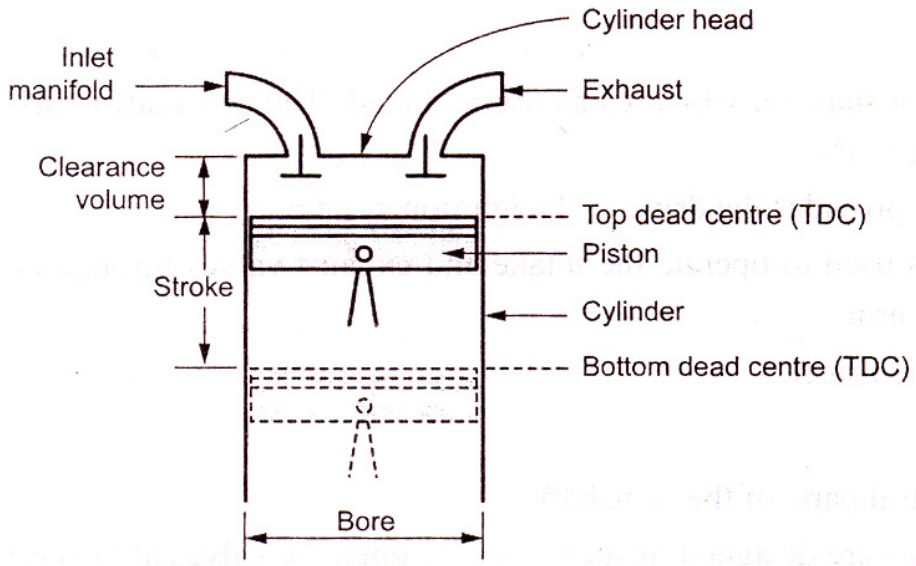
IC ENGINE TERMINOLOGY:

The following terms/Nomenclature associated with an engine are explained for the better understanding of the working principle of the IC engines.



1. Bore:

The nominal inside diameter of the engine cylinder is called bore.

2. Top Dead Centre (TDC):

The extreme position of the piston at the top of the cylinder of the vertical engine is called top dead centre (TDC),

Incase of horizontal engines. It is known as inner dead centre (IDC).

3. Bottom Dead Centre (BDC):

The extreme position of the piston at the bottom of the cylinder of the vertical engine called bottom dead centre (BDC).

In case of horizontal engines, it is known as outer dead center (ODC).

4. Stroke:

The distance travelled by the piston from TDC to BDC is called stroke.

In other words, the maximum distance travelled by the piston in the cylinder in one direction is known as stroke.

It is equal to twice the radius of the crank.

5. Clearance Volume (Vc):

The volume contained in the cylinder above the top of the piston, when the piston is at top dead centre is called the clearance volume.

6. Swept Volume (Vs):

The volume swept by the piston during one stroke is called the swept volume or piston displacement.

Swept volume is the volume covered by the piston while moving from TDC to BDC.

Swept volume = Vs = A x L = $\frac{\Pi}{4} D^2 L$

where A = Cross sectional area of the piston in Sq.m,
L = Stroke in m, and
D = Cylinder bore i.e., inner diameter of the cylinder in m.

7. Compression Ratio (rc):

Compression ratio is a ratio of the volume when the piston is at bottom dead centre to the volume when the piston is at top dead centre.

Mathematically,

$$\text{Compression ratio} = \frac{MaximumCylinderVolume}{MinimumCylinderVolume}$$

$$= \frac{SweptVolume + ClearenceVolume}{ClearenceVolume}$$

The compression ratio varies from 5 : 1 to 10 : I for petrol engines and from 12:1 to 22 : I for diesel engines.

Sl.No	Classification Criteria	Types
1.	No of Strokes per cycle	1. Four Stroke Engine 2. Two Stroke Engine
2.	Types of Fuel Used	1. Petrol or Gasoline Engine 2. Diesel Engine 3. Gas Engine 4. Bi-Fuel Engine
3.	Nature of Thermodynamic Cycle	1. Otto Cycle Engine 2. Diesel Cycle Engine 3. Dual Combustion Cycle Engine
4.	Method of Ignition	1. Spark Ignition (SI) Engine 2. Compression Ignition (CI) Engine
5.	No of Cylinders	1. Single Cylinder Engine 2. Multi Cylinder Engine
6.	Arrangement of Cylinders	1. Horizontal Engine 2. Vertical Engine 3. V – Type Engine 4. Radial Engine 5. Inline Engine 6. Opposed Cylinder Engine 7. Opposed Piston Engine
7.	Cooling System	1. Air Cooled Engine 2. Water Cooled Engine
8.	Lubrication System	1. Wet Sump Lubrication System 2. Dry Sump Lubrication System
9.	Speed of the Engine.	1. Slow Speed Engine 2. Medium Speed Engine 3. High Speed Engine
10.	Location of Valves	1. Over Head Valve Engine 2. Side Valve Engine

CONSTRUCTION & COMPONENTS OF IC ENGINE:

1. Cylinder Block:

It is the heart of the engine.

It consists of three parts.

(i) The cylinders in which the piston slides up and down.

(ii) The ports or openings for valves.

(iii) The passages (water jackets) for the flow of cooling water.

Function: In the bore of the cylinder, the charge is compressed by piston, ignited and expanded to give power to piston.

