Mechanical Engineering Fundamentals

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Mechanical Engineering Fundamentals

(MEC103)

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Content

1) Fundamental Concepts of Thermodynamics
2) Laws of Thermodynamics
3) Pressure and its Measurement
4) Heat Transfer
5) Power Absorbing Devices
6) **Power Producing Devices**
7) Principles of Design
8) Power Transmission Devices and Machine Elements

Power Producing Devices

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Lecture No. - 1

- Power Producing Devices
- Heat Engines & its Types
- Advantages, Disadvantages and Applications of Heat Engines
- Classification of Heat Engines
- Engine Components (Parts, Functions, Location & Material)
- Basic Terminology Used in IC Engines

Heat Engines

- These are devices that convert heat or thermal energy to mechanical work, which can then be used to do mechanical work by performing series of processes.
- Heat Engines requires working substance (liquid, solid or gas) in which energy can be stored, released and absorbed as per machine requirement.

Examples of Heat Engines

- Internal Combustion Engine
- Steam Engine
- Steam Turbine etc.

Types of Heat Engines

- External Combustion Engines
- Internal Combustion Engines

External Combustion Engines

The engine in which combustion of fuel takes place outside the working system of heat engine.

Steam Engine, Steam Turbines are the examples of EC Engines, where the steam is working substance generated in the boiler by the combustion of fuel.

Internal Combustion Engines

The engine in which combustion of fuel takes place inside the working system of heat engine.

Petrol Engine, Diesel Engine and Gas Engine are the examples of IC Engines.

Advantage of IC Engine over EC Engine

a) These are having low weight to power ratio.

b) Low maintenance cost.

c) IC engines are compact and efficient.

d) They do not need auxiliary equipment's like boiler, furnace etc.

e) They are suitable for mobile applications.

f) Their thermal efficiency is higher than other heat engines

Disadvantage of IC Engine over EC Engine

a) Not suitable for large capacities.

b) Fuel used in IC engine is not economical.

Applications of IC Engine

- **Road Vehicles**
  - Car
  - Truck/Bus
  - Scooter/Motor cycle
- **Locomotive**
- **Light Aircraft**
- **Marine**
  - Outboard/ Inboard
  - Ship
- **Power Generation**
- **Agricultural**
  - Tractors
  - Pump set
- **Domestic Use**
  - Lawnmowers
  - Snow blowers
  - Tools etc.

Classification of IC Engine

The Internal combustion engines may be classified on following bases:

Based on fuel used

- Petrol Engine
- Diesel Engine
- Gas Engine

Based on No. of strokes per cycle

- Four Stroke Engine
- Two Stroke Engine

Based on cycle of operations

- Otto Cycle Engine (Combustion at constant Volume)
- Diesel Cycle Engine (Combustion at constant Pressure)
- Dual Cycle Engine (Combustion partly at constant volume and partly at constant pressure)

Based on type of ignition

- Spark Ignition Engine (S.I. Engine)
- Compression Ignition Engine (C.I. Engine)

Based on the number of cylinders

- Single Cylinder Engine (Like Scooters)
- Multi Cylinder Engine (Like Cars, Trucks etc.)
- Twin Cylinder Engine
- Three Cylinder Engine
- Four Cylinder Engine
- Six Cylinder Engine
- Eight Cylinder Engine
- Twelve Cylinder Engine
- Sixteen Cylinder Engine

Based on arrangement of cylinders

- Horizontal Engine
- Vertical Engine
- Radial Engine
- V Engine
- W Engine
- Inline or Straight Engine
- Opposed Piston Engine
- Opposed Cylinder Engine

Based on valve arrangement

- F-head Engine
- I-head Engine
- L-head Engine
- T-head Engine

Based on the cooling system used

- Air Cooled Engine (In small engines like scooters and motorcycles)
- Water Cooled Engine (In medium and heavy engines like cars)

