

I.C ENGINES

An internal combustion engine is most 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 like high efficiency, light weight, compactness, easy starting, adaptability, suitability for mobile applications, comparatively lower initial cost has made its use as prime mover universal

E.g.: Automobiles, scooters, motorbikes, powerboats, aircrafts etc.

CLASSIFICATION

I.C Engines are classified according to:

1. Nature of thermodynamic cycle as:-
 - Otto cycle engine
 - Diesel cycle engine
 - Dual combustion cycle engine
2. Type of fuel used as:-
 - Petrol engine
 - Diesel engine
 - Gas engine
 - Bi-fuel engine
3. Number of strokes as:-
 - Four stroke engine
 - Two stroke engine
4. Method of ignition as:-
 - Spark ignition engine
 - Compression ignition engine
5. Number of cylinders as:-
 - Single cylinder engine
 - Multi cylinder engine
6. Method of cooling as:-
 - Air cooled engine
 - Water cooled engine

PARTS OF I.C. ENGINES:

1. Cylinder: The heart of engine is the cylinder in which the fuel is burnt and the power is developed. The inside diameter is called bore. To prevent the wearing of cylinder block, a sleeve will be fitted tightly in the cylinder. The piston reciprocates inside the cylinder.
2. Piston: the piston is a close fitting hollow cylinder plunger moving to and fro in the cylinder. The power developed by the combustion of the fuel is transmitted from the piston to the crank shaft through the connecting rod.
3. Piston rings: The piston rings are 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 cylinder while the piston is reciprocating in the cylinder.
4. Connecting rod: It is the ring that connects the piston and the crankshaft by means of pin joints. It converts the rectilinear motion of the piston into the rotary motion of the crankshaft.

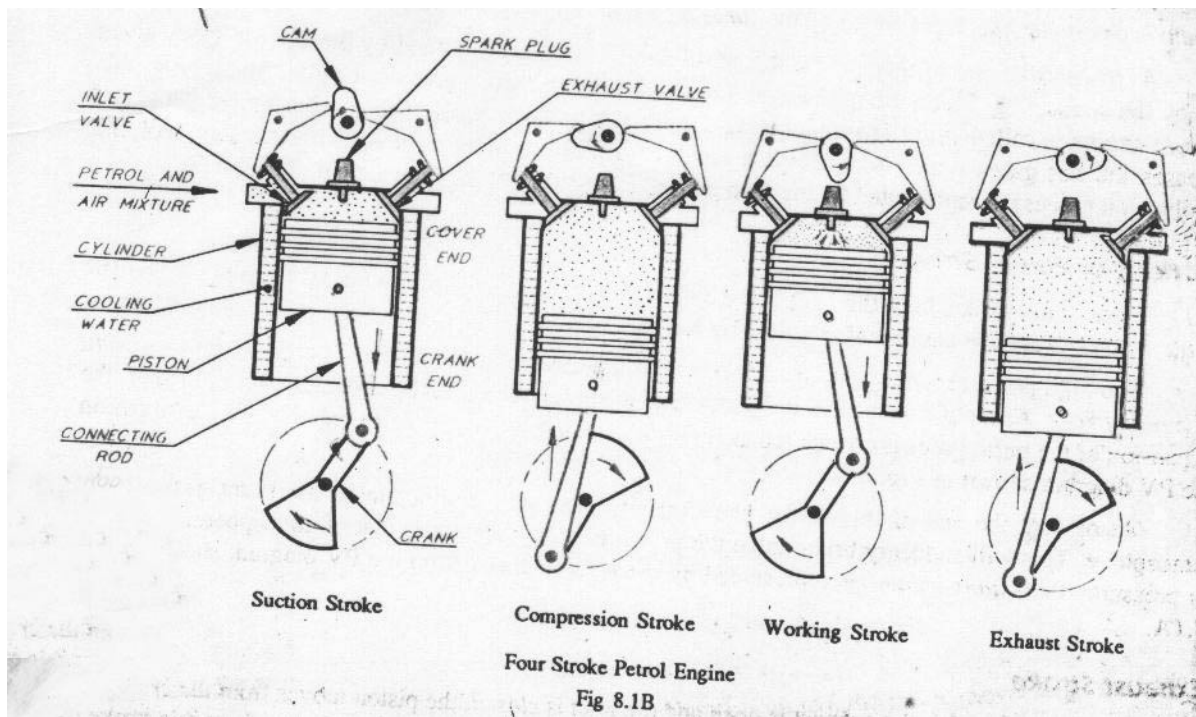
5. Crank and crankshaft: the crank is the lever that connected to the end of the connecting rod by a pin joints with its other end rigidly connected to a shaft, called crankshaft. It rotates about the axis of the crankshaft and causes connecting rod to oscillate.
6. Valves: The valves are the devices which control the flow of intake and exhaust gases to and from the engine cylinder. They are also called poppet valves. These are operated by means of cams driven by the crankshaft.
7. Cams: It is a machine element designed to control the movement of the valves.
8. Camshaft: It is the output shaft which supports the cam. It is driven through a gear or chain drive.
9. Governor: It is a control device used to maintain the engine speed constant by regulating charge when the load changes.
10. Valve springs: These are springs fitted inside the valve.
11. Flywheel: It is a heavy disc mounted on the crankshaft. It is used as an energy reservoir. It stores the excess energy delivered by the engine during power stroke and supplies the energy needed during the other strokes.

