

X WORKING PRINCIPLE OF AN I.C. ENGINE

The internal combustion engine may be a four-stroke or two-stroke engine. A four-stroke engine makes two revolutions of crankshaft to develop one power impulse, whereas a two-stroke engine develops one power impulse in each revolution of crankshaft. The working principle of these engines is discussed as under.

4.1 FOUR-STROKE ENGINE

In a four-stroke engine, the piston performs four events in one cycle, which are as follows.

4.1.1 Suction stroke (Inlet valve open and Exhaust closed)

The suction stroke is also called intake or induction stroke. In this stroke the piston moves from top-dead center (TDC) to bottom-dead center (BDC). The inlet valve is opened to allow the fuel mixture (petrol engine) or air (diesel engine) to enter into the cylinder and fill the partial vacuum created by the movement of the piston. The exhaust valve remains closed.

4.1.2 Compression stroke (Both valves closed)

In this stroke both the intake and the exhaust valves remain closed and the piston moves from BDC to TDC and thus compresses the fuel mixture (petrol engine) or air (diesel engine) into clearance volume thereby raising the temperature and pressure of the intake charge. In petrol engines the compression ratio is usually between 6 and 9. The pressure at the end of this stroke is 6 to 8 kg/cm². In diesel engines compression ratio could vary from 15 to 22.

4.1.3 Power stroke (Both valves closed)

When the piston approaches TDC during compression stroke, a spark plug ignites the fuel mixture in petrol engine. Whereas in case of a diesel engine, diesel fuel is injected into the cylinder in the form of mist with the help of an injector and fuel injection pump. The fuel charge ignites inside the cylinder and the expanding gases push the piston downwards towards BDC and hence power is developed.

Petrol
system

4.1.4 Exhaust stroke (Inlet valve closed and Exhaust-valve opened)

In this stroke, the piston runs from BDC to TDC and sweep out through the exhaust valve, which is opened while the intake valve remains closed.

NOTE: To complete four strokes stated above, in one cycle, the crankshaft must turn through $180^\circ \times 4 = 720^\circ$. In two revolutions of the crankshaft or one cycle, one impulse is produced (during the power stroke). Except power stroke the rest of the strokes (suction, compression and exhaust) are called as idle strokes, which are performed by consuming the energy stored in the flywheel.

4.2 TWO-STROKE ENGINE

This type of engine completes one cycle in only two strokes of the piston. There are no definite intake and exhaust valves, but instead there are ports or openings in the cylinder walls, which are opened and closed by the piston.

Each cylinder contains two openings i.e. inlet and exhaust ports one for the intake of fuel charge and the other for exhaust of burnt gases. When the piston moves from TDC to BDC, a fresh fuel mixture enters through the intake port. At the same time burnt gases escape through the exhaust port, which is also uncovered. The compression and expansion strokes are similar to those of the four-stroke engine. However, in order to complete one cycle the piston makes only two strokes, which is equivalent to $2 \times 180 = 360^\circ$ revolution of the crankshaft.