Material: Aluminium alloy and grey cast iron.

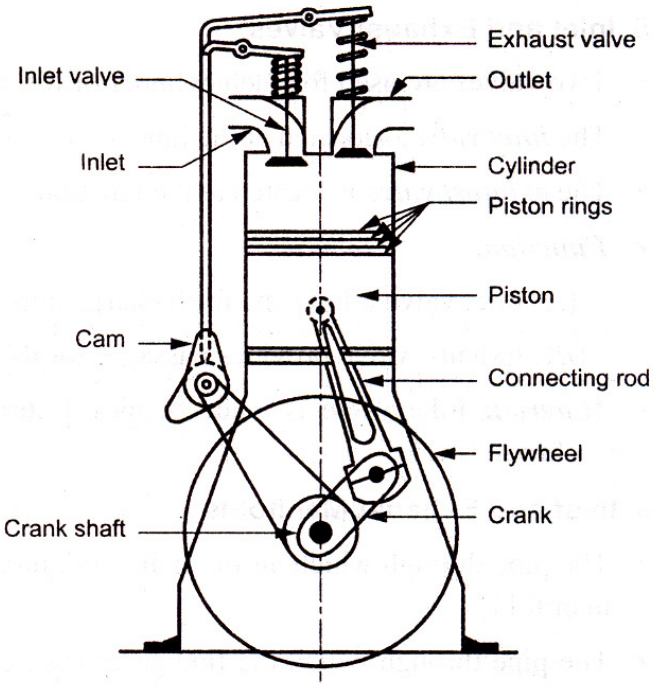
2. Cylinder Head:

It is fitted on the top of the cylinder.

It has inlet valve, exhaust valve and the spark plug or fuel injector.

Function: Through inlet valve fresh charge is admitted and through exhaust valve burnt gases are send out

Material: Grey cast iron, Aluminium alloy and cast steel.



3. Piston:

It is the main active part of the engine.

It is cylindrical in construction and slides tip and down inside the cylinder.

It has piston rings to provide good seal between the cylinder wall and the piston.

There are three grooves to accommodate piston rings.

Function:

(i) To compress the fresh charge during the compression stroke.

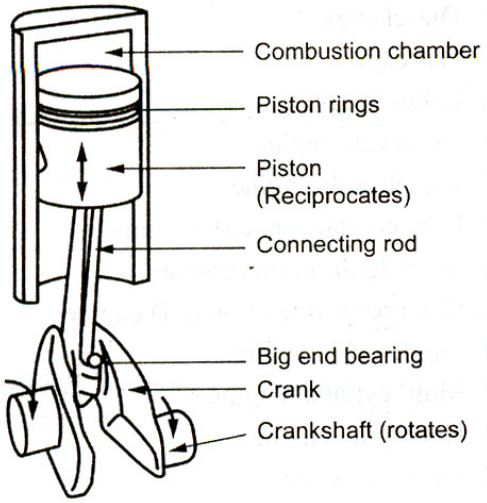
(ii) To transmit the force exerted due to combustion of the charge to the connecting rod finally to the crankshaft during the power stroke.

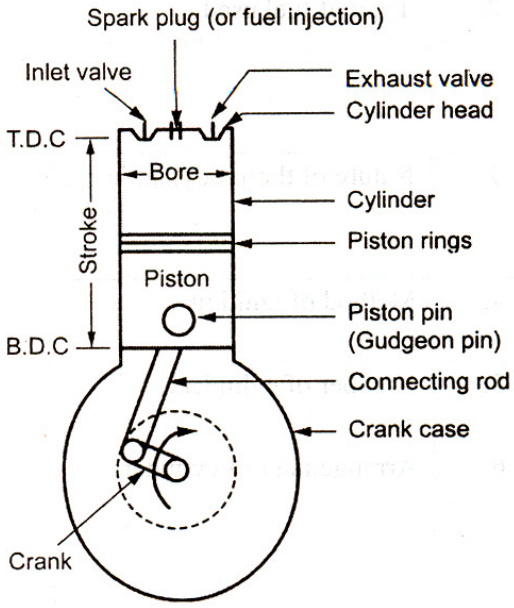
Material: Aluminium alloy cast steel, cast iron and chrome nickel

4. Combustion Chamber:

The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber.

Combustion chamber is the closed space in which combustion of fuel takes place.





5. Inlet and Exhaust Valves:

There are two valves in the cylinder of IC engines inlet and exhaust valve
The inlet valve is located at the junction of intake port and cylinder.
The exhaust valve is located at the junction of exhaust port and cylinder.

Function:

(i) Inlet valve allows the fresh charge into the cylinder.
(ii) Exhaust valve provides passages for the burnt gases to escape from the cylinder.

Material: Inlet valve is made of nickel chromium steel
Exhaust valve is made of silchrome steel.

6. Inlet and Exhaust Manifolds:

The pipe through which air or air fuel mixture is drawn into the cylinder is called the inlet manifold.

The pipe through which the flue gases (i.e., exhaust gases) escape into the atmosphere is called the exhaust manifold.

7. Piston Rings:

Piston rings are fitted into the grooves of the piston to maintain good seal between the piston and the cylinder walls.

There are two types of pistons rings. Upper rings are called compression rings and the lower rings are called oil rings.

Function:

Compression rings are used to provide gas tight sealing to prevent leakage of the lubricating oil into the engine cylinder.