I.C ENGINE TERMINOLOGY:

1. Bore: It is the inside diameter of the cylinder.
2. Crank radius: It is the linear distance between the shaft center crank pin center. It is equal to half the stroke length.
3. Top dead center: It is the extreme position of the piston towards cover end side of the cylinder. The crank pin comes between the piston and the crankshaft.
4. Bottom dead center: It is the extreme position of the piston towards the crank end side of the cylinder. The crank pin moves to the farthest distance from the cylinder.
5. Stroke: it is the linear distance traveled by the piston from one dead center to the other dead center. It is equal to twice the crank radius.
6. Swept volume: It is the volume through which the piston sweeps during a stroke. It is equal to the product of surface area of piston and its stroke length.
7. Clearance Volume: It is the volume included between the top of the piston and the cylinder head, when the piston is at TDC or IDC. Generally it is expressed as a percentage of swept volume.
8. Compression ratio: It is the ratio of total cylinder volume to the clearance volume.

$$C.R = (V_c + V_s) / 2$$

FOUR STROKE PETROL ENGINE:



It operates on theoretical Otto cycle. Here cycle is complete is completed in two revolutions of the crankshaft with four-strokes of the piston namely suction , compression, working or power, exhaust, which are identified as per the function.

Working:

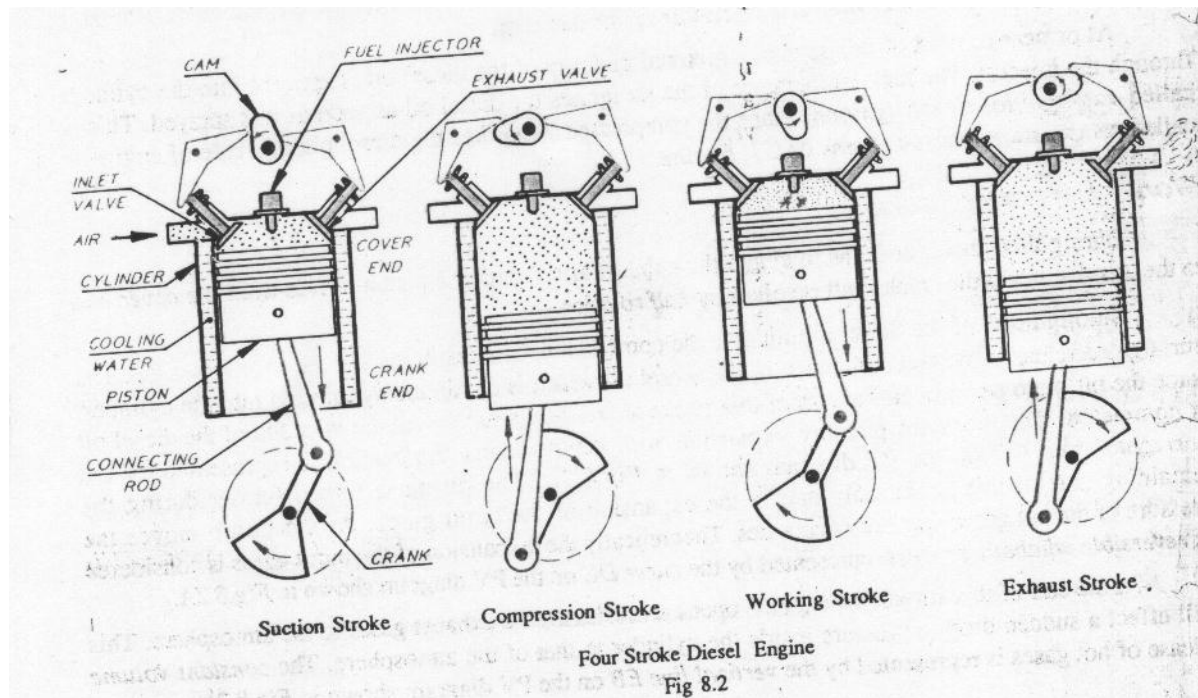
Suction stroke: It starts when the piston is at TDC and is about to move downward. The crankshaft is revolved either by momentum of the flywheel or by the electric motor to move the piston to BDC. The inlet valve opens and exhaust valve closes. Due to suction created by the downward motion of the piston, the charge is drawn into the cylinder. When crank completes half a revolution and the piston reaches BDC, suction stroke ends and inlet valve closes.

