

Introduction : A Heat engine is a device which converts heat energy derived from the combustion of fuel into mechanical work.

The heat engines are mainly classified into

- ① External Combustion engines : A Heat engine in which combustion of fuel takes place outside the engine cylinder is called External Combustion engine. Eg. Steam engine, steam turbine, gas turbine etc.
- ② Internal Combustion (I.C.) engine : A Heat engine in which combustion of fuel takes place inside the engine cylinder is called internal Combustion engine. Eg. petrol engine, Diesel engine, gas engine etc.

Internal Combustion engine :

An internal Combustion engine popularly known as I.C engine is a heat engine which converts the heat energy released by the combustion of fuel taking place inside the engine cylinder into mechanical work. Its various advantages such as high efficiency, light weight, compactness, easy starting, adaptability, suitability for mobile applications etc. has made its use as a prime mover universally.

Classification of I.C. engines :

I.C engine can be classified depending upon various aspects as follows.

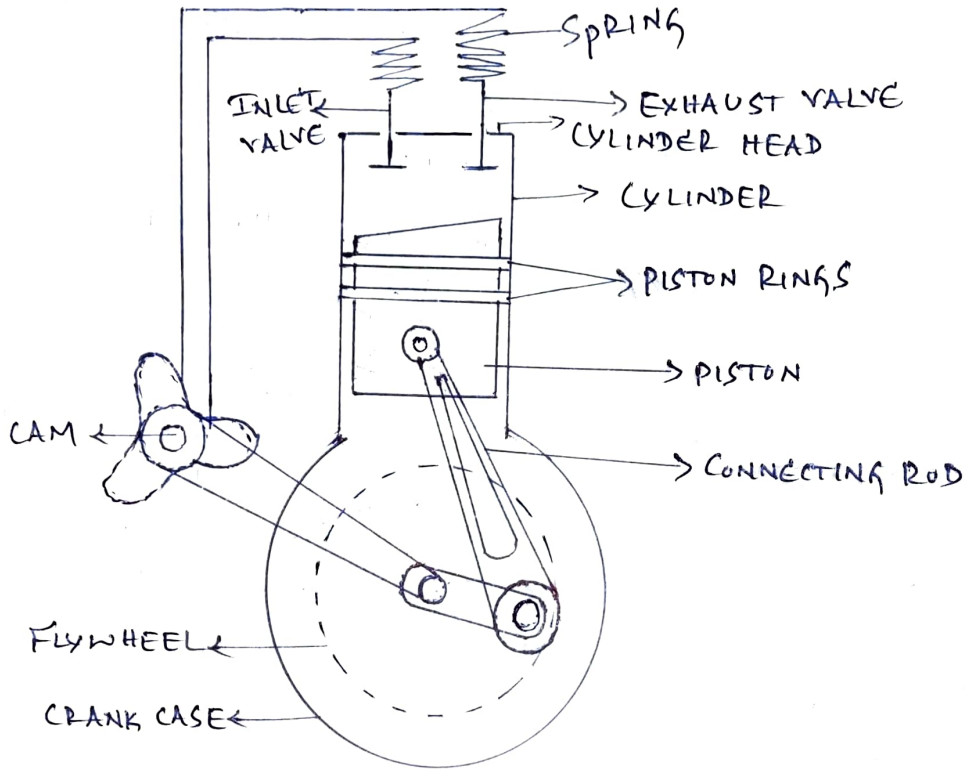
- ① According to the type of fuel used
 - a) petrol engine b) Diesel engine c) Gas engine
- ② According to the no. of strokes
 - a) Four stroke cycle engines b) Two stroke cycle engines
- ③ According to the method of ignition
 - a) Spark ignition (SI) engines b) Compression ignition (CI) engines
- ④ According to the no. of cylinders
 - a) Single cylinder engine b) Multi cylinder engine
- ⑤ According to the arrangement of cylinders
 - a) Horizontal engine b) Vertical engine c) V-Engine d) Inline engine etc.
- ⑥ According to the speed of the engine
 - a) Low Speed engine b) Medium Speed engine c) High Speed engine
- ⑦ According to the method of cooling
 - a) Air cooled engines b) Water cooled engines

② According to the thermodynamic cycle

a) Otto cycle b) Diesel cycle c) Dual combustion cycle

Main components of I.C. engines

The important parts of an I.C. engine are as follows.



- ① Cylinder: It is the most important component of the engine where combustion of fuel takes place. The cylinder is supported in position by the cylinder block at the top end & is covered by the cylinder head.
- ② piston: It is a hollow cylindrical plug which reciprocates inside the cylinder whose main function is to transmit the force exerted by the burning of charge to the connecting rod.
- ③ connecting rod: It is a link that connects the piston & the crankshaft by means of pin joints. It converts reciprocating motion of the piston into rotary motion of the crankshaft.
- ④ cylinder head: It is fitted on one end of the cylinder & acts as a cover to close the cylinder bore. Generally the cylinder head contains inlet & exit valves for admitting fresh charge & exhausting the burnt gases.
- ⑤ crank & crank shaft: Both crank & crank shaft are steel forgings. They are held together by means of a key. The connecting rod supplies

rotary motion to the crank & the power required for any work delivered from the crankshaft.