The oil rings, also called as scrapper rings are used to scrap the used lubricating oil into the crank case.

Material: Alloy cast iron containing silicon, manganese, alloy steels, etc.

8. Connecting Rod:

The connecting rod interconnects the piston to the crankshaft.

The upper end of the connecting rod is fitted to the piston and lower end to the crankshaft.

Function:

(i) It transmits the power produced in the cylinder to the crankshaft.

(ii) It converts the reciprocating motion of the piston into rotary motion of tile crankshaft.

Material: Medium carbon steel and alloy steel.

9. Piston Pin:

The piston pin is a pin that connects the small end of the connecting rod to the piston. It is also known as gudgeon pin or wristpin.

10. Crank Pin:

Crank pin connects the connecting rod big end to the crankshaft

11. Crank and Crankshaft:

The crank is a lever that is connected to the end of the connecting rod by a pin joint with its other end connected rigidly to a shaft, called crankshaft.

The crankshaft is the principle rotating part of the engine. The crankshaft is provided with suitable holes to help in the lubrication system.

Function: It converts the reciprocating motion of the piston into useful rotary motion of the Output Shaft.

Material: Forged steel.

12. Camshaft:

A camshaft is a shaft on which cams are mounted.

The camshaft is driven by crankshaft through timing gears.

This shaft also provides the drive to the ignition system.

Function: It is used to operate the intake and exhaust valves through cam follower, push rod and rocker arm.

Material: Forged steel.

13. Cams:

Cams are integral parts of the camshaft.

Function: Cams are designed in such a way to open the valves at the correct timing and to keep them open for the necessary duration.

14. Flywheel:

The flywheel is a heavy wheel that is connected to the extreme end of the crankshaft.

The size of the flywheel depends upon the number of cylinders and the general construction of the engine.

Function: The flywheel stores the excess energy during the power stroke of the engine and supply the energy for the movement of the piston during the remaining stroke.

Thus its function is to maintain Uniform rotation of the crankshaft.

Material: Cast iron.

Use of Flywheel: The net torque exerted to the crankshaft during one complete cycle of operation of the engine fluctuates causing a change in the angular velocity of the shaft. In order to achieve a uniform torque an inertia mass in the form of wheel is attached to the output shaft and this wheel is called the flywheel.

A single cylinder engine will have a larger flywheel whereas a multi cylinder engine will have a smaller flywheel. This is due to the reason that the variation of net torque decreases with increase in the number of cylinders in the engine and thereby the size of the flywheel also becomes smaller.

15. Crankcase:

It is a cast iron case, which holds the cylinder and the crankshaft.

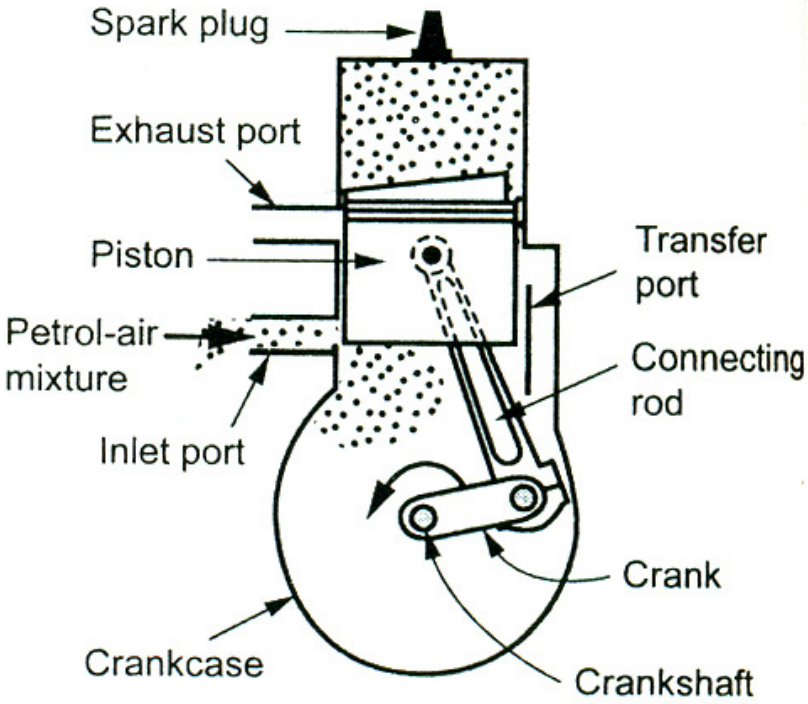
It also serves as sump for the lubricating oil.

Material: Cast iron and Aluminium alloy.

TWO STROKE ENGINES

Two stroke engines perform only two strokes to complete one cycle.

In a four stroke cycle, the power is obtained only once in two revolutions of the crankshaft. Therefore, much attention was paid to obtain power once in every revolution of the crankshaft and this lead to the development of a two stroke cycle. Two stroke Cycle engines will theoretically give twice the power obtained from a four stroke cycle engine of similar size.



Construction:

The two stroke IC engine is similar in construction to the four stroke IC engine except that the valves are replaced by ports,

The two stroke engines are provided with Inlet port ports or openings cut in the cylinder walls.

The closing and opening of the ports are controlled by the movement of piston.

Inlet port is provided to feed the fresh charge into the crankcase.

