Lect.- 2

I.C. engines, working principles of I. C. engines. Comparison of two stoke and four stroke cycle engines.

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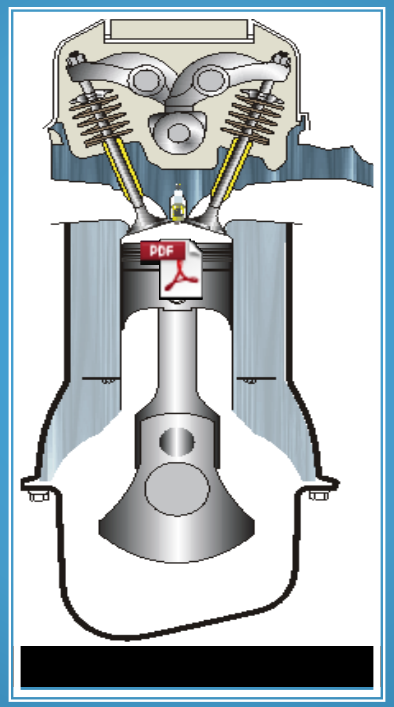

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Heat engine

A **heat engine** is a machine that converts heat developed by burning fuel into mechanical work output, thus it transforms chemical energy into mechanical energy.

On the basis of how thermal energy is being delivered to working fluid of the heat engine, heat engine can be classified as external combustion engine, and internal combustion engine.

External combustion engine:

- It is the engine designed to derive its power from the fuel, burnt outside the engine cylinder.
- Steam engine is an example of external combustion engine, where the working fluid is steam which is generated in a boiler, placed entirely separate from the working cylinder.

Internal combustion engine (I. C. engine):

- It is the engine designed to derive its power from the fuel, burnt within the engine cylinder. Here combustion of fuel and generation of heat takes place within the cylinder of the engine.
- Petrol engine is an example of internal combustion engine, where the working fluid is a mixture of air and fuel.

Classification of I C engines

Internal combustion engines are classified as given below:

1. Type of mobility:

stationary or automotive (mobile) engines.

Stationary engines are designed without transmission system.

These engines are generally used in the situations where it is not required to move the engine. For example for pumping water, to operate thresher.

2. Type of piston movement:

Reciprocating and wankel rotary.

When the piston moves up and down or from left to right, they are called reciprocating engines.

A Wankel rotary engine uses rotary design to convert pressure into a rotating motion instead of using reciprocating pistons.

3, Number of cylinders:

Single or multiple cylinder engines.

A single cylinder engine requires a large flywheel (for having more momentum) to move the piston up and down during idle strikes and to overcome the friction between moving parts.

A multi cylinder (more than one) is a combination of several single cylinders which have a common crankshaft, camshaft etc.

4. Engine speed:

Low, medium or high speed engine

Low speed – below 350 rpm,

Medium- 350 to 1000 rpm,

High speed- over 1000 rpm

5. Position of engine:

Horizontal or vertical engine.

Generally, the engines used now- a- days are vertical engines.

6.No of strokes:

Depending on the number of strokes required to complete one cycle the engines are classified as *two stroke or four stroke engine.*

When the cycle is completed in two revolutions of the crankshaft, it is called *four stroke cycle engines*.

When the cycle is completed in one revolution of the crankshaft, it is called *two stroke cycle engines*.

7. **With regard to the fuel used in them:**

(i) Petrol or gasoline engines in which petrol or petrol gas is used;

(ii) Diesel engines in which diesel is used as fuel.

8. **With regard to the method of ignition in the engines:**

(i) Spark ignition engines in which ignition takes place by means of an electric spark.- Petrol engines are spark ignition engines.

(ii) (ii) Compression ignition engines in which the injected fuel is ignited due to the temperature of compressed air in the cylinder. Diesel engines are compression ignition engines.

9. With regard to their cycle of operation:

(a) **Otto cycle engines** or constant volume cycle engines.

- The engines which work on this cycle are known as Otto Cycle engines. In Otto Cycle, combustion takes place at constant volume as whole of the fuel is burned instantaneously as an explosion.
- Petrol engines are Otto cycle engines.
- The fuel is ignited in the cylinder by an electric spark.
- These engines are generally simple and lighter and are used predominantly in automobiles requiring high speeds.
- But these engines are not good for pulling purpose or for works requiring higher torque.

