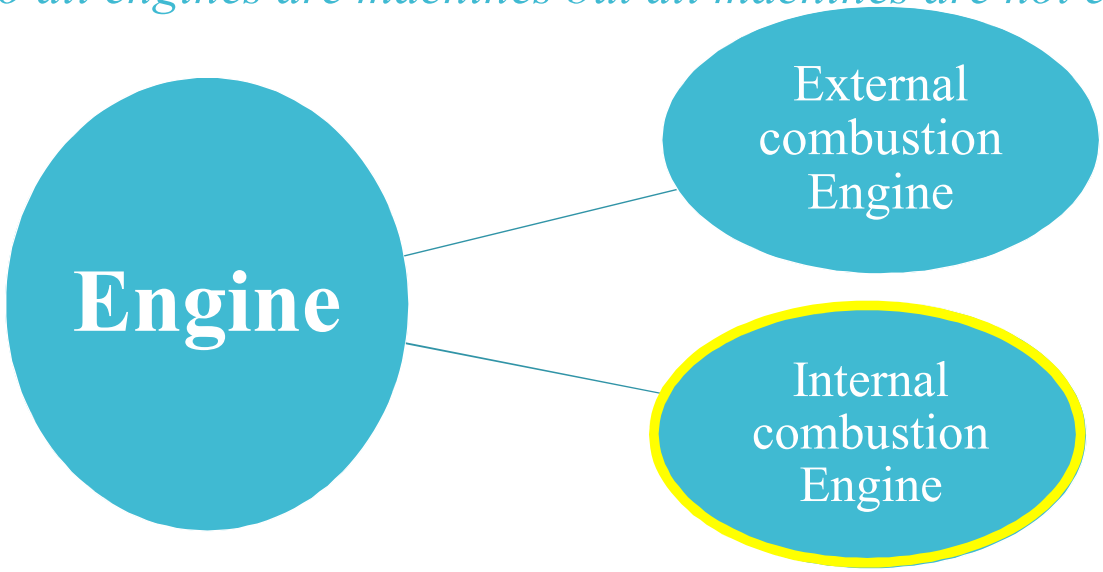
Introduction to IC Engines

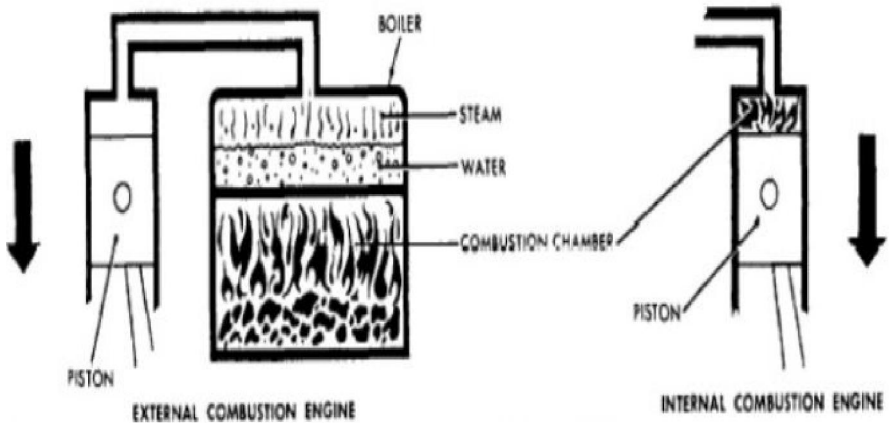
Engine & Machine

- Machine is a device which converts any available form of energy into useful work(i.e. mechanical energy). Example: Lathe machine, milling machine, drilling machine etc.
- Engine is a device which converts thermal energy into useful work work(i.e. mechanical energy). Example: Diesel Engine, petrol engine, steam engine etc.
- *"So all engines are machines but all machines are not engines".*



Internal Combustion Engine

- **External combustion Engine:** External combustion engines are those in which combustion takes place outside the engines. Heat produced during external combustion is used for inducing useful mechanical motion in the cylinder of the engine. Ex: Steam Engine, Steam Turbine etc.
- **Internal combustion Engine:** Internal combustion Engines are those in which combustion takes place within the engine. Chemical energy of the fuel is converted to thermal energy and thermal energy is converted to mechanical energy. Ex: Gasoline Engine, Diesel Engine etc.