A transfer port is provided to take the compressed charge from the crankcase to the cylinder.

The burnt waste gases are discharged into the atmosphere through a exhaust port.

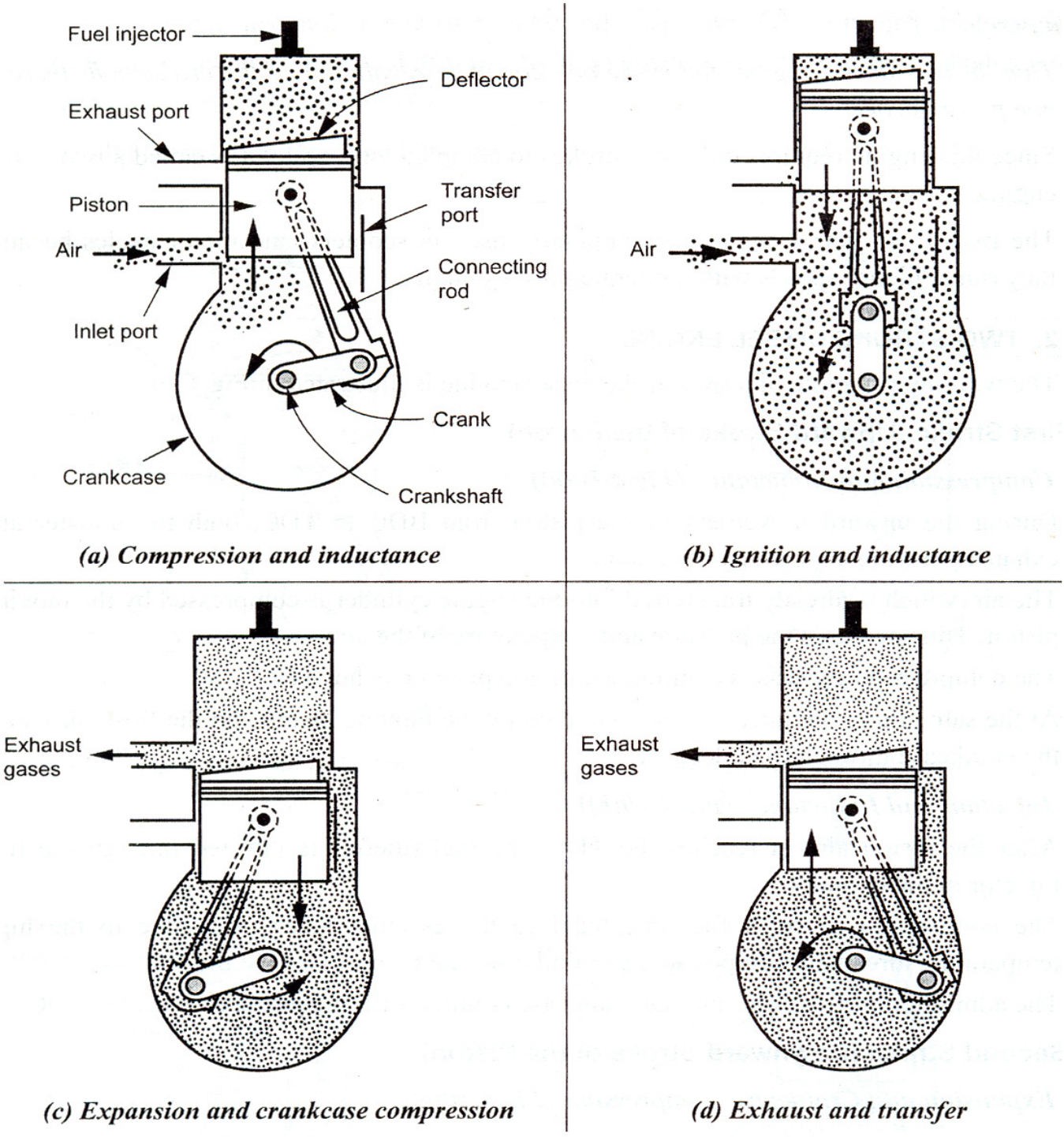
The crown of the piston (i.e., top of the piston) is shaped in such a way to assist in deflecting the fresh charge upwards in the cylinder and help scavenging.

Scavenging: Scavenging is the process of forcing out the burnt exhaust gases from the cylinder by admitting the fresh charge into the cylinder.

TWO STROKE DIESEL ENGINE

The working principle of a two stroke diesel engine is shown in the Fig.

For every one revolution of Crankshaft there is One Power Stroke



1. First Stroke (Upward Stroke of the Piston)

(a) Compression and Inductance:

During the upward movement of the piston from BDC to TDC, both the transfer and exhaust ports are covered by the piston.

The air which is already transferred into the engine cylinder is compressed by the moving piston. This increases the pressure and temperature of the air.

The compression process is continued until the piston reaches TDC.

At the same time, the inlet port is uncovered by the moving piston and the fresh air enters the crankcase through the inlet port.

(b) Injection and Inductance:

After the piston almost reaches the TDC, the fuel (diesel) is injected through the fuel injector in the cylinder.

The combustion of fresh fuel injected into the cylinder takes place due to the high temperature already developed in the cylinder during compression of the air.