- (b) **Diesel Cycle Engines**
- or Constant Pressure Cycle Engines which work on diesel cycle or constant pressure cycle.
- In diesel cycle, the combustion takes place at constant pressure because burning takes place gradually without an explosion as the fuel enters. Hence this cycle is known as constant pressure cycle.
- Diesel engines work on this cycle.
- In C.I. engine the fuel is injected at high pressure through fuel injectors and ignited by heat of compression.

10. With regard to the type of cooling system of the engine:

(i) **Air cooled engines** which are cooled by air. Air cooled engines contain fins around the cylinders, cylinder heads and exhaust ports etc. to provide more area for better radiation of heat.

(ii) **Liquid or water cooled engines** in which some liquid or water is used to cool them. These engines contain water jackets around the cylinders, combustion chambers and valve ports etc. A radiator is provided to cool down hot water.

Spark ignition engine

- It is designed on the basis of Otto cycle.
- In this engine fuel is atomized, vaporized and mixed with air in correct proportion before inducing into the cylinder through inlet manifold.
- It is also known as Carburetor type, or petrol or gasoline engine.
- The fuel is ignited in the cylinder by an electric spark.
- These engines are generally simple and lighter and are used predominantly in automobiles requiring high speeds.
- But these engines are not good for pulling purpose or for works requiring higher torque.

Compression ignition engine

- It is designed on the basis of Diesel cycle that is why it is also known as diesel engine.
- In this engine, during suction stroke, only air is entered into the cylinder and compressed.
- The fuel is injected at high pressure through fuel injectors and ignited by heat of compression.

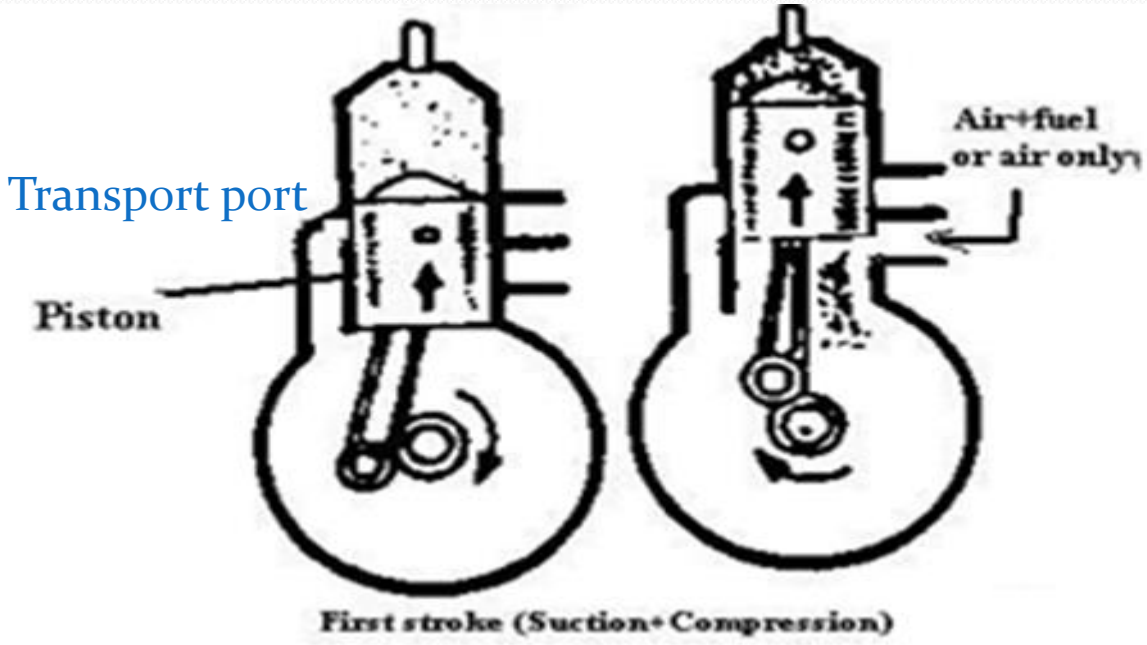
In tractors- automotive, multi cylinder, high speed (1500rpm), water cooled, vertical engines are mostly used.

