MECHANICAL ENGINEERING SCIENCE (UE25ME141A/B)

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MECHANICAL ENGINEERING SCIENCE

IC Engines

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- *The distinctive feature of our civilization today, one that makes it different from all others, is the wide use of mechanical power.*
- *At one time, the primary source of power for the work of peace or war was chiefly man's muscles.*
- *Later, animals were trained to help and afterwards the wind and the running stream were harnessed.*
- *But, the great step was taken in this direction when man learned the art of energy conversion from one form to another.*
- *The machine which does this job of energy conversion is called an ENGINE.*

ENGINE – An engine is a device which transforms one form of energy into another form.

HEAT ENGINE - Heat engine is a device which transforms the chemical energy of a fuel into thermal energy and utilizes this thermal energy to perform useful work. Thus, thermal energy is converted to mechanical energy in a heat engine.

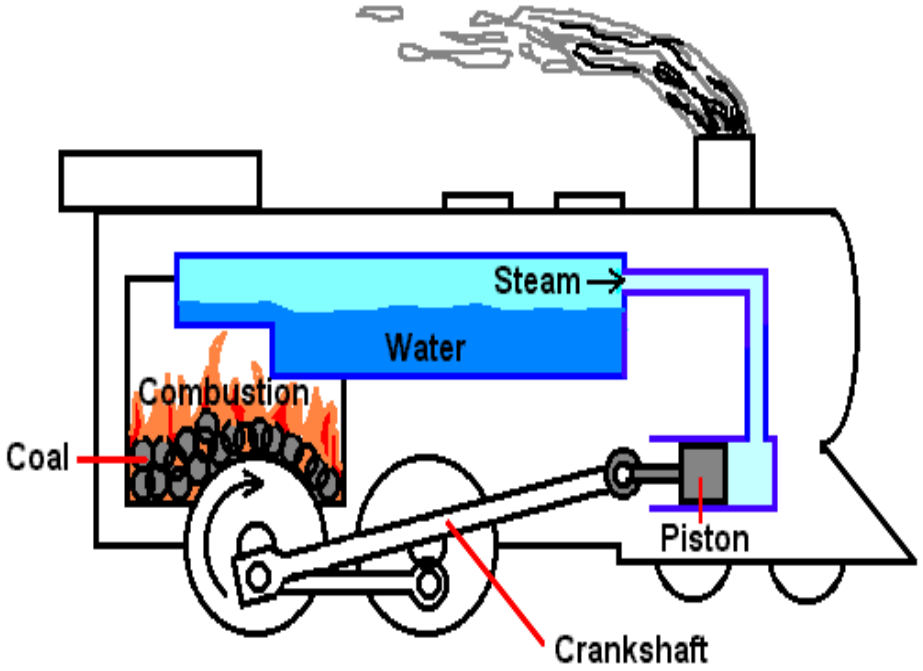
Heat engines can be broadly classified into two categories:

(i) Internal Combustion Engines (IC Engines)

(ii) External Combustion Engines (EC Engines)

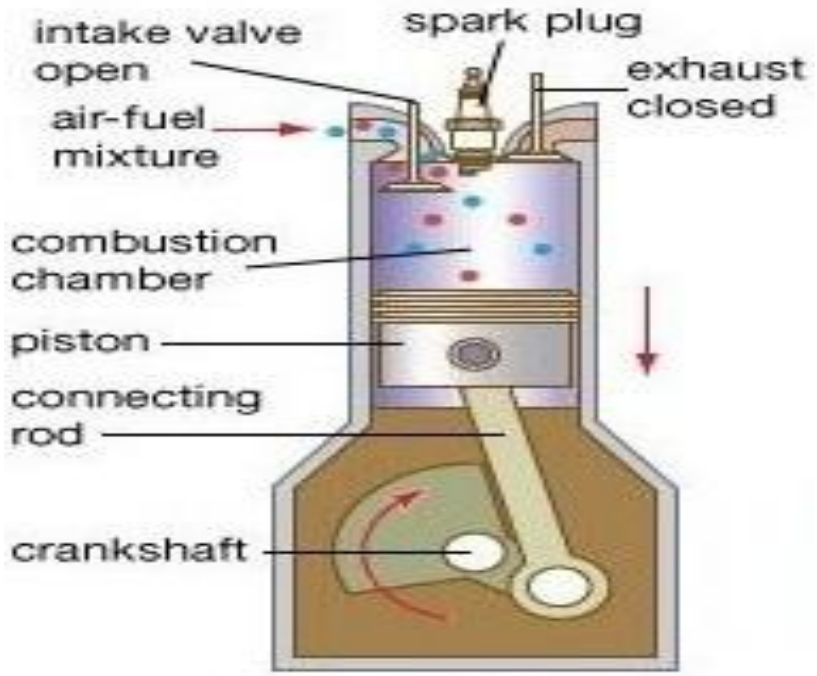
External combustion engines are those in which combustion takes place outside the engine.

