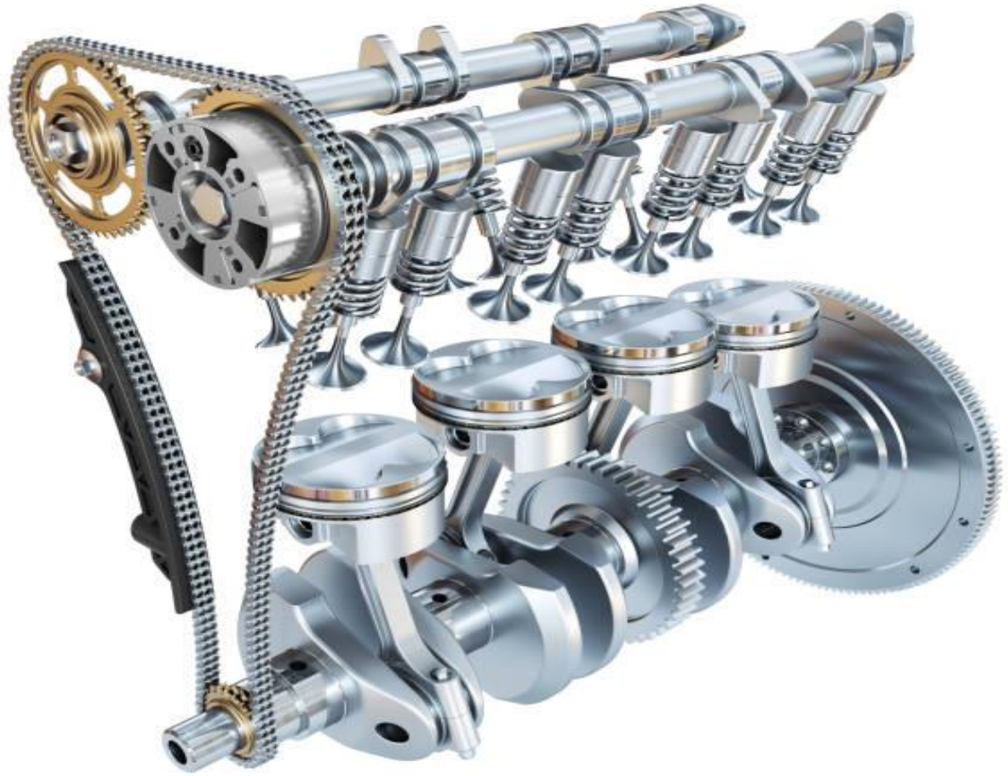
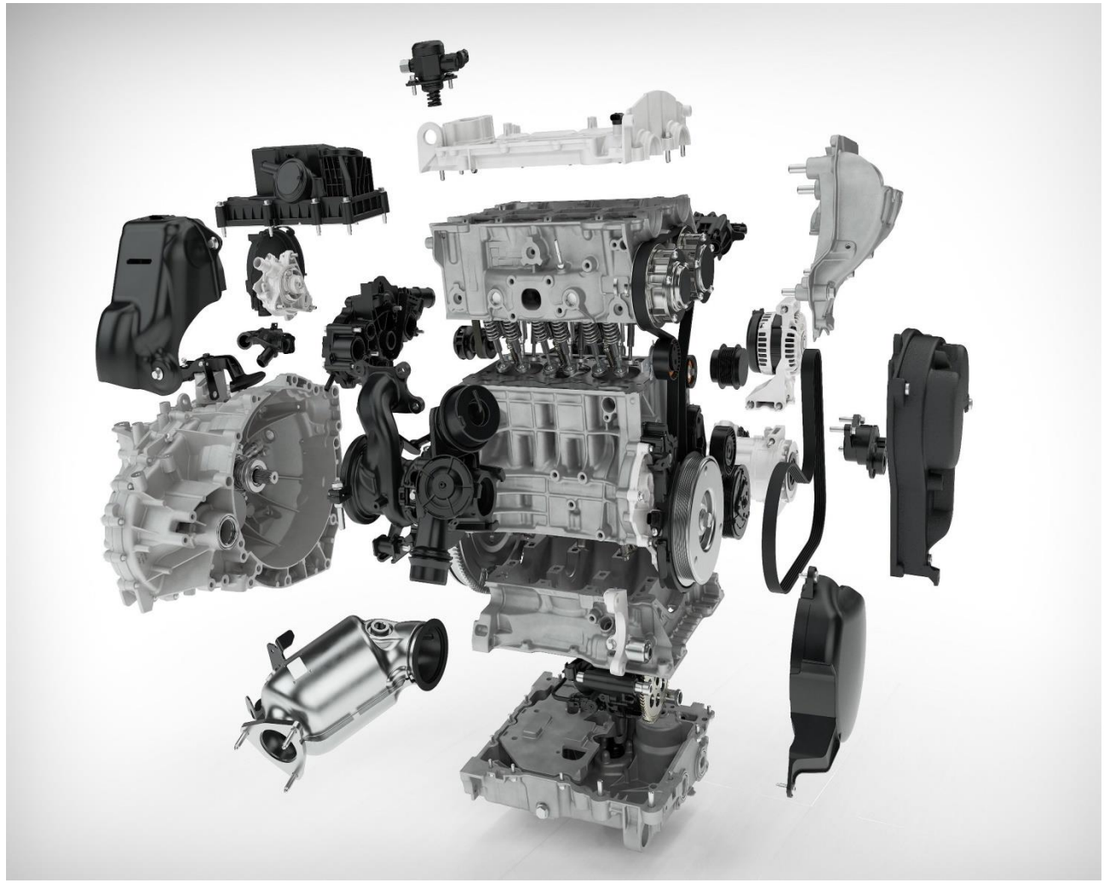
AUTOMOBILE ENGINEERING



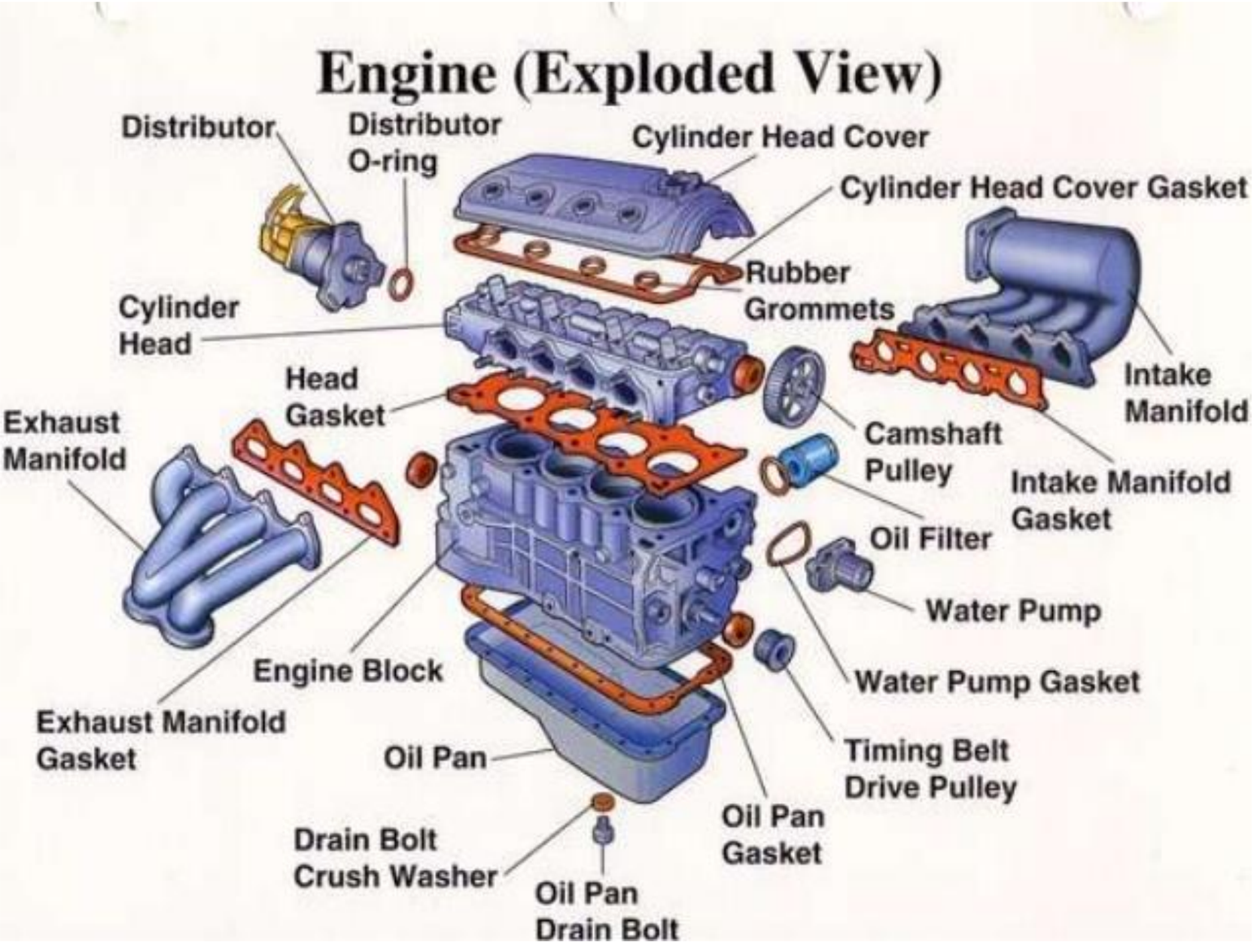


MODULE 1

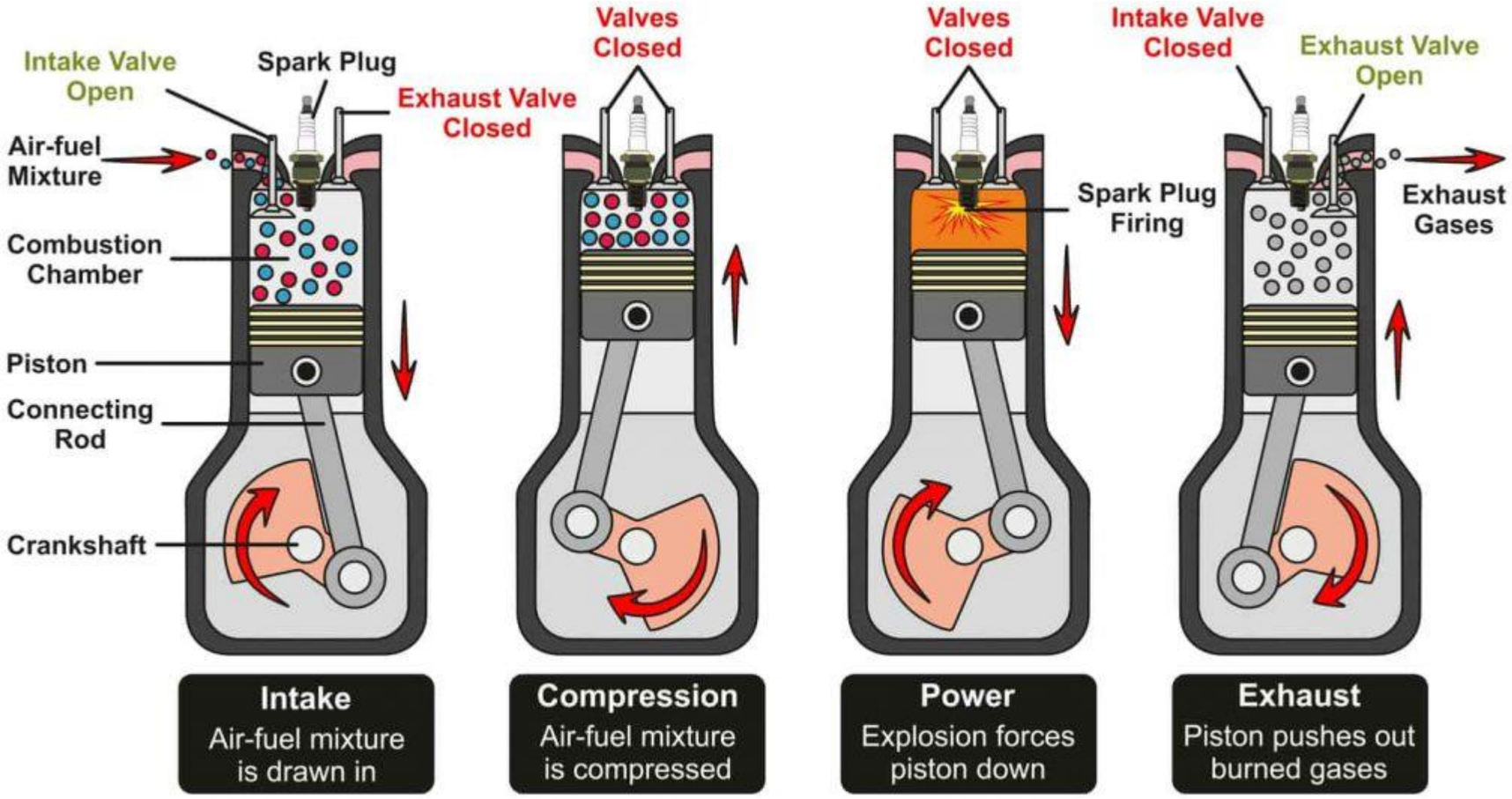
Contents:

Introduction to classification and basic structure of an automobile, Basic engine components; Cylinder block; Cylinder head; Gaskets; cylinder liners, types of cylinder liners; Piston and piston pin; piston rings; Connecting rod; Crank shaft; Cam shaft; Crankcase; Engine valves- valve operating mechanism-overhead and side valve engines only; Flywheel and Governor. The necessity of **cooling system**; Types of cooling system -air cooling and liquid cooling; Air cooling system; Types of liquid-cooling system – Thermo siphon system and pump circulation system; The components of water-cooling system –fan, radiator, pump and thermostat; The necessity of **lubrication system**, Types of lubrication system- splash system; forced system and (mist)/ petroil system; **Fuel system**: Working of A.C mechanical pump; Working of simple carburetor; Bosch Fuel Pump; Fuel Injector; Single point and multi point fuel injection systems; working of CRDI and MPFI. Fuel filters; **Ignition system:** Introduction to ignition system; Battery Ignition systems and Electronic Ignition systems; Construction and working of lead acid battery; Elements of charging system; Elements of starting system; **Governing system**: Types of governing system – Quantity; Quality; hit and miss.