Working of Two stroke cycle engine

- In such engines, the whole sequence of events i.e. suction, compression, power and exhaust are completed in two strokes of the piston and in one complete revolution of the crankshaft.
- There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder.
- The crankcase of the engine is gas tight in which the crankshaft rotates.

First stroke (suction + compression):

- The piston moves up the cylinder, it covers two of the ports, the exhaust port and the transfer port, which are normally almost opposite to each other.
- Further movement of the piston uncovers a third port in the cylinder- suction port. Fresh mixture is drawn through this port into the crankcase.

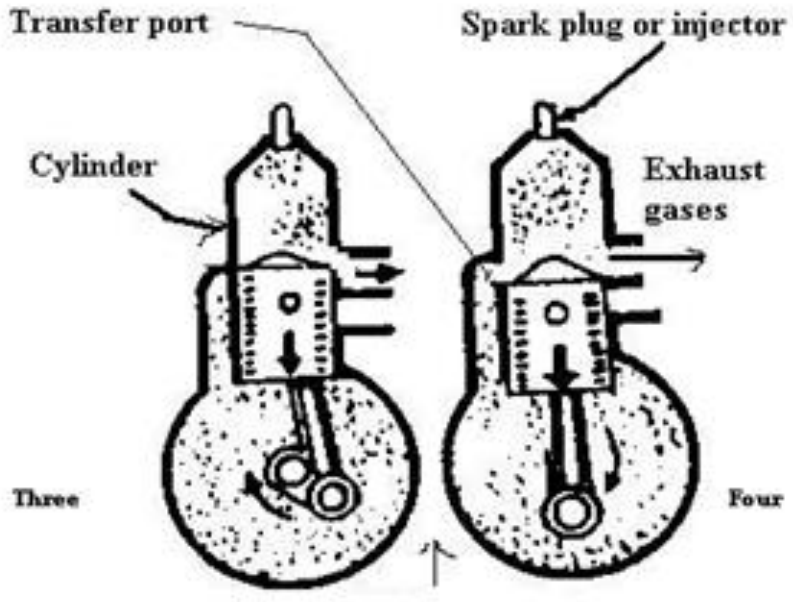


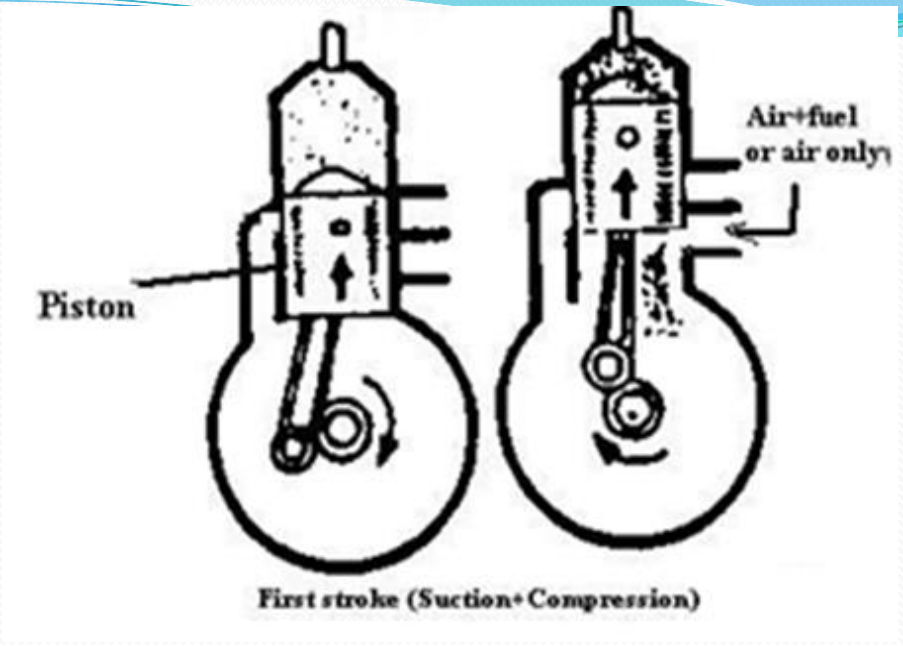
- This trapped charge of fresh mixture in the cylinder is compressed by the further upward movement of the piston.
- Just before the end of this stroke, the mixture in the cylinder is ignited as in the four stroke cycle.