For example, in a steam engine or a steam turbine, the heat generated due to the combustion of fuel is employed to generate high pressure steam which is used as the working fluid in a reciprocating engine or a turbine.



Internal combustion engines are those in which combustion takes place within the engine.

For example, in case of petrol or diesel engines, the products of combustion generated by the combustion of fuel and air within the cylinder form the working fluid.



CLASSIFICATION OF IC ENGINES - There are several criteria for classification of I.C. engines. Some of the important criteria can be explained as:

- Number of strokes per cycle
- Nature of thermodynamic cycle
- Ignition systems
- Fuel used
- Arrangement of cylinders
- Cooling systems
- Fuel supply systems

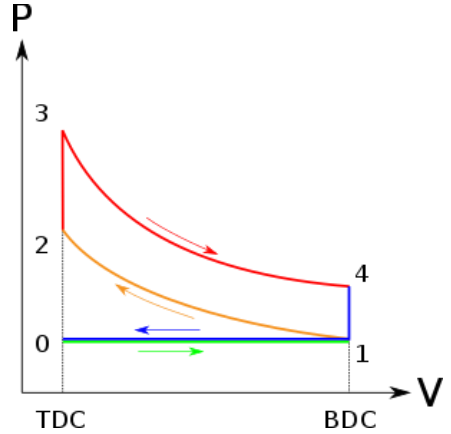
Number of Strokes Per Cycle:

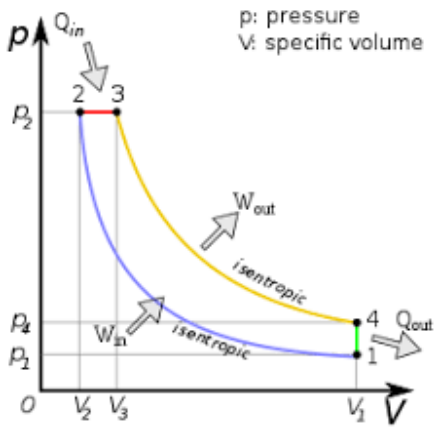
- I.C. engines can be classified as **four-stroke engines (4S)** and **two-stroke engines (2S).**

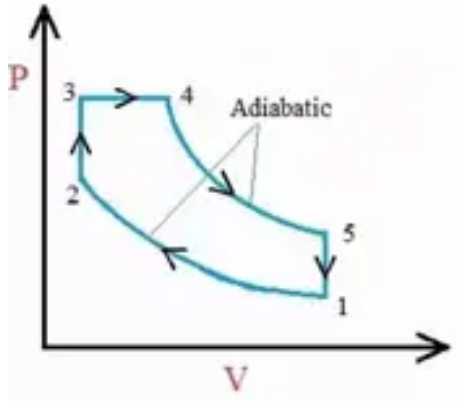
- In four-stroke engines, the thermodynamic cycle is completed in four strokes of the piston or two revolutions of the crankshaft whereas, in two-stroke engines, the thermodynamic cycle is completed in two strokes of the piston or one revolution of the crankshaft.

Nature of Thermodynamic Cycle:

- I.C. engines can be classified as **Otto cycle, Diesel cycle, and Dual cycle engines**.







Ignition Systems:

- There are two modes of ignition of fuel inside the cylinder — **spark ignition** and **compression ignition**.