Engine (Exploded View)



HOW AN ENGINE WORKS

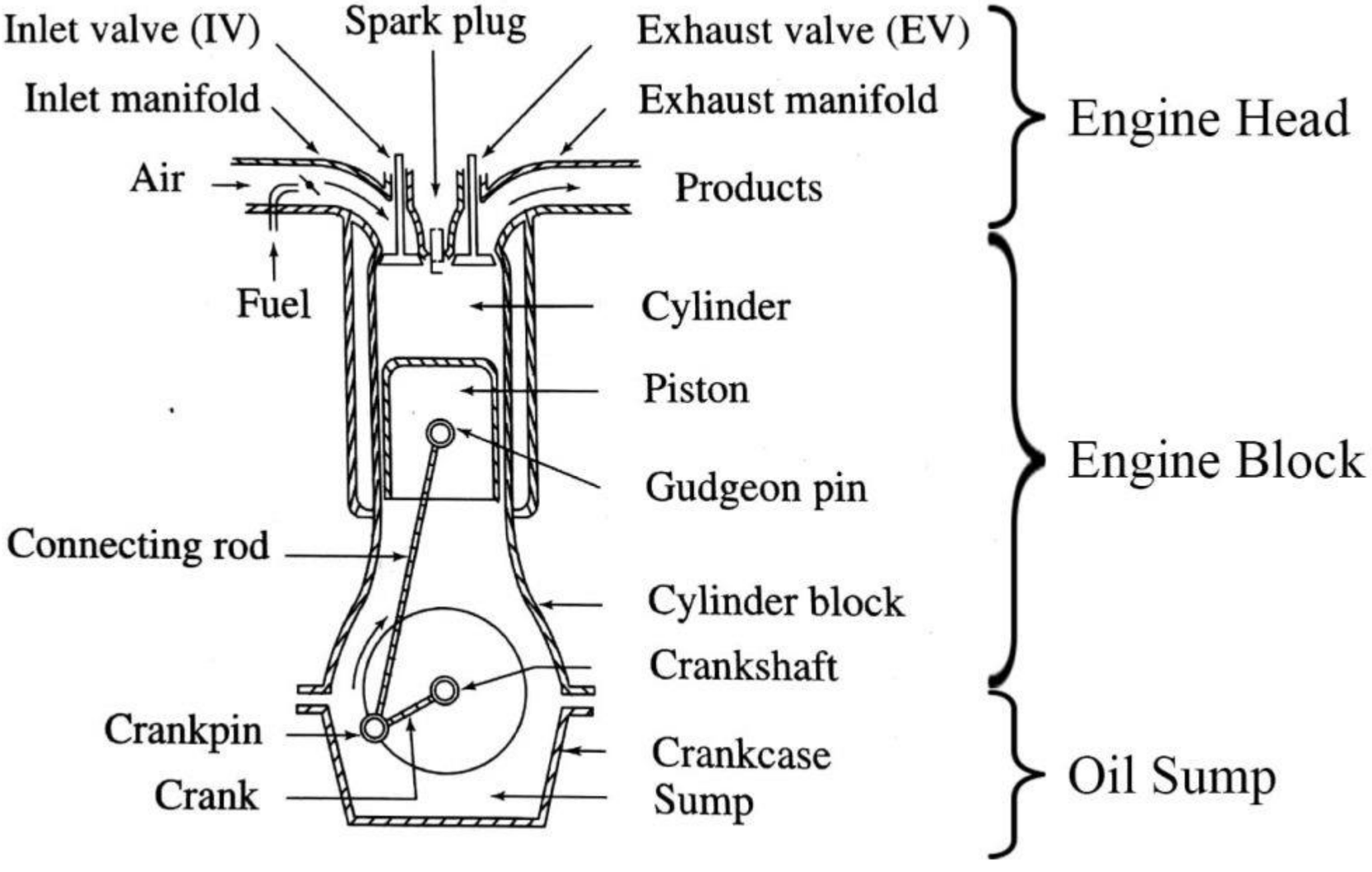


CYLINDER BLOCK

- Cylinder Block is the main part of the IC (Internal Combustion) engine. It is the part where all the functions of the engine take place inside it, such as intake, Suction, Compression, Combustion, Exhaust, etc.
- The function of the cylinder in IC engines is to hold the fuel and guide the piston.
- The cylinders are made of high grade Cast iron and Cast steel by the process of casting and usually cast in one piece to handle all the temperature and pressure which is generated after the combustion of fuel.
- So the cylinder is designed in such a way that its compressive strength is high. It also requires cooling in the engine cylinder because of high pressure and temperature.
- It is in direct contact with the products of combustion so it must be cooled.
- For cooling of cylinder, a water jacket (for liquid cooling used in most of cars) or fin (for air cooling used in most of bikes) are situated at the outer side of cylinder. At the upper end of cylinder, cylinder head and at the bottom end crank case is bolted. The upper side of cylinder is consisting a combustion chamber where fuel burns.

CYLINDER HEAD

- The cylinder head is the top cover of the engine cylinder which covers the cylinder from the topside to seal the cylinder and does not give a permit to air and gas to enter and exit from the system.
- There are two holes or ports at the cylinder head, one for intake of fuel and other for exhaust. Both the intake and exhaust ports are closed by the two valves known as inlet and exhaust valve. The inlet valve, exhaust valve, spark plug, injector etc. are bolted on the cylinder head.
- The head is made by cast iron or aluminum by the manufacturing process of forging or casting and usually in one piece.
- The cylinder head consists above the cylinder block and contains various components such as a spark plug in a petrol engine, inlet valve, exhaust valve, and injector for fuel supply in case of a diesel engine.
- For proper leakproof between cylinder and cylinder head, an asbestos packing and metal gasket are provided.


Inlet valve (IV)
Spark plug
Exhaust valve (EV)
Inlet manifold
Exhaust manifold
Air
Products
Fuel
Cylinder
Piston
Gudgeon pin
Connecting rod
Cylinder block
Crankshaft
Crankpin
Crankcase
Crank
Sump
Engine Head
Engine Block
Oil Sump

GASKET

- Gaskets are used to provide a tight, leak-proof connection between the cylinder head and block, which are connected by studs mounted to the block. Above each cylinder, the cylinder head contains a combustion chamber. Additionally, it has threaded holes for spark plugs as well as valve guides, valve seats, ports, and coolant jackets. It includes channels for the circulation of cooling water.
- Through the cylinder bolts, the head gasket seals it off from the engine. The valve springs, valves, lifters, pushrods, rockers, and camshafts are just a few of the components in the cylinder head that govern the channels that let intake airflow into the cylinders during the intake stroke. Additionally, there are exhaust channels for removing exhaust gases during the exhaust stroke.

CYLINDER LINERS

- In order to prevent the issue of cylinder wear, these cylindrical shapes are used in the cylinders. It is one of the most crucial structural components that make up an engine's interior. When they become worn out, these can be changed. They are constructed from an iron alloy with silicon, manganese, nickel, and chromium. These are typically centrifugally cast. These liners are corrosion and wear-resistant. These oil-hardening liners provide the engine with a significantly longer lifespan.
- The piston rings have a sliding surface formed by the cylinder liner, which acts as the inner wall of a cylinder and keeps the lubricant inside. The friction of the piston rings and piston skirt causes the cylinder liner to deteriorate over time. A thin oil coating that covers the cylinder walls and a layer of glaze that develops naturally as the engine is driven help to reduce this wear.

PISTON

- A Piston slides inside the cylinder in reciprocating motion and transfers mechanical energy to the crankshaft with the help of connecting rod.
- A piston is fitted to each cylinder as a face to receive gas pressure and transmit the thrust to the connecting rod. It is a prime mover in the engine.
- The main function of piston is to give tight seal to the cylinder through bore and slide freely inside the cylinder.
- Piston should be light and sufficient strong to handle gas pressure and temperature generated by combustion of fuel.
- So the piston is made by aluminum alloy and sometimes it is made by cast iron because light alloy piston expands more than cast iron so they need more clearances to the bore.

PISTON RINGS

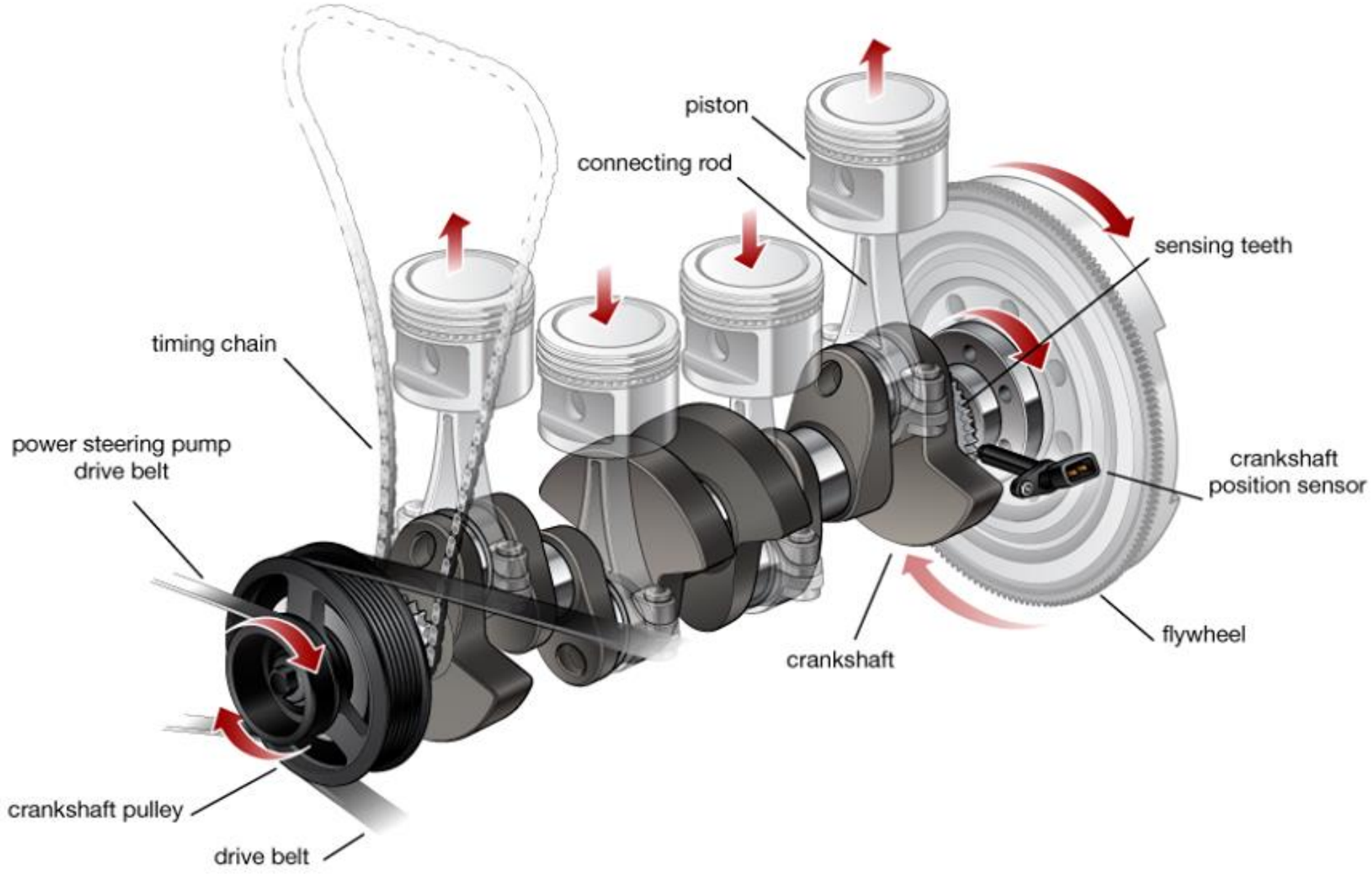
- The piston rings are used to provide the sealing effect between the cylinder and the piston. It helps to do not leak the engine's combustion gas and bypass the piston and also helps to overcome the friction around the piston.
- Piston rings are made up of cast iron and alloy cast iron.

It is of two types:

- Compressor Ring (Pressure Ring)
- Oil Controller Ring
- Compressor Ring transfers heat from the piston to the cylinder liner and it is inserted into the top grooves of the piston. Compressor rings are also used to overcome the side thrust over the piston which causes fluctuations.
- The oil controller ring maintains the proper lubrication between the cylinder and the piston and is placed under the pressure ring. it also maintains access to lubrication.
- A piston must be a fairly loose fit in the cylinder so it can move freely inside the cylinder. If the piston is too tight fit, it would expand as it got hot and might stick tight in the cylinder and if it is too loose it would leaks the vapor pressure. To provide a good sealing fit and less friction resistance between the piston and cylinder, pistons are equipped with piston rings. These rings are fitted in grooves which have been cut in the piston. They are split at one end so they can expand or slipped over the end of piston. A small two stroke engine has two piston rings to provide good sealing but a four-stroke engine has an extra ring which is known as oil ring. Piston rings are made of cast iron of fine grain and high elastic material which is not affected by the working heat. Sometimes it is made by alloy spring steel.