Differences Between Internal Combustion Engine and Steam Engine

S. No	Steam Engine	IC Engine
1	Combustion of fuel takes place outside the engine cylinder(i.e. in a boiler)	Combustion of fuel takes place inside the engine cylinder
2	Since combustion of fuel takes place outside the engine cylinder, therefore these engines are smooth and silent running.	Since combustion of fuel takes place inside the engine cylinder, these engines are very noisy.
3	The working temperature and pressure inside the steam engines are low.	The working temperature and pressure inside the IC engines are very high
4	Because of low pressure and temperature, ordinary alloys are used for the manufacture of engine cylinder and its parts.	Because of high pressure and temperature, special alloys are used for the manufacture of engine cylinder and its parts.
5	It is heavy and cumbersome(because it requires a boiler and other component).	It is light and compact.
6	Efficiency is about 15-20%	Efficiency is about 35-40%
7	It can not be started instantaneously	It can be started instantaneously

Classification of IC Engine

- **According to the type of fuel used**

  a) Petrol engines, b) Diesel engines, and c) Gas engines.

- **According to the method of igniting the fuel**

  a) Spark ignition engines, and b) Compression ignition engines.

- **According to the number of strokes per cycle**

  a) Four stroke cycle engines, and b) Two stroke cycle engines.

- **According to the cycle of operation**

  a) Otto cycle engines, b) Diesel cycle engines, and c) Dual cycle engines.

Classification of IC Engine

- **According to the speed of the engine**
  - a) Slow speed engines, b) Medium speed engines, and
  - c) High speed engines.
- **According to the cooling system**
  - a) Air-cooled engines, and b) Water-cooled engines.
- **According to the method of fuel injection**
  - a) Carburetor engines, and b) Air injection engines.
- **According to the number of cylinders**
  - a) Single cylinder engines, and b) Multi-cylinder engines.

Classification of IC Engine

- **According to the arrangement of cylinders**

  a) Vertical engines, b) Horizontal engines, c) Radial engines, d) In-line multi-cylinder engines, e) V-type multi-cylinder engines, f) Opposite-cylinder engines, and g) Opposite-piston engines.

- **According to the valve mechanism**

  a) Overhead valve engines, and b) Side valve engines.

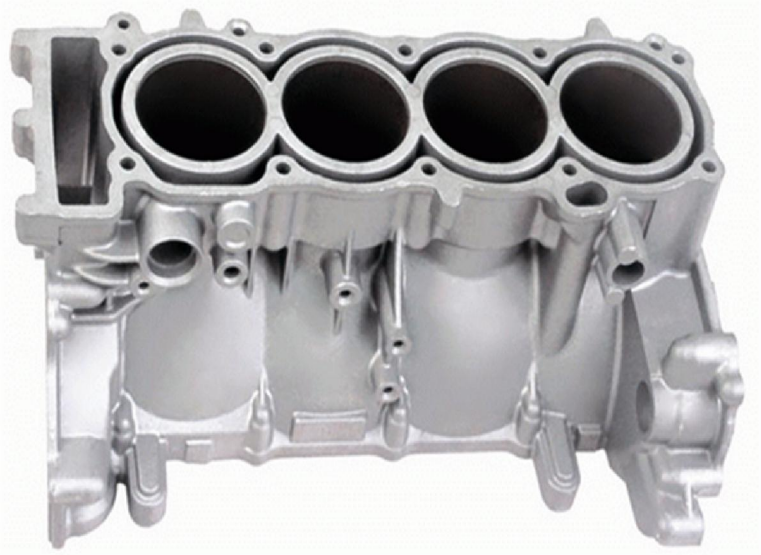
- **According to the method of governing**

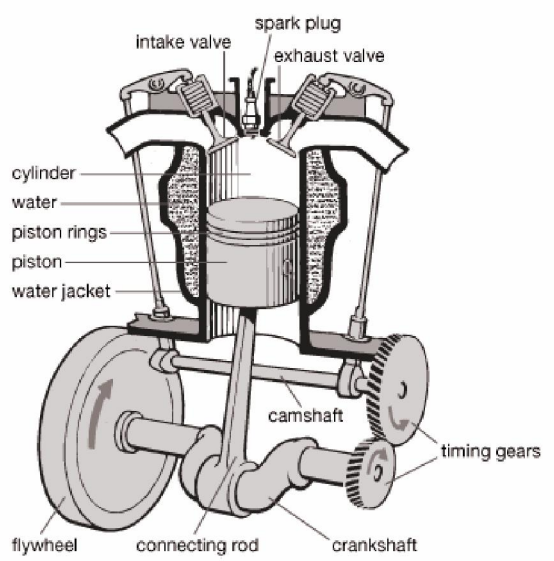
  a) Hit and miss governed engines, b) Quantitatively governed engines, and Qualitatively governed engines.

Parts of IC Engine

Cylinder

It is one of the most important part of the engine, in which the piston moves to and fro in order to develop power. The material(cast iron for ordinary engine and steel alloy & aluminum alloy for heavy duty engine) for the engine cylinder should be such that it can retain sufficient strength at such a high pressure and temperature.

