I. C. ENGINES

Internal Comburstion Engines

Prime mover

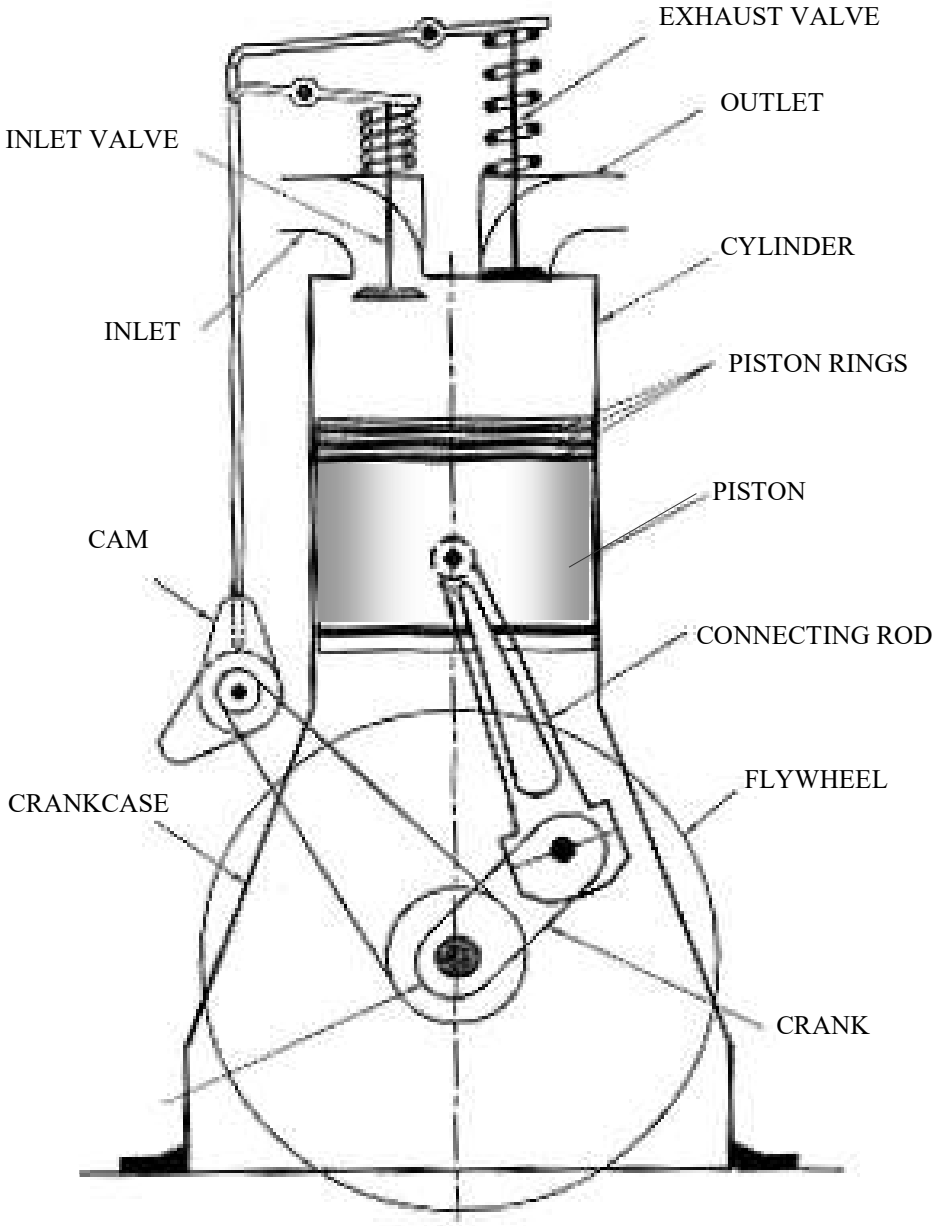
A prime mover is a self moving device which converts the available natural source of energy into mechanical energy of motion to drive other machines. The various types of prime movers which convert heat energy produced by the combustion of fuels into mechanical energy are: Steam engines, Steam turbines, Gas turbines and Internal Combustion engines out of which steam engine have almost become obsolete.

Different parts of an I.C. Engine

The various important parts of an I.C. Engine are shown in the figure below.