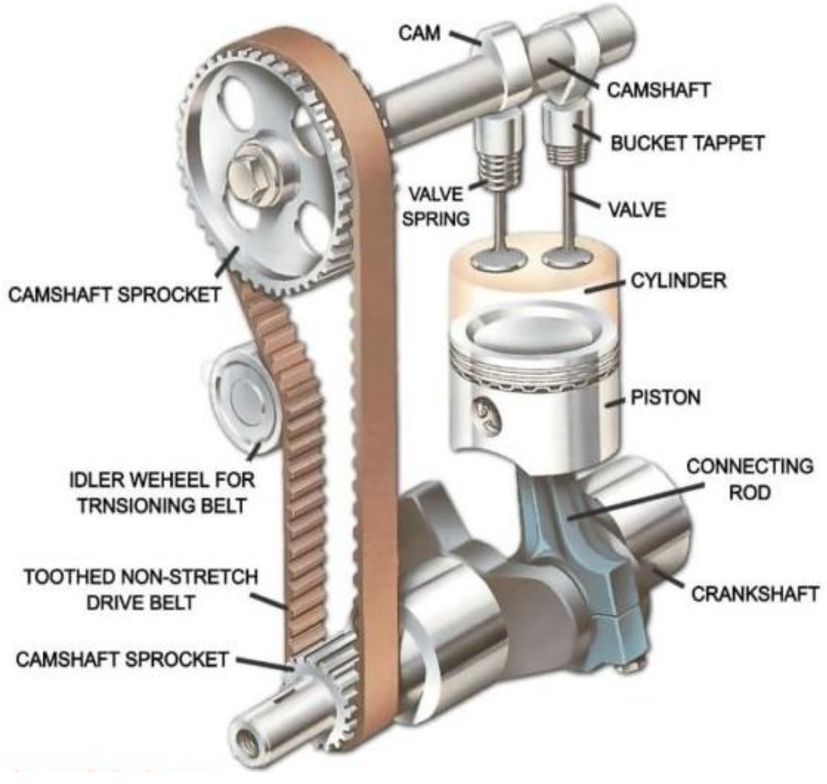
CONNECTING ROD

- A connecting rod is used to connect the piston to the crankshaft with the help of a piston pin and crank pin.
- Connecting rod transmits the reciprocating motion of the piston to into rotary motion of the crankshaft so this is works as a lever arm that transfers the motion from one end to another end.
- There are two end of connecting rod;
- One end is called the big end which is connected to the crankshaft and another end is called the small end which is connected to the piston by use of piston pin.
- Connecting rod made up of Low carbon steel, by the manufacturing process of Heat treatment and forging process.
- The connecting rods are also made of nickel, chrome, and chrome vanadium steels or duralumin by drop forging and has an I-beam cross-section. For small engines the material may be aluminum.
- The piston's compressive and tensile forces must be transmitted by the connecting rod. It can pivot on the piston end and rotate on the shaft end in an internal combustion engine.


piston
connecting rod
sensing teeth
timing chain
power steering pump
drive belt
crankshaft
position sensor
flywheel
crankshaft
crankshaft pulley
drive belt

CRANKSHAFT

- Crank means simply rotating or turning the engine's crankshaft. The crank works as a rotating member that receives power from the connecting rod and transmits to the crankshaft, so the crank works as a lever between the connecting and crankshaft.
- The crankshaft mounts in bearing so it can rotate freely. The shape and size of crankshaft depends on the number and arrangement of cylinders. It is usually made by steel forging, but some makers use special types of cast-iron such as spheroidal graphitic or nickel alloy castings which are cheaper to produce and have good service life.
- In an engine, the crankshaft receives the power or efforts or thrust by the piston through the connecting rod and transmits this power of reciprocating motion of the piston into rotary motion of the crankshaft which is further connected to the flywheel and transmission shaft which is used to move the vehicle.



CAMSHAFT

- A camshaft is a mechanical device used in an IC engine to perform the opening and closing action of the inlet and exhaust valve at the right time. The basic function is to convert rotatory motion into linear motion.
- In an internal combustion engine it is very important that the fuel should come into the cylinder at the right time and the exhaust gases should also leave the cylinder at the right moment of time. This function is accomplished with the help of a camshaft. A camshaft achieves its motion either independently or by the engine crankshaft.
- There are several cams along the length of this part of the car's engine,

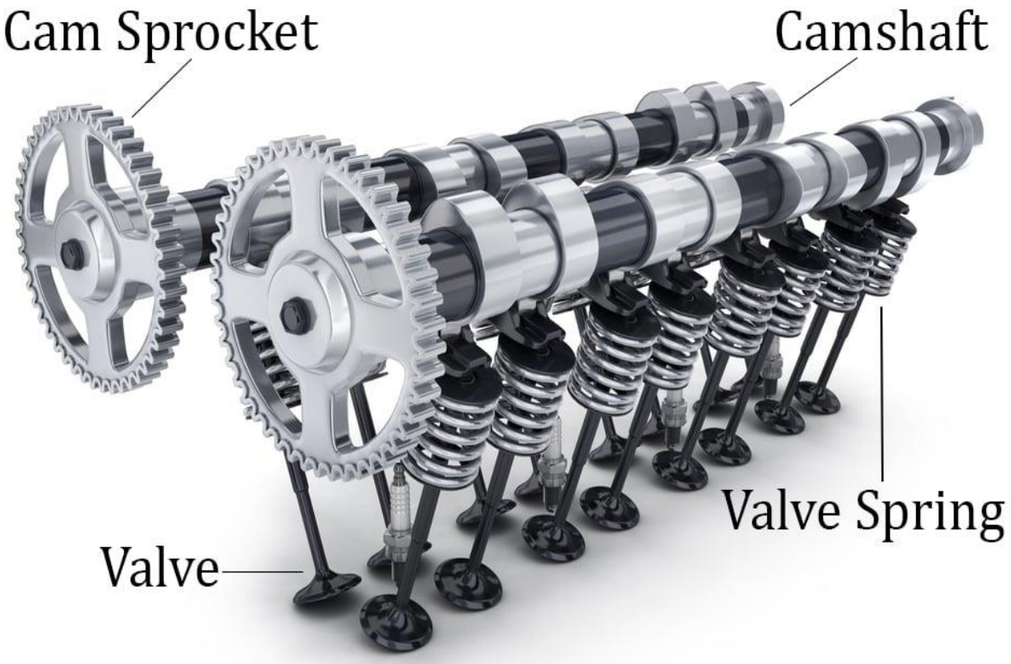
two for each cylinder, one for the inlet valve, and one for the exhaust valve.

The camshaft also contains an eccentric to run the fuel pump and gear

to run the oil pump and ignition distributor.

function of camshaft:

- The following **three functions** are:
- It promotes the opening of the inlet valve during the suction stroke.
- The second function is to open the exhaust valve during the exhaust stroke.
- Lastly, It keeps both the valves closed the rest of the time.

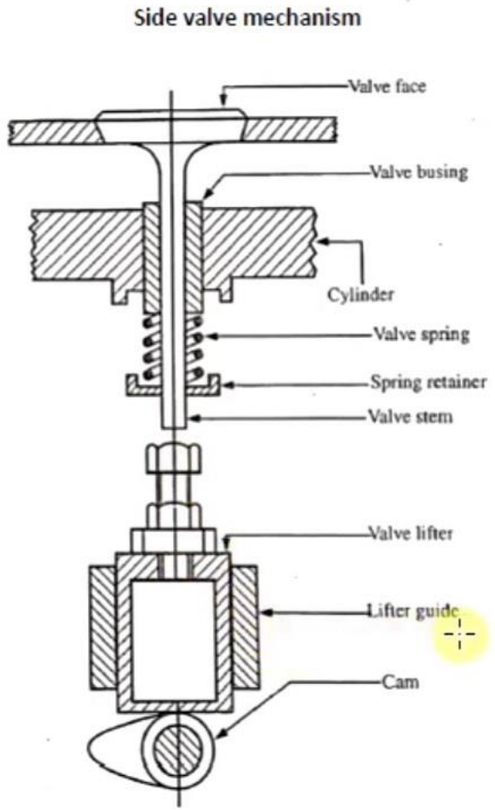


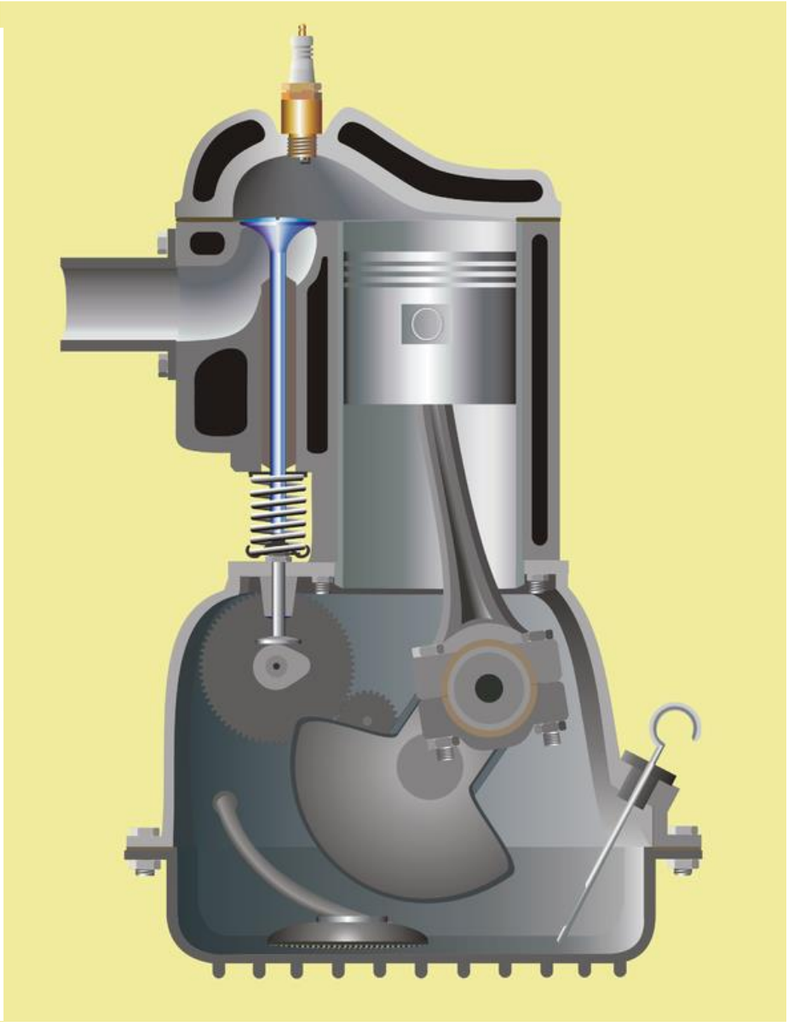
INTAKE AND EXHAUST VALVES

- Intake and Exhaust valves both are responsible for regulating and controlling the charge of air and fuel mixture for coming and burning in the combustion chamber and thereafter to go out the charge of the air from the engine cylinder.
- Both valves are situated either on the cylinder head or on cylinder walls in various shapes generally mushroom shapes.
- The entrance valve is where the air and fuel combination enters petrol engines. Diesel engines' intake valves, meanwhile, can only let air in. The exhaust valve's goal in either scenario is to let exhaust gases out. Intake valves are connected to the intake manifold, while exhaust valves are tied to the exhaust manifold.
- The air-fuel mixture and exhaust gases are carried by separate sets of pipes that are connected to the cylinder head and are known as manifolds. To be able to withstand the high temperature of exhaust gases, it is typically made of cast iron.

SIDE VALVE MECHANISM

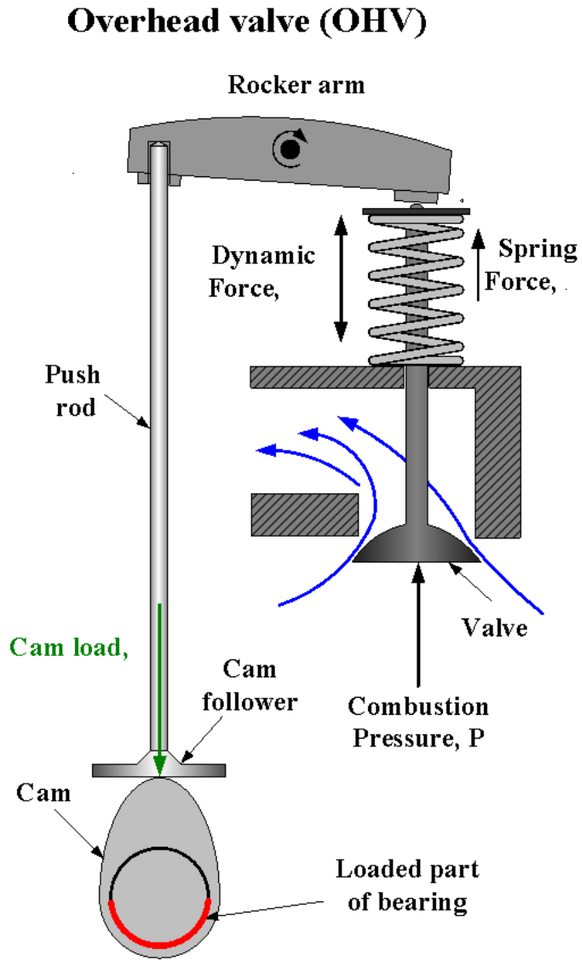
- In this mechanism, the inlet valve is placed on the side of the cylinder valve. When the camshaft rotates the cam, the lobe opens the valve directly through the tappet against the spring's tension. When the cam lobe attains the maximum height, the valve opens completely. Additional rotation of the cam triggers the tappet to move downwards and the valve is stopped by the tension of the valve spring.





