

INTERNAL COMBUSTION ENGINE

External combustion engine: In this engine, the products of combustion of air and fuel transfer heat to a second fluid which is the working fluid of the cycle.

Examples:

*In the steam engine or a steam turbine plant, the heat of combustion is employed to generate steam which is used in a piston engine (reciprocating type engine) or a turbine (rotary type engine) for useful work.

*In a closed cycle gas turbine, the heat of combustion in an external furnace is transferred to gas, usually air which the working fluid of the cycle.

Internal combustion engine:

In this engine, the combustion of air and fuels take place inside the cylinder and are used as the direct motive force. It can be classified into the following types:

Main components of reciprocating IC engines:

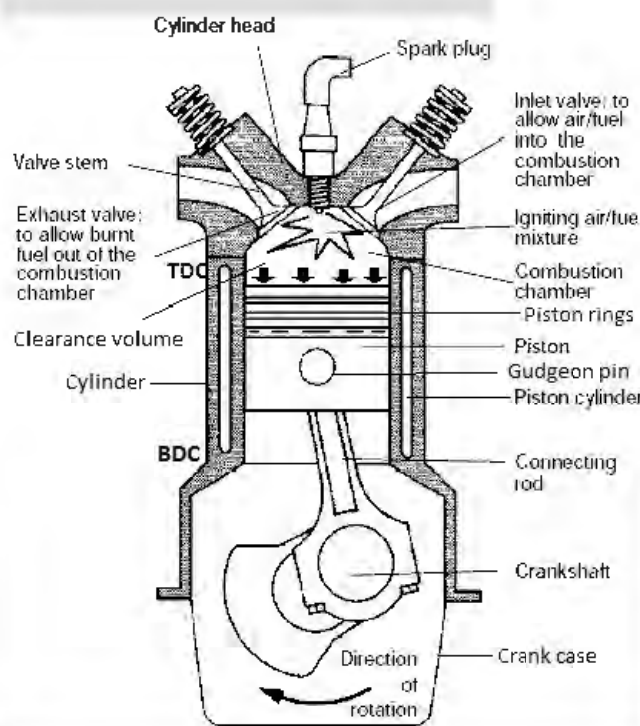


Fig. 1. Different parts of IC engine

Cylinder: It is the main part of the engine inside which piston reciprocates to and fro. It should have high strength to withstand high pressure above 50 bar and temperature above 2000 °C. The ordinary engine is made of cast iron and heavy duty engines are made of steel alloys or aluminum alloys. In the multi-cylinder engine, the cylinders are cast in one block known as cylinder block.

Cylinder head: The top end of the cylinder is covered by cylinder head over which inlet and exhaust valve, spark plug or injectors are mounted. A copper or asbestos gasket is provided between the engine cylinder and cylinder head to make an air tight joint.

Piston: Transmit the force exerted by the burning of charge to the connecting rod. Usually made of aluminium alloy which has good heat conducting property and greater strength at higher temperature.

Piston rings: These are housed in the circumferential grooves provided on the outer surface of the piston and made of steel alloys which retain elastic properties even at high temperature. 2 types of rings-compression and oil rings. Compression ring is upper ring of the piston which provides air tight seal to prevent leakage of the burnt gases into the lower portion. Oil ring is lower ring which provides effective seal to prevent leakage of the oil into the engine cylinder.

Connecting rod: It converts reciprocating motion of the piston into circular motion of the crank shaft, in the working stroke. The smaller end of the connecting rod is connected with the piston by gudgeon pin and bigger end of the connecting rod is connected with the crank with crank pin. The special steel alloys or aluminium alloys are used for the manufacture of connecting rod.

Crankshaft: It converts the reciprocating motion of the piston into the rotary motion with the help of connecting rod. The special steel alloys are used for the manufacturing of the crankshaft. It consists of eccentric portion called crank.

Crank case: It houses cylinder and crankshaft of the IC engine and also serves as sump for the lubricating oil.

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

Terminology used in IC engine:

1. Cylinder bore (D): The nominal inner diameter of the working cylinder.
2. Piston area (A): The area of circle of diameter equal to the cylinder bore.
3. Stroke (L): The nominal distance through which a working piston moves between two successive reversals of its direction of motion.
4. Dead centre: The position of the working piston and the moving parts which are mechanically connected to it at the moment when the direction of the piston motion is reversed (at either end point of the stroke).
 - (a) Bottom dead centre (BDC): Dead centre when the piston is nearest to the crankshaft.
 - (b) Top dead centre (TDC): Dead centre when the position is farthest from the crankshaft.
5. Displacement volume or swept volume (V_s): The nominal volume generated by the working piston when travelling from the one dead centre to next one and given as,

$$V_s = A \times L$$

6. Clearance volume (V_c): the nominal volume of the space on the combustion side of the piston at the top dead centre.

7. Cylinder volume (V): Total volume of the cylinder.

$$V = V_s + V_c$$

Four stroke engine: Cycle of operation completed in four strokes of the piston or two revolution of

the piston.

- (i) Suction stroke (suction valve open, exhaust valve closed)-charge consisting of fresh air mixed with the fuel is drawn into the cylinder due to the vacuum pressure created by the movement of the piston from TDC to BDC.
- (ii) Compression stroke (both valves closed)-fresh charge is compressed into clearance volume by the return stroke of the piston and ignited by the spark for combustion. Hence pressure and temperature is increased due to the combustion of fuel
- (iii) Expansion stroke (both valves closed)-high pressure of the burnt gases force the piston towards BDC and hence power is obtained at the crankshaft.