Based on the lubrication system used

- Dry sump lubricated engine
- Wet sump lubricated Engine

Based on speed of engine

- Low Speed Engine
- Medium Speed Engine
- High Speed Engine

Based on fuel Injection

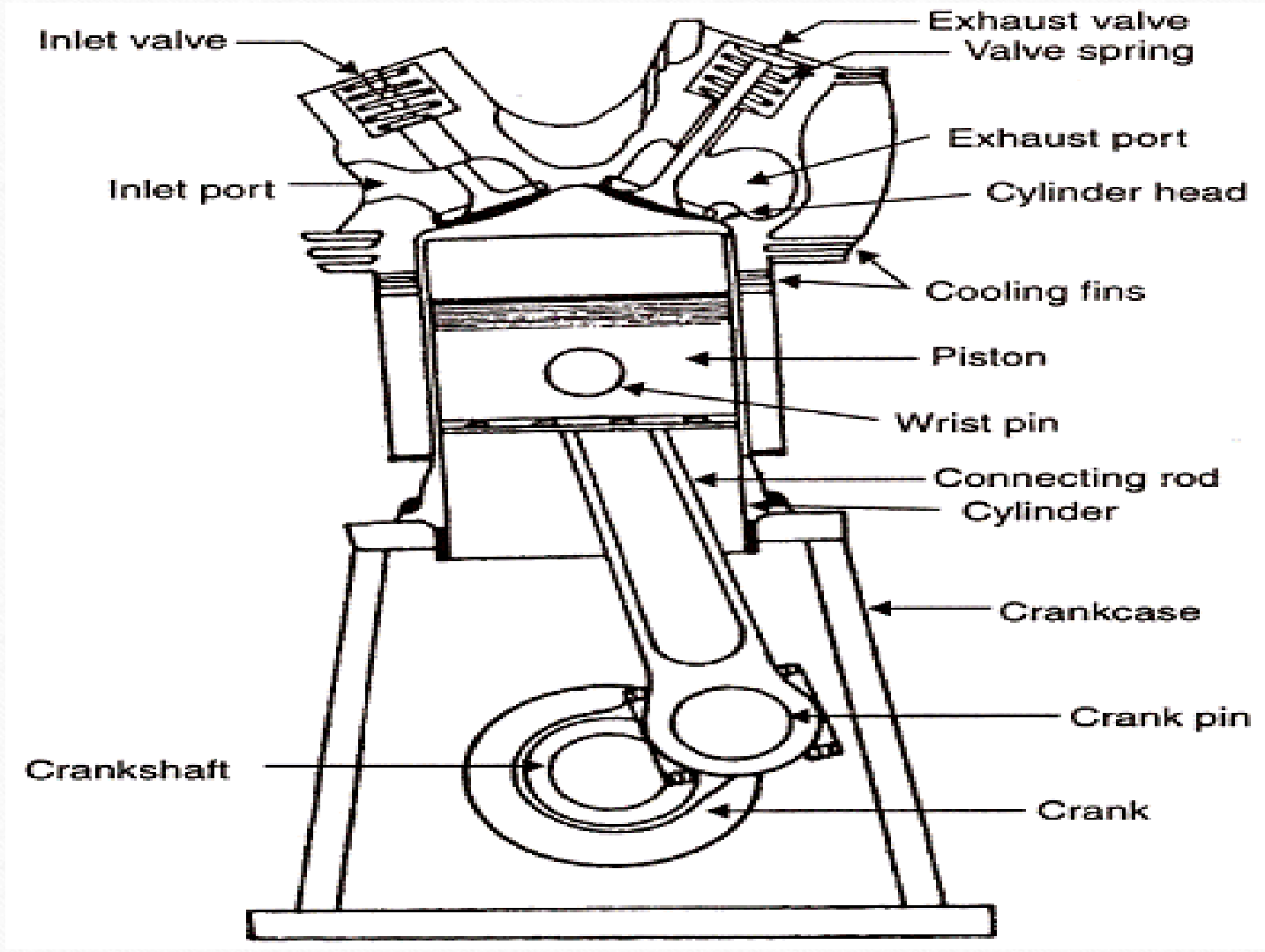
- Carburetor Engine
- Air Injection Engine
- Airless or Solid Injection Engine

Based on application

- Automobile Engine
- Aircraft Engine
- Locomotive Engine
- Marine Engine
- Agro Engine
- Stationary Engine

Engine Components

Location – Function - Material


Inlet valve
Exhaust valve
Valve spring
Exhaust port
Inlet port
Cylinder head
Cooling fins
Piston
Wrist pin
Connecting rod
Cylinder
Crankcase
Crank pin
Crankshaft
Crank