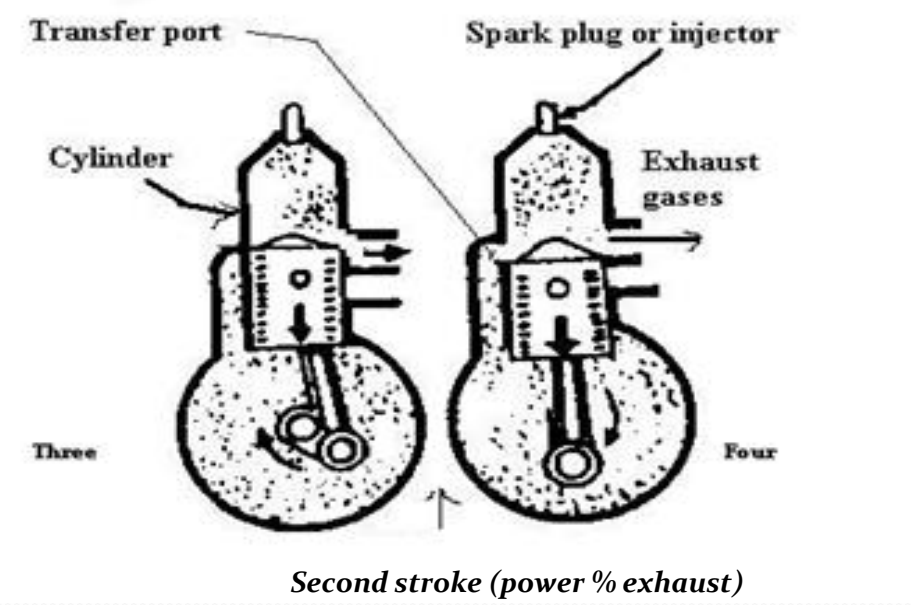
Second stroke (Power + exhaust):

- The rise in pressure in the cylinder caused by the burning gases forces the piston to move down the cylinder.
- When the piston goes down, it covers and closes the suction port.
- Further downward movements of the piston uncover first the exhaust port and then transfer port.
- This allows the burnt gases to flow out through exhaust port.

- When the piston is at the top of its stroke, it is said to be at the top dead centre (TDC).
- When the piston is at the bottom of its stroke, it is said to be at its bottom dead centre (BDC).
- In two stroke cycle engine, both the sides of the piston are effective, which is not the case in case of four stroke cycle engine.





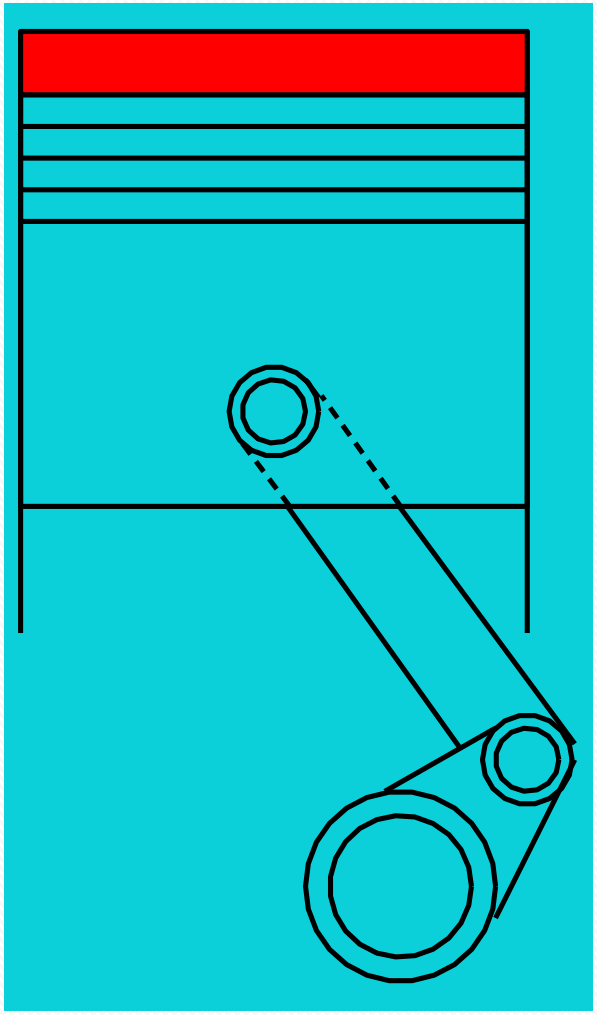


Second stroke (power % exhaust)