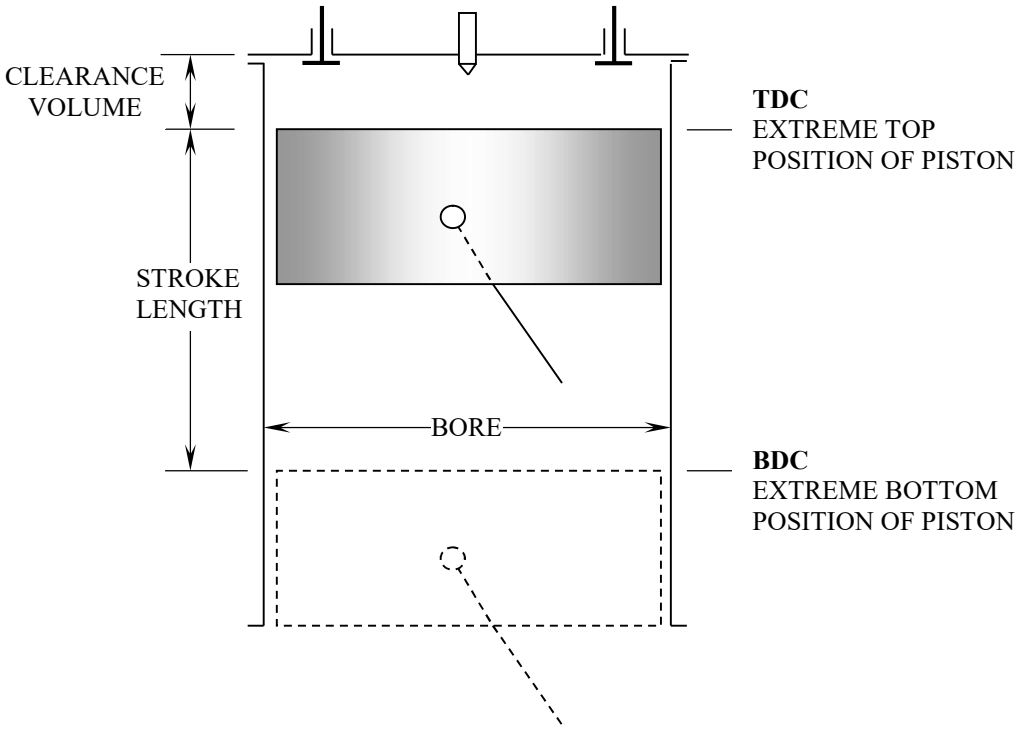
a) Cylinder: The heart of the engine is the cylinder in which the combustion of the fuel takes place and power is developed. The inside diameter of the cylinder is called bore. The piston reciprocates inside the cylinder.
b) Piston: The piston is a close fitting hollow-cylindrical plunger moving to and-fro in the cylinder. The power developed by the combustion of the fuel is transmitted by the piston to the crank shaft through the connecting rod.
c) Piston Rings: The piston rings are the metallic rings inserted into the circumferential grooves provided at the top end of the piston. These rings maintain a gas-tight joint between the piston and the cylinder while the piston is reciprocating in the cylinder. They also help in conducting the heat from the piston to the cylinder.
d) Connecting Rod: It is a link that connects the piston and the crankshaft by means of pin joints. It converts the rectilinear motion of the piston into rotary motion of the crankshaft. It has two ends small end and big end. Small end is connected to the piston by gudgeon pin or piston pin and big end is connected to the crank.
e) Crank and Crankshaft: The crank is a lever that is connected to the big end of the connecting rod by a pin joint with its other end connected rigidly to a shaft, called crankshaft. It rotates about the axis of the crankshaft and causes the connecting rod to oscillate.
f) Valves: The valves are the devices used in a four stroke engine, which facilitate the flow of the intake charge into the cylinder and the exhaust gases out of the engine cylinder. They are also called poppet valves. These valves are operated by means of cams fitted on a cam shaft which in turn is driven by the crankshaft through a timing gear or chain. Since the valves will have to open and close once in two revolutions of the crank shaft the speed of the cam shaft is half of that of the crank shaft.

g) Flywheel: It is a heavy wheel mounted on the crank shaft of the engine to maintain uniform rotation of the crankshaft.



Parts of I. C. Engine

I.C. Engine Terminologies



I.C. Engine Terminologies

The following are the important terminologies related to an I.C. Engine

a) Bore: The inside diameter of the cylinder is called the *bore diameter*.

b) Top Dead Centre (T.D.C): The top most position occupied by the piston towards cover end side of the cylinder is called top dead centre.

c) Bottom Dead Centre (B.D.C): The lowest position occupied by the piston towards the crank end side of the cylinder is called bottom dead centre.

d) Stroke: The linear distance along the cylinder axis between the two limiting positions of the piston is called stroke or stroke length. It is the distance between TDc and BDC.

e) Clearance Volume: The volume contained in the cylinder above the top of the piston, when the piston is at the top dead centre is called clearance volume.

f) Compression Ratio: It is the ratio of total cylinder volume to the clearance volume.