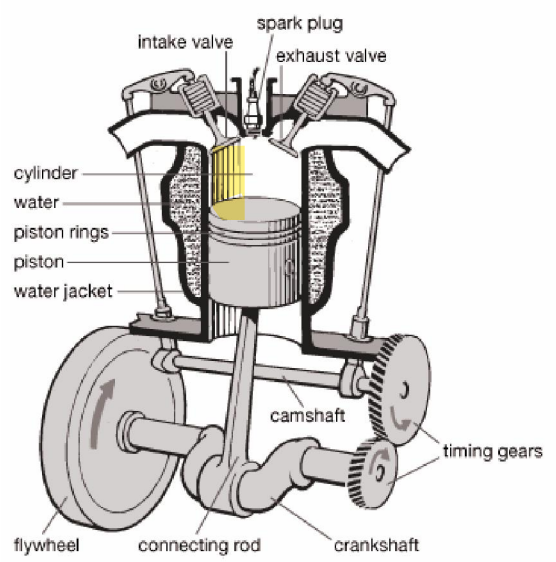




Parts of IC Engine

Cylinder Head

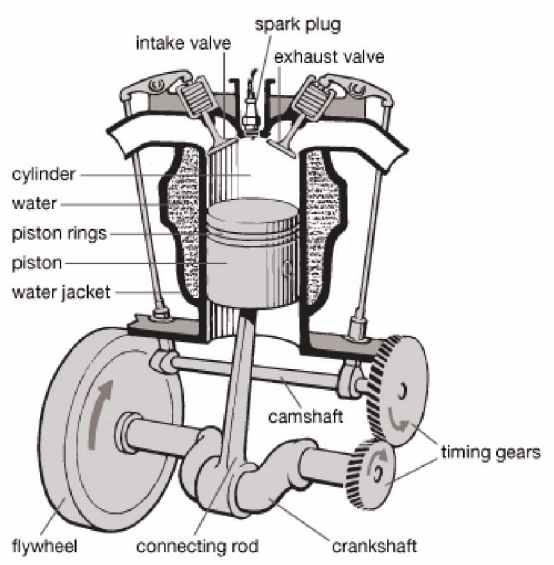
It is fitted on one end of the cylinder, and act as a cover to close the cylinder bore. Generally, the cylinder head contains inlet and exit valves for admitting fresh charge and exhausting the burnt gases. In petrol engines, the cylinder head also contains a spark plug, but in diesel engines, the cylinder head contain nozzles.



Parts of IC Engine

Piston

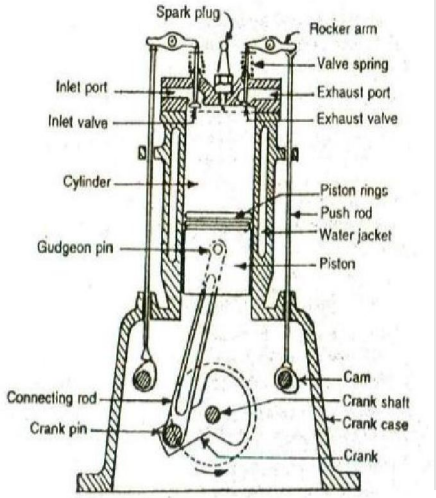
It is considered as the heart of an I.C. engine, whose main function is to transmit the force exerted by the burning of charge to the connecting rod. The piston are generally made of aluminum alloys which are light in weight. They have good heat conducting property and also greater strength at higher temperature.



Parts of IC Engine

Piston Rings

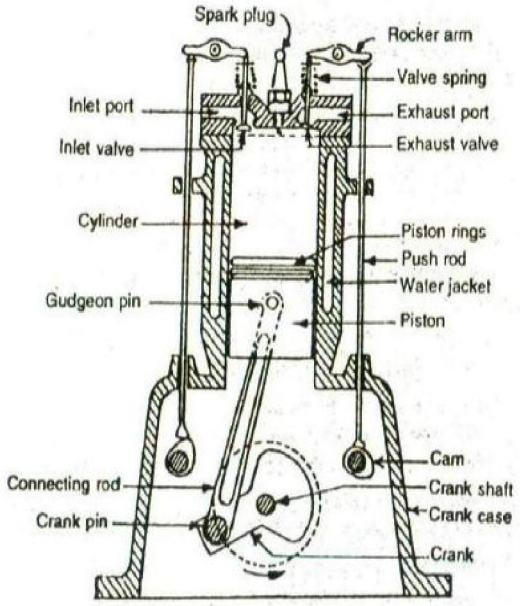
These are circular rings and made of special steel alloys which are housed in the circumferential grooves provided on the outer surface of the piston. Generally, there are two sets of rings mounted for the piston. The function of the upper rings is to provide air tight seal to prevent leakage of the burnt gases into the lower portion. Similarly, the function of the lower rings is to provide effective seal to prevent leakage of the oil into the engine cylinder.



