness:** The oil should be sufficiently clean and stable itself so that the crank case and oil lines are kept clean.

- **Flash Point or Fire Point.** The lowest temperatures at which the oil flashes and fires, known as flash and fire points.
- **Emulsification. T**he tendency of any oil to emulsify with water.

GOVERNING OF IC ENGINES

- The process of controlling the speed of the engine by adjusting the fuel supply is called governing, and the device used for controlling the speed automatically is called governor

Methods of governing IC engine

1. Hit and miss method governing
2. Quality governing
3. Quantity governing and
4. Combined method of governing

Hit and Miss Method of governing:

- In this method, the supply of fuel is stopped for one or more cylinders when the speed of engine increases.
- It is simple, but a large fluctuation of speed takes place in the idle cycle which needs a heavy flywheel.
- This method is suitable for small gas or oil engines.

Quality governing

- This method is employed for high speed diesel engines (CI engines).
- In this method the quality of fuel supplied is varied by altering the air fuel ratio.
- For quality governing the amount of air drawn into cylinder is constant, but the supply of fuel varies. Thus the quality of the mixture is varied.

3. Quantity governing

- This method is employed in spark ignition engines (petrol or gas engines).
- In this method, the quality (i.e., air fuel ratio) of fuel is not altered but the quantity of mixture supplied

to the engine varied by regulating the throttle valve.

- It is simple, but combustion of fuel is not effective there by the thermal efficiency is reduced.

Combined method

- It is the combination of the quality and quantity governing methods.