Heat Engine & I.C. Engine

A *heat engine* is a prime mover which derives the heat energy from the combustion of fuels any other source and converts this energy into mechanical work. In the heat engines, the mechanical work produced is a *linear work* which in turn is converted into *rotational work* by the elements such as cylinder, piston, connecting rod, crank, etc.

The heat engines are mainly classified into: (1) External combustion engines and (2) Internal combustion engines. In the external combustion engines known as *E.C. Engines,* the combustion the fuel takes place *outside the engine cylinder,* ex: steam engine. In the internal combustion engines known as *I. C. Engines,* the combustion of the fuel takes place *inside the engine cylinder,* ex: petrol engines, diesel engines.

I.C. Engines: An internal combustion engine more popularly known as I.C. Engine, is a heat engine which converts the heat energy released by the combustion of the fuel taking place inside the engine cylinder into mechanical work. Its versatile advantages such as high efficiency, light weight, compactness, easy starting, adaptability, suitability for mobile applications, comparatively lower initial cost has made its use as an universal prime mover.

Classifications of I.C. Engines

I.C. Engines are classified according to:

(i) Nature of Thermodynamic Cycle,

1. Otto cycle engine.
2. Diesel cycle engine.
3. Dual combustion cycle engine.

(ii) Type of the Fuel- used,

1. Petrol engine.
2. Diesel engine.
3. Gas engine.
4. Bi-fuel Engine.
5. Dual Fuel Engine

(iii) Number of Strokes,

1. Four stroke engine.
2. Two stroke engine.

(iv) Method of Ignition as..

1. Spark ignition engine, known as S.I. Engine.

2. Compression ignition engine, known as C.I. engine.

(v) Number of Cylinders,

1. Single cylinder engine.
2. Multi-cylinder engine.

(vi) Position of the Cylinder as,

1. Horizontal engine
2. Vertical engine.
3. V- engine.
4. In – line engine
5. Opposed cylinder engine.
6. Radial engine.

(vii) Method of Cooling,

1. Air cooled engine.
2. Water cooled engine.

(viii) Speed of the Engine,

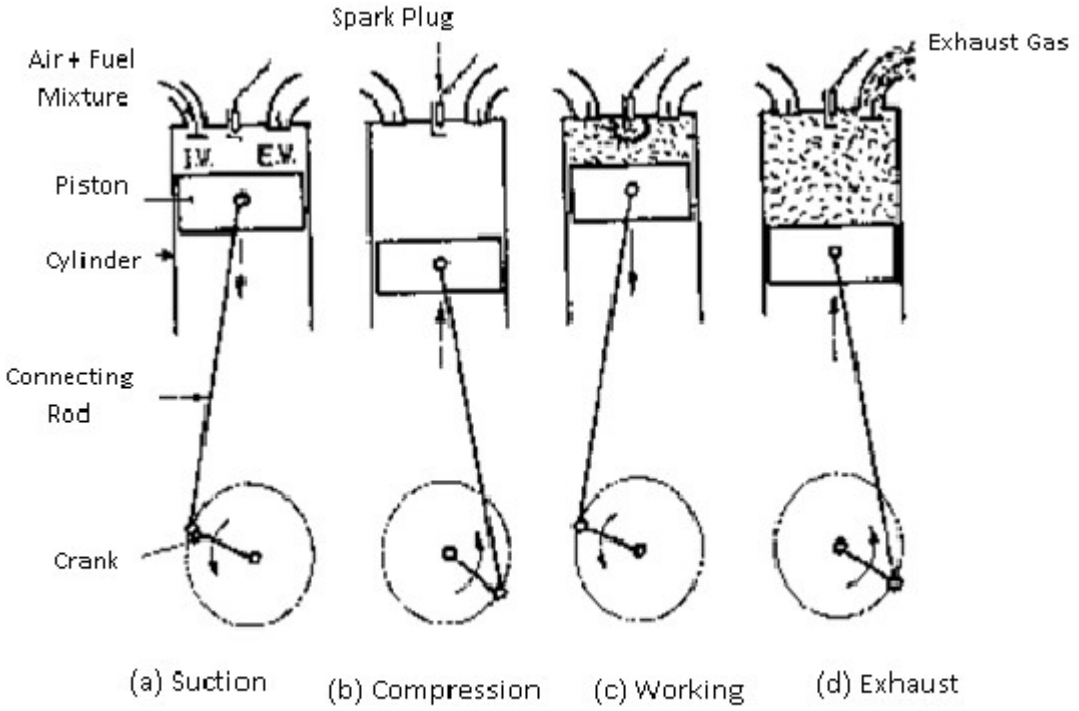
1. Low speed engine.
2. Medium speed engine.
3. High speed engine.