Parts of IC Engine

Connecting Rod

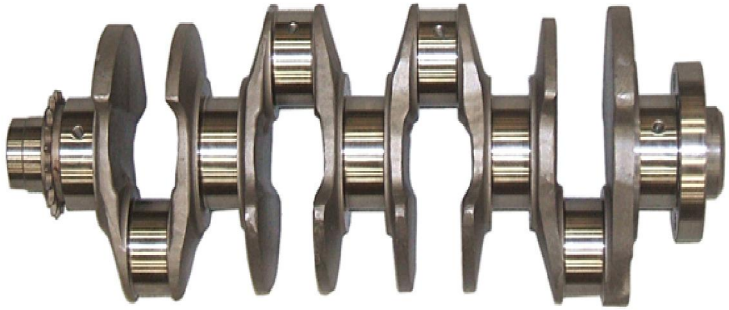
It is a link between the piston and crankshaft, whose main function is to transmit force from the piston to the crankshaft. Moreover, it converts reciprocating motion of the piston into circular motion of the crankshaft, in the working stroke. The upper (i.e. smaller) end of the connecting rod is fitted to the piston and the lower (i.e. bigger) end of the crank.

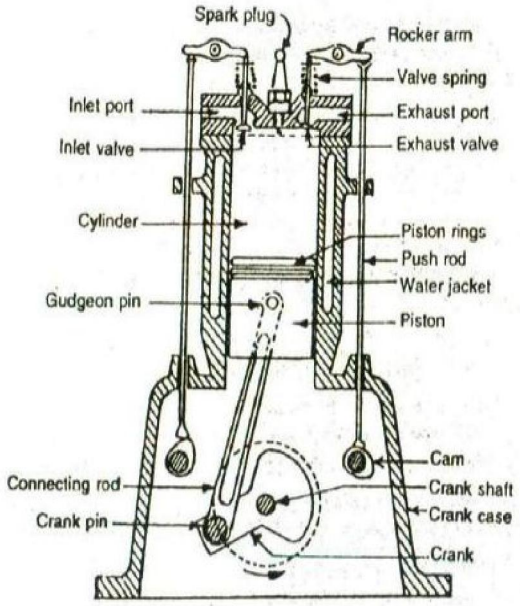


Parts of IC Engine

Crankshaft

It is considered as the backbone of an IC engine whose function is to convert the reciprocating motion of the piston into the rotary motion with the help of connecting rod. This shaft contains one or more eccentric portions called cranks. This part of the crank, to which bigger end of the connecting rod is fitted, is called crank pin.