Crank Case: It is a cast iron case, which holds the cylinder & crankshaft of an IC engine. It also serves as a sump for the lubricating oil.

- ⑦ **Inlet valve:** This valve controls the admission of the charge into the petrol engine (or) air in the Diesel engine during the suction stroke of the engine.
- ⑧ **Exhaust valve:** The removal of exhaust gases after the work, is controlled by this valve.
- ⑨ **Cam-shaft:** The function of the camshaft is to operate the inlet & the exhaust valves through the cams, cam followers, push rods & rocker arms.
- ⑩ **piston rings:** piston rings are housed in the circumferential grooves provided on the outer surface of the piston. Generally there are 2 sets of rings. The function of the upper rings is to provide airtight 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 cylinders.
- ⑪ **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 the power stroke, which is returned during other strokes.

IC Engine Terminology:

- ① **Cylinder bore:** The inner diameter of the cylinder (is) called bore. It is denoted by 'D'.
- ② **piston area:** The area of a circle of diameter equal to the cylinder bore is called the piston area.
- ③ **Top Dead Centre [TDC]:** The extreme position of the piston at the top of the cylinder (or) away from the crankshaft is called T.D.C. In case of a horizontal engine it is called inner dead centre [IDC] it is also referred as cover end.
- ④ **Bottom Dead Centre [BDC]:** The extreme position of the piston at the bottom of the cylinder (or) near to the crankshaft is called BDC. In case of horizontal engine it is called outer dead centre

Bottom dead centre can also be referred as crank end.

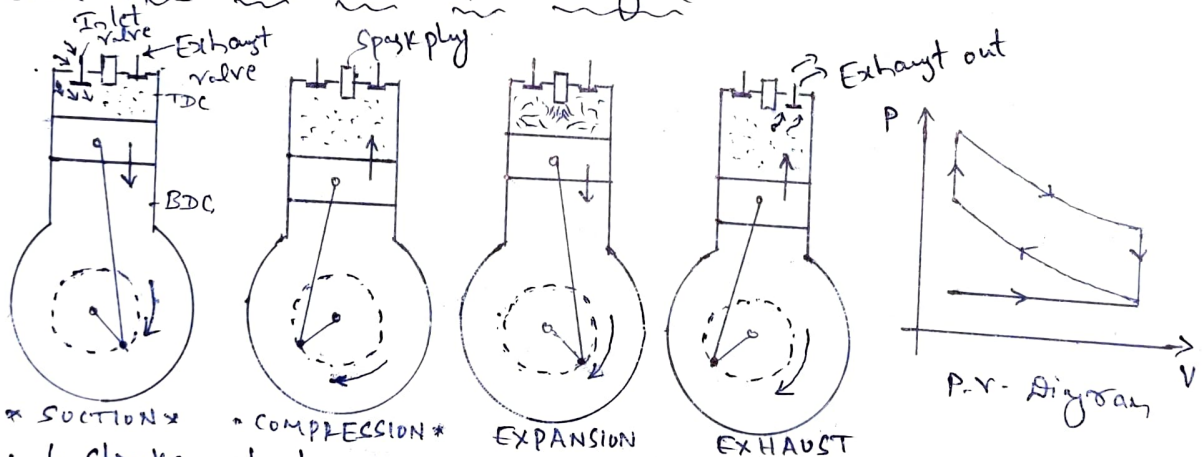
- ⑤ Stroke: The distance b/w TDC & BDC is called stroke & is denoted by L .
- ⑥ Displacement volume (or) piston swept volume (or) stroke volume: The nominal volume generated by the working piston when it moves from BDC to TDC is called displacement volume. It is calculated as the product of piston area & stroke.

i.e. $V_s = \text{Area of piston} \times \text{stroke}$

$$V_s = \frac{\pi D^2}{4} \times L$$

- ⑦ clearance volume: The nominal space on the combustion side of the piston at TDC is called clearance volume $\{V_c\}$.
- ⑧ cylinder volume: The sum of piston swept volume $\{V_s\}$ & clearance volume $\{V_c\}$ is known as total cylinder volume. i.e. $V = V_s + V_c$
- ⑨ compression ratio: The ratio of total volume of the cylinder to the clearance volume of the cylinder is called compression ratio & it is denoted by ' σ ' i.e. $\sigma = \frac{V}{V_c} = \frac{V_c + V_s}{V_c} = 1 + \frac{V_s}{V_c}$

Working of Four stroke petrol engine



The 4-stroke petrol engine works on Otto cycle. The various strokes are as shown in the sketch.

- ① Suction stroke: During the suction stroke the piston moves from TDC to BDC. During this the inlet valve opens & the fuel-air mixture called charge is sucked into the engine cylinder. The exhaust valve remains closed during this stroke.
- ② compression stroke: In this stroke both inlet & exhaust valves are closed & the charge is compressed as the piston moves upwards.