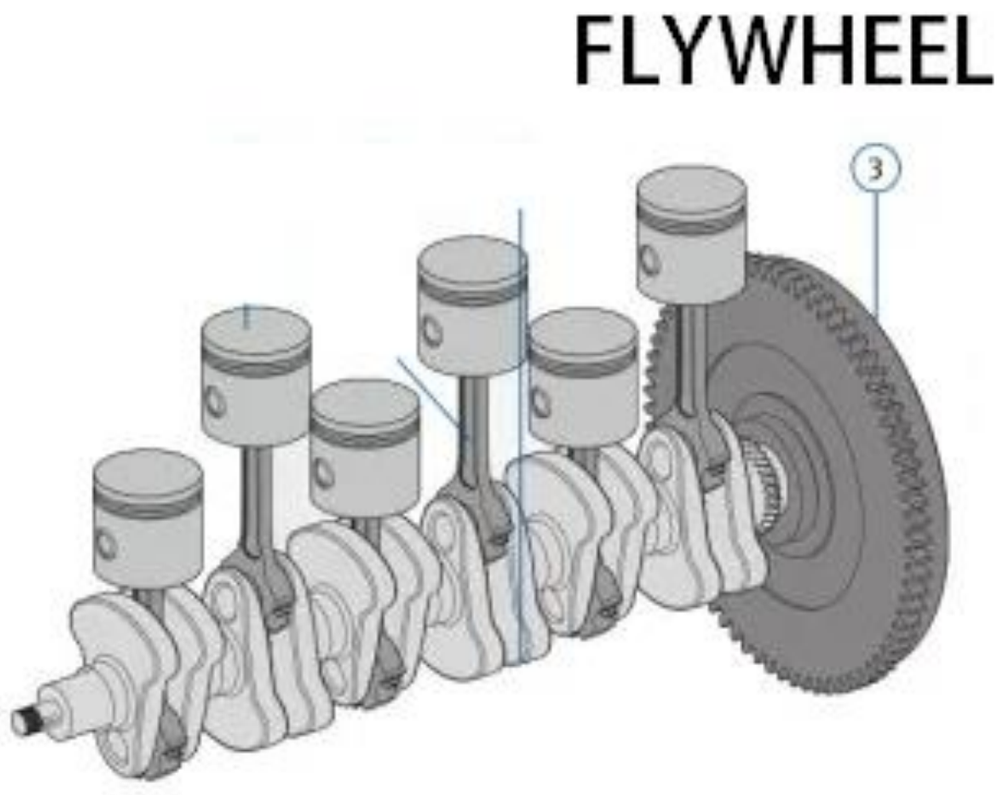
OVERHEAD VALVE MECHANISM

- In this mechanism valves are placed overhead on the combustion chamber. As the camshaft turns, the cam lobe brings the tappet upward. When the tappet moves up, it pushes the push-rod and one end of the rocker arm upwards. The other end of the rocker arm's tip moves downward and the inlet valve opens against the spring's tension. When the cam lobe reaches the maximum height, the valve opens fully. Further rotation of camshaft causes the tappet to move down and the valve is closed by the tension of the spring.



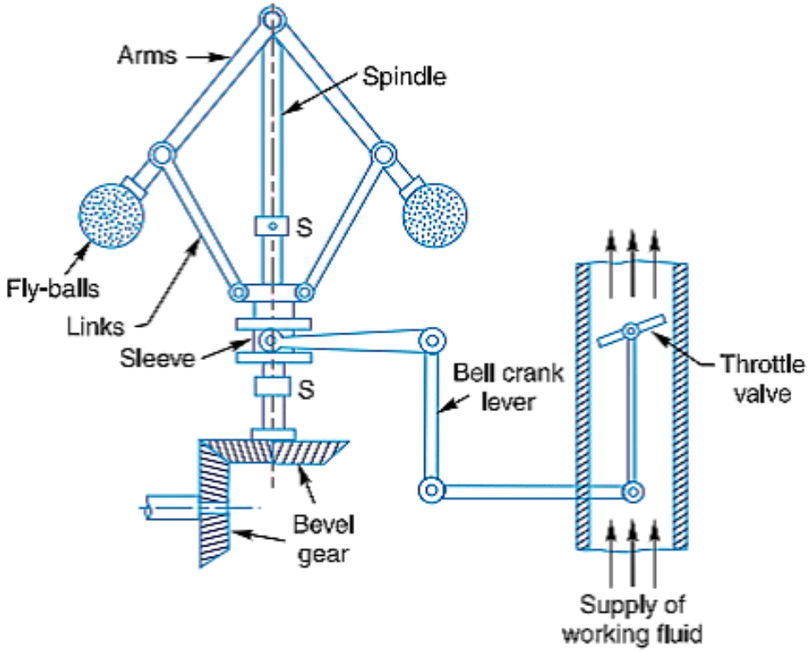
FLYWHEEL

- Flywheel means fluctuation of energy, it reserves the energy and uses this energy when requires it. A Flywheel is an inertial (force) energy storage device.
- The flywheel absorbs mechanical energy and serves as a reservoir during the period when the supply of energy is more than the requirement and releases it during the period when energy is less than required.
- flywheel stores rotational energy, a type of kinetic energy proportional to the product of its moment of inertia and the square of its rotational speed, using the principle of conservation of angular momentum. The engine produces torque, but it is not constant and fluctuates. If a vehicle keeps moving while this erratic power is there. In addition to making the rider extremely uncomfortable, it will also shorten the lifespan of its many components.
- Therefore, a flywheel is employed to tackle the issue of fluctuating load. Typically, a flywheel is positioned on the camshaft. In a cycle of operation, it accumulates torque when it is high and releases it when it is low.



GOVERNOR

- Governor controls the variations of load and maintains the speed of the engine within a specific unit. it controls the speed of the engine by regulating the supply of fuel.
- In governor, there are metal valves that rotate about an axis and generate centrifugal force.
- Governor is a self-acting device. it controls the speed of the engine. when the load on the engine suddenly increases the engine speed will be decreased greater decrement in engine speed can stop the engine
- It is connected to the engine crankshaft when the speed of the engine decreases, the governor also slows down and the sleeve moves downward that opening the valve of fuel supply with the help of lever increment in fuel increase the speed of the engine to mean speed.
- Whereas, in the second case when the load on the engine decreases, Governor also decreases the fuel and controls the speed



NECESSITY OF COOLING SYSTEM

- To carry away the heat produced by combustion of fuel
- To avoid pre-ignition of charge
- To avoid burning away of lubricant ,which causes piston to seize.
- To avoid damage to cylinder material
- To improve the thermal efficiency
- For proper vaporization of fuel , thereby increasing combustion efficiency
- To maintain viscosity of lubricant ,thereby reducing friction and increasing mechanical efficiency

METHODS OF COOLING

- 1. Air cooling
- 2.Water cooling

Air cooling

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

(a) Surface area of metal into contact with air.

(b) Mass flow rate of air.

(c) Temperature difference between the heated surface and air.

(d) Conductivity of metal.

Thus for an effective cooling the surface area of the metal which is in contact with the air should be increased. This is done by using fins over the cylinder barrels.

Advantages:

1. Air cooled engines are lighter because of the absence of the radiator, the cooling jackets and the coolant.
2. They can be operated in extreme climates, where the water may freeze.
3. In certain areas where there is scarcity of cooling water, the air cooled engine is an advantage.
4. Maintenance is easier because the problem of leakage is not there.
5. Air cooled engines get warmed up earlier than the water cooled engines.

Disadvantages:

1 . It is not easy to maintain even cooling all around the cylinder, so that the distortion of the axis takes place.

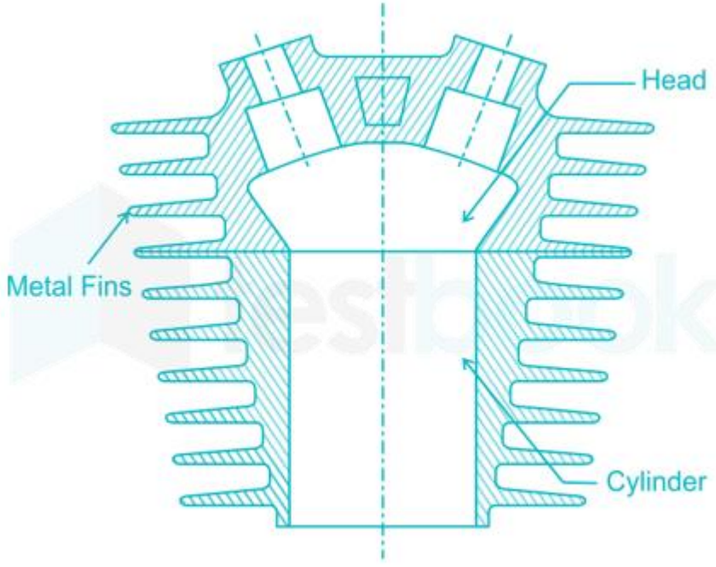
2. As the coefficient of heat transfer for air is less than that for water, there is less efficient cooling as a result the highest useful compression ratio is lesser in the case of air cooled engines than in the water cooled ones.

3. The fan used is very bulky and absorbs a considerable portion of the engine power (about 5%) to drive it.

4. Air cooled engines are more noisy, because of the absence of cooling water which acts as sound insulator.

5. Some engine components may become inaccessible easily due to the guiding baffles and cooling, which makes the maintenance difficult.

6. The cooling fins around the cylinders may vibrate under certain conditions due to which noise level would be considerably enhanced.



WATER COOLING (LIQUID COOLING)

- In water cooling system, the cooling medium used is water. In this, the engine cylinders are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water which goes to the radiator where it loses its heat to the air. Usually some antifreeze is added to the cooling water, due to which it is often referred to as coolant and, the cooling system then also called the 'liquid cooling system'.

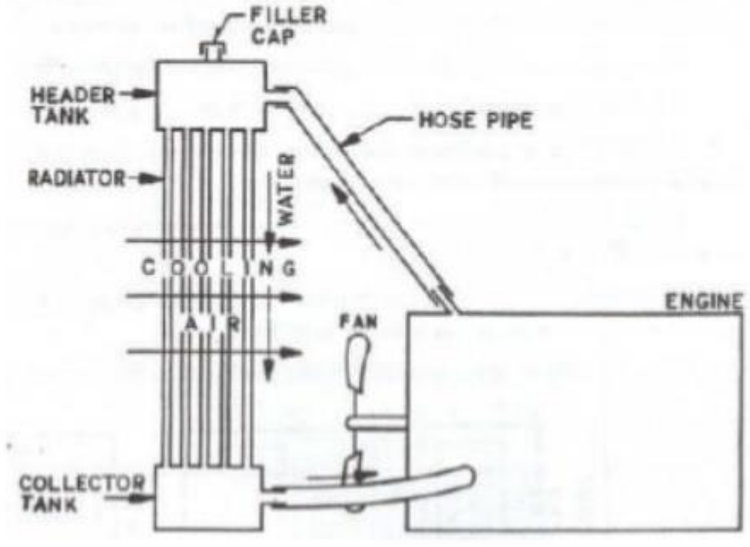
Water cooling systems are of two types:

1. Thermosyphon system
2. Pump circulation system

Thermosyphon system.

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

Thermo syphon cooling system:



advantages of this system are simplicity and low initial cost.

disadvantages

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

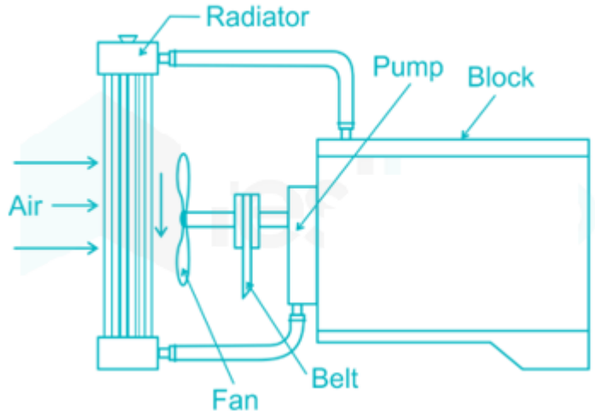
Pump circulation system.

- This system is similar to thermosyphon system with the only differences that a pump is used for the circulation of coolant and a thermostat is employed to control the flow of coolant .The pump is driven by means of a belt from the engine crankshaft. The drive for the fan is also obtained from the same belt that drives the pump and the generator.

advantages over the thermosyphon system:

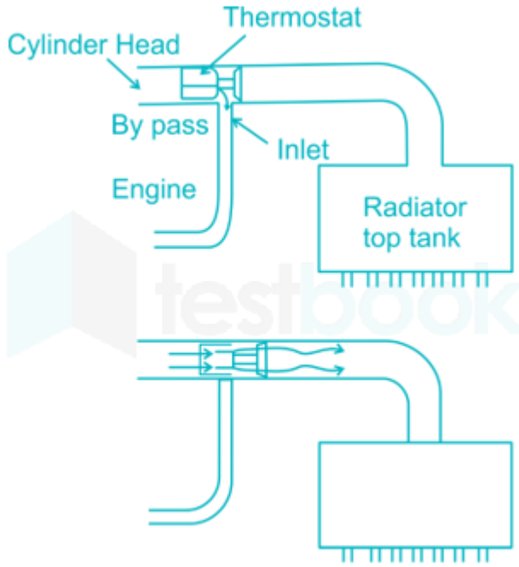
1. Circulation of coolant is proportional to both load and speed.
2. Circulation of coolant is positive and hence more efficient due to which the smaller water jackets can be used resulting in overall decrease of engine size.
3. Unlike in thermosyphon system, it is not necessary to place the radiator header (upper) tank at above the engine level.
4. Even the radiator need not be placed in the front. It can be placed on the side or in the rear. if the design conditions so require.