Compression stroke: Both inlet and exhaust valve closed. The piston starts moving from BDC to TDC by compressing the charge. The compression is adiabatic with decrease in volume and increase in pressure and temperature. Just before the end of the stroke, the spark plug initiates a spark and ignites the charge. Burning of the charge takes place almost instantaneously. The crank completes one revolution.

Working (power) stroke: Both inlet and exhaust valve still remain closed. The burning gas exerts pressure on the piston and pushes it from TDC to BDC. Hence the work or power is delivered. As a result burning gases expand adiabatically with increase in volume and decrease in pressure. At the end of the stroke, exhaust valve opens and the hot gases are discharged into the atmosphere at constant volume. The crank completes one and half revolution.

Exhaust stroke: The inlet valve remains closed. The piston returns from BDC to TDC and tries to push the remaining burnt gases to the atmosphere at constant pressure with decrease in volume. At the end of stroke, the exhaust valve closes and some quantity of gases gets trapped in the clearance volume, which mix with the fresh charge entering the cylinder in the succeeding cycle. The crank completes two rotations.

FOUR STROKE DIESEL ENGINE:



It operates on theoretical diesel cycle. It is also called constant pressure combustion cycle as the combustion of the fuel takes place at constant pressure with increase of temperature. Here the cycle is completed in the two revolution of the crankshaft with 4 strokes of piston. Since ignition result due to high temperature of compressed air these are also called compression ignition (C.I) engines.

Working:

Suction stroke: It starts when the piston is at TDC and about to move downwards. The inlet valve opens and exhaust valve is closed. Due to suction created by the downward motion of the piston, only air from the atmosphere is drawn into the cylinder. When the crank completes half a revolution and piston reaches BDC, suction stroke ends and inlet valve closes.

Compression stroke: Both inlet and exhaust valves remain closed. The piston starts moving from the BDC to TDC by compressing the air adiabatically with decrease in volume and increase in pressure as high as 4Mpa and temperature as high as 1000 c. Just before the end of the stroke ,the fuel injector opens and a fine spray of fuel is injected into the hot compressed air ,where it starts burning, maintaining the pressure constant. By this time the crank completes one revolution.

Working (power) stroke: Both inlet and exhaust valve remains closed. The hot gases and air exerts pressure on the piston and pushes it from TDC to BDC. Hence the work is derived. As a result the burning gases and air expands adiabatically with increase in volume and decrease in pressure. At the end of the stroke exhaust valve opens and hot gases are discharged into the atmosphere at constant volume. The crank completes one and half revolutions.