Four-Stroke Petrol Engine

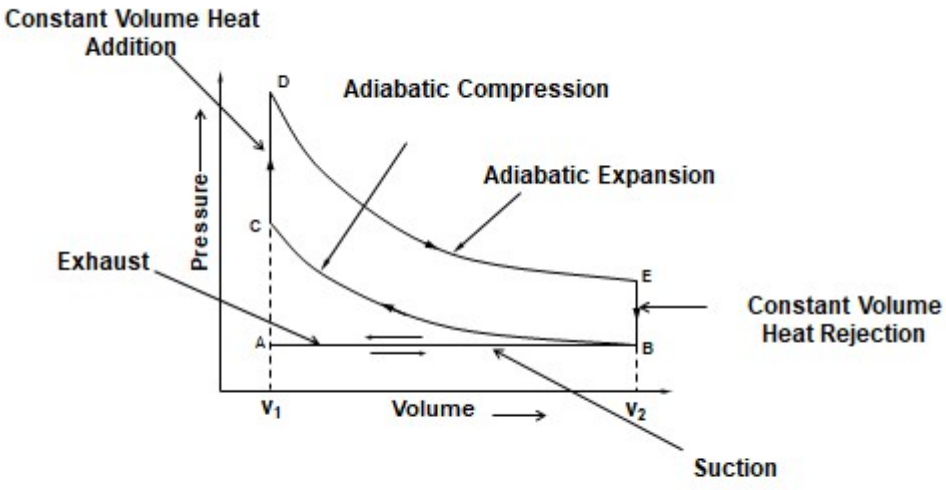
A four-stroke cycle petrol engines operates on Otto (constant volume) cycle. Since ignition in these engines is due to a spark, they are also called spark ignition engines. The working is completed in four strokes of the piston or in two revolutions of the crank shaft. The four strokes are:

1) *Suction stroke,*
2) *Compression stroke*
3) *Working or power or expansion stroke*
4) *Exhaust stroke.*

The working and theoretical Otto cycle of a four-stroke petrol engine are shown in the figures below.



Four stroke petrol engine



Theoretical Otto cycle

Suction Stroke: During suction stroke, the piston is moved from the top dead centre to the bottom dead centre by the crank shaft. The crank shaft is revloved either by the momentum of the flywheel or by the electric starting motor. The inlet valve remains open and the exhaust valve is closed during this stroke. The proportionate air-petrol mixture either from the carburetor or the MPFI system is sucked into the cylinder due to the downward movement of the piston. This operation is represented by the line AB on the P-V diagram.

Compression Stroke: During compression stroke, the piston moves from bottom dead centre to the top dead centre, thus compressing air petrol mixture. Due to compression, the pressure and temperature are increased and is shown by the line BC on the P- V diagram. Just before the end of this stroke the spark - plug initiates a spark which ignites the mixture and combustion takes place at constant volume as shown by the line CD. Both the inlet and exhaust valves remain closed during this stroke.

Working Stroke: The expansion of gases due to the heat of combustion exerts a pressure on the piston. Under this impulse, the piston moves from top dead centre to bottom dead centre and thus the work is obtained during this stroke. Both the inlet and exhaust valves remain closed during this stroke. The expansion of the gas during which pressure reduces and volume increases is represented by the curve DE. Near the end of this stroke exhaust valve opens which will suddenly release the burnt gases into the atmosphere. This drop in pressure at constant volume is represented by vertical line EB on the PV diagram.