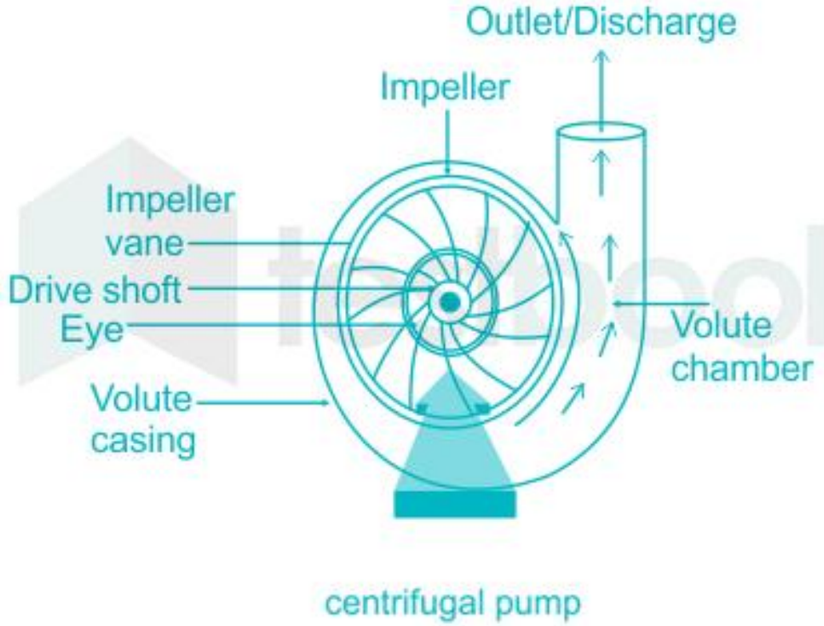
Pump circulation system (Forced feed system)

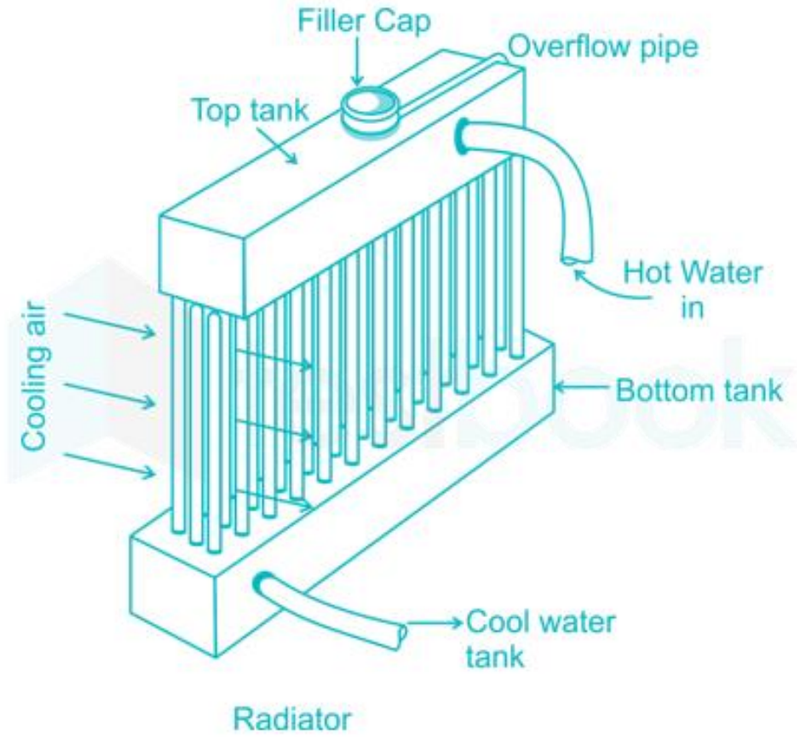


COMPONENTS OF WATER COOLING SYSTEM

- FAN
- RADIATOR
- PUMP
- THERMOSTAT







RADIATOR

- The function of the radiator is to ensure close contact of the hot coolant coming out of the engine with outside air, so as to ensure high rates of heat transfer from the coolant to air.
- A radiator consists of an upper (or header) tank, core and the lower (or collector) tank . Besides, an overflow the header tank and drainpipe in the lower tank are provided.
- Hot coolant from the engine enters the radiator at the top and is cooled by the cross flow of air, while flowing down the radiator. The coolant collects in the collector tank from where it is pumped to the engine for cooling.
- The materials used for radiators should be resistant to corrosion, possess higher thermal conductivity and form easily, apart from having adequate strength.
- Copper and yellow brass are the widely used materials for radiators. Aluminium is also used from weight and cost considerations. The size of the radiator must be adequate to remove the heat which is approximately equal to the heat energy utilized for producing power in the engine. Alternatively, the radiator size is matched to the displacement volume of the engine. The air conditioned vehicle would require a larger radiator due to extra heat load on account of the compressor.
- Besides, it is also ensured that maximum cooling is attained with minimum air resistance. Thus frontal area of the radiator is kept minimum, which may be achieved by making the core thicker and accommodating more core material into the same volume without increasing the air resistance.

THERMOSTAT

- optimum cooling of the engine is desirable and overcooling results in deterioration of engine efficiency. To keep a rigid control over the cooling, therefore, a thermostat is used which automatically keeps the cooling water temperature at a predetermined value.
- it also helps the engine to reach the operating temperature as soon as possible after starting as the engines are designed to operate most efficiently over a small temperature range of 80 C to 100 C
- types of thermostats are used in automobiles: 1.Bellows or aneroid type 2.wax or hydrostatic type
- it consists of with some volatile liquid like acetone, alcohol or ether which boils between 70-85°C. The thermostat is fitted in the coolant hose pipe at the engine outlet . When the engine after start is warming up. it is desired that the cooling system should not operate so that the engine warms up early. During this period, the thermostat valve remains closed, because the liquid inside as yet has not changed its state and. therefore, does not exert any pressure on the valve. As the thermostat valve is closed with the coolant pump running, to avoid excessive pressure build-up, a part of the held-up coolant is made to circulate back through a by-pass to the pump inlet. But as 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. The valve then opens gradually further as the water temperature rises, until it is fully open at about 90-95°C. Thus the thermostat controls the flow of water through the radiator according to the engine cooling requirements.

PUMP

- Pump is used for forced circulation of engine coolant.
- it is driven by crankshaft.
- Centrifugal pump is used for this purpose.
- The coolant from radiator enters the pump at the center .The flow of the coolant depends upon pump speed which is proportional to engine speed.
- At higher engine speed more heat is developed which requires more cooling.
- When the impeller of centrifugal pump rotates the coolant is thrown out due to centrifugal force ,this force is proportional to engine speed .Here the kinetic energy of coolant leaving the pump is converted into pressure energy for circulation of coolant through cooling system

FAN

- When the vehicle is going at high speed with light load ,the natural air passing through the radiator is sufficient for cooling the engine ,but when the vehicle is moving under heavy load and at slow speed (driving uphill) then natural air circulation will be insufficient ,so a fan is used .
- It is mounted behind radiator on the same shaft water pump is mounted.
- Its blade is spaced unevenly to avoid noise.
- It is made of sheet metal.
- A fan should work only at slow speed and should not work at high speed(to reduce engine power wastage , to reduce overcooling) to ensure this blades are of speed sensitive type or temperature sensitive type or the fan is not directly driven from engine but is driven by fluid coupling .

NECESSITY OF LUBRICATION

1. To reduce friction between moving parts to its minimum value so that power loss is minimised.

2. To reduce wear of the moving parts as far as possible.

3. To provide cooling effect. The lubricating oil takes heat from the hot moving parts during its circulation and delivers it to the surrounding air through the crank case.

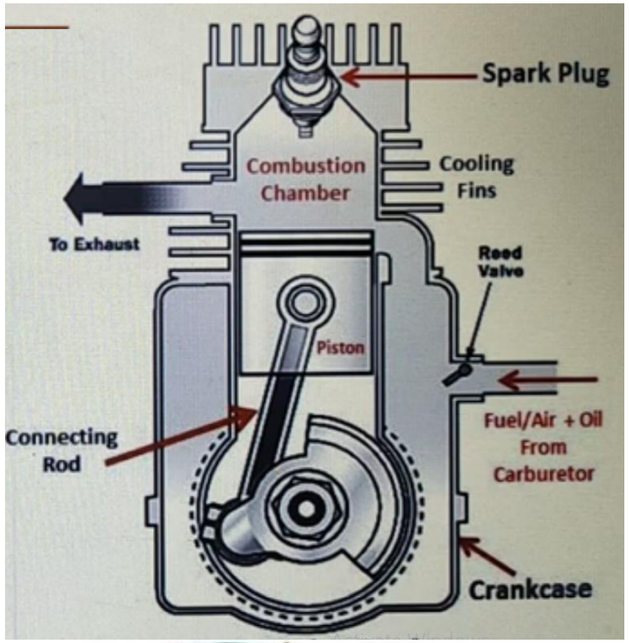
4. To provide cushioning effect. The lubricating oil serves also as a good cushion against the shocks present in the engine. For example, instant combustion of the fuel in the combustion chamber produces a sudden pressure rise in the cylinder and the shock goes to the bearings through the piston, gudgeon pin and the connecting rod. This shock is then absorbed by the layer of oil present in the main bearings.

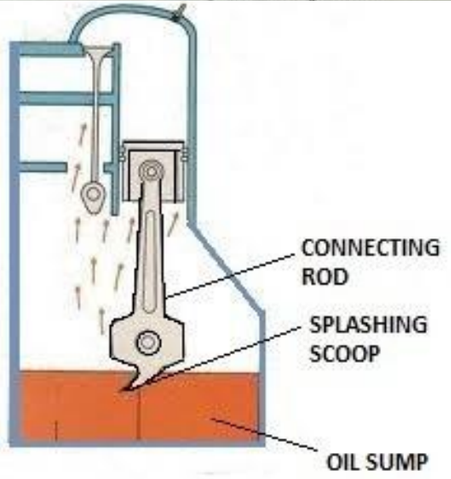
5. To provide cleaning action. Apart from the objects to be achieved by lubrication as described above, the lubricating oil serves another useful purpose in providing a cleaning action. During its circulation it dissolves many impurities, e.g., carbon particles. This oil may be purified by filtration.

6. To provide a sealing action The lubricating oil also helps the piston rings to maintain an effective seal against the high pressure gases in the cylinder from leaking out toward the crank case side.

TYPES OF LUBRICATION

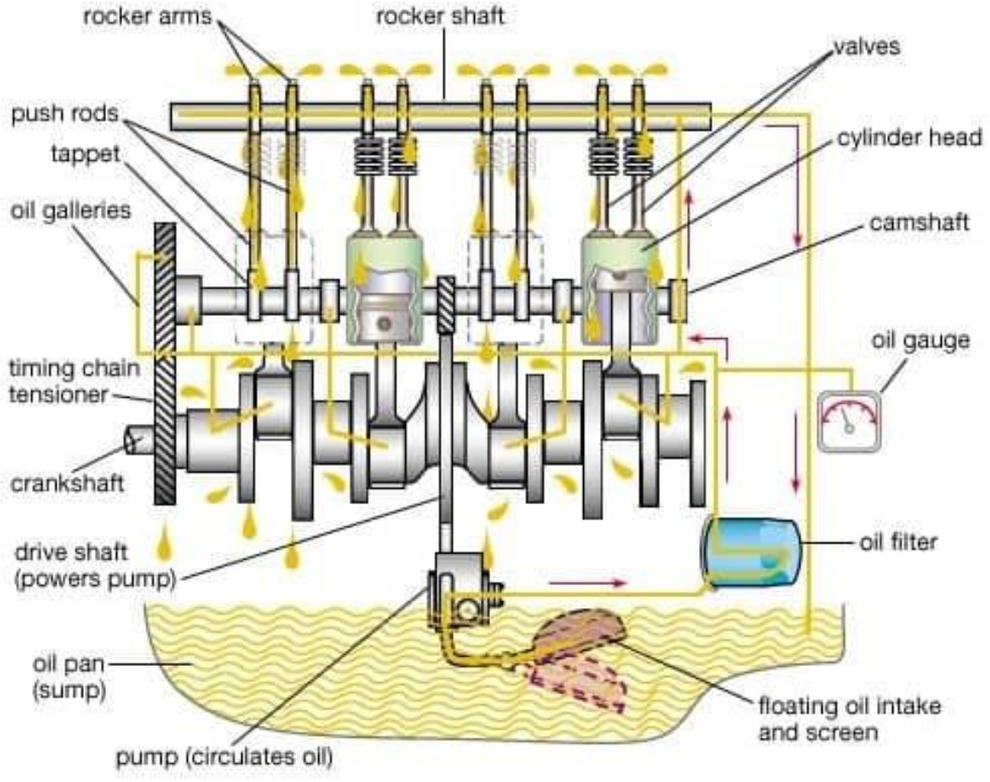
- Petroil/mist System- This is used generally for small two-stroke engines, e.g. in majority of scooter and motorcycle engines‘ It is the simplest of all types of engine lubrication systems. Certain amount of the lubricating oil is mixed with the petrol itself, the usual ratio being 2% to 3% of oil. If it is less, there is danger of oil starvation or insufficient lubrication causing damage to the engine; if however it is more, there will be excessive carbon deposits in the cylinder head and the engine will also give dark smoke. -When the petrol mixture enters the crankcase, due to high temperatures there, the petrol component vaporizes leaving a thin film of lubricating oil on the crankcase, cylinder walls, crankshaft and bearings. The main requirements of lubricating oil for two-stroke engine are that it should readily mix with petrol and burn without leaving much residue.
- Splash System This was employed for the engines of early motor cycles. It is one of the cheapest methods of engine lubrication. A scoop is made in the lowest part of the connecting rod and the oil is stored in the oil trough .it being pumped there from the crankcase oil sump. When the engine runs, the scoop causes the oil to splash on the cylinder walls each time it passes through its B.D.C. position. This affects the lubrication of engine walls,gudgeon pin,main crank shaft bearing, big end bearing etc