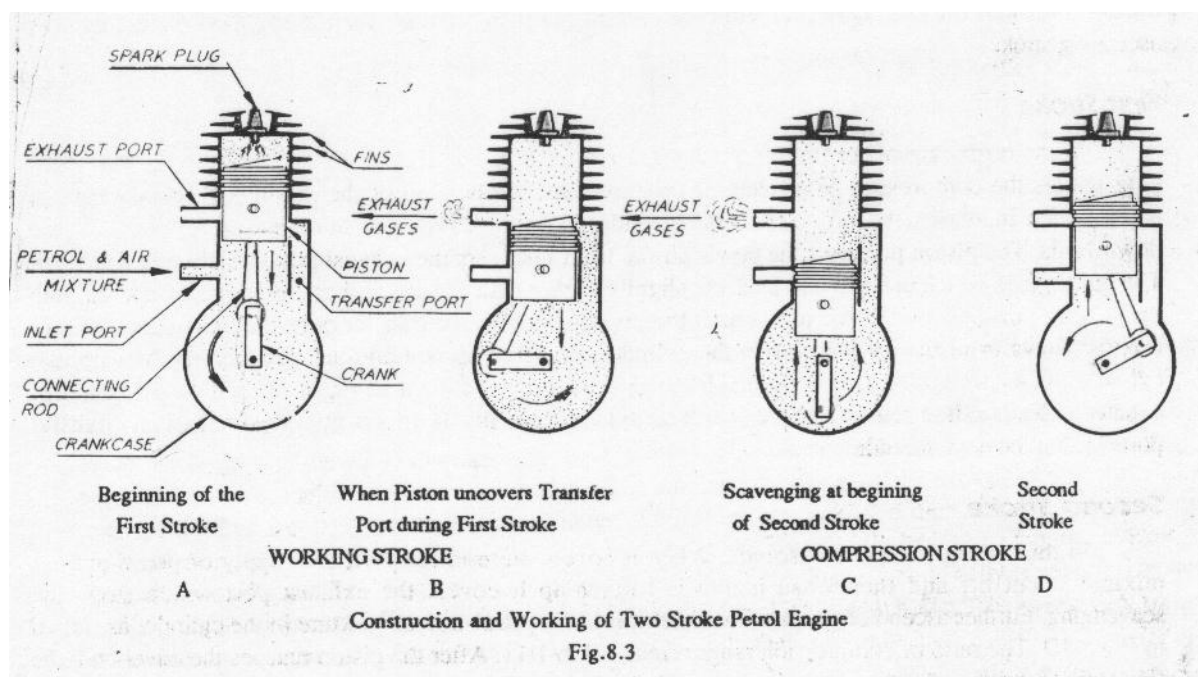
Exhaust stroke: The inlet valve remains closed. The piston returns from BDC to TDC and pushes the remaining burnt gases to the atmosphere at constant pressure with decrease in volume.

At the end of the stroke, exhaust valve closes and small quantities of air gets trapped in the clearance volume which mix with the air entering in the cylinder in the succeeding cycle. The crank completes two revolutions.

TWO STROKE CYCLE ENGINES

These are designed to drive the power stroke during every revolution of the crankshaft. Hence here suction and exhaust strokes are eliminated. Here valves are replaced by the ports and burnt exhaust gases are forced out either by scavenging pump system. 2-stroke engines are widely used for small power required for mopeds, scooters, and motor cycles. These have single cylinder and three ports.

Working of two stroke petrol engine:
It works on theoretical Otto cycle.



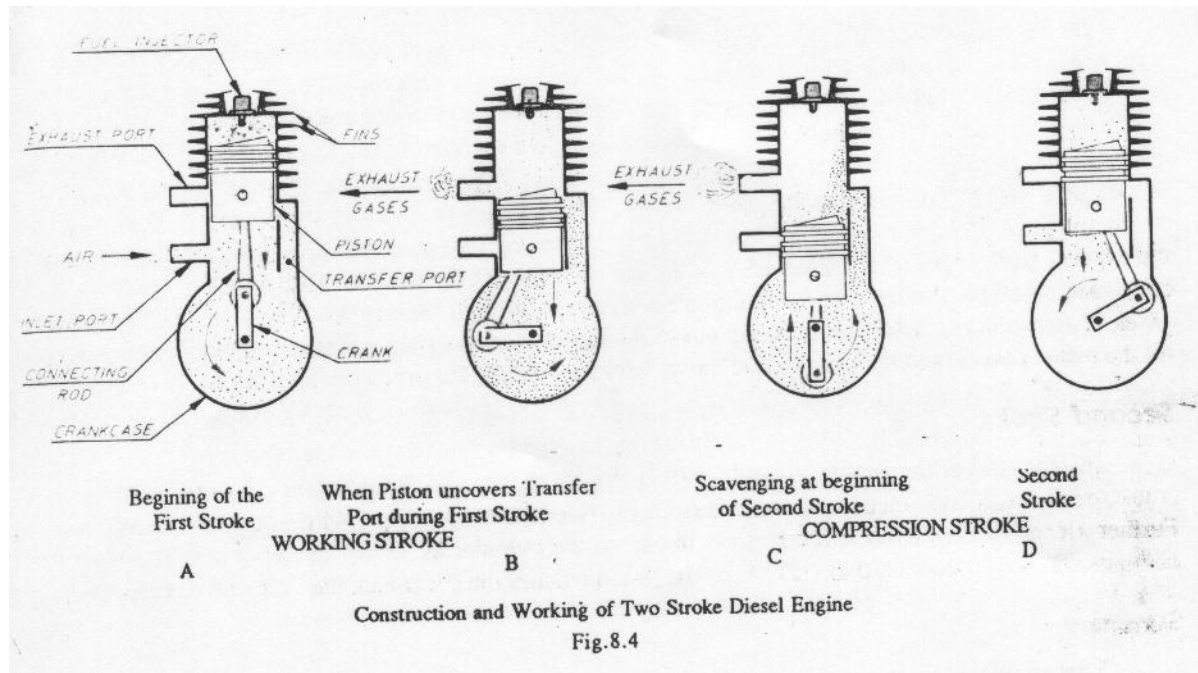
First stroke: The spark is produced by spark plug as the piston reaches TDC. Instantaneous combustion occurs at constant volume with increase of pressure and temperature. The hot gas expands adiabatically and exerts pressure and push the piston downwards producing the power stroke. The piston uncovers the exhaust port during its downward motion. The burnt gases rush out of the cylinder through exhaust port. Little later the top side of the piston uncovers the transfer port. At the same time the charge in the crankcase is compressed by the under side of the piston. As a result charge rushes through transfer port to the upper part of the cylinder and exhaust gases are pushed out by fresh charge. This is continued until the piston reaches BDC. Hence the crank completes half a revolution.