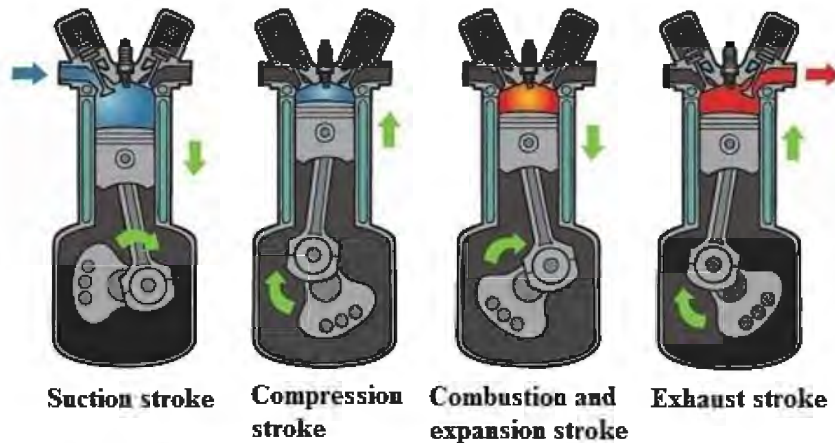


Fig. 2. Cycle of operation in four stroke engine

- (iv) Exhaust stroke (exhaust valve open, suction valve closed)- burnt gases expel out due to the movement of piston from BDC to TDC.

Two stroke engine:-No piston stroke for suction and exhaust operations

-Suction is accomplished by air compressed in crankcase or by a blower

-Induction of compressed air removes the products of combustion through exhaust ports

-Transfer port is there to supply the fresh charge into combustion chamber

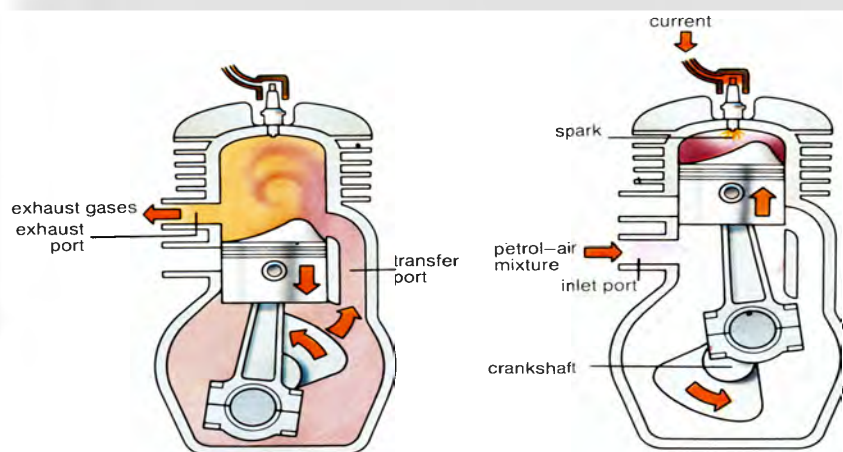


Fig. 3. Cycle of operation in two stroke engine

Comparison of Four-stroke and two-stroke engine:

Four-stroke engine	Two-stroke engine
Four stroke of the piston and two revolution of crankshaft	Two stroke of the piston and one revolution of crankshaft
One power stroke in every two revolution of crankshaft	One power stroke in each revolution of crankshaft
Heavier flywheel due to non-uniform turning movement	Lighter flywheel due to more uniform turning movement
Power produce is less	Theoretically power produce is twice than the four stroke engine for same size
Heavy and bulky	Light and compact
Lesser cooling and lubrication requirements	Greater cooling and lubrication requirements
Lesser rate of wear and tear	Higher rate of wear and tear
Contains valve and valve mechanism	Contains ports arrangement
Higher initial cost	Cheaper initial cost
Volumetric efficiency is more due to greater time of induction	Volumetric efficiency less due to lesser time of induction
Thermal efficiency is high and also part load efficiency better	Thermal efficiency is low, part load efficiency lesser
It is used where efficiency is important.	It is used where low cost, compactness and light weight are important.
Ex-cars, buses, trucks, tractors, industrial engines, aero planes, power generation etc.	Ex-lawn mowers, scooters, motor cycles, mopeds, propulsion ship etc.

Comparison of SI and CI engine:

SI Enigne	CI Engine
Working cycle is Otto cycle	Working cycle is diesel cycle.
Petrol or gasoline or high octane fuel is used.	Diesel or high cetane fuel is used.
Fuel and air introduced as a gaseous mixture in the suction stroke	Fuel is injected directly into the combustion chamber at high pressure at the end of compression stroke
Carburettor used to provide the mixture. Throttle controls the quantity of mixture introduced	Injector and high pressure pump used to supply of fuel. Quantity of fuel regulated in pump.
Use of spark plug for ignition system	Self-ignition by the compression of air which Increased the temperature required for combustion
Compression ratio is 6 to 10.5	Compression ratio is 14 to 22 Higher
maximum RPM due to lower weight	Lower maximum RPM
Maximum efficiency lower due to lower compression ratio	Higher maximum efficiency due to higher compression ratio
Lighter	Heavier due to higher pressure