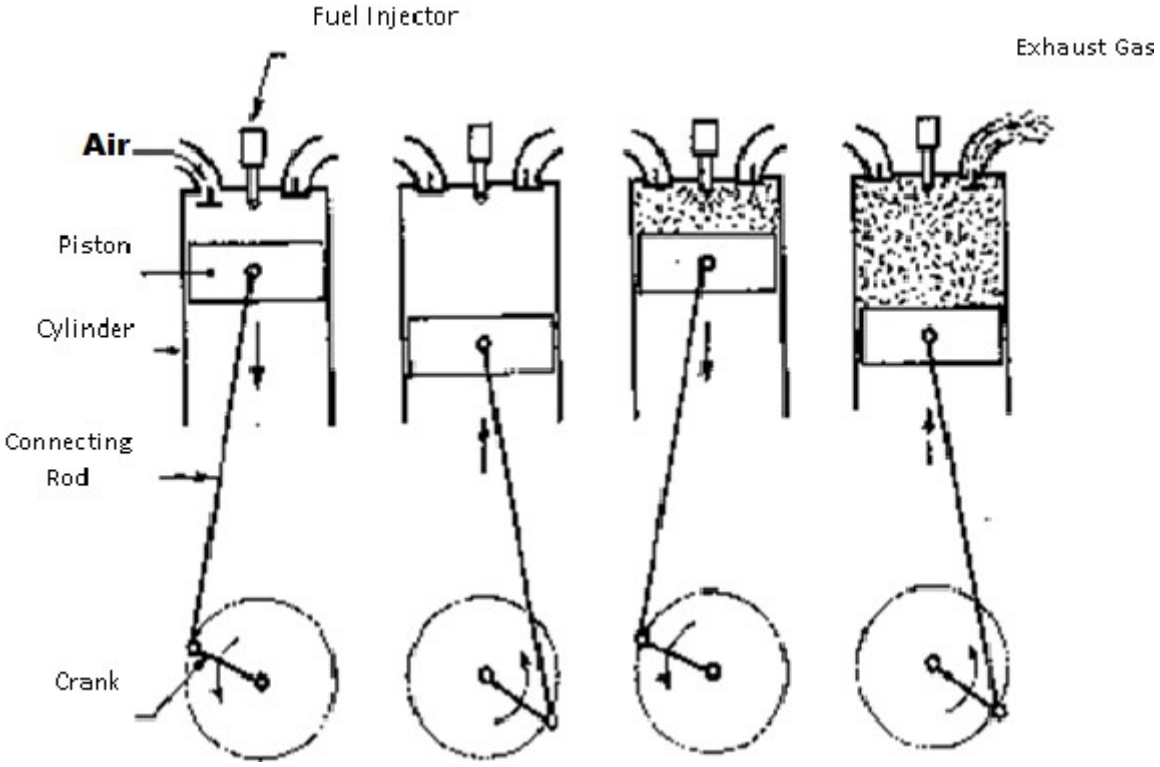
Exhaust Stroke: During this stroke, the inlet valve remains closed and the exhaust valve opens. The piston moves from bottom dead centre to top dead centre and pushes the remaining gases into the atmosphere. When the piston reaches the top dead centre the exhaust valve closes and the cycle is completed. This stroke is represented by line BA on the P-V diagram. The operations are repeated over and over again in running the engine.

Four Stroke Diesel Engine

The four stroke cycle diesel engine operates on diesel cycle or constant pressure cycle. Since ignition in these engines is due to the temperature of the compressed air, they are also called compression ignition engines. The working is completed in four strokes of the piston or in two revolutions of the crank shaft. The four strokes are:

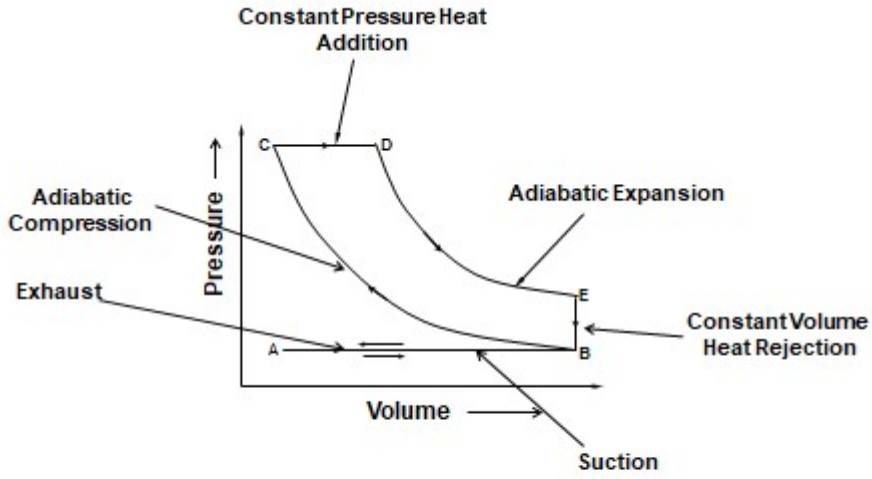
1) *Suction stroke*
2) *Compression stroke*
3) *Working or power or expansion stroke*
4) *Exhaust stroke.*

The working and theoretical Diesel cycle of a four-stroke diesel engine are shown in the figures below.



(a) Suction (b) Compression (c) Working (d) Exhaust

Four stroke diesel engine



Theoretical Diesel cycle

Suction Stroke: During suction stroke, the piston is moved from the top dead centre to the bottom dead centre by the crank shaft. The crank shaft is revolved either by the momentum of the flywheel or by the power generated by the electric starting motor. The inlet valve remains open and the exhaust valve is closed during this stroke. The air from the air filter is sucked into the cylinder due to the downward movement of the piston. This operation is represented by the line AB on the P-V diagram.