Comparison between two stroke and four stroke engine

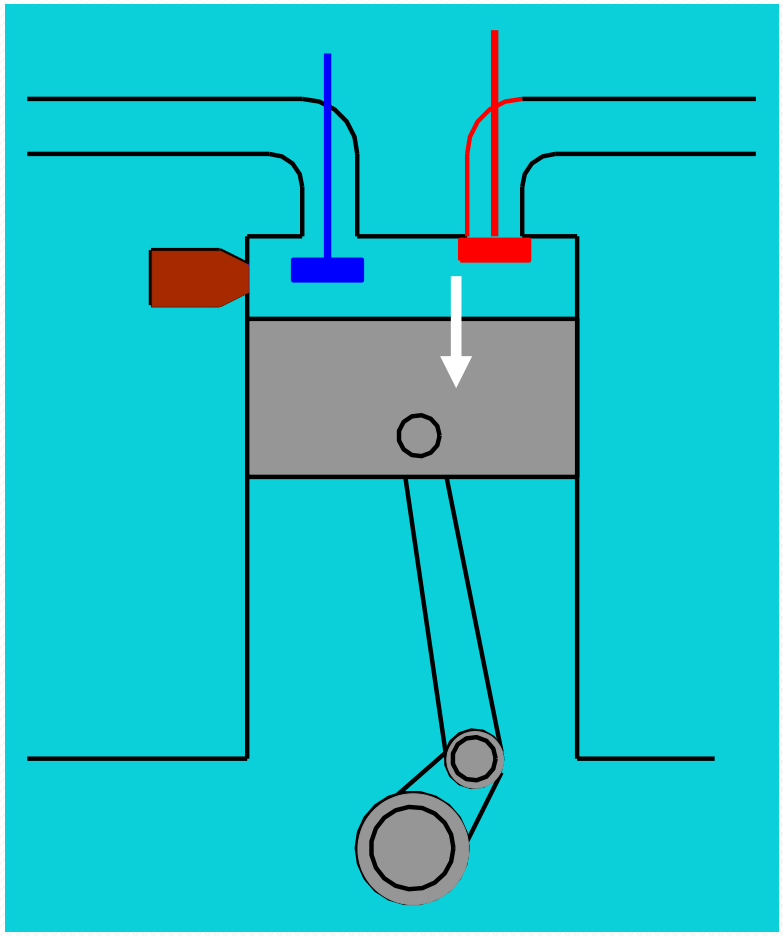
S.No.	Parameter	Two stroke engine	Four stoke engine
12.	Mechanical efficiency	Higher due to absence of cam, camshaft, rockers etc.	Comparatively less
13.	Crankcase	Must be sealed (Air tight)	Sealing not necessary
14.	Engine availability as per speed	Only high speed type engines are available.	All types (low, medium and high speed) are available.
15.	Compression ratio	Lower than 4 stroke engine of the same dimensions.	Higher than 2 stroke engine of the same dimensions.