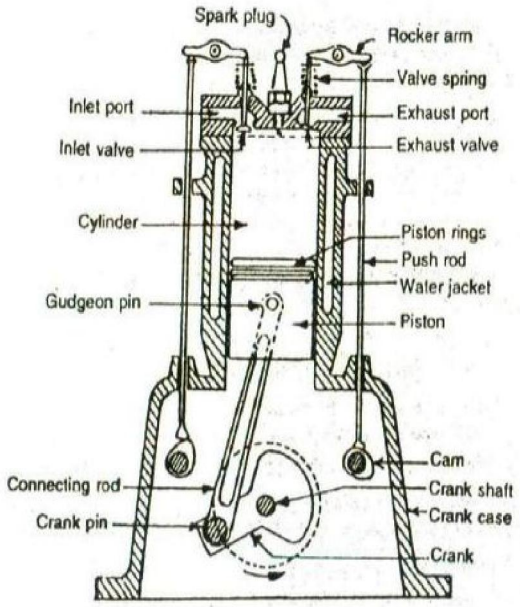




Parts of IC Engine

Crank case

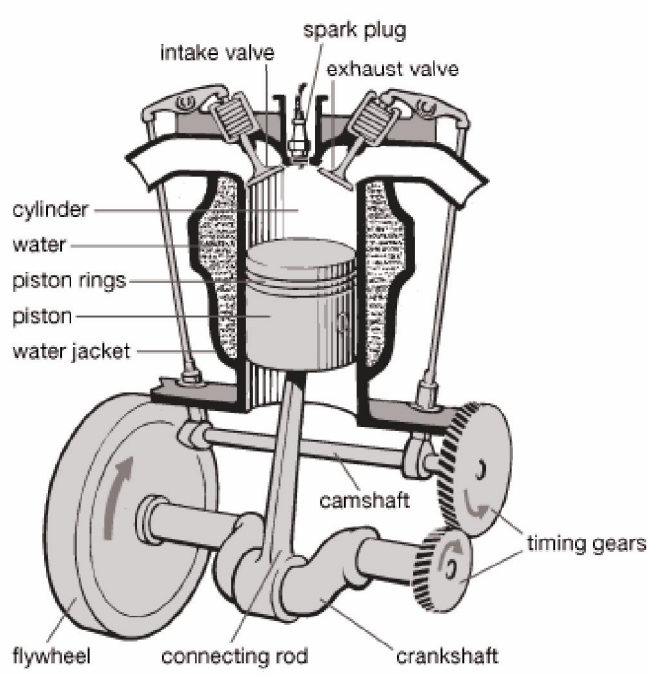
It is a cast iron case, which holds the cylinder and crankshaft of an IC engine. It also serves as a sump for the lubricating oil. The lower portion of the crank case is known as bed plate, which is fixed with the help of bolts.



Parts of IC Engine

Flywheel

It is a big wheel, mounted on the crankshaft, whose function is to maintain its speed constant. It is done by storing excess energy during power stroke, which, is returned during other stroke.



Terms Used in IC Engine

- Bore: The inside diameter of the cylinder is called bore.
- Top Dead Centre (T.D.C.): The top most position towards cover end side of the cylinder is called “top dead center”. In case of horizontal engines, this is known as inner dead center.
- Bottom Dead Centre: The lowest position of the piston towards the crank end side of the cylinder is called “bottom dead center”. In case of horizontal engines it is called outer dead center.
- Stroke: The distance between top dead center and bottom dead center is called stroke length or stroke.

Terms Used in IC Engine

- Clearance volume: The volume contained in the cylinder above the top of the piston, when the piston is at top dead center, is called the clearance volume.
- Swept volume: The volume swept through by the piston in moving between top dead center and bottom dead center, is called swept volume or piston displacement.

Thus, when piston is at bottom dead center,

Total volume = swept volume + clearance volume.

- Compression ratio: The ratio of total cylinder volume to the clearance volume is known as compression ratio.

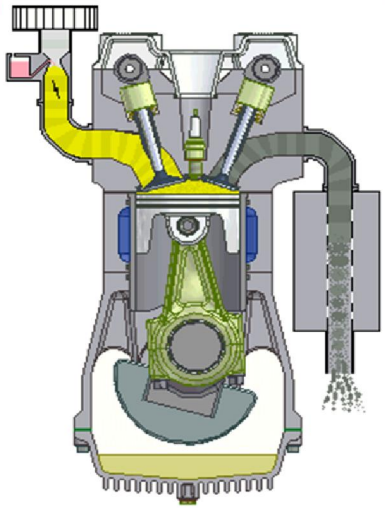
SI and CI Engine

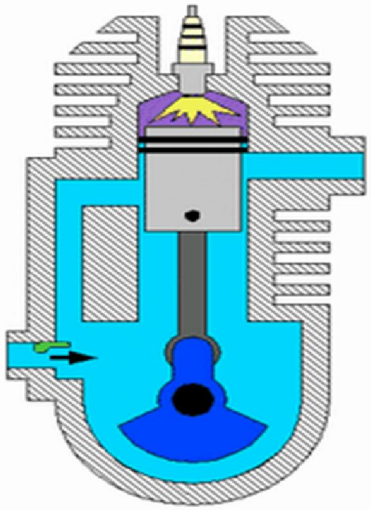
- SI Engine: SI engine stands for *spark ignition* engine. Spark ignition engine means any engine in which fuel is ignited by a spark plug or by a predefined ignition source. Example: Petrol Engine

- CI Engine: CI engine stands for *compression ignition* engine in which the fuel ignite due to temperature rise inside the cylinder during compression. Example: Diesel Engine