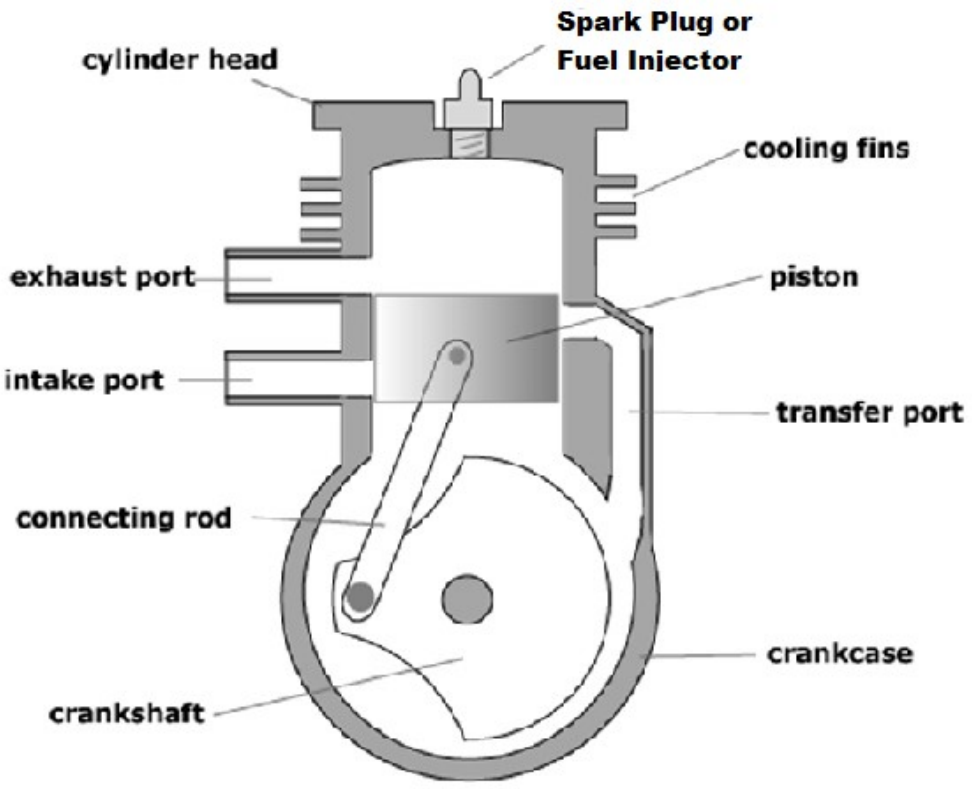
Compression Stroke: The air drawn at the atmospheric pressure during suction stroke is compressed to high pressure and temperature as piston moves from the bottom dead centre to top dead centre during this stroke. This operation is represented by the curve BC on the P- V diagram. Just before the end of this stroke, a metered quantity of fuel is injected into the hot compressed air in the form of fine spray by means of a fuel injector. The fuel starts burning at constant pressure as shown by the line CD. At point D, fuel supply is cut off. Both the inlet and exhaust valves remain closed during this stroke.

Working Stroke: The expansion of gases due to the heat of combustion exerts a pressure on the piston. Under this impulse, the piston moves from top dead centre to bottom dead centre and thus the work is obtained during this stroke. Both the inlet and exhaust valves remain closed during this stroke. The expansion of the gas during which pressure reduces and volume increases is represented by the curve DE. Near the end of this stroke exhaust valve

opens which will suddenly release the burnt gases into the atmosphere. This drop in pressure at constant volume is represented by vertical line EB on the PV diagram.

Exhaust Stroke: During this stroke, the inlet valve remains closed and the exhaust valve opens. The piston moves from bottom dead centre to top dead centre and pushes the remaining gases into the atmosphere. When the piston reaches the top dead centre the exhaust valve closes and the cycle is completed. This stroke is represented by the line BA on the P-V diagram. The operations are repeated over and over again in running the engine.