4-Stroke Cycle Engine Operation



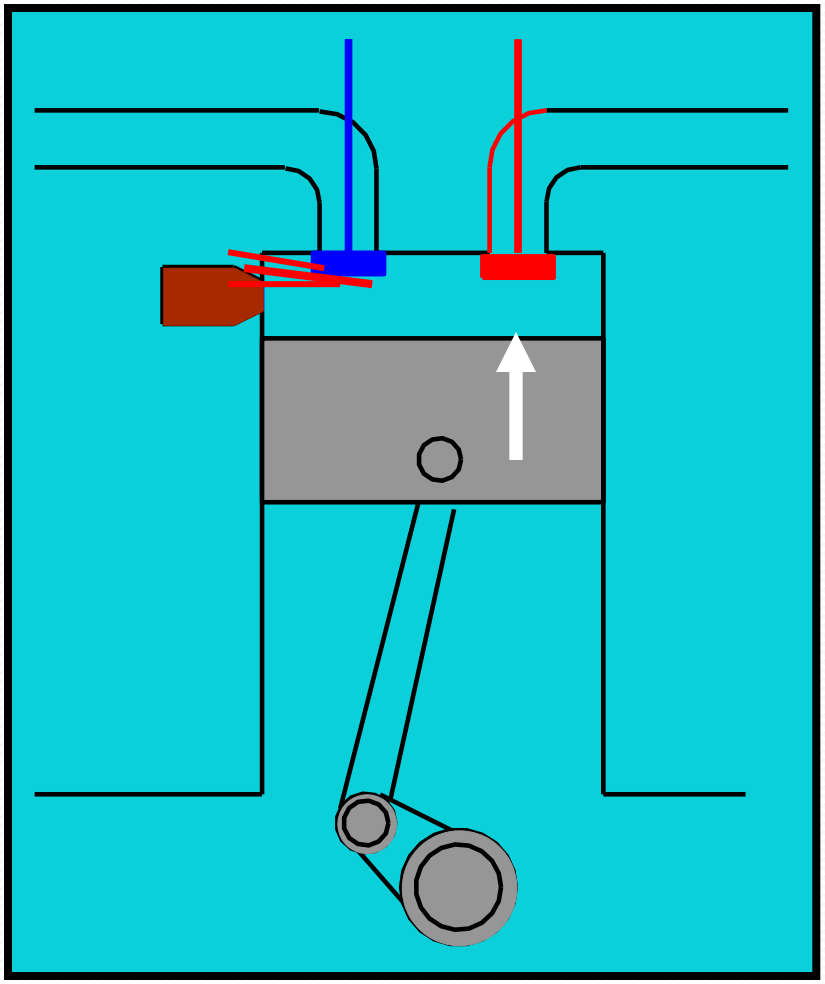
- 4-stroke cycle engines require four strokes of the piston to complete the five events necessary for engine operation.
  - 1 piston stroke = ½ crankshaft revolution.
  - 4 piston strokes = 2 crankshaft revolutions.

4-Stroke Cycle Engine Operation



- Intake Stroke
  - Intake valve open.
  - Piston moves down (TDC to BDC) in cylinder.
  - Low pressure is created in cylinder.
  - Air is brought into the combustion chamber due to pressure differences.