The admission of fresh air into the crankcase continues till the piston reaches the TDC

2. Second Stroke (Downward Stroke of the Piston)

(c) Expansion and Crankcase Compression:

The burnt gases expand and forces the piston to move down, thus useful work is obtained.

When the piston moves down, the air is partially compressed in the crankcase. This compression is known as crankcase compression.

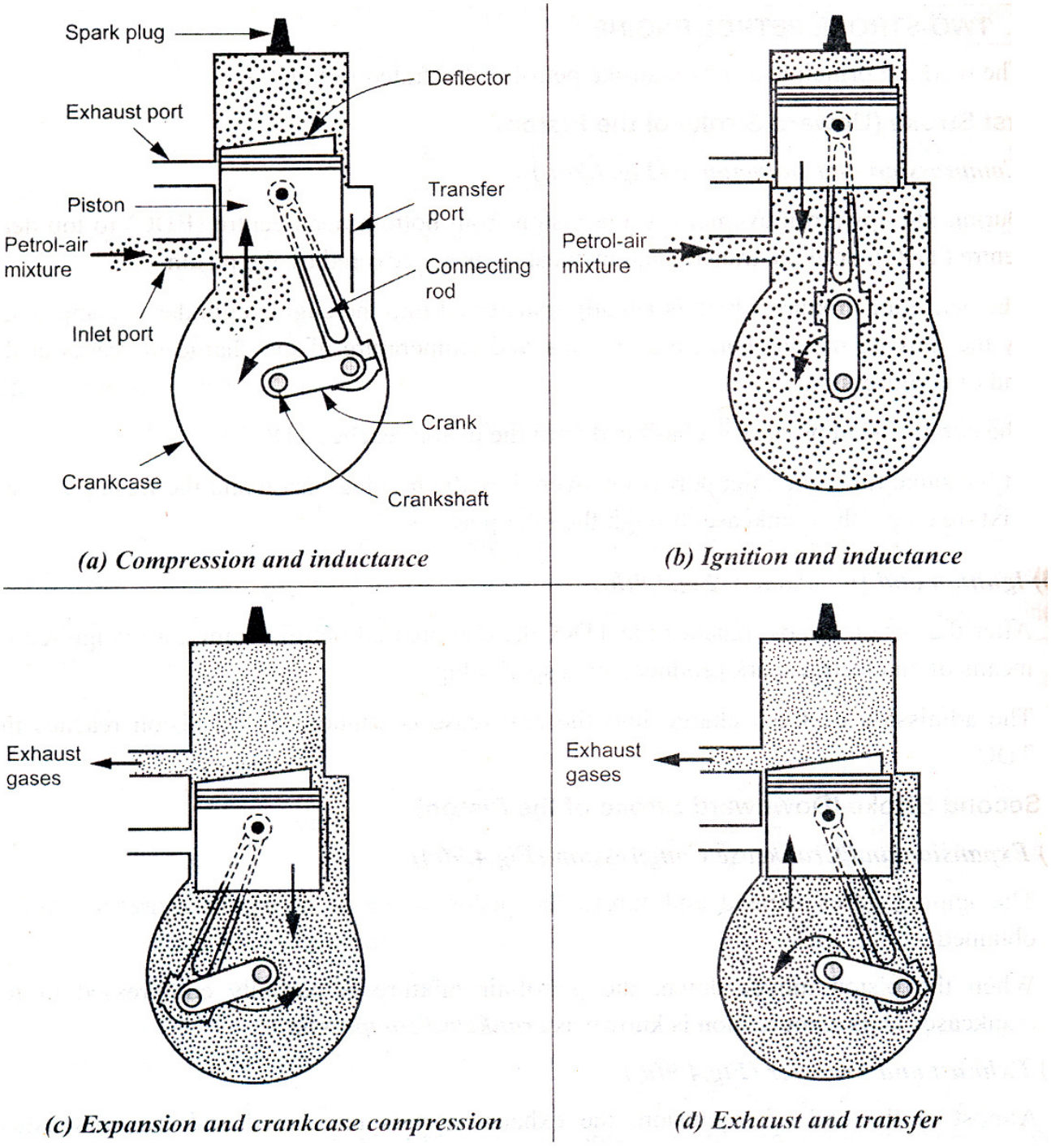
(d) Exhaust and Transfer:

Nearly at the end of expansion, the exhaust port is uncovered and the combustion products escape to the atmosphere. Immediately the transfer port is also uncovered and the partially compressed air from the crankcase enters the cylinder through the transfer port.

The cycle of the operations are then repeated.

TWO STROKE PETROL ENGINE

The working principle of two stroke petrol engine is shown in the Fig.



1. First Stroke (Upward Stroke of the Piston)

(a) Compression and Inductance:

During the upward movement of the piston from BDC to TDC, both the transfer and exhaust ports are covered by the piston.

The petrol air mixture which is already transferred into the engine cylinder is compressed by the moving piston. Thus, the pressure and temperature of the charge increases at the end of compression.

The compression process is continued until the piston reaches TDC.

At the same time, the inlet port is uncovered by the moving piston and the fresh petrol air mixture enters the crankcase through the inlet port.

(b) Ignition and Inductance:

After the piston almost reaches the TDC, the compressed petrol air mixture is ignited by means of an electric spark produced by a spark plug.

The admission of fresh charge into the crankcase continues till the piston reaches the TDC.