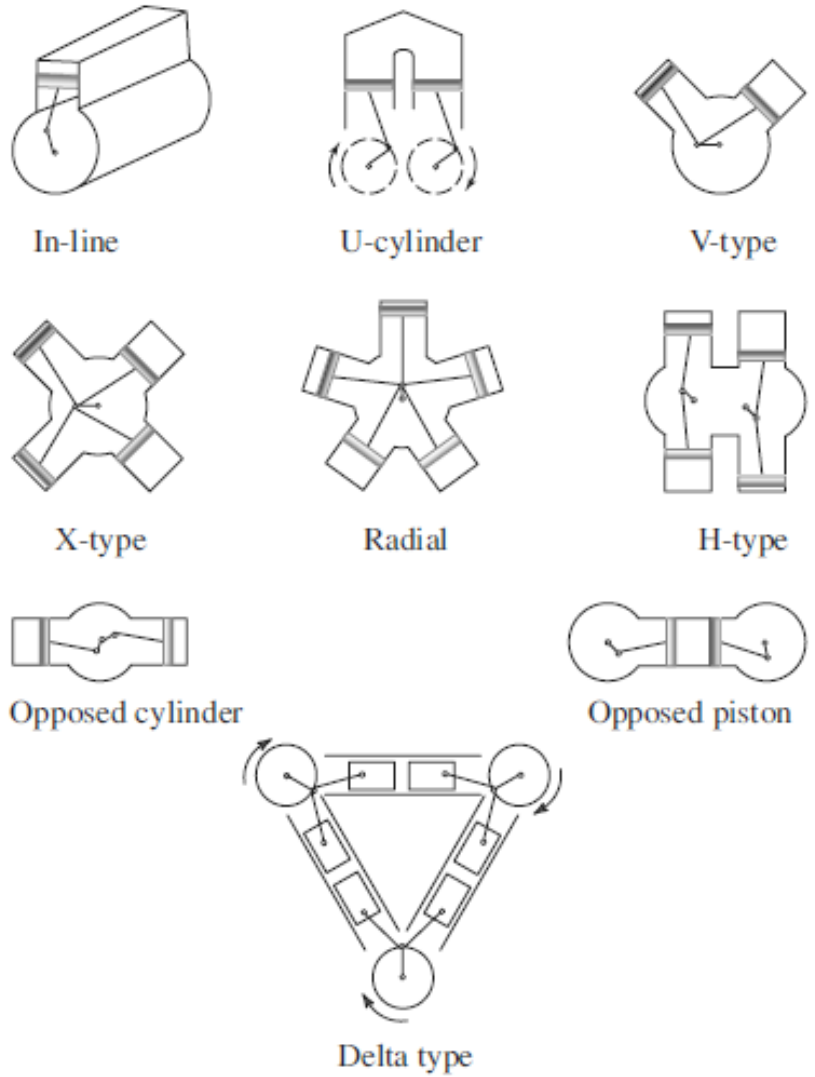
- In spark ignition, sparking starts at the end of compression stroke from spark plug while in compression ignition the temperature of the fuel is increased to the self-ignition point by compressing the air alone and at the end of compression, fuel is injected into the cylinder.

Fuel Used:

- On the basis of fuel used, I.C. Engines can be classified as (a) **Gas engines** like CNG, LPG, etc. (b) **Petrol engine**, (c) **Diesel engine**, and (d) **Bi-fuel engine**. In a bi-fuel engine, two types of fuels are used like gaseous fuel and liquid fuel.

Arrangement of Cylinders:

- Another common method of classifying IC engines is by the cylinder arrangement. The cylinder arrangement is only applicable to multi cylinder engines.
- A number of cylinder arrangements are popular with designers. The details of various cylinder arrangements are shown.



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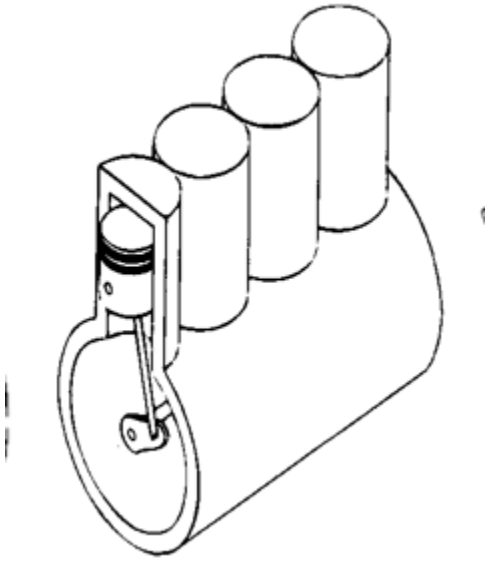
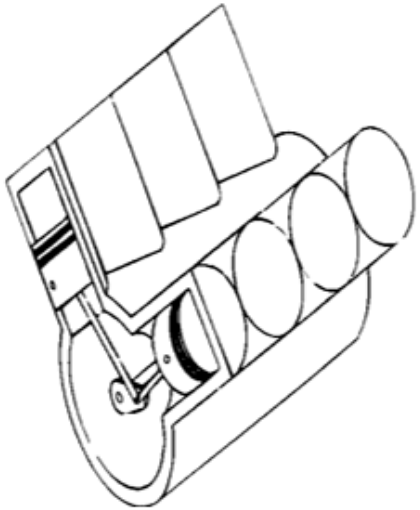
In-line Engine : The in-line engine is an engine with one cylinder bank, i.e. all cylinders are arranged linearly, and transmit power to a single crankshaft.
Variants: Inline-2, Inline-3, Inline-4, Inline-6, etc.
Characteristics: Simple design, easy manufacturing, good balance in even-numbered cylinders.
Applications: Passenger cars, motorcycles, small trucks.