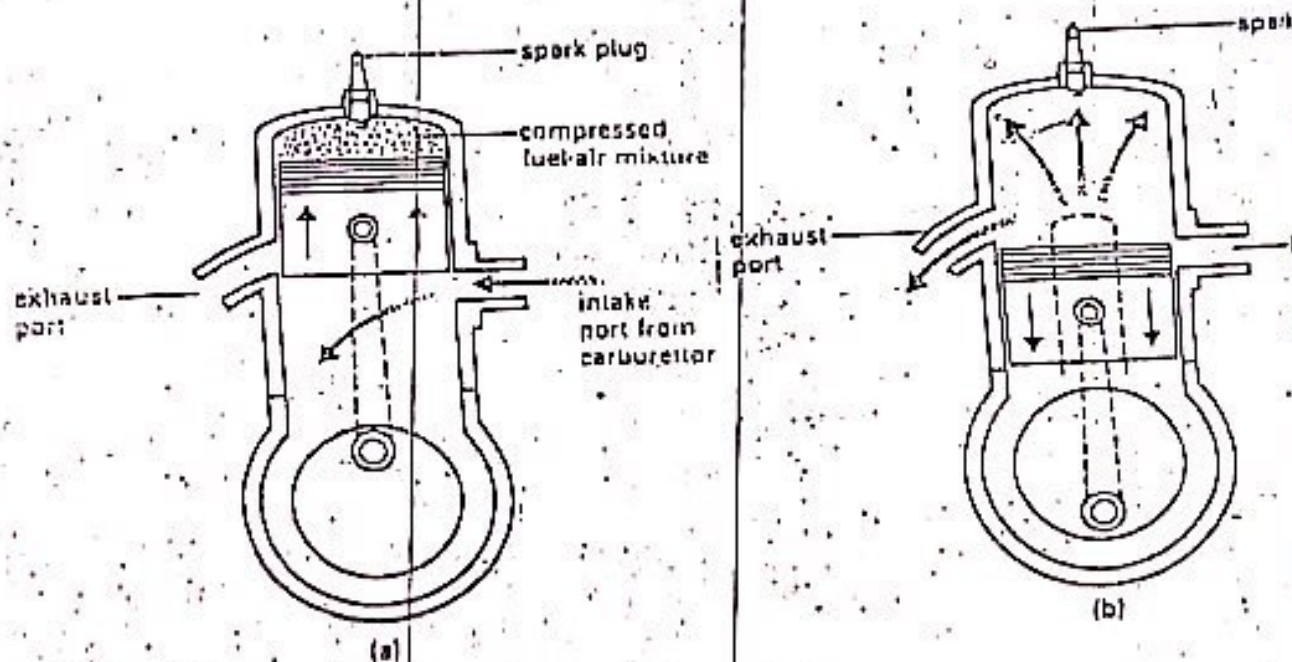


Figure 4.2. Working of two-stroke cycle engine

COMPARISON OF 4-STROKE PETROL AND DIESEL ENGINE

1. In a petrol engine mixture of petrol and air is taken into the cylinder during suction stroke whereas only clean air is sucked in diesel engines.
2. Injector is used to inject or spray the diesel fuel into the cylinder whereas in petrol engines no injector is used.
3. Electric spark plug is used to ignite the mixture in petrol engines whereas in diesel engines no spark plug is used.
4. A carburetor to vaporize the petrol is used in petrol engines. But in diesel engines fuel is converted into mist with the help of a fuel injection pump and injector.
5. The compression ratio of diesel engine is higher than that of a petrol engine.
6. The working temperature of diesel engine is higher than that of a petrol engine.
7. Diesel engine is heavier than petrol engine for the same horsepower rating due to its higher compression ratio, which demands a heavy cylinder block.
8. Diesel engine develops more power from same quantity of fuel and hence it is more efficient.
9. Petrol engine is more complicated to repair as compared to diesel engine due to complicated circuits of carburetor and ignition system.
10. The petrol engine accelerates (speed up) more rapidly than that of a diesel engine due to its lighter weight.

4.4 COMPARISON OF 2-STROKE AND 4-STROKE ENGINES

1. For each revolution of crankshaft there is a power stroke in 2-stroke engine. Theoretically, the power developed by 2-stroke engine will be twice to that of 4-stroke engine having same dimensions.
2. Expulsion of exhaust gases (scavenging) in 2-stroke low speed engines is more complete as all the gases find no restriction for their escape when compared to a 4-stroke engine.
3. In 2-stroke engines, work required to overcome the friction of exhaust and suction strokes is saved.
4. As two idle strokes are omitted in 2-stroke engines so there is a more balanced turning moment on the crankshaft, which avoid vibration.
5. ~~High speed engines working on 2-stroke cycle are less efficient owing to low volumetric efficiency.~~
6. During scavenging of 2-stroke engine, fuel mixture can escape through exhaust port as both the inlet and outlet ports are opened at the same time.
7. Two-stroke engine consumes more lubricating oil as some of the oil burns along with the fuel.
8. Inlet and exhaust ports are provided in 2-stroke engine instead of valves in 4-stroke engine, which demand special attention of wear, tear and lubrication.
9. Two-stroke engine is cheaper to repair as compared to 4-stroke engine.
10. Four-stroke engine is heavier in weight so it is recommended for medium speed running vehicles and stationary power plants. Whereas a 2-stroke engine being lighter in weight but high speed, is recommended for small running vehicles as well as for marine engines.