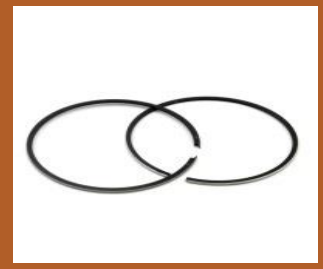
Part Name	Location	Function	Material
Engine Block	It is considered as main body of IC engine.	It supports all other components of IC engine.	Cast Iron

Part Name	Location	Function	Material
Cylinder	Cylinders may be machined directly in the engine block. One side of cylinder is covered with cylinder head and other side open towards crank case.	In this piston reciprocates to develop power and it has to withstand high pressure (about 75 bar) and temperature (about 2500°c) because there is direct combustion inside it.	Material should be such that it can retain high temperature and strength, good conductor of heat, resist wear and tear due to reciprocating parts. Generally, Cast Iron is used (Usually cast in one piece). For heavy duty alloy steels are used.

Part Name	Location	Function	Material
Cylinder Liner	These are inserted into the engine cylinder.	For easy maintenance of heavy engine blocks liners are inserted into the engine cylinder which can be replaced when worn out.	Nickel Chrome Iron

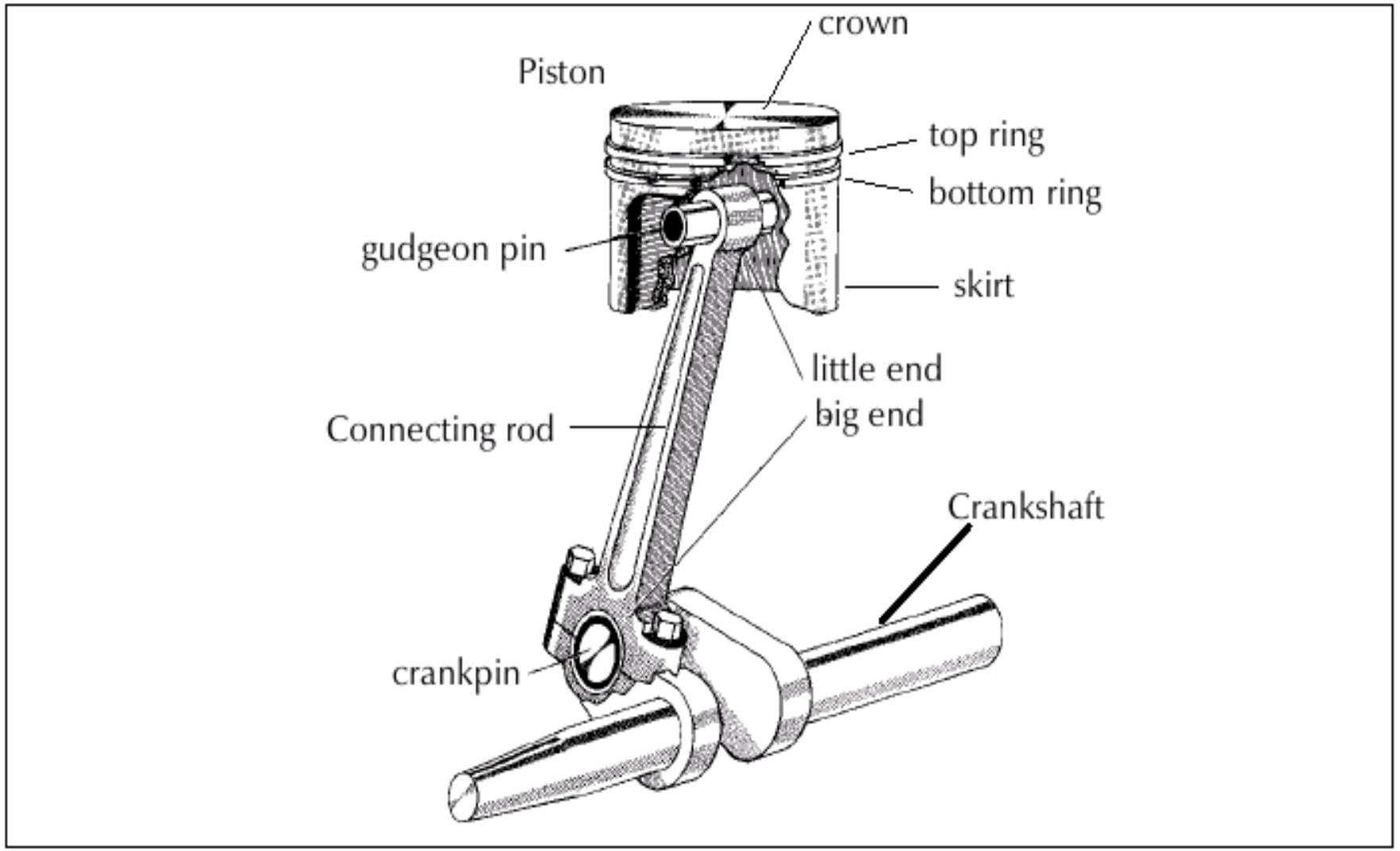
Part Name	Location	Function	Material
Cylinder Head	It is secured to cylinder head by means of studs. It contains inlet valve, exhaust valve, spark plug (in Petrol Engine) or injector (in Diesel Engine)	It covers one end of cylinder and not to allow the entry and exit of gases on cover head valve engine. The cylinder head and also and forms the combustion chamber.	Gray Cast Iron or Aluminum Alloy