'V' Engine : In this engine there are two banks of cylinders (i.e., two in line engines) inclined at an angle to each other and with one crankshaft.

- Characteristics: More compact lengthwise than inline engines; better balance with more cylinders.
- Variants: V6, V8, V12, etc.
- Advantages: More cylinders in less space; smoother operation.
- Applications: High-performance cars, trucks, motorcycles.



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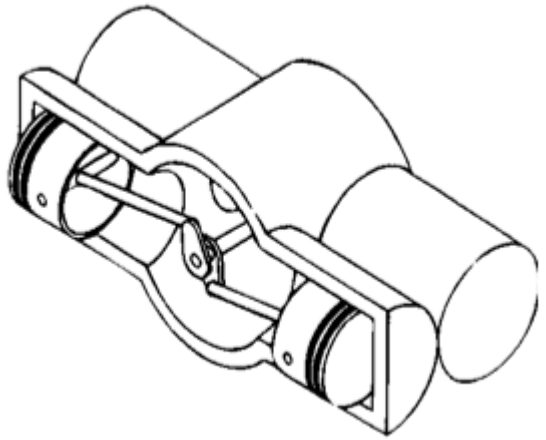
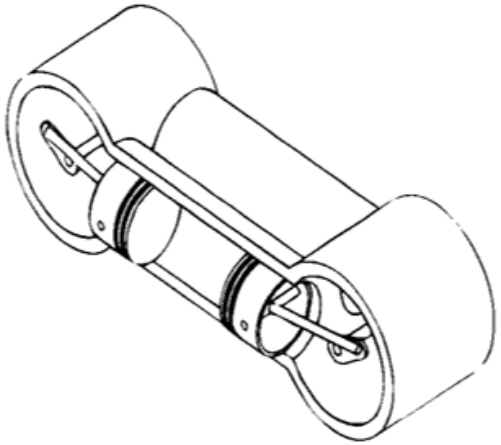
Opposed Cylinder Engine : Cylinders are arranged in two banks on opposite sides of a single crankshaft, with the pistons moving in **horizontally opposite directions**.

- It is inherently a well-balanced engine and has the advantages of a single crankshaft.
- This design is used in small aircrafts.
- As the crankshaft rotates, one piston from each bank moves toward the center while its counterpart moves outward.



Opposed Piston Engine : When a single cylinder houses two pistons, each of which driving a separate crankshaft, it is called an opposed piston engine.

- Arrangement: Two pistons share a single cylinder from opposite ends.
- Characteristics: Eliminates the cylinder head, reducing weight and heat losses.
- Applications: Some diesel engines in heavy machinery, military.