Sequence of Operation of IC Engine

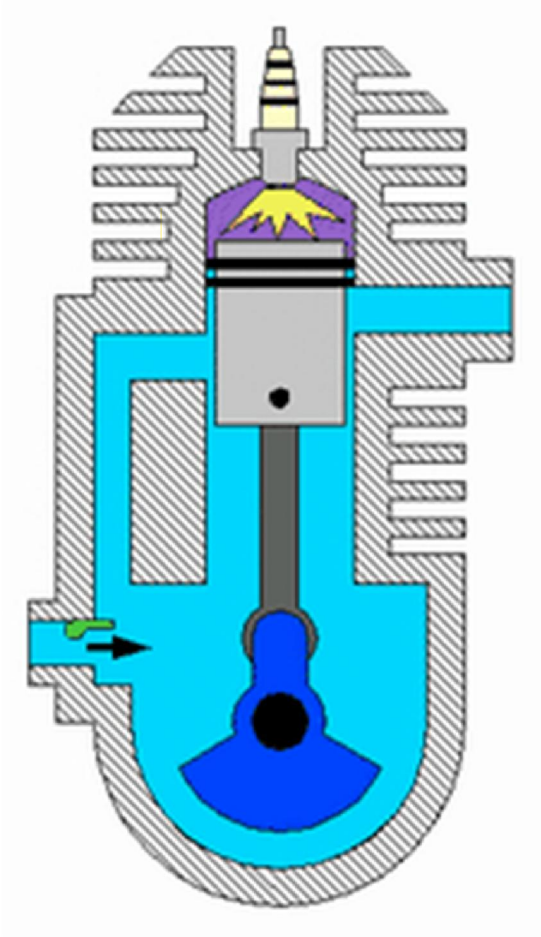
Suction	Air/air-fuel mixture is supplied to engine
Compression	Charge(i.e air) is compressed
Expansion	Charge is ignited hence power obtained
Exhaust	Burnt gases are exhausted

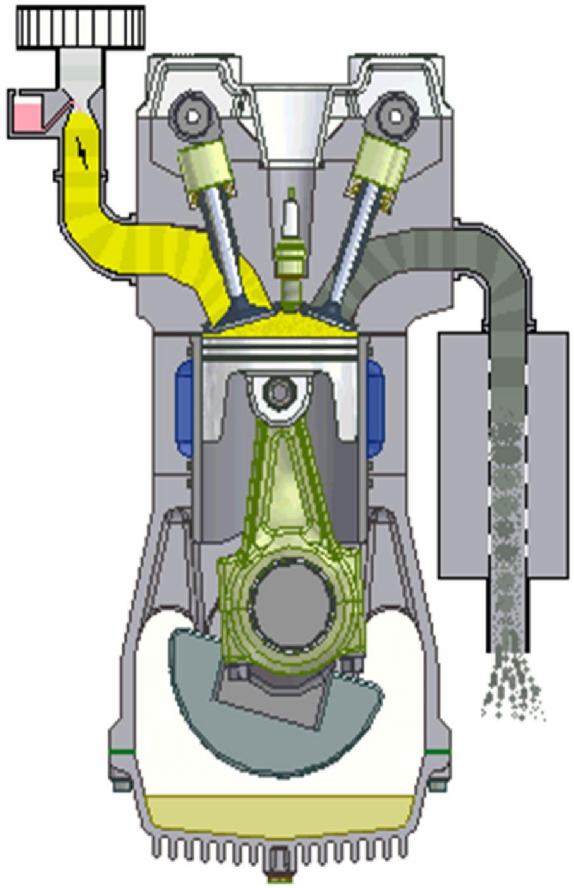




Two Stroke Engine & Four Stroke Engine

Two Stroke Engine & Four Stroke Engine





Two Stroke Engine & Four Stroke Engine

- In a two stroke engine, the working cycle is completed in two stroke of the piston or the one revolution of the crankshaft. This is achieved by carrying out the suction and compression process in one stroke(or more precisely in inward stroke), expansion and exhaust processes in the second stroke (or more precisely in outward stroke).
- In a four stroke engine, the working cycle is completed in four strokes of the piston or two revolution of the crankshaft. This is achieved by carrying out suction, compression, expansion and exhaust processes in each stroke.
- It is interesting that, from thermodynamic point of view, there is no differences between two stroke and four stroke cycle engines. The difference is purely mechanical.

Advantages of 2 Stroke Engine over 4 stroke engine

1. A two stroke cycle engine gives twice the number of power strokes than the four stroke cycle engine at the same engine speed.
2. For the same power developed, a two-stroke cycle engine is lighter and occupies less floor area.
3. The initial cost of a two-stroke cycle engine is considerably less than a four-stroke cycle engine.
4. The mechanism of a two-stroke cycle engine is much simpler than a four-stroke cycle engine.
5. The two-stroke cycle engines are much easier to start.

Disadvantages of 2 Stroke Engine over 4 stroke engine

1. Thermal efficiency of a two-stroke cycle engine is less than that a four stroke cycle engine.
2. Overall efficiency of a two-stroke cycle engine is also less than that of a four-stroke cycle engine.
3. The consumption of lubricating oil is large in a two-stroke cycle engine because of high operating temperature.
4. The exhaust gases in a two-stroke cycle engine creates noise, because of short time available for their exhaust.