Part Name	Location	Function	Material
Piston	Piston is the heart of the engine. It reciprocates inside the engine cylinder.	The piston is used to compress the mixture during compression stroke and transmit the power to crank through connecting rod.	Cast Iron, Cast Steel or Aluminum alloy

Part Name	Location	Function	Material
Piston Rings	The circular rings which are mounted in the grooves provided around the circumference of the piston are known as piston rings. These are of two types: Compression Rings (Mounted on upper portion of piston) Oil Control Rings (Mounted on lower portion of piston) In IC Engine piston have at-least two compression rings and one oil ring.	Compression rings provide the tight seal between piston and cylinder walls thus prevents the leakage of fuel air mixture. Oil control ring prevents the oil to mix with the charge.	Cast Iron (Made by centrifugal casting) 

Part Name	Location	Function	Material
Gudgeon Pin or Piston Pin or Wrist Pin	It is a cylindrical pin (Made hollow since it is reciprocating part) which connects small end of connecting rod and bosses provided inside the piston.	It helps in pivoting the piston to small end of connecting rod thus helps in transmitting power from piston to connecting rod.	Case Hardened Steel

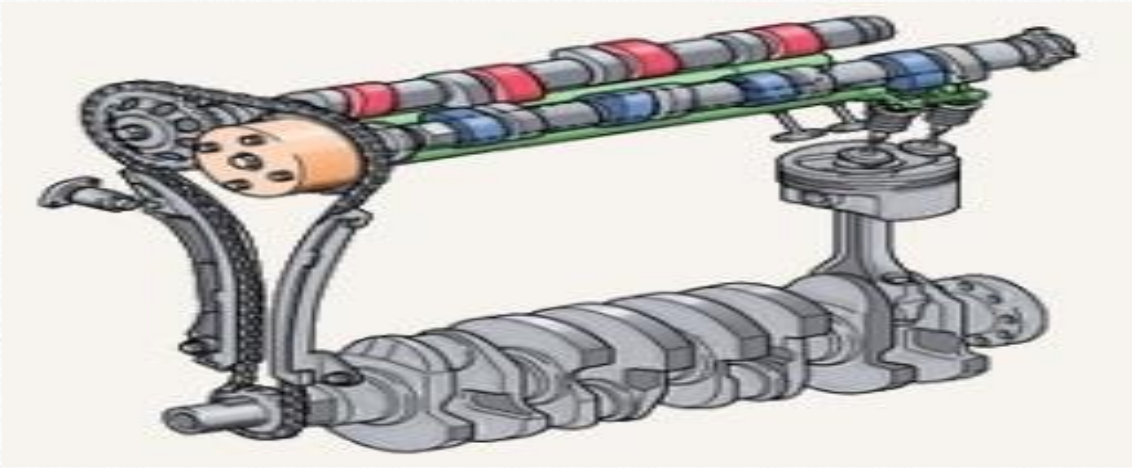
Part Name	Location	Function	Material
Connecting Rod	It is located in between the piston (small end) and the crank shaft (big end).	It transmits the reciprocating motion of the piston into rotary motion of the crank shaft.	Carbon Steel or Aluminum Alloy


crown
Piston
top ring
bottom ring
gudgeon pin
skirt
little end
big end
Connecting rod
Crankshaft
crankpin