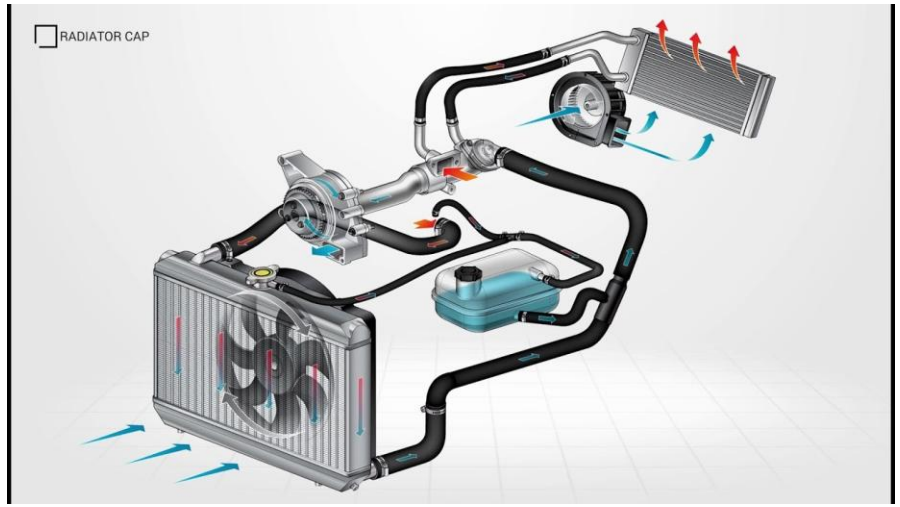


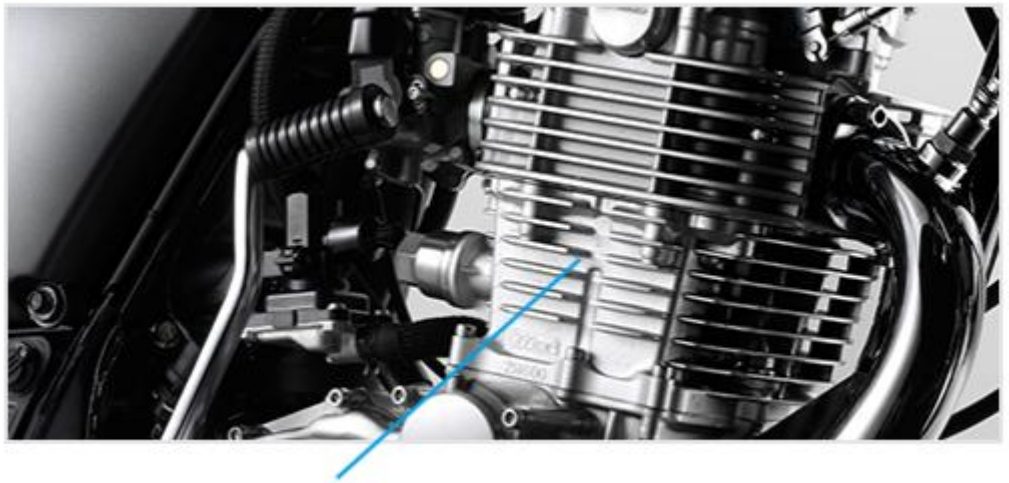
Radial Engine :

- Arrangement: Cylinders arranged in a circle around the crankshaft.
- The radial arrangement of cylinders is most commonly used in conventional air-cooled aircraft engines.
- Pistons of all the cylinders are coupled to the same crankshaft.
- Characteristics: Common in aircraft engines.
- Advantages: Good air cooling, compact diameter, smooth power delivery.

Cooling Systems:

- There are two types of cooling systems in I.C. Engines—**water cooling** and **air cooling**.
- In water cooling, coolant and radiators are provided to cool the cylinder.
- Large power producing engines like a car, bus, truck, etc. are equipped with water cooling systems.
- In air cooling, fins are provided on the surface of the cylinder to radiate the heat into the atmosphere.
- Low power engines like motorbikes are equipped with air cooling systems.





Fins on an air-cooled engine

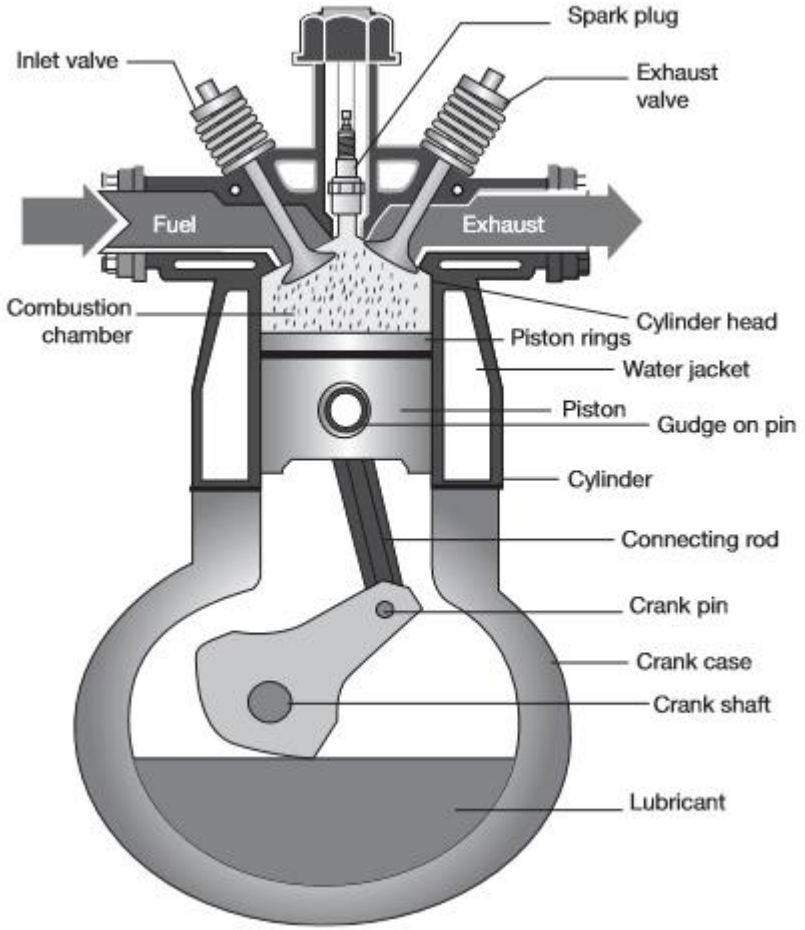
Fuel Supply Systems:

On the basis of fuel supply systems, I.C. Engines can be classified as:

(a) Carburetor engine,
(b) Air injection engine, and
(c) Airless or solid or Mechanical injection engines.