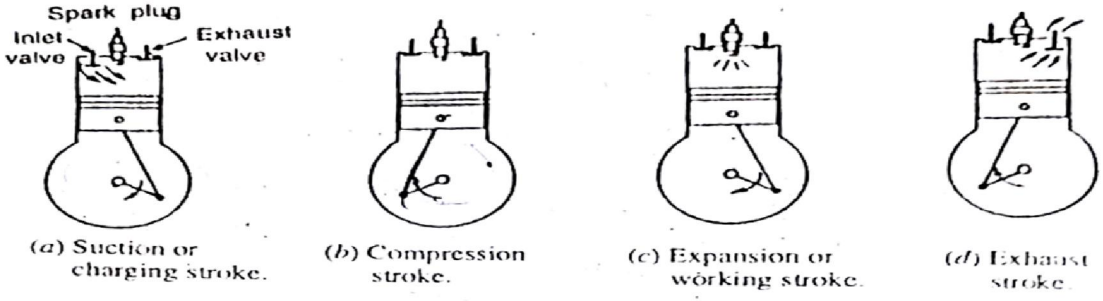
Application Of Four Stroke Engine

- Four stroke engine widely used in automobile industries.
- They are used in bus, trucks and other transportation vehicles.
- They are used in pumping system.
- These engines find application in mobile electric generators.
- These engines widely used in aircraft and marine engines.
- Diesel engines find application in pump sets, construction machinery, air compressor, drilling rigs, etc.

Application Of Two Stroke Engine

- These engines are used in small vehicles like mopeds, scooters etc.
- Small gasoline engines are used for lawn mowers.
- It is also used for small electric generator set, pumping set, outboard motor boats.
- Two stroke diesel engines are used for ship propulsion.

Four Stroke Cycle Petrol Engine



Four Stroke Cycle Petrol Engine

It is also known as Otto cycle. It requires four strokes of piston to complete one cycle of operation in the engine cylinder. The four strokes of a petrol engine are-

Suction or charging stroke: In this stroke, the inlet valve opens and charge is sucked into the cylinder as the piston moves downward from top dead center (T.D.C). It continues till the piston reaches its bottom dead center (B.D.C).

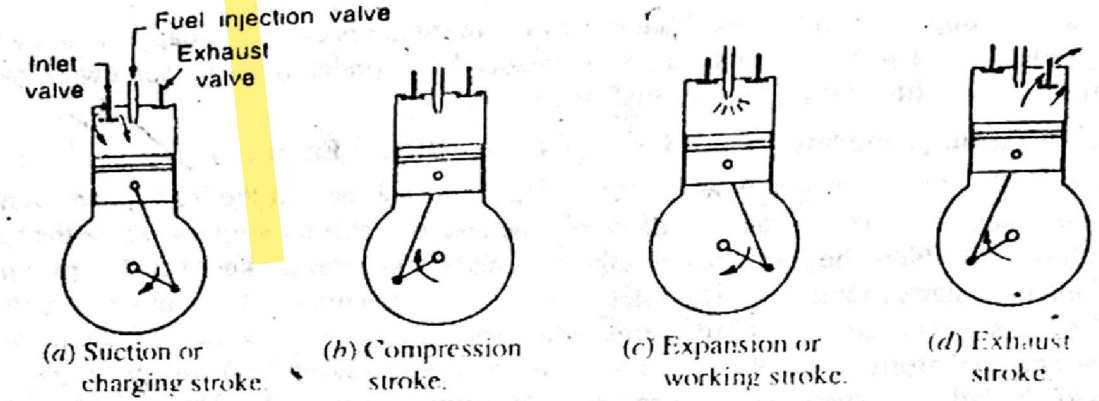
Compression Stroke: In this stroke, both inlet and exhaust valves are closed and the charge is compressed as the piston moves upward from B.D.C to T.D.C. As a result of compression, the pressure and temperature of the charge increases considerably. This completes one revolution of the crankshaft.

Four Stroke Cycle Petrol Engine

Expansion or Working stroke: Shortly before the piston reaches T.D.C (during compression), the charge is ignited with the help of a spark plug. It suddenly increases the pressure and temperature of the products of combustion but the volume, practically, remains constant. Due to the rise in pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston. During this expansion, some of the heat energy produced is transformed into mechanical work. It may be noted that during this working stroke, both the valves are closed and piston moves from T.D.C to B.D.C

Exhaust Stroke: In this stroke , the exhaust valve is open as piston moves from B.D.C to T.D.C. This movement of the piston pushes out the products of combustion, from the engine cylinder and are exhausted through exhaust valve into the atmosphere. This completes the cycle, and the engine cylinder is ready to suck the charge again.