Part Name	Location	Function	Material
Crank Pin	Crank pin joins the big end of connecting rod and crank shaft.	Transfer the power and motion to crankshaft comes from connecting rod through piston.	Steel Alloy

Part Name	Location	Function	Material
Crank Shaft	Crankshaft is located in crank case or in the main body of the engine. It is connected to the axle of wheels which moves as crankshaft rotates.	Crank shaft is the backbone of the engine. It receives the oscillation motion from the connecting rod and gives it to main shaft as rotary motion. It also drives the camshaft which actuates the valve of the engine.	Forged Steel

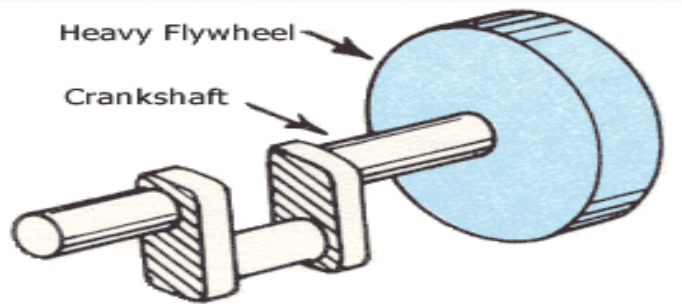
Part Name	Location	Function	Material
Cam Shaft	Camshaft is located in the engine. It takes driving force from the crankshaft either through the chain drive or gear mechanism.	Camshaft operated the engine valves and fuel pump (Petrol engine). It rotates half the speed of crankshaft.	Forged Steel



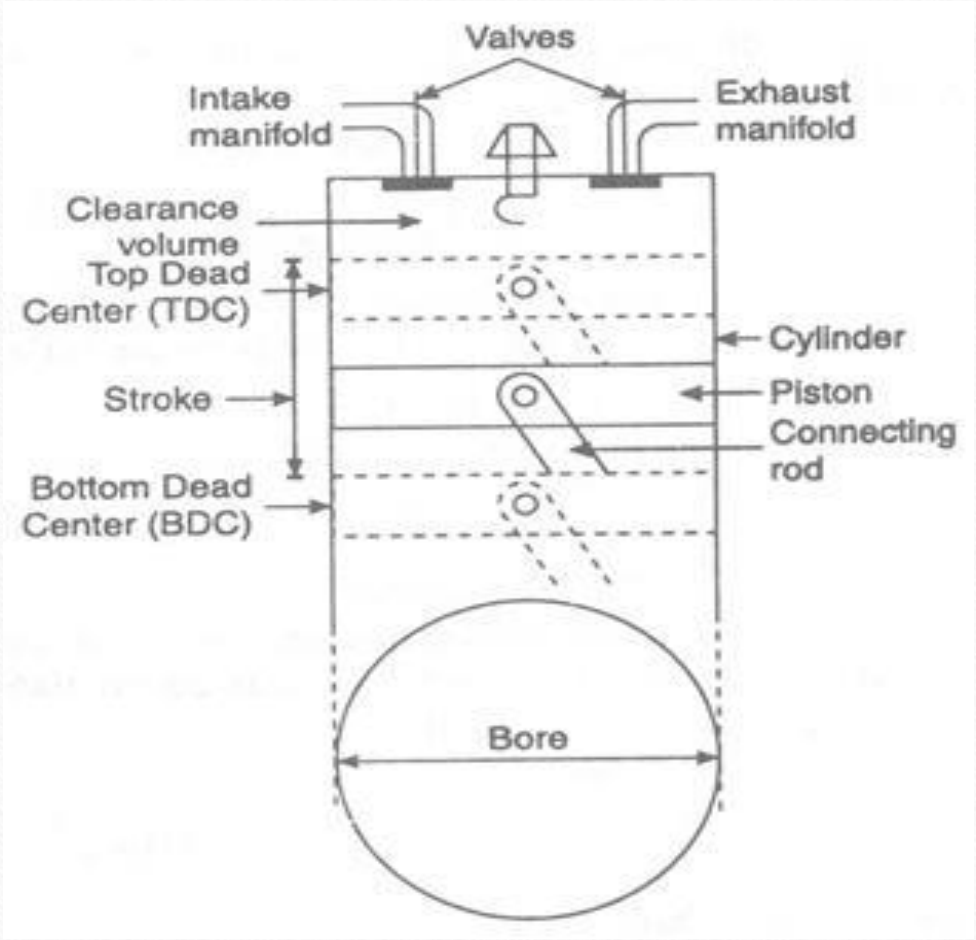
Part Name	Location	Function	Material
Valves Inlet Valve Exhaust Valve	Valves are fitted in the cylinder head either on the top or side. Inlet valve is fitted in inlet port and exhaust valve is fitted in exhaust port.	Through inlet valve either air fuel mixture (Petrol Engine) or only air (Diesel Engine) admitted into the engine cylinder. Through exhaust valve burnt gases escape out from the engine cylinder.	Inlet Valve: Nickel Chrome Alloy Steel Exhaust Valve: Silicrome Steel