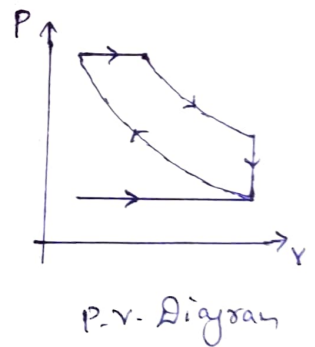
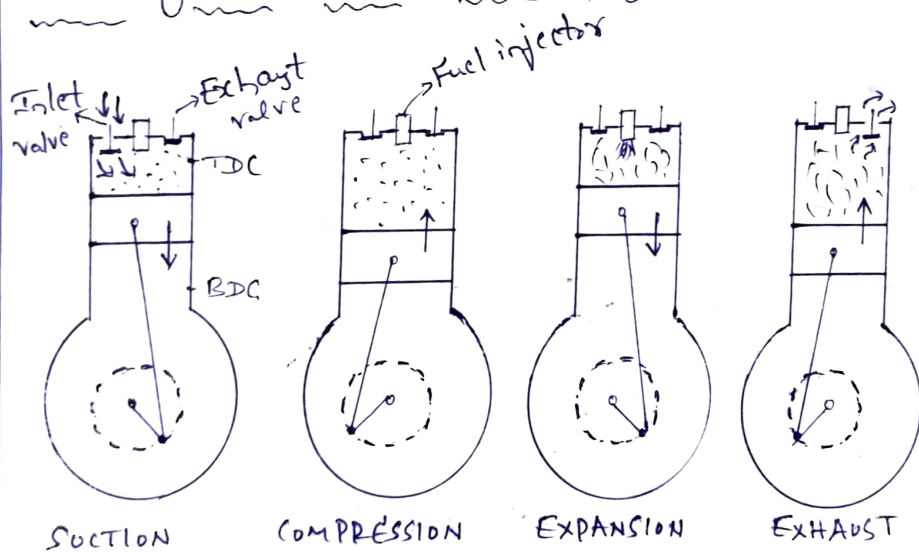
B.D.C. to T.D.C. As a result of compression the pressure of charge increases considerably. (about 8 bar)

Expansion/Working/power stroke: Shortly before the piston reaches T.D.C. the charge is ignited with the help of a spark plug. It suddenly increases the pressure & temperature of the products of combustion. This pushes the piston with great force. The heat energy so produced is transformed into mechanical work.

④ **Exhaust stroke:** As the piston moves from B.D.C. to T.D.C. the products of combustion are pushed out from the engine cylinder & are exhausted through the exhaust valve into the atmosphere.

* Hence the cycle is completed in four strokes & in each stroke crank shaft gives half a revolution & for four strokes crank shaft gives 2 revolutions.

Working of 4-stroke Diesel engine:



① **Suction (or) charging stroke:** In this stroke the inlet valve opens & pure air is sucked into the cylinder as the piston moves downwards from T.D.C. to B.D.C.

② **Compression stroke:** The air drawn at atmospheric pressure during the suction stroke is compressed to high pressure and temperature as the piston moves from B.D.C. to T.D.C. The temperature attained by the air is such that it can ignite the fuel for combustion. Both the valves are remain closed during this stroke.

③ Expansion stroke : Shortly before the piston reaches T.D.C. Diesel fuel is injected in the form of fine spray into the cylinder through the fuel injector. At this moment temperature of compressed air is sufficiently high to ignite the fuel & fuel burns due to increased pressure & temperature owing to the combustion of oil the piston is pushed down & work is done.

④ Exhaust stroke : During this stroke the exhaust valve opens. The piston moves from B.D.C. to T.D.C. & exhaust gases escape to the atmosphere through the exhaust valve.

* The cycle is completed in 4-strokes & crank shaft revolves by 2 revolutions.

petrol engine

- ① It works on otto cycle which is also known as Constant volume cycle
- ② Fuel used is petrol
- ③ Air & petrol mixture is drawn during Suction Stroke
- ④ low Compression ratio ranging from 7:1 to 12:1
- ⑤ Spark plug is present
- ⑥ Quantitative method of governing is employed.
- ⑦ Engine Speed is high which is about 3000 rpm
- ⑧ power developed will be less due to low Compression ratio
- ⑨ Thermal efficiency is low
- ⑩ noise & vibrations are less
- ⑪ Weight of the engine is less
- ⑫ Lighter in Construction & initial cost is less
- ⑬ Running & operating cost is high
- ⑭ can be started easily
- ⑮ used in Scooter, Car, Motorcycles

Diesel engine

- ① It works on Diesel cycle which is also known as constant pressure cycle
- ② Fuel used is Diesel
- ③ only air is drawn during the Suction Stroke.
- ④ High Compression ratio ranging from 16:1 to 20:1
- ⑤ Fuel injector is present
- ⑥ Qualitative method of governing is employed.
- ⑦ Engine Speed is low which is about 1500 rpm.
- ⑧ power developed will be more due to High Compression ratio
- ⑨ Thermal efficiency is high
- ⑩ noise & vibrations are more
- ⑪ Weight of the engine is more
- ⑫ Heavier in Construction & initial cost is more.
- ⑬ Running & operating cost is less
- ⑭ Difficult to start in cold
- ⑮ used in buses, Trucks, Tractors etc.