Four Stroke Cycle Diesel Engine



Four Stroke Cycle Diesel Engine

It is also known as *compression ignition engine* because the ignition takes place due to the heat produced in the engine cylinder at the end of compression stroke. The four strokes of a diesel engine

Suction or charging stroke: In this stroke, the inlet valve opens and pure air is sucked into the cylinder as the piston moves downward from top dead center (T.D.C). It continues till the piston reaches its bottom dead center (B.D.C).

Compression Stroke: In this stroke, both inlet and exhaust valves are closed and the air is compressed as the piston moves upward from B.D.C to T.D.C. As a result of compression, the pressure and temperature of the air increases considerably. This completes one revolution of the crankshaft.

Four Stroke Cycle Diesel Engine

Expansion or Working stroke: Shortly before the piston reaches T.D.C (during compression), fuel oil is injected in the form of very fine spray into engine cylinder, through the nozzle, known as fuel injection valve. At this moment, the temperature of the compressed air is sufficiently high to ignite the fuel It suddenly increases the pressure and temperature of the products of the combustion. The fuel oil is assumed to be burnt at constant pressure . Due to the rise in pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston. During this expansion, some of the heat energy produced is transformed into mechanical work. It may be noted that during this working stroke, both the valves are closed and piston moves from T.D.C to B.D.C

Exhaust Stroke: In this stroke , the exhaust valve is open as piston moves from B.D.C to T.D.C. This movement of the piston pushes out the products of combustion, from the engine cylinder and are exhausted through exhaust valve into the atmosphere. This completes the cycle, and the engine cylinder is ready to suck the fresh air again.

Differences Between Diesel Engine And Petrol Engine

S. No	Petrol Engine	Diesel Engine
1	A petrol engine draws a mixture of petrol and air during suction Stroke.	A diesel engine draws only air during suction stroke.
2	The carburetor is employed to mix air and petrol in the required proportion and to supply it to the engine during suction stroke.	The injector or atomizer is employed to inject the fuel at the end of combustion stroke.
3	Pressure at the end of compression is about 10 bar.	Pressure at the end of compression is about 35 bar.
4	The charge (i.e. petrol and air mixture) is ignited with the help of spark plug.	The fuel is injected in the form of fine spray. The temperature of the compressed air is sufficiently high to ignite the fuel.
5	The combustion of the fuel takes place at constant volume. It works on Otto cycle.	The combustion of the fuel takes place at constant pressure. It works on Diesel cycle
6	A petrol engine has compression ratio from 6 to 10.	A diesel engine has compression ratio from 15 to 25.

Differences Between Diesel Engine And Petrol Engine

S. No	Petrol Engine	Diesel Engine
7	The starting is easy due to low compression ratio.	The starting is difficult due to high compression ratio
8	As the compression ratio is low, the petrol engines are lighter and cheaper.	As the compression ratio is high, the diesel engines are heavier and costlier.
9	The running cost of a petrol engine is high because of the higher cost of petrol.	The running cost of diesel engine is low because of the lower cost of diesel.
10	The maintenance cost is less.	The maintenance cost is more.
11	The thermal efficiency is about 26%.	The thermal efficiency is about 40%.
12	Overheating trouble is more due to low thermal efficiency.	Overheating trouble is less due to high thermal efficiency
13	These are high speed engines.	These are relatively low speed engines
14	The petrol engines are generally employed in light duty vehicle such as scooters, motorcycles and cars. These are also used in aero planes.	The diesel engines are generally employed in heavy duty vehicles like buses, trucks, and earth moving machines

Frequently used terms in IC Engine

Scavenging: Scavenging is the process of removing burnt exhaust gases from the combustion chamber of the engine cylinder.

Supercharging: The process of increasing the weight or density of air-fuel mixture or compressed air, induced into the cylinder during the induction stroke is the terms known as supercharging.

Turbocharger: A turbocharger is a form of supercharger. It increases the amount of air entering the engine to create more power. A turbocharger has the compressor powered by a turbine.

Indicated Power: Indicated Power(briefly written as I.P.) is defined as the power developed by combustion of fuel inside the engine cylinder.

Frequently used terms in IC Engine

Brake Power: The brake power (briefly written as B.P.) of an IC Engine is the power available at the crankshaft.

Frictional Power, F.P. = I.P. - B.P.

Detonation: The loud pulsating noise heard within the engine cylinder is known as detonation(also called knocking or pinking).

SFC: The quantity of fuel consumed (by weight) to produce one unit of power in one unit of time is called specific fuel consumption(sfc).

Blow-by: Blow-by is simply gases getting past the piston-rings in internal combustion engines. There will be a small amount of blow-by in any IC engine, even a brand-new one, as the seal between the piston-rings and the cylinder walls cannot be 100% effective.