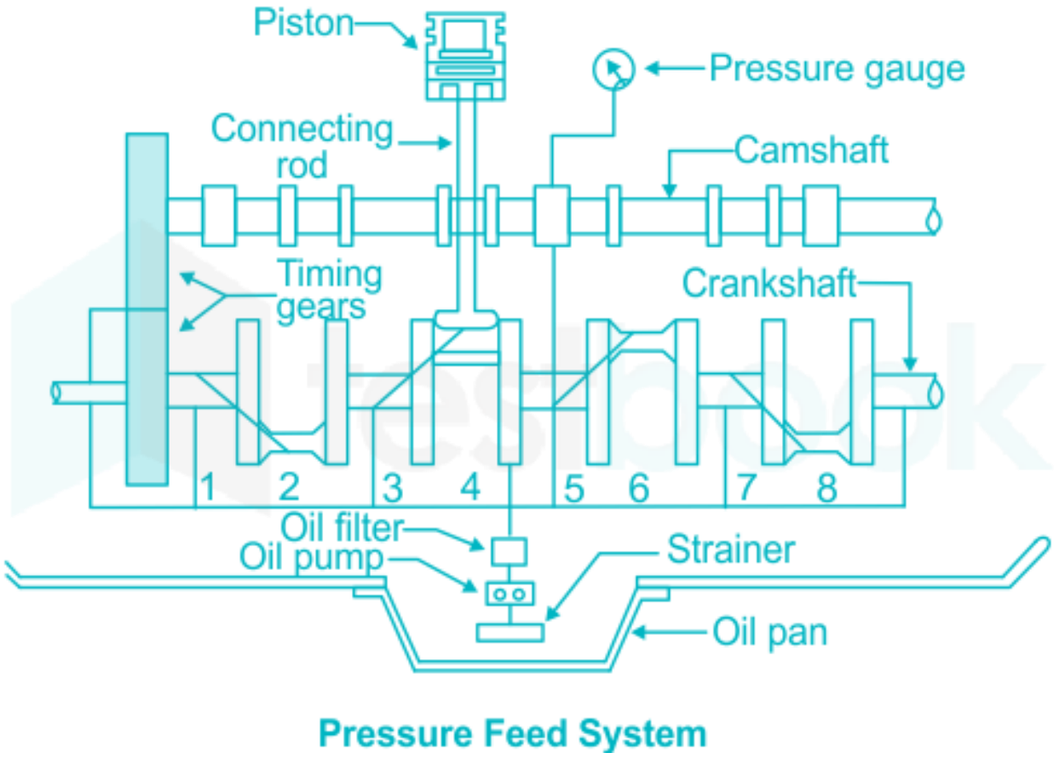




SPLASH SYSTEM LUBRICATION

- Forced system- in this system an oil pump takes oil from wet sump through a strainer and delivers it through a filter to main oil gallery .This pressure is controlled by pressure relief valve .From the gallery oil goes through the drilled passages to the main bearings ,some oil falls back to the sump, some oil is splashed to lubricate cylinder walls,rest of oil goes crank pin and connecting rod .For cam shaft and timing gear lubricating oil is led through separate oil lines through a pressure reducing valve.

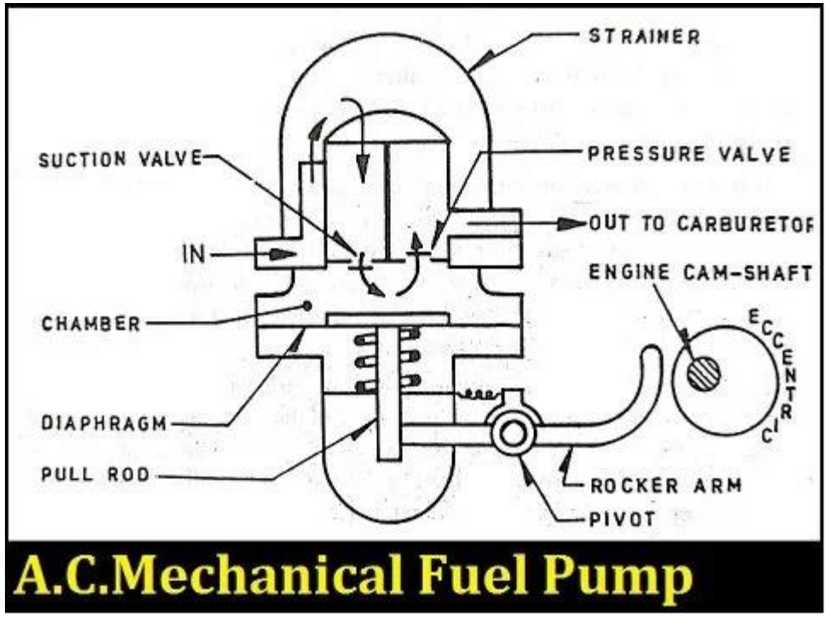




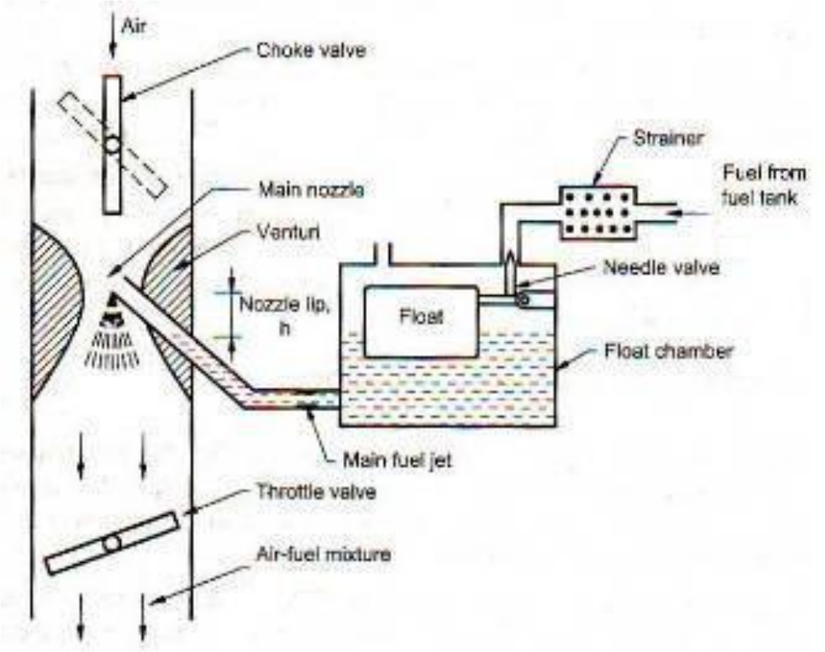
Pressure Feed System

FUEL SYSTEM

- A.C.MECHANICAL PUMP
- The drive for the pump is taken from the camshaft by means of an eccentric or cam. The eccentric operates the rocker arm which is in conjunction with the diaphragm return spring, which pushes the diaphragm up and down.
- The downward movement of the diaphragm causes vacuum in the chamber which causes the inlet valve to open and the fuel then goes through the strainer into the chamber .The next upward movement of the diaphragm causes the inlet valve to close while the outlet valve opens and the fuel goes out to the carburettor float chamber.
- The exact pressure range is being determined by the stiffness of the diaphragm return spring. If the pressure is low, the petrol supply will not be able to keep pace with the demand under high speed or high load conditions. if the pressure is excessive, the needle valve of the carburetor float chamber may be forced open causing the flooding of the carburetor.
- There is no need to pump more fuel when the float chamber of the carburetor is completely filled up. But if the engine continues to run at light load, the camshaft will be running all the time and if no other means are provided the pump will build excessive pressure which may damage the pump itself.



SIMPLE CARBURETOR



The main functions of carburetor are

- To maintain a small reserve of petrol at a constant level in float chamber
- To atomise the liquid fuel and to mix it with air
- To supply air fuel mixture at correct ratio according to engine requirements .
- simple carburettor 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 the float chamber. As the float chamber is filled with fuel, the float rises and actuates the needle to close the valve. When the desired level is reached the valve closes completely so that no additional fuel can enter. When the fuel level drops, the float descends to open the valve, allowing more fuel to enter the float chamber. 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 atomized, mixed with air and vaporized to form homogeneous air-fuel mixture which is admitted to the engine cylinder.

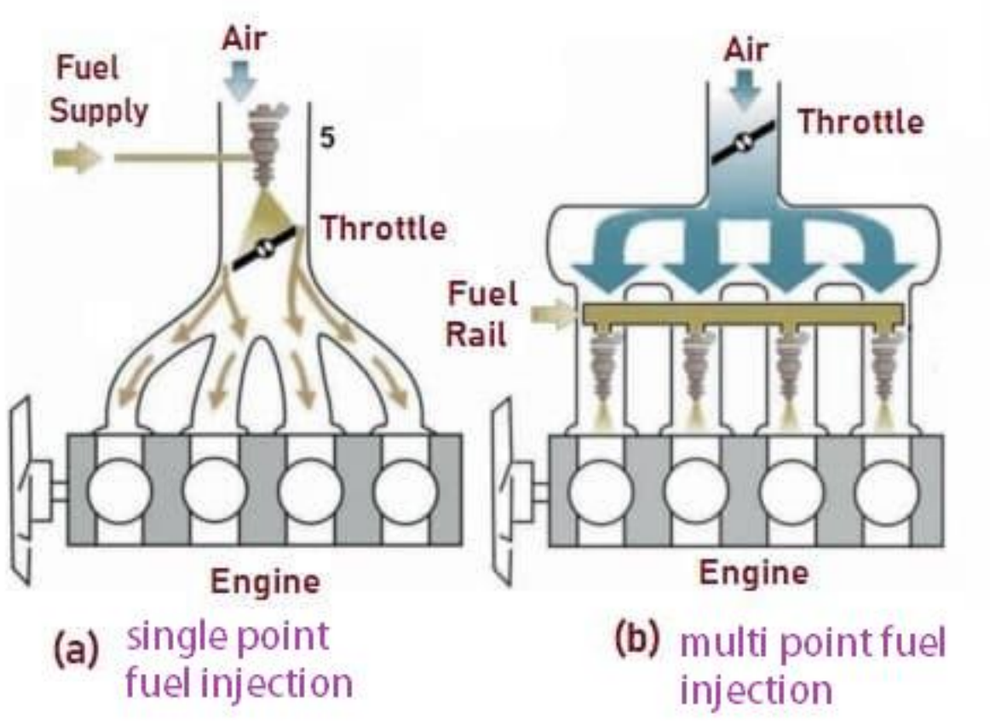
SINGLE POINT AND MULTI POINT FUEL INJECTION SYSTEM

Single point fuel injection system

- It is the fuel injection system that uses a single fuel injector for the mixing of fuel. In this system, the fuel is mixed with air before it reaches to the intake manifold.
- The single-point fuel injection system is also known as the throttle body fuel injection system.

Multi-point fuel injection system

- Multi-point fuel injection is the type of fuel injection system that uses a separate fuel injector for each cylinder.
- The injector sprays the fuel in the intake manifold above the intake valve of each cylinder.
- This fuel injection system is considered as more efficient than the single-point fuel injection system.



Sr.No.	Single-point fuel injection system	Multi-point fuel injection system
1	It uses only a single injector for fuel injection.	It uses a separate fuel injector for each cylinder.
2	The fuel is injected before the intake manifold.	The fuel is injected into the intake manifold before the intake valve.
3	It is arranged before the throttling body.	It is provided after the throttling body.
4	It is also known as throttle body injection.	It is also known as a port fuel injection system.
5	The air-fuel ratio is not uniform for all the cylinders.	The air-fuel ratio is more uniform than single-point fuel injection.