Second stroke: As the piston starts moving upward, the exhaust gases are partly pushed through exhaust port. Later it covers the transfer port and stops the flow of fresh charge into the cylinder. Little later the piston covers the exhaust port and uncovers the inlet port, through which the fresh charge is drawn into the cylinder. The actual compression of the charge starts now and follows

adiabatic compression until the piston reaches TDC and cycle completes. Hence the crank completes one revolution.

Working of two stroke diesel engine

It works on theoretical diesel cycle.



First stroke: the diesel fuel is injected just before the completing the compression and it starts burning at the end of compression. The pressure and temperature inside the cylinder are sufficient to burn the fuel. The supply of fuel continues. The high fuel gases try to push the piston downwards at a constant pressure. The hot gases exert pressure on piston and push it downward. Hence the work or the power is developed. As a result burning gases expand adiabatically with increase in volume and decrease in pressure. When piston uncovers the exhaust port during the downward motion, the burn gases rushes out of the cylinder through exhaust port. The pressure drops. A little later top side of the piston uncovers the transfer port. At the same time the air in the crankcase is compressed by the under side of the piston As a result the air rushes through transfer port to the upper part of the cylinder and pushes the exhaust gases out through the exhaust port.

Second stroke: As the piston starts moving upward, the exhaust gases are partly pushed through the exhaust port. Later the piston covers the transfer port and stops the flow of the air inside the cylinder. A little later piston covers the exhaust port and uncovers the inlet port through which the fresh air is drawn into the cylinder. The actual compression of air starts now and follows adiabatic compression, until the piston reaches TDC and cycle completes. Hence the crank completes one complete revolution.

COMPARISION OF FOUR STROKE AND TWO STROKE ENGINES

Basis	Four stroke engine	Two stroke engine
Number of stroke per cycle	4	2
Number of revolutions of crank Per cycle	2	1
Number of cycle per second	$N=n/2$	$N=n$
Power derived	In every alternate revolution of the crankshaft	In every revolution of the crank Shaft
Cooling and lubrication	required less	Severely required
Entry and exhaust of charge	through valves	Through ports
Thermal efficiency	higher	Comparatively low
Mechanical efficiency	Low	High
Specific fuel consumption	Less	High
Running noise	Less	More
Engine size	Heavy and bulky	More compact
Initial cost	High	Low
Uses	Automobiles ,aeroplanes, etc Where high power is required.	Mopeds ,scooters etc. where low power are required.
Direction of rotation of crankshaft	It rotates only in one direction	It rotates in both clockwise and anticlockwise direction.

COMPARISION OF PETROL AND DIESEL ENGINE

Basis	Petrol engine	Diesel engine
Cycle of operation	Otto cycle	Diesel cycle
Fuel used	Petrol	Diesel
Fuel supply	Using carburettor	Using fuel pump and injector.
Charge contains	Mixture of air and petrol	Only air
Ignition of charge	Using spark plug	Self ignition
Range of C.R	4:1 to 10:1	12:1 to 22:1
Engine speed	2000 to 6000rpm	400 to 1200rpm
Thermal efficiency	lower	higher
Power output	less	more
Initial cost	less	more
Construction	light	heavy
Noise and vibration	less	high
Method of governing	quantitative method	qualitative method