2. Second Stroke (Downward Stroke of the Piston)

(c) Expansion and Crankcase Compression:

The ignited gases expand and forces the piston to move down, thus useful work is obtained.

When the piston moves down, the petrol air mixture is partially compressed in the crankcase. Thus compression is known as crankcase compression.

(d) Exhaust and Transfer:

Almost at the end of expansion, the exhaust port is uncovered and the combustion products escape to the atmosphere. Immediately, the transfer port is also uncovered and the partially compressed air fuel mixture from the crankcase enters the cylinder through transfer port.

The crown of the piston is made of a deflected shape, so the fresh air – petrol mixture entering the cylinder is deflected upward in the cylinder. Thus the escape of fresh charge along with the exhaust gases is reduced.

The cycle of operations are then repeated.

FOUR STROKE DIESEL ENGINE

Diesel engine is also known as **compression ignition (CI) Engine.**

It is invented by **Rudolf Diesel (1892)**

The four stroke diesel engine is similar to four stroke petrol engine except that it operates at a **higher compression ratio (14 to 22).**

In a diesel engine, only **air is sucked from the atmosphere** instead of air fuel mixture during the suction stroke.

In diesel engines, spark plug is not required for igniting the air fuel mixture. Because **the fuel is injected and forms an explosive mixture, which ignites spontaneously under pressure.**

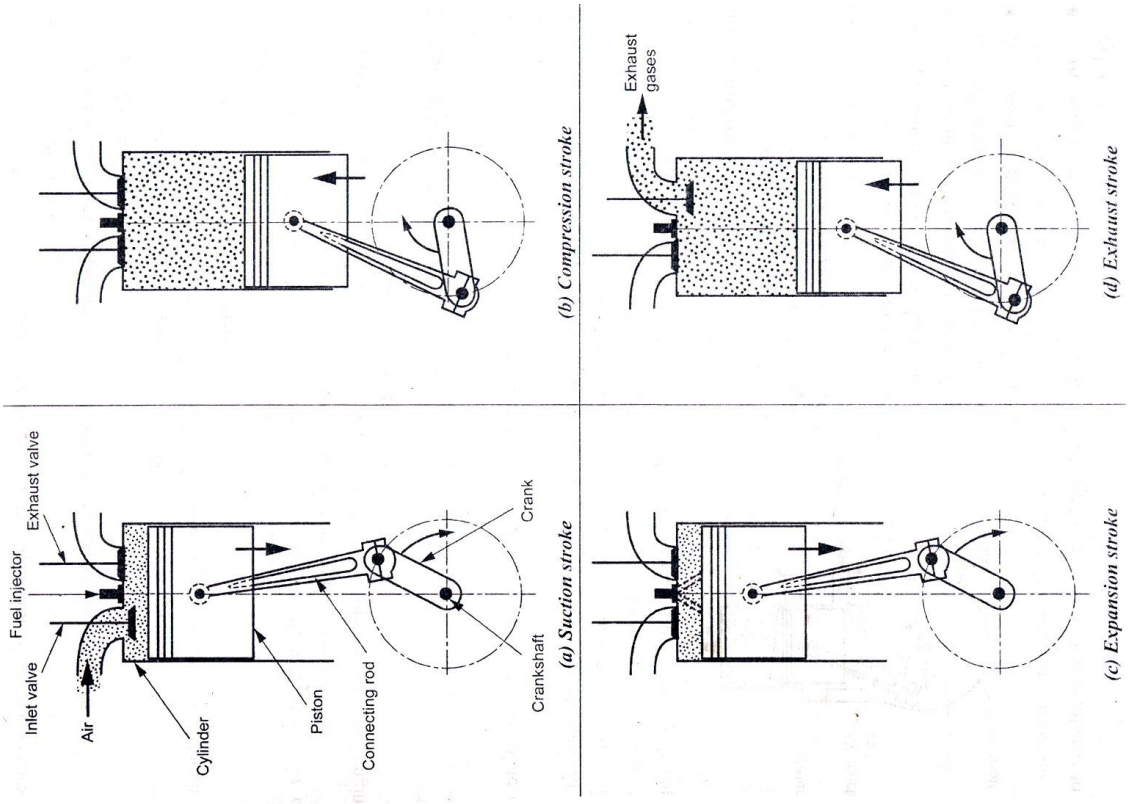
Diesel engine works on the principle of **diesel cycle**.

It is also called as **constant pressure combustion cycle** as the combustion of fuel takes place at constant pressure with increase of temperature.

Since ignition results due to high temperature of compressed air, these are called compression ignition (CI) engines.

The cycle of operation of a four stroke diesel engine consists of the following strokes:

1. Suction or intake stroke,
2. Compression stroke,
3. Expansion or power stroke, and
4. Exhaust stroke.



1. Suction Stroke:

During suction stroke, the inlet valve opens and the exhaust valve closes.

The piston moves from TDC to BDC.

This piston movement reduces the pressure inside the cylinder below the atmospheric pressure.

Due to the pressure difference, the fresh air is sucked into the cylinder through the inlet valve.

2. Compression Stroke:

During this stroke, both the inlet and exhaust valves are closed.

The air in the cylinder is compressed as the piston moves upwards from BDC to TDC.

As a result of this compression, pressure and temperature of the air is increased.

Just before the piston reaches the TDC, the diesel is injected into the cylinder in the form of a fine spray.