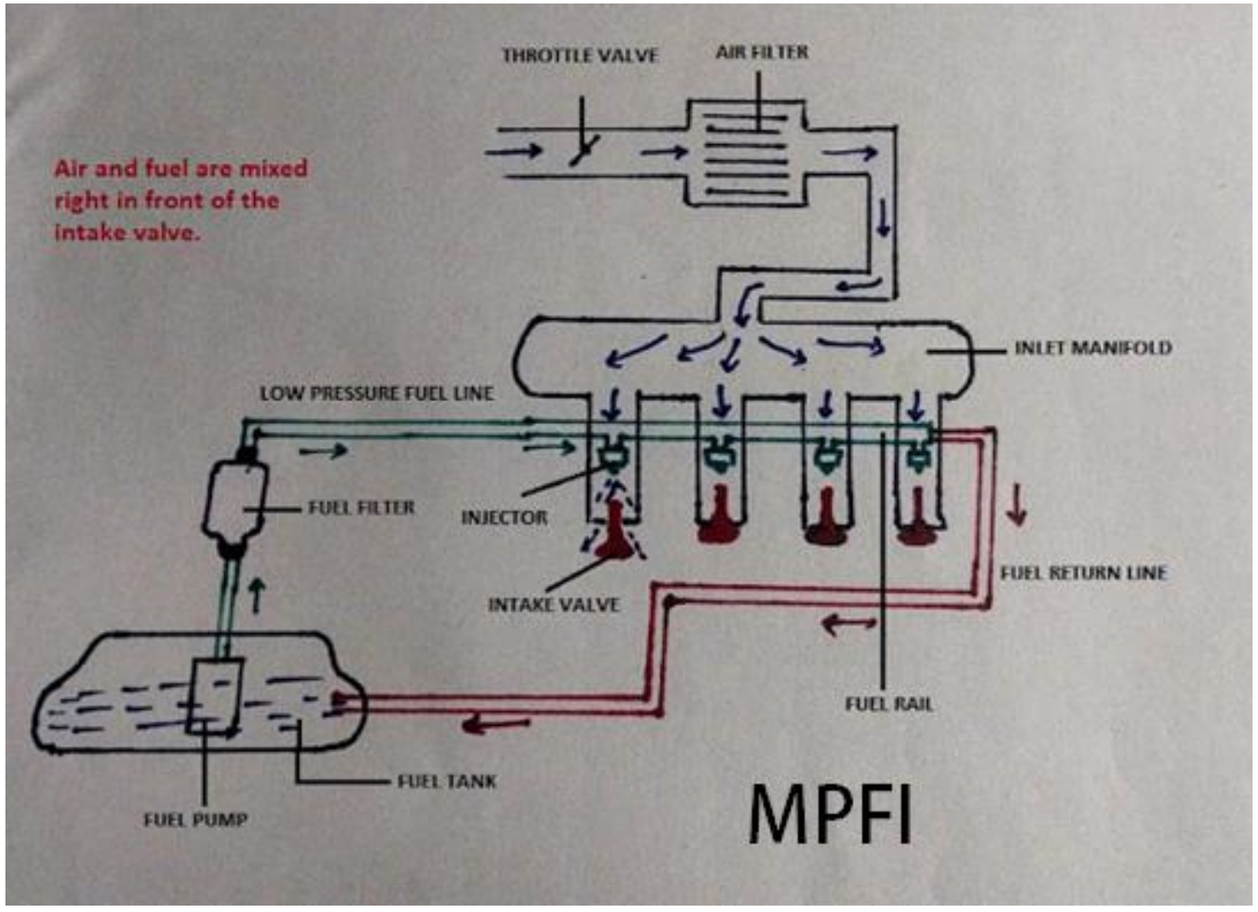
CRDI AND MPFI

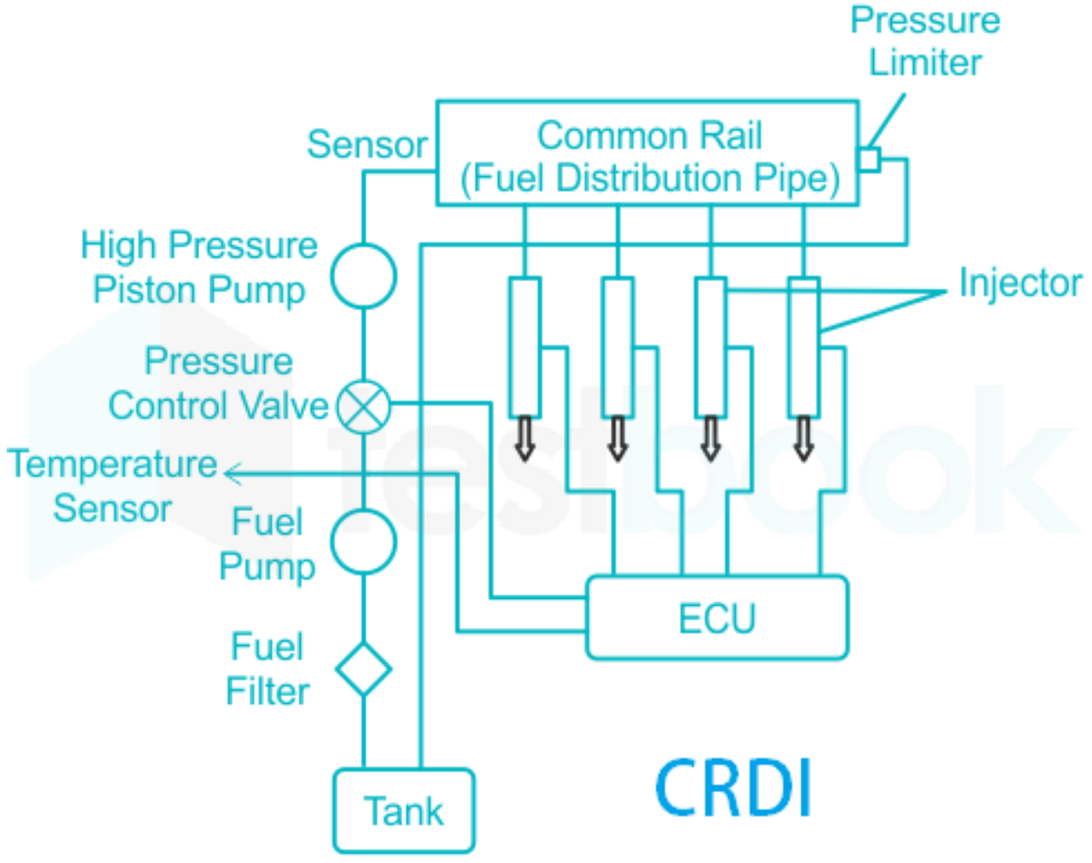
MPFI:

- The multi-point fuel injection is the type of indirect fuel injection system used in gasoline engines. It consists of the fuel injectors fitted before the intake valve of each cylinder. The fuel to the fuel injectors is supplied by the common rail which is pressurized by the fuel pump.
- The opening of the nozzle is controlled by the ECU. The ECU takes the input from different sensors about engine RPM, flowrate and temperature of the air, etc to control the opening of the injectors.

CRDI:

- Common rail direct injection is the fuel injection system used in diesel engines. The fuel injectors in the CRDI system inject the fuel directly into each engine cylinder. All the fuel injectors are connected to the common rail for the fuel supply.
- The higher pressure inside of the common rail is maintained by the two fuel pumps: A high-pressure pump, and a low-pressure pump. In CRDI the opening of the fuel injectors is controlled by the ECU unit. The ECU unit takes the input from throttle sensor pressure and temperature sensor, oxygen sensor, etc to control the opening of the injector.


Air and fuel are mixed right in front of the intake valve.
THROTTLE VALVE
AIR FILTER
INLET MANIFOLD
LOW PRESSURE FUEL LINE
FUEL FILTER
INJECTOR
INTAKE VALVE
FUEL RETURN LINE
FUEL RAIL
FUEL TANK
FUEL PUMP
MPFI


Pressure Limiter
Sensor
Common Rail (Fuel Distribution Pipe)
High Pressure Piston Pump
Injector
Pressure Control Valve
Temperature Sensor
Fuel Pump
ECU
Fuel Filter
Tank
CRDI

Sr. No.	MPFI	CRDI
1	MPFI stands for multi-point fuel injection.	CRDI stands for common rail direct injection system.
2	It is used in petrol or gasoline engines.	It is used in diesel engines.
3	Fuel is injected into the runner of the intake manifold before the intake valve.	Fuel is directly injected into the combustion chamber.
4	The system uses a single fuel injection pump.	The system uses two fuel injection pumps: Low pressure and high pressure.
5	The system operates at a lower pressure than the CRDI system.	The fuel pressure is higher than the MPFI system.
6	The cost of the MPFI system is comparatively lower.	The CRDI is expensive.
7	It has a comparatively lower maintenance cost	The maintenance cost is comparatively higher as it operates at higher pressure.

NECESSITY OF IGNITION SYSTEM

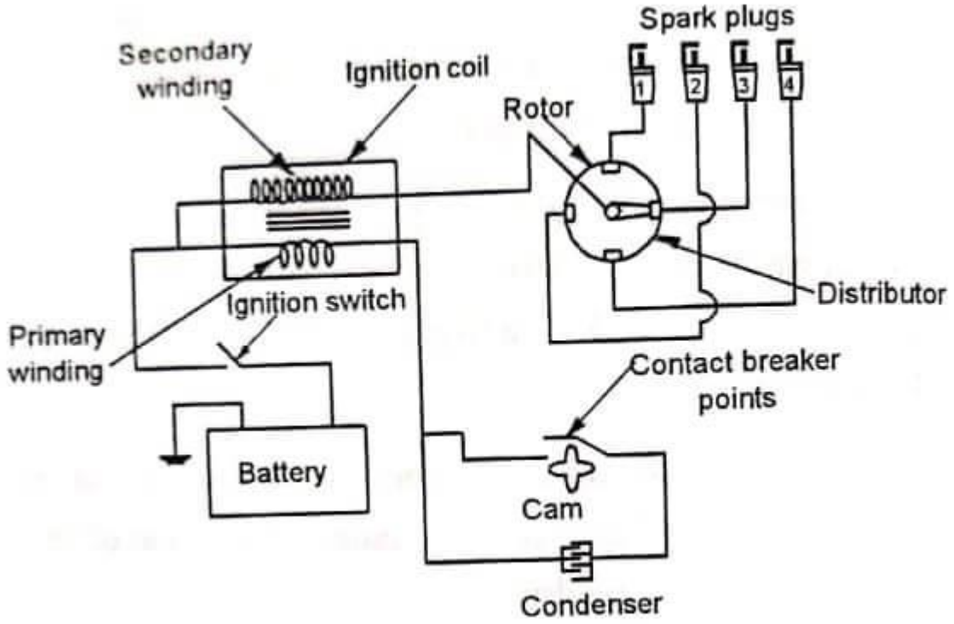
- To produce 30000 volt spark across spark plug
- To distribute high voltage spark to each spark plug in correct sequence
- To time the spark so it occurs as piston is nearing top dead centre
- To vary the spark timing with load ,speed and other conditions

BATTERY IGNITION SYSTEM

It consists of two circuits ,primary and secondary circuits

—The primary circuit consist of the battery, ignition switch, primary coil winding, capacitor, and breaker points. The function of these components are :

- Battery — Provides the power to run the system
- Ignition switch — allows the driver to turn the system on and off
- ignition coil — produces the magnetic field to create the high voltage in the secondary coil.
- Breaker points — a mechanical switch that acts as the triggering mechanism .it is in sync with engine cam.
- Capacitor/condenser — to intensify the spark and to protects the points from burning out.
- Distributor-to distribute the high voltage at regular time interval in the sequence of engine firing order

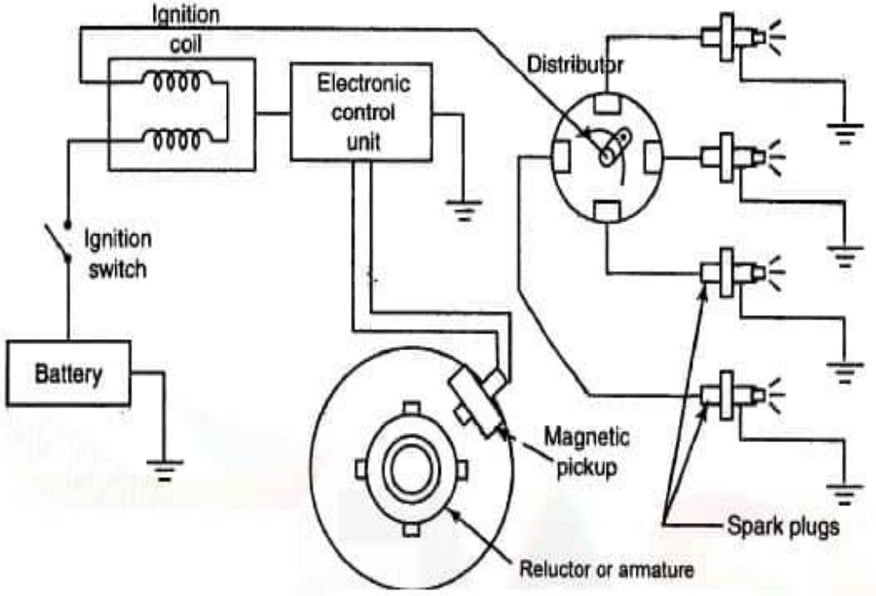


The Secondary circuit converts magnetic induction into high voltage electricity to jump across the spark plug gap, firing the mixture at the right time. The function of the components are —

- secondary coil — the part of the coil that creates the high voltage electricity.
- Rotor — spin around on the top of the distributor shaft, and distributes the spark to the right spark plug.
- spark plug — Take the electricity from the wires and give it an air gap in the combustion chamber to jump across to light the mixture.

ELECTRONIC IGNITION SYSTEM

- **the system is fully controlled electronically**
- **Battery:**it stores energy and whenever require it gives.
- **Ignition switch:** works like on and of the system.
- **Electronic control module:**It is used to ON and OFF the primary current.
- The ignition control module performs the same operation as that contact point performs in battery ignition system.
- **Armature:**It plays an important role in generating the magnetic field. Here armature is used instead of contact breaker point in a conventional ignition system.
- **Ignition coil:**It is a pulse-type transformer, that is capable of producing short fire of high volt for beginning combustion.It produces high voltage required to make pass the current in the gap at the spark plug.
- An ignition coil is set of two sets of winding:Primary Winding and Secondary winding
- **Distributor:**From the primary winding the current flows, Distributor controls on and of the cycle of the current flow.
- The distributor makes spark occurs at each of the spark plugs and distributes high voltage to it.
- **Spark plugs:**It uses ignition coil high voltages to ignites the fuel.