- In a carburetor engine, air and fuel are properly mixed into the carburetor and then fed into the cylinder.
- In air injection engines, fuel is supplied to the cylinder with the help of compressed air.
- In mechanical injection engines, the fuel is injected into the cylinder with the help of mechanical pump and nozzle.

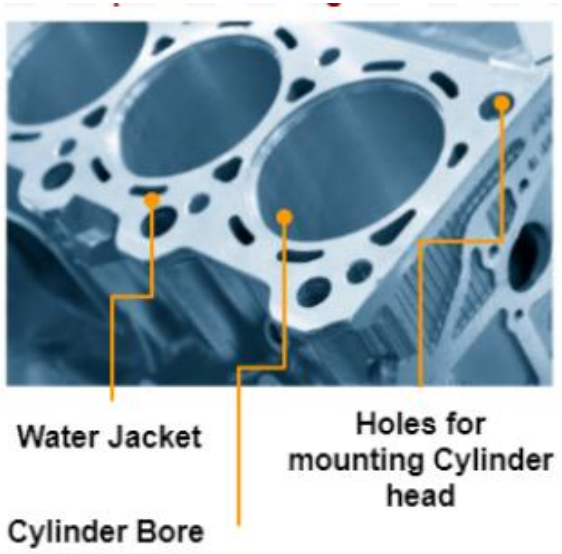
BASIC STRUCTURE OF AN IC ENGINE:



Cylinder:

- It is a hollow cylindrical structure closed at one end with the cylinder head.
- The combustion of the fuel takes place inside the cylinder.
- This is known as the heart of the engine.
- It is made of hard and high thermal conductivity materials by casting.
- A piston reciprocates inside the cylinder and produces power.

Cylinder Head: It covers one end of the cylinder and consists of valves/ports and spark plug/injector.



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Piston:

- It is a cylindrical component which is fitted perfectly inside the cylinder providing a gas-tight space with the piston rings and the lubricant.
- The piston is connected to connecting rod by gudgeon pin.
- The main function of the piston is to transfer the power produced by combustion of the fuel to the crankshaft.

Piston Rings:

- The outer periphery of the piston is provided with several grooves into which piston rings are fitted.
- The upper ring is known as **compression ring** and the lower rings are known as **oil rings**.
- The function of the compression ring is to compress the air or air-fuel mixture and the function of the oil rings is to collect the surplus lubricating oil on the liner surface.

Connecting Rod:

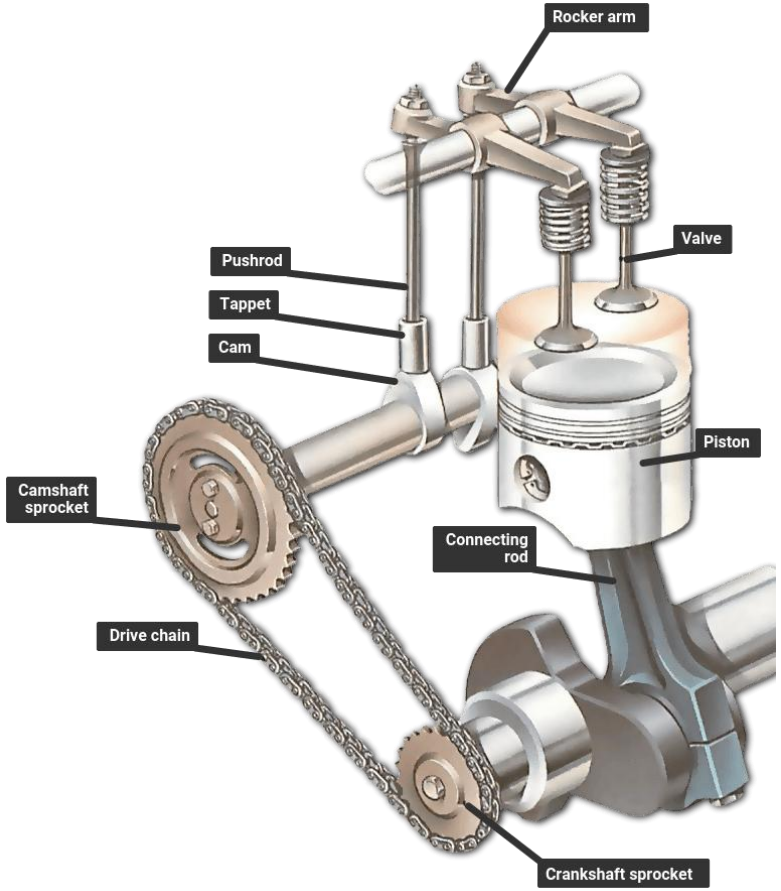
- It connects the piston and the crankshaft. One end, called the small end, is connected to the gudgeon pin located in the piston and the other end, called big end, is connected to crank pin.
- The function of the connecting rod is to transfer the reciprocating motion of the piston into rotary motion of the crankshaft.