Two Stroke Engine: In a two stroke engine the working is completed in two strokes of the piston or in single revolution of the crank shaft. Out of the four strokes, two strokes that are eliminated are, suction and exhaust strokes. In fact the suction and exhaust processes are performed while the power and compression strokes are in progress. The constructional features of a two stroke engine is illustrated in the figure below



Two Stroke Engine

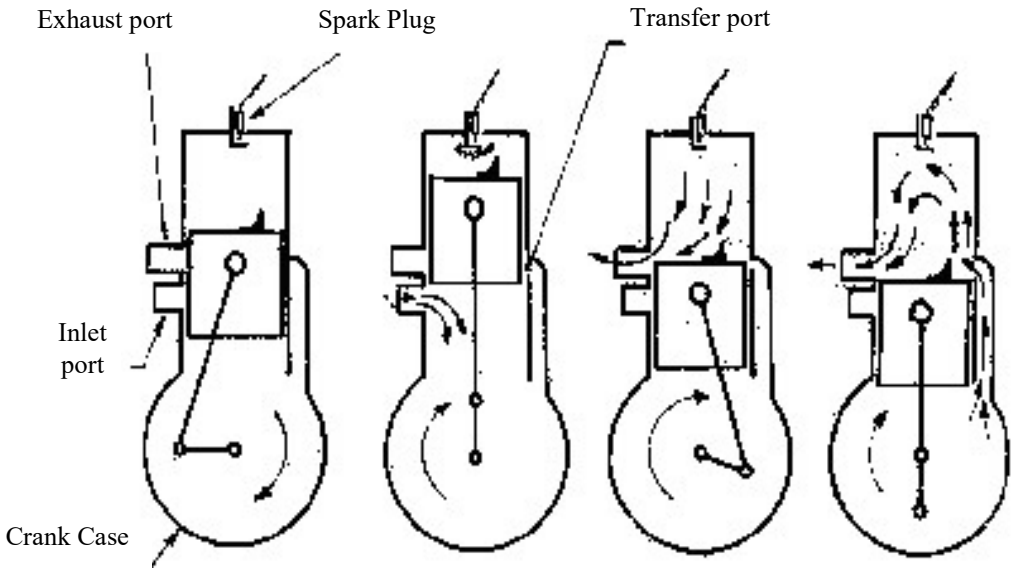
In case of two stroke engines instead of valves, ports are used. Ports are the openings cut on the wall of the engine cylinder which are opened and closed by the piston itself. As the piston reciprocates up and down it periodically covers and uncovers the ports.

A two stroke engine cylinder is fitted with a cover at one end and the other end fitted with a crankcase. On one side two ports are provided one below the other on the circumference of the cylinder. The lower one is the inlet port which admits the fresh charge into the crankcase and the upper one is the exhaust port which expels the burnt gases into the atmosphere.

A transfer port is provided diametrically opposite to the exhaust port but slightly at a lower level. It serves as the passage for the transfer of the charge from the crankcase to the cylinder.

Two Stroke Petrol Engine

The principle of working of a two stroke petrol engine is illustrated in the figures below.



Two stroke cycle petrol engine

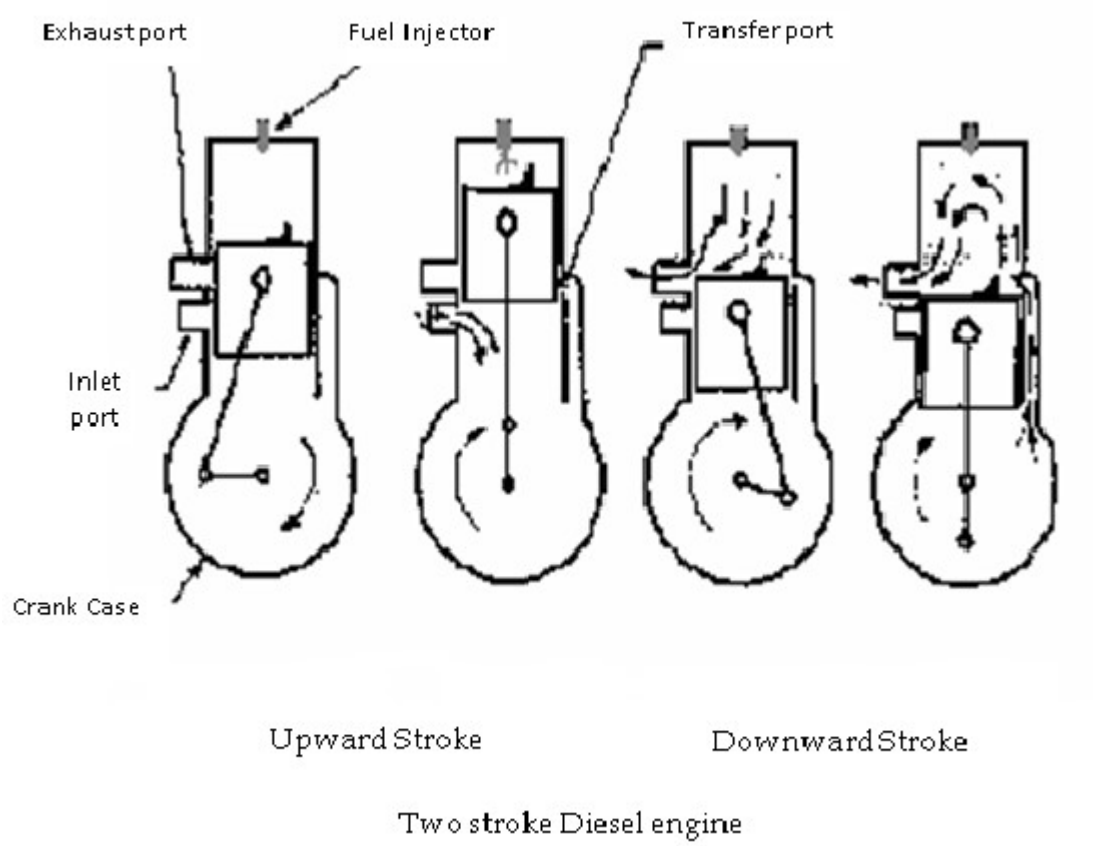
The two strokes occurring are described as follows:

Downward Stroke: At the beginning of this stroke piston is at the TDC position and previously drawn and compressed charge (air- petrol mixture) is ignited by the spark plug. As soon as the charge is ignited, the hot gases force the piston to move downwards, rotating the crankshaft thus producing the useful work. The downward movement of the piston first uncovers or opens the exhaust port causing the burnt gases to escape into the atmosphere. Further downward movement of the piston covers or closes the inlet port thereby stopping the entry of fresh air petrol mixture in to the crankcase and compressing the already drawn fresh charge in the crankcase. As soon as the top edge of the piston uncovers the transfer port during its further downward movement the compressed charge from the crankcase flows into the cylinder. The momentum of the compressed charge entering the engine cylinder, pushes the exhaust gases out of the cylinder. This process of removal of exhaust gases by the fresh incoming charge is known as scavenging. Scavenging continues till the piston covers the transfer and exhaust ports during its next upward stroke. The piston reaches the BDC and the crank shaft completes first half revolution.

Upward Stroke: During the upward stroke, the piston moves from bottom dead centre to top dead centre. As the piston moves upwards first it covers the transfer port thereby stopping the entry of fresh charge into the cylinder from the crankcase. Further upward movement of the piston uncovers the inlet port thereby creating a partial vacuum in the crankcase and fresh air – petrol mixture starts entering the crankcase.Further upward movement of the piston covers the exhaust port thereby stopping scavenging and compressing the petrol air mixture in the cylinder. The compressed charge in the combustion chamber is then ignited by the spark plug and the cycle of events are then repeated. Crankshaft completes second half revolution.

Two Stroke Diesel Engine

In two stroke cycle diesel engine, only air is compressed inside the cylinder and the diesel is injected by an injector. The remaining operations of the two stroke cycle diesel engine are exactly the same as those of the two stroke cycle petrol engine. The principle of working of a two stroke diesel engine is illustrated in the figures below.



Two stroke Diesel engine

Its two strokes are described as follows:

Downward Stroke: At the beginning of this stroke piston is at the TDC position and previously drawn and compressed charge (air) gets ignited when the diesel fuel is sprayed by the fuel injector. As soon as the charge is ignited, the hot gases force the piston to move downwards, rotating the crankshaft thus producing the useful work. The downward movement of the piston first uncovers or opens the exhaust port causing the burnt gases to escape into the atmosphere. Further downward movement of the piston covers or closes the inlet port thereby stopping the entry of fresh air in to the crankcase and compressing the already drawn fresh air in the crankcase. As soon as the top edge of the piston uncovers the transfer port during its further downward movement the compressed air from the crankcase flows into the cylinder. The momentum of the compressed charge entering the engine cylinder, pushes the exhaust gases out of the cylinder. This process of removal of exhaust gases by the fresh incoming charge is known as scavenging. Scavenging continues till the piston covers the transfer and exhaust ports during its next upward stroke. The piston reaches the BDC and the crank shaft completes first half revolution.

Upward Stroke: During the upward stroke, the piston moves from bottom dead centre to top dead centre. As the piston moves upwards first it covers the transfer port thereby stopping the entry of fresh charge into the cylinder from the crankcase. Further upward movement of the piston uncovers the inlet port thereby creating a partial vacuum in the crankcase and fresh air from the air filter starts entering the crankcase. Further upward movement of the piston covers the exhaust port thereby stopping scavenging and compressing the air in the cylinder to a temperature beyond the ignition point of diesel. The compressed charge in the combustion chamber is then gets ignited when the fuel injector sprays diesel fuel and the cycle of events are then repeated. Crankshaft completes second half revolution.