Electronic ignition system

- **Applications of Electronic Ignition System:**
- *This system used in aircraft engines.*
- *It also used in modern bikes and cars.*
- **Advantages of Electronic Ignition System:**
- *It has fewer moving parts.*
- *Low maintenance required.*
- *Less emission generates.*
- *Efficiency is good.*
- *It also increases fuel efficiency.*
- **Disadvantages of Electronic Ignition System:**
- *The cost of this system is high it means expensive in cost.*

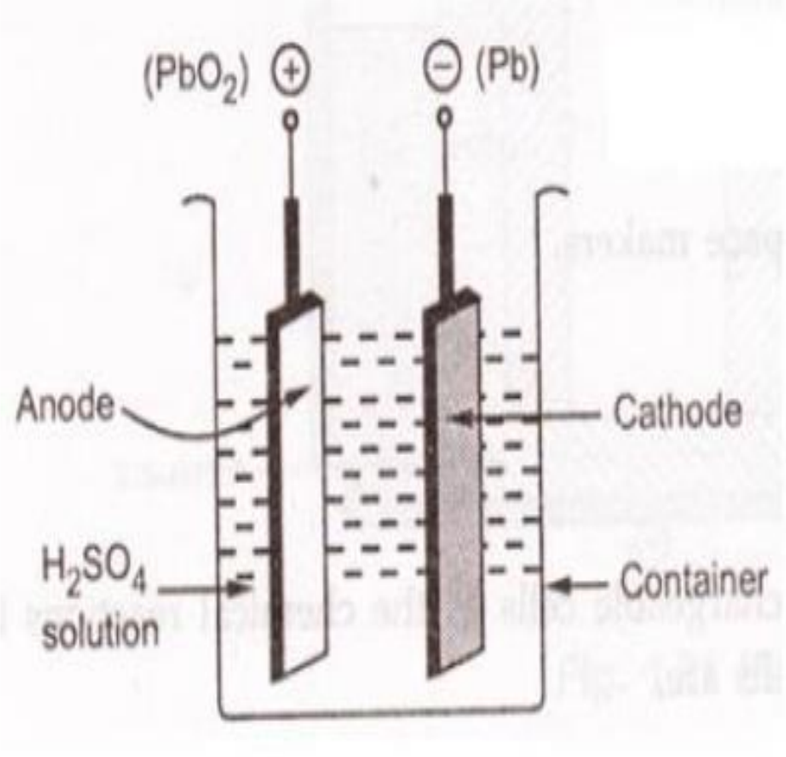
LEAD ACID BATTERY

Lead acid cell

- it contains two plates immersed in dilute sulphuric acid A- Positive plate (anode) is lead peroxide (PbO2) and the negative plate is lead (Pb).

Working .

- When the cell is supplies current to a load (Discharging), the chemical action takes place forms lead sulphate (PbSO4) on both plates with water being formed in the electrolyte.
- To recharge the cell, direct current is passed through the cell in the reverse direction to that in which the cell provided current. This reverses the chemical process and again form lead peroxide (Pb02) positive plates and pure lead (Pb) negative plates. At the same time H2SO4 is formed at the expense of water.



Charging and Discharging of Lead acid cell

Discharging

- When the cell is fully charged its positive plate or anode is PbO_2 and its negative plate or cathode is Pb.
- When the cell discharges i.e. it sends current through the external load, then H_2SO_4 is dissociated into positive H_2 and negative SO_4 ions.
- As the current within the cell is flowing from cathode to anode, H_2 ions move to anode and SO_4 ions move to the cathode

At anode

$$PbO_2 + H_2 + H_2SO_4 \longrightarrow PbSO_4 + 2H_2O$$

At cathode

$$Pb + SO_4 \longrightarrow PbSO_4$$

Charging

- Inoder to recharge the cell, direct current is passed through the cell in the reverse direction to that in which the cell provided current.
- During charging the H_2 ions move to cathode and SO_4 ions goto anode .

At anode

$$PbSO_4 + H_2 \longrightarrow Pb + H_2SO_4$$

At cathode

$$PbSO_4 + 2H_2O \longrightarrow PbO_2 + 2\,H_2SO_4$$

Construction of Lead Acid Battery

Following are the essential parts of lead acid battery

Container:

- The container houses the plates and the electrolyte.
- It is made of acid resisting materials like glass or hard rubber depending upon service requirements.

Positive Plate

- Positive plate is made of lead peroxide (PbO_2) deposited on a grid frame.
- The grid frame is made of antimony-lead alloy.

Negative Plate:

- Negative plate is made spongy lead (Pb).
- It is also deposited on a grid frame for stiffness and strength.

Separator:

- It is made of thin sheet of porous insulating materials.
- The positive and negative plates are separated electrically by the separators.
- The separators must allow free circulation of the electrolyte between the plates.
- These are made of specially treated wood, glass, rubber etc.

Electrolyte:

- The electrolyte is dilute sulphuric acid (H_2SO_4). Battery grade sulphuric acid is used for the preparation of electrolyte.

Cell covers and Vent plugs:

- Each cell has a cover made of moulded hard rubber.
- Openings are provided in these covers for two terminal posts and vent plug.
- Vent plug has a vent hole for easy escape of gas formed inside the cell during charging.
- Vent plugs can be easily removed for adding electrolyte.

Cell connectors:

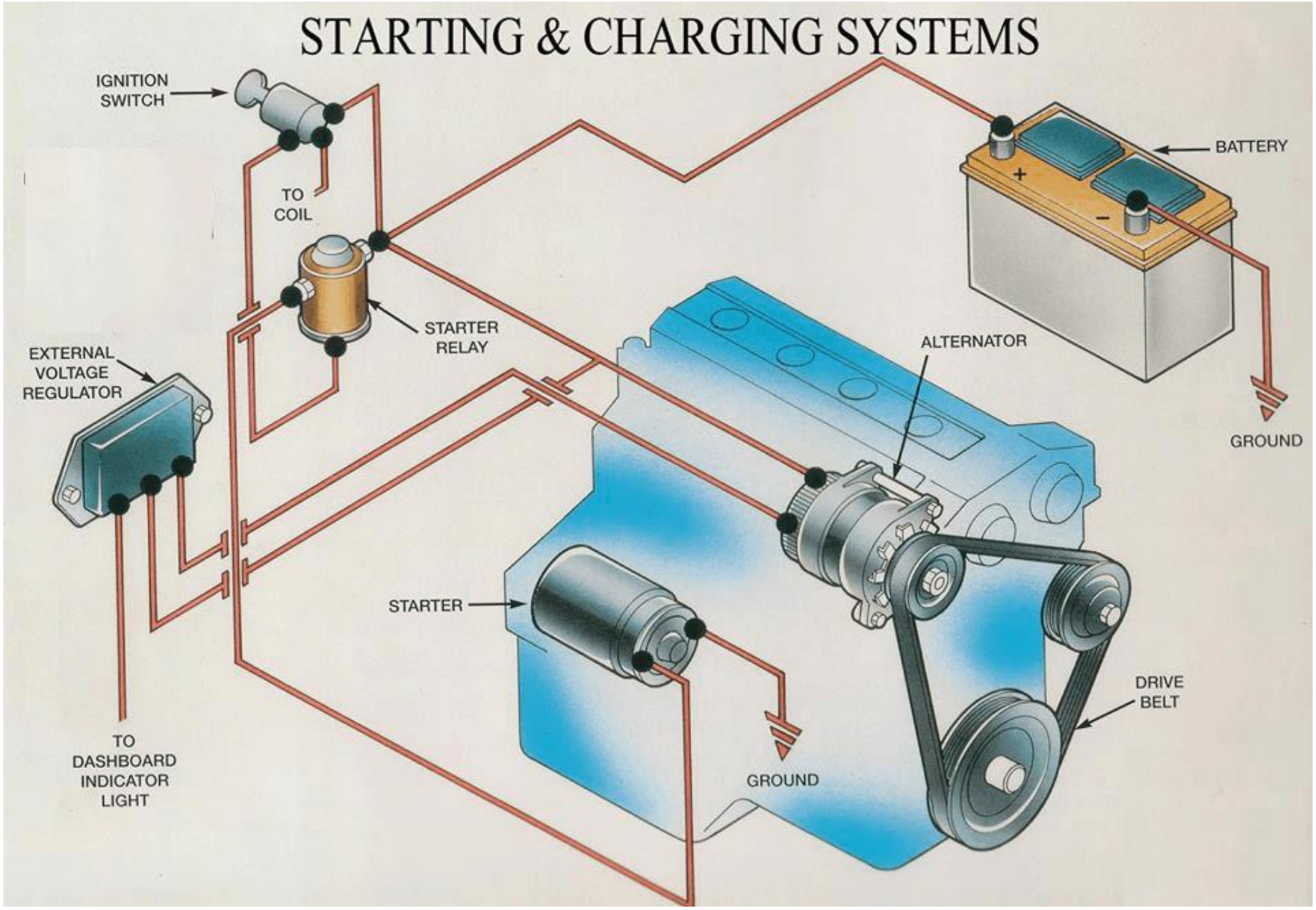
- Cell connectors are used to connect the individual cells in series to give the required voltage.
- Lead alloys are the material normally used as cell Connector.
- Corrosion due to sulphuric acid is normally avoided by proper coating.

Battery terminals:

- A battery has two terminals, the +ve and the -ve.
- The polarities are marked on the terminals.
- The terminals are generally made of lead alloys

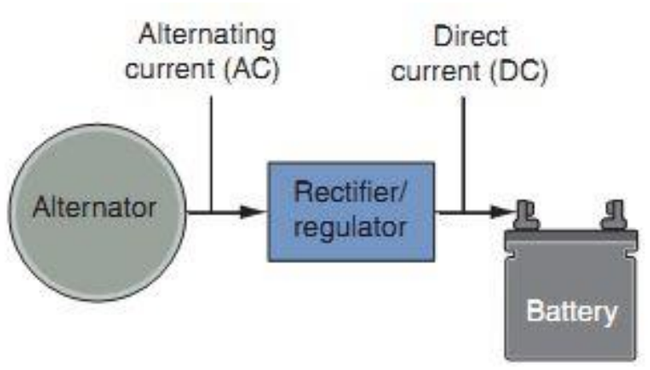
Capacity of a battery

- It is the quantity of electricity which can give out during single discharge.
- It is measured in Amper – houre


STARTING & CHARGING SYSTEMS
IGNITION SWITCH
TO COIL
STARTER RELAY
BATTERY
+
−
GROUND
EXTERNAL VOLTAGE REGULATOR
ALTERNATOR
STARTER
DRIVE BELT
TO DASHBOARD INDICATOR LIGHT
GROUND

ELEMENTS OF CHARGING SYSTEM

- **Battery** The function of the battery is as a storage of electrical energy. Like a warehouse, the battery will store all the electrical energy generated by the alternator and then this stored electricity is removed when necessary.



CHARGING SYSTEM

Regulator The function of the regulator is to regulate the voltage generated by the alternator.it is used because the voltage generated by the alternator depends the engine's RPM. This means that if the engine RPM is low, the alternator voltage is also low, but if the engine RPM is high then the alternator voltage is also high. The regulator will be used to keep the voltage generated by the alternator not exceeding 14 volts even if the engine run in high RPM. This voltage setting aims to protect the electrical components of the vehicle to prevents over-voltage.

There are two types of regulators, namely type or conventional type and IC type . The point type/conventional uses two coils to adjust the alternator's output voltage. While the IC Regulator uses an IC circuit (Integrated Circuit) to regulate the output voltage.

- **ALTERNATOR-**The function of the alternator is to convert a partial engine's rotating energy into electricity. The alternator input comes from the engine pulley connected through a V belt, the rotation of the rotor will cause the intersection of the magnetic force line with the stator coil so that the electrons flow on the stator coil.

  The electricity in the stator coil is not directly connected to the battery, but it must pass through the diode bridge to rectify the current. This is done because the current in the stator coil is AC (Alternate Current).

ELEMENTS OF STARTING SYSTEM

- **1. Battery**
- The automotive battery, also known as a lead-acid storage battery, is an electrochemical device that produces voltage and delivers current. In an automotive battery we can reverse the electrochemical action, thereby recharging the battery, which will then give us many years of service. The purpose of the battery is to supply current to the starter motor, provide current to the ignition system while cranking, to supply additional current when the demand is higher than the alternator can supply and to act as an electrical reservoir.
- **2. Starter Relay**
- A relay is a device that allows a small amount of electrical current to control a large amount of current. An automobile starter uses a large amount of current (250+ amps) to start an engine. If we were to allow that much current to go through the ignition switch, we would not only need a very large switch, but all the wires would have to be the size of battery cables (not very practical). A starter relay is installed in series between the battery and the starter. Some cars use a starter solenoid to accomplish the same purpose of allowing a small amount of current from the ignition switch to control a high current flow from the battery to the starter. The starter solenoid in some cases also mechanically engages the starter gear with the engine.

- **3.Starter Motor**
- The starter motor is a powerful electric motor, with a small gear (pinion) attached to the end. When activated, the gear is meshed with a larger gear (ring), which is attached to the engine. The starter motor then spins the engine over so that the piston can draw in a fuel/ air mixture, which is then ignited to start the engine. When the engine starts to spin faster than the starter, a device called an overrunning clutch (bendix drive) automatically disengages the starter gear from the engine gear.

GOVERNING SYSTEM

- Types of governing system
- **Hit and miss governing**. In this system of governing, whenever the engine starts running at higher speed (due to decreased load), some explosions are omitted or missed. This is done with the help of a centrifugal governor. This method of governing is widely used for I. C. engines of smaller capacity or gas engines.
- **2. Qualitative governing**. In this system of governing, a control valve is fitted in the fuel delivery pipe, which controls the quantity of fuel to be mixed in the charge. The movement of control valve is regulated by the centrifugal governor through rack and pinion arrangement.
- **3. Quantitative governing**. In this system of goverliing, the quality of charge (i.e. air-fuel ratio of the mixture) is kept constant. But the quantity of mixture supplied to the engine cylinder is varied by means of a throttle valve which is regulated by the centrifugal governor through rack and pinion arrangement.