Crankshaft:

- It is principal rotating part of the engine which controls the sequence of reciprocating motion of the pistons.
- It consists of several bearings and crank pins.

Valves:

- Normally, the two valves are used for each cylinder, which may be of mushroom shaped poppet type.
- They are provided on the cylinder head for regulating the charge coming into the cylinder and for discharging the products of combustion from the cylinder.
- The valve mechanism consists of cams, cam follower, push rod, rocker arms, and spring.

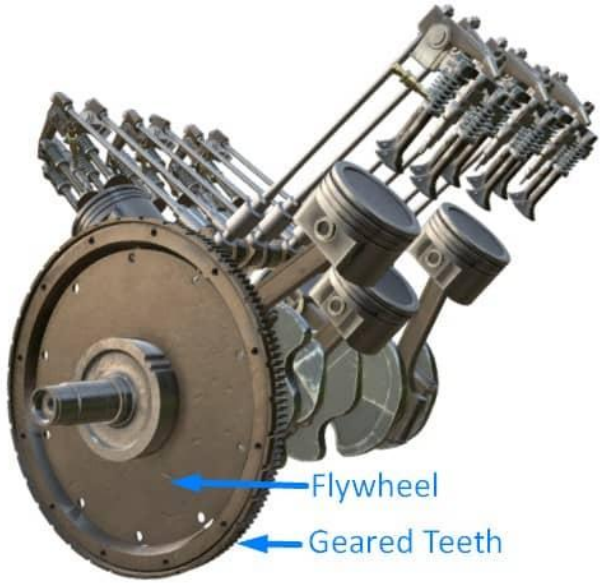


Crankcase:

- The bottom portion of the cylinder block is called crankcase.
- A cover called crankcase which becomes a sump for lubricating oil is fastened to the bottom of the cylinder block.

Flywheel:

- It is a heavy wheel mounted on the crankshaft to minimize the cyclic variations in speed.
- It absorbs the energy during the power stroke and releases it during the non-power stroke.



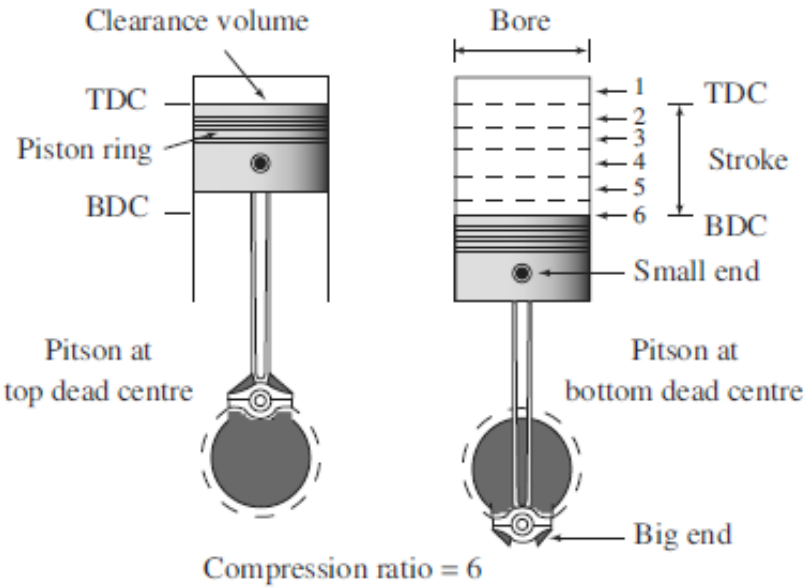
NOMENCLATURE:

Cylinder Bore (d) : The nominal inner diameter of the working cylinder is called the cylinder bore and is designated by the letter d.