The fuel gets vaporized and self ignited due to the heat of compressed air.

The fuel burns instantaneously at constant pressure.

3. Expansion or Power Stroke:

During this stroke, both inlet and exhaust valves are closed.

The combustion of fresh fuel injected into the cylinder is due to the high pressure and temperature developed during compression stroke.

The fuel is continuously injected for 20% of the expansion stroke.

The high pressure of the combustion products due to expansion of charge pushes piston from TDC to BDC. It is also called as working stroke as work is done by the expansion of hot gases.

4. Exhaust Stroke:

During this stroke, inlet valve is closed and the exhaust valve is opened

The piston moves from BDC to TDC. The burnt waste gases are sent out through exhaust valve and the cycle is repeated.

Summary:

Four strokes are completed in two revolutions of the crankshaft. Hence for one complete cycle, there is only one power stroke and two revolutions of crankshaft. Since four stroke diesel engines produce higher power than the four stroke petrol engines they are generally used in tractors, tracks, etc.

FOUR STROKE PETROL ENGINE

Petrol engine is also known as **Spark Ignition (SI) engine**.

Invented **by Nicolaus A. Otto in 1876** that is why petrol engine is also known as **Otto engine**.

Since ignition occurs due to a spark petrol engines are called spark ignition (SI) engines.

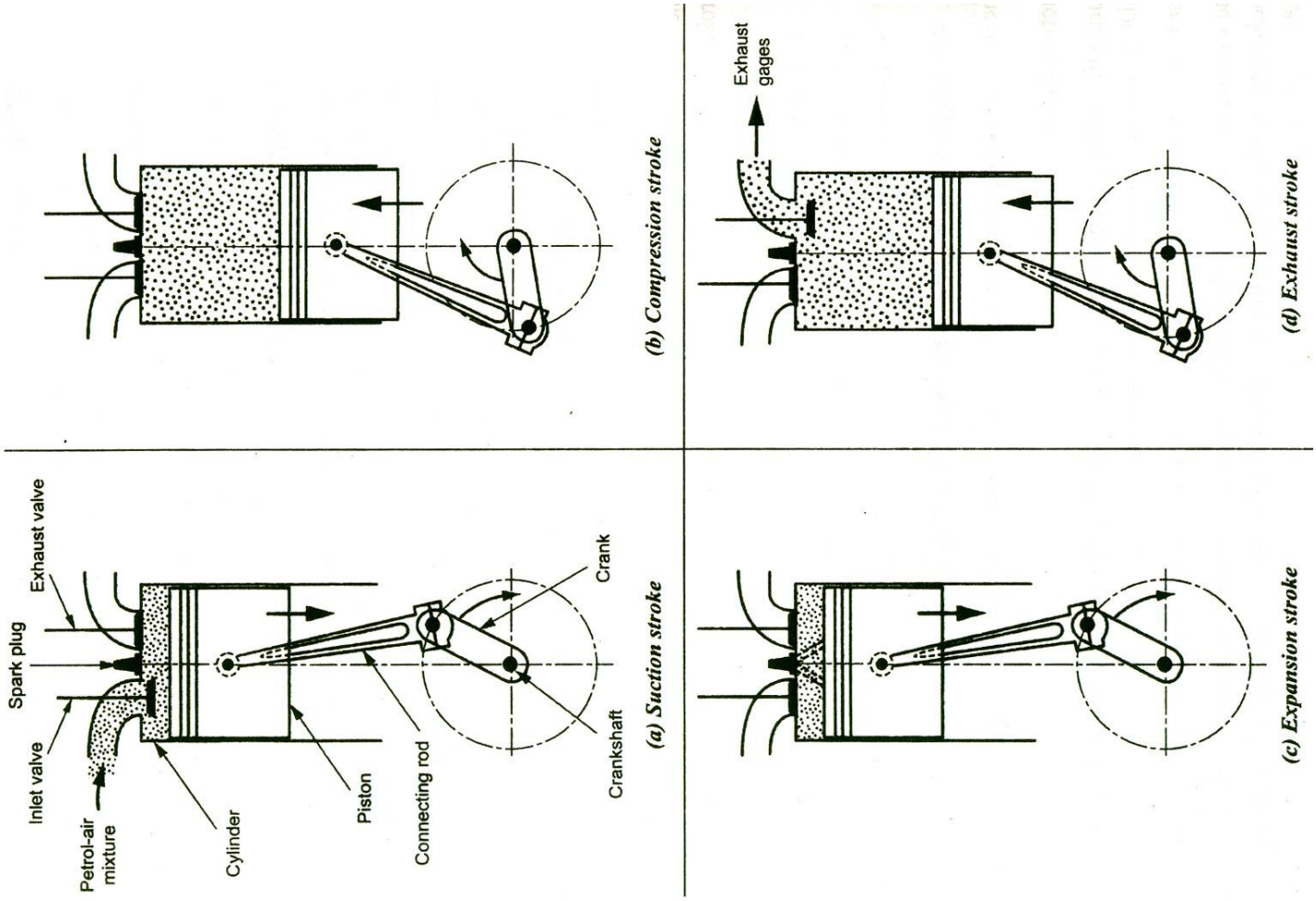
A four stroke engine gives a power stroke in every set of four strokes of the piston or two revolution of the crankshaft.

The petrol engine operates on theoretical Otto cycle.