Part Name	**Location**	**Function**	**Material**
Gaskets	Gasket is located between cylinder head and cylinder block.	Its function is to prevent the leakage of any type.	Asbestos or Copper Sheet

Part Name	Location	Function	Material
Flywheel	**Flywheel is mounted on the crankshaft normally at the rear end.**	**It is energy reservoir which stores the energy during power stroke and delivers it during idle stroke to keep the engine speed uniform.**	**Cast Iron**



Basic Terminology Used in IC Engines



Bore

The internal diameter of the cylinder is called as Bore and it is measured in millimeter (mm).

Dead Centre

They extreme position occupied by the piston inside the cylinder at the end of its Stroke, where the centre line of the Connecting Rod and Crank are in the same straight line is called as dead centre.

There are two dead centres:

- For Vertical Engines, these are known as Top Dead Centre (T.D.C) and Bottom Dead Centre (B.D.C) position.
- For Horizontal Engines, these are known as Inner Dead Centre (I.D.C) and Outer Dead Centre (O.D.C) position.

Top Dead Centre

In Vertical Engines, the top most position of the Piston towards the cover end side of the cylinder is known as Top Dead Centre.

Bottom Dead Centre

In Vertical Engines, the lower position of the Piston towards the Crank end side of the cylinder is known as Bottom Dead Centre.

Stroke

It is the distance travelled by the Piston from one of its dead centre to the other dead centre. It is equal to twice the crank radius and measured in millimeter (mm).

Swept Volume

It is the volume swept by the piston when it moves from one dead centre to another dead centre positions. It is also known as Piston Displacement. It is denoted by Vs. It is measured in cc (Cubic Centimeter).

For example: Vehicle has 4 cylinders: Each cylinder has a volume of 700cc: 700cc X 4 = 2800cc: 2800cc = 2.8 Litre

$Vs = A \times L = \pi d^2/4 \times L$

d = Internal diameter of cylinder in cm.

L = Stroke length in cm.

Clearance Volume

It is the volume included between the piston and the cylinder head when the piston is at its T.D.C. in vertical engines and I.D.C. in horizontal engines. The Clearance Volume is generally expressed as percentages of Swept Volume. It is denoted by Vc. It is measured in cc (Cubic Centimeter).

$Vc = \pi d^2/4 \ X \ a$

d = Internal diameter of cylinder in cm,

a = Length between top position of piston at T.D.C. and bottom position of cylinder head in cm.

Total Cylinder Volume

The sum of swept volume and clearance volume is called total cylinder volume.

Total Cylinder Volume = Vs+ Vc

Compression Ratio

It is the ratio of the total Cylinder Volume to the Clearance Volume. It is denoted by ϒ.

ϒ = Vs+ Vc / Vc

For Petrol Engines the value of Compression Ratio is varies from 5:1 to 9:1 and for Diesel Engines varies from 14:1 To 22:1.

Piston Speed

It is the distance travelled by the Piston per unit time.

The piston Speed=2LN meter/min.

If the R.P.M. of Engine Shaft=N and length of Stroke=L meter.

Crank Throw

This is the distance between the centres of crankshaft and crank pin. The distance will be equal to half the Stroke Length. It is also called crank radius.

Question

Give the location, function and material of following components:

Engine Block

Cylinder

Piston and Piston rings

Connecting rod

Crankshaft

Camshaft

Valves

Flywheel

Outcomes

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THANK YOU