Piston Area (A) : The area of a circle of diameter equal to the cylinder bore is called the piston area and is designated by the letter A.

Stroke (L) : The nominal distance through which a working piston moves between two successive reversals of its direction of motion is called the stroke and is designated by the letter L.

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 of the stroke is called the dead centre.



NOMENCLATURE:

There are two dead centres in the engine as indicated in Fig. They are:

(i) Top Dead Centre (ii) Bottom Dead Centre

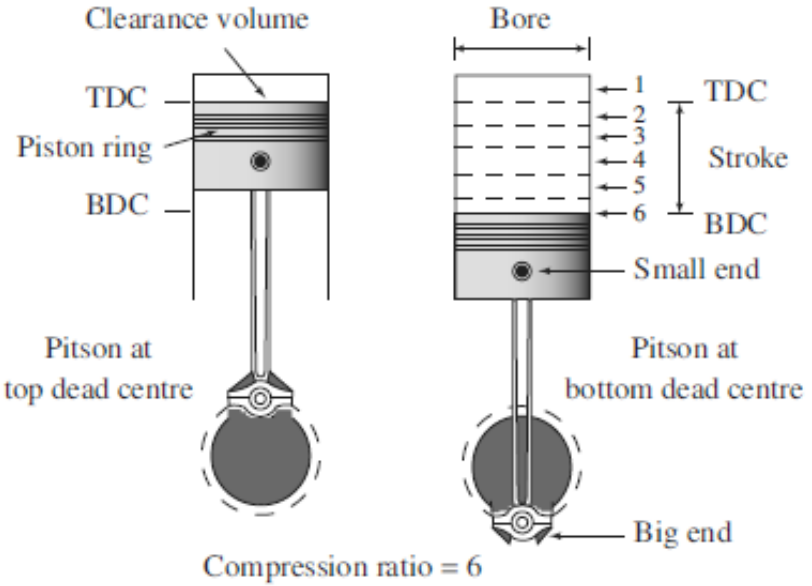
(i) Top Dead Centre (TDC) : It is the dead centre when the piston is farthest from the crankshaft.

(ii) Bottom Dead Centre (BDC) : It is the dead centre when the piston is nearest to the crankshaft.

Displacement or Swept Volume (Vs) : The nominal volume swept by the working piston when travelling from one dead centre to the other is called the displacement volume.

It is usually expressed in terms of cubic centimeter (cc).

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

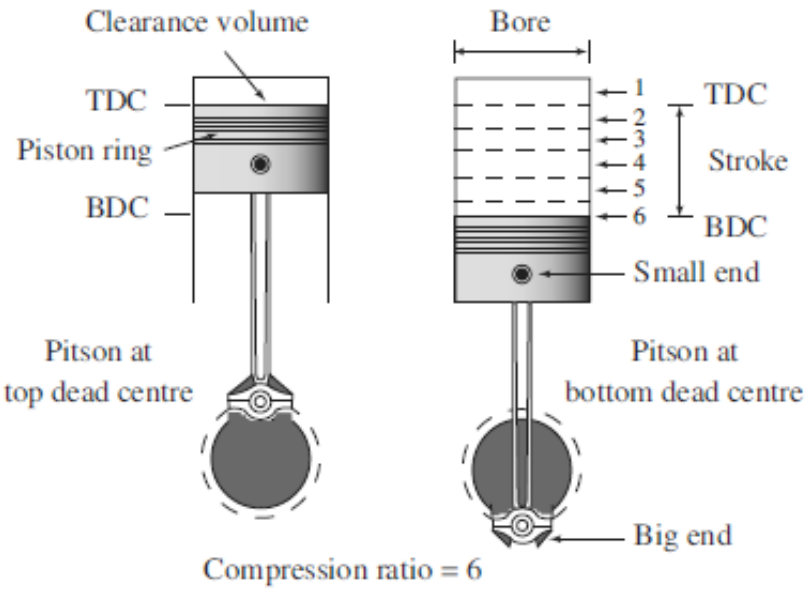


NOMENCLATURE:

Clearance Volume (Vc): The nominal volume of the combustion chamber above the piston when it is at the top dead centre is the clearance volume.

Compression Ratio (r) : It is the ratio of the total cylinder volume when the piston is at the bottom dead centre, V_T , to the clearance volume, Vc.

$$r = \frac{V_T}{V_C} = \frac{V_C + V_s}{V_C} = 1 + \frac{V_s}{V_C}$$



THANK YOU

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