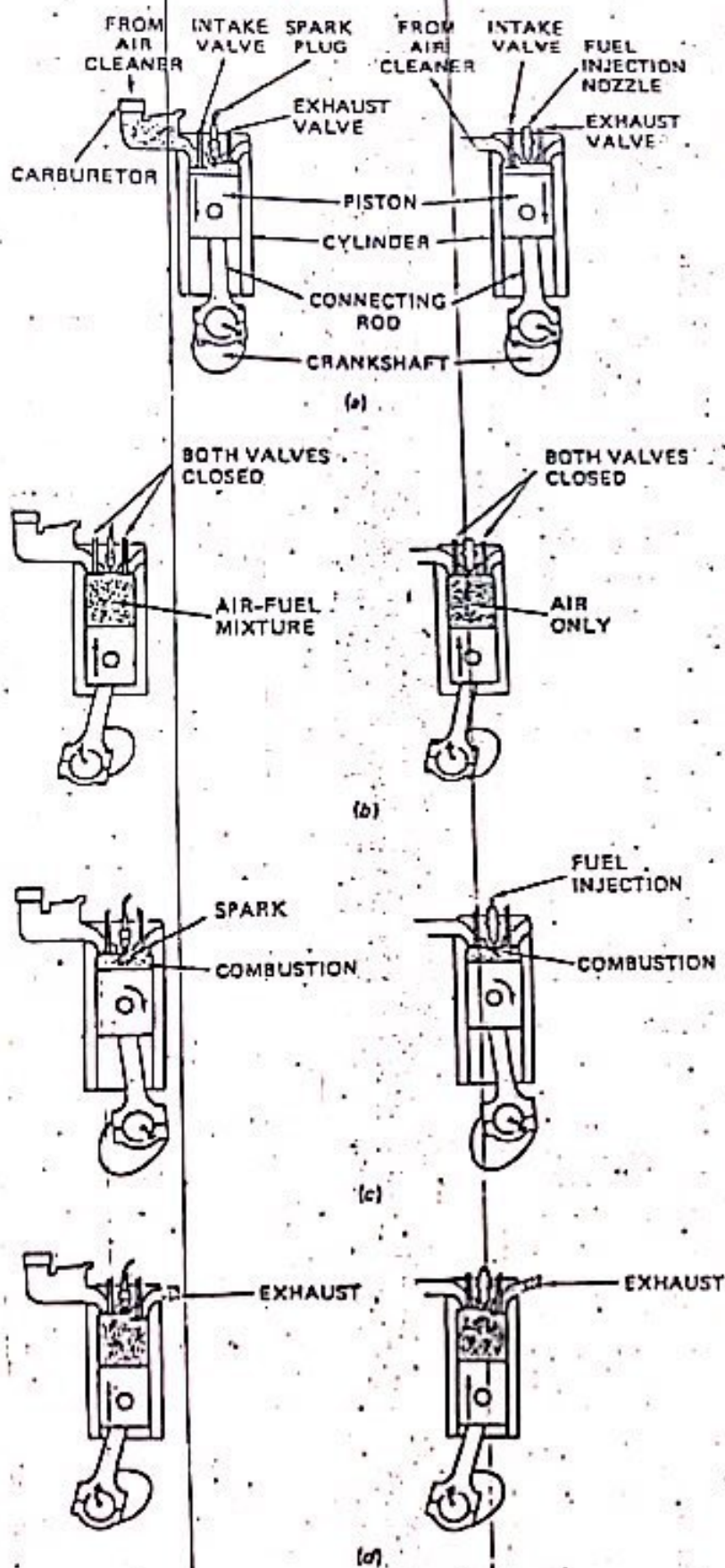


Figure 4.1. Working of 4-stroke cycle petrol and diesel engines

4.5 FIRING ORDER

The sequence of ignition that takes place in a multi cylinder engine is called firing order. This is achieved primarily by the shape of the crankshaft, which determines position of each piston. The arrangement chosen should ensure a complete-balance between the power and compression strokes.

In a four-stroke four-cylinder engine for example, the firing order can be 1-3-4 or 1-2-4-3. Similarly for a six-cylinder engine it is usually 1-5-3-6-2-4 or 1-4-2-6-3-5.

Table 4.1 Possible Firing order detail of a 4-cylinder engine.

Crankshaft Angle (degrees)	Cylinder 1	Cylinder 2	Cylinder 3	Cylinder 4
0-180	Power	Exhaust/C	Compression/E	Suction
180-360	Exhaust	Suction/P	Power/S	Compression
360-540	Suction	Compression/E	Exhaust/C	Power
540-720	Compression	Power/S	Suction/P	Exhaust

Where S = Suction, C = Compression, P = Power and E = Exhaust stroke

4.6 ENGINE SYSTEMS

The internal combustion engine is provided with different systems to govern engine operations and performance. Some of the systems and their intended functions are outline below.

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| 1. Valve system | To govern the operation of intake and exhaust valves. |
| 2. Fuel system | To supply regulated amounts of fuel and air in accordance operational needs. |
| 3. Ignition & Electrical system | To create a spark in the engine (for ignition), and provide and power for self-starting mechanism. |
| 4. Cooling system | To keep the engine operating at an optimum temperature. |
| 5. Lubrication system | To lubricate all moving and other stationary parts to mini friction. |

0-180	Power	Exhaust	Compr	Suction
180-360	Exhaust	Power	Suction	Compr
360-540	Compr	Suction	Exhaust	Power
540-720	Suction	Compr	Power	Exhaust