It is also called as constant volume combustion cycle as the combustion takes place at constant volume with increase of pressure.

The cycle of operation of a four stroke petrol engine consists of the following strokes:

1. Suction or intake stroke,
2. Compression stroke,
3. Expansion or power stroke, and
4. Exhaust stroke.



1. Suction Stroke:

During this stroke, the piston moves from Top Dead Centre (TDC) to Bottom Dead Centre (BDC) creating a vaccum inside the cylinder.

During this stroke, the inlet valve is kept opened and the exhaust valve is kept closed

The vacuum created inside the cylinder draws the air petrol mixture (which is also known as charge) into the cylinder through the inlet valve. It is performed till the piston reaches BDC.

The above process is known as suction and this stroke is called the suction stroke.

2. Compression Stroke:

During this stroke, both the inlet and exhaust valves are closed

The air petrol mixture is compressed as the piston moves upwards from BDC to TDC.

As a result of this compression, pressure and temperature of the air fuel mixture or charge is increased.

Just before the piston reaches the TDC, the air petrol mixture (charge) is ignited by a spark plug; suddenly burning of the air fuel mixture takes place almost instantaneously.

It increases the pressure and temperature inside the cylinder. Volume remains constant during combustion.

These two strokes (i.e., suction and compression stroke) complete one revolution of the crankshaft.

3. Expansion or Power Stroke or Working Stroke:

During this stroke, both the inlet and exhaust valves remain closed.

The high pressure of the products of combustion (due to expansion of charge) pushes tile piston from TDC to BDC. It is also called as working stroke as work is done by the expansion of hot gases.

The force above the piston is transmitted to the crankshaft through the connecting rod and crank mechanism.

Excess energy due to the combustion is stored in the flywheel which helps for the operation of three idle strokes.

4. Exhaust Stroke:

At the end of the expansion stroke, the exhaust valve opens and the pressure inside falls suddenly. Thus during this stroke, the inlet valve is closed and the exhaust valve is kept opened.

The upward movement of the piston from BDC to TDC, pushes out the products of combustion from the engine cylinder through the exhaust valve into the atmosphere. The cycle of operation is then repeated.

These two strokes (i.e., expansion and exhaust strokes) complete one revolution of the crankshaft.

S.NO	PARAMETERS	4 STROKE ENGINE	2 STROKE ENGINE
1.	No of Strokes per Cycle	Four	Two
2.	No of Revolutions of Crank per cycle	Two	One
3.	No of Cycles per min	n = N/2 N = Engine Speed	n = N
4.	Power Derived	In every alternate revolution of crank shaft	In every revolution of crank shaft
5.	Direction of rotation of Crankshaft	Crankshaft Rotates in One Direction	Crankshaft Rotates in Either Direction
6.	Valves / Ports	Inlet, Exhaust Valve Operated by cam using Valve – Gear Mechanism	Inlet, Transfer & Exhaust Port are in Cylinder Walls Piston Movement Covers & Uncovers the Ports
7.	Torque Fluctuations	High	More Uniform
8.	Flywheel	Heavy Flywheel due to Non Uniform Torque on the	Lighter Flywheel is enough due to Uniform Torque
9.	Admission of the Charge	Charge is Directly admitted into cylinder during Suction Stroke	Charge is Admitted into the Crankcase and then Transferred to the cylinder
10.	Exhaust of products of Combustion	Due to upward movement of the piston during Suction Stroke	Due to Scavenging
11.	Fuel Consumption	Less	More
12.	Mechanical Efficiency	Low	High
13.	Noise	Less	More
14.	Engine Size	Heavy & Bulky	Compact
15.	Initial Cost	High	Low
16.	Cooling & Lubrication	Required in Less	Required Severely
17.	Starting of Engine	Fairly Difficult	Easy

18.	Wear & Tear	Lesser	Greater
19.	Uses	Buses, lorries, Trucks & Cars	Motorcycles, Scooters, Mopeds, etc.,

S.NO	DETAILS	PETROL ENGINE	DIESEL ENGINE
1.	Fuel Used	Petrol	Diesel
2.	Operating Cycle	Otto or Constant Volume Cycle	Diesel or Constant Pressure Cycle
3.	Charge	Air – Fuel Mixture	Air & Fuel is Injected
4.	Fuel Admission	Through Carburetor	Through Fuel Injector
5.	Ignition System	Spark Ignition	Compression Ignition
6.	Compression Ratio	Low (6 to 8)	High (16 to 20)
7.	Engine Speed	High about 3000 r.p.m due to its light weight	Low 400 to 1200 r.p.m due to its heavy weight
8.	Thermal Efficiency	Less due to Low Compression ratio	More due to High Compression ratio
9.	Starting of Engine	Easy	Difficult. More Cranking effort is required
10.	Weight of Engine	Lighter	Heavier due to high pressure
11.	Output Power	Less	More
12.	Initial Cost	Less	More
13.	Fuel Cost	More	Less
14.	Maintenance Cost	Less	More
15.	Vibration & Noise	Very Less	More due to high operation pressure
16.	Engine Life	Less than 60000 Km	More than 1,50,000 Km
17.	Space	Less Space	More Space

18.	Method of Governing	Quantitative Method	Qualitative Method
19.	Uses	Automobiles & Aero planes	Busses, Tractors, Trucks, etc.,