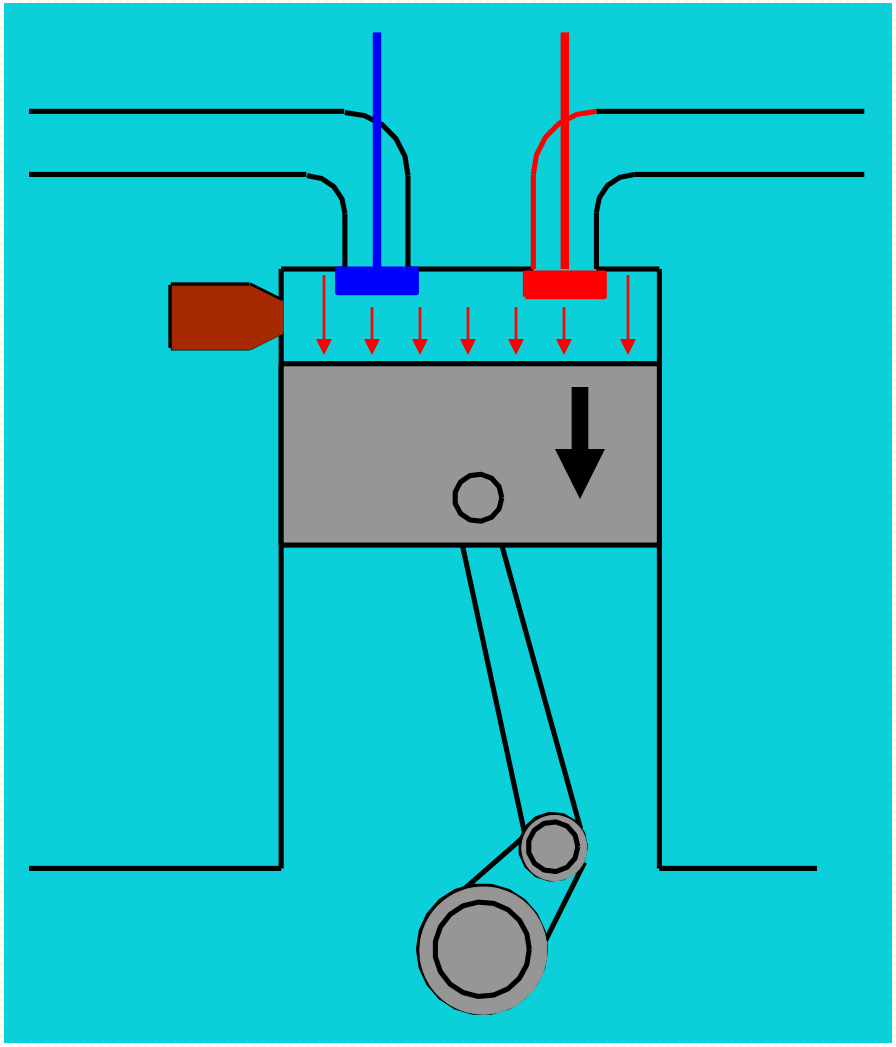
4-Stroke Cycle Engine Operation



Compression Stroke

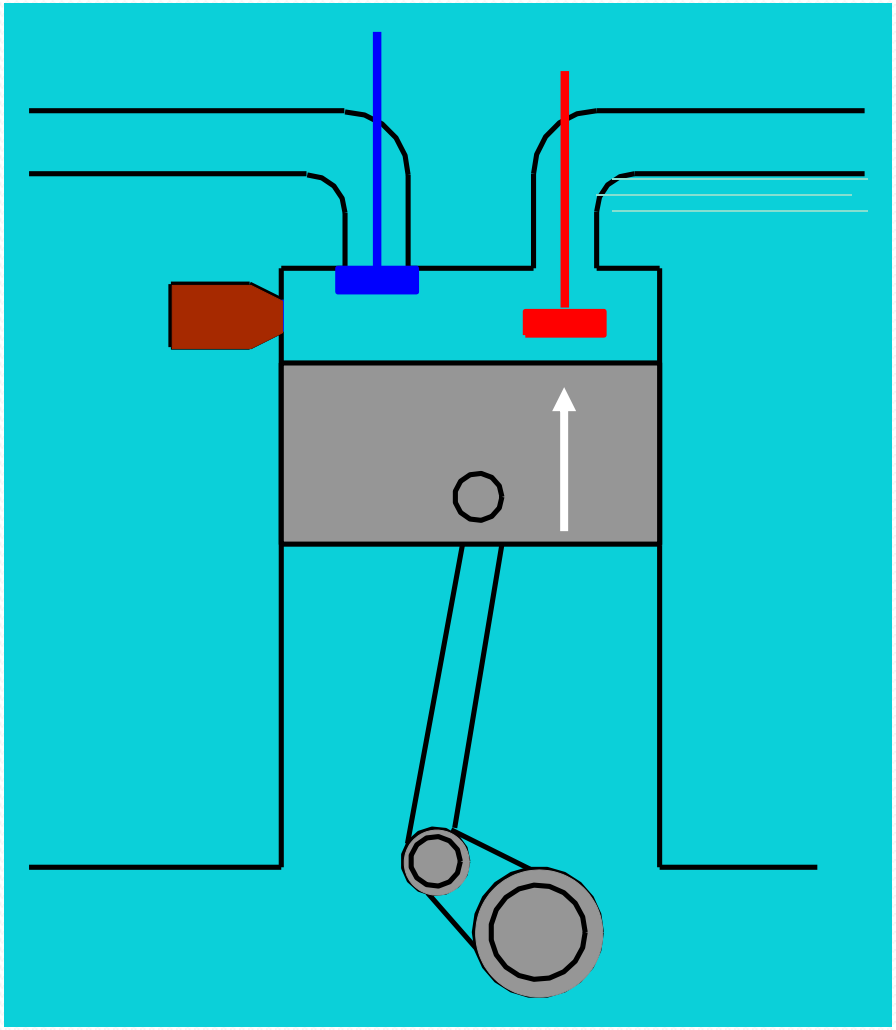
- Both valves closed.
- Piston moves from BDC to TDC
- Air in combustion chamber is compressed, raising its temperature.
- Near TDC of Compression stroke, diesel fuel is injected into the combustion chamber.

4-Stroke Cycle Engine Operation



- Power Stroke
  - Both valves are closed
  - Air-fuel mixture burns rapidly
  - Expansion of the burning air-fuel mix applies force to the head of the piston
  - Piston is driven down in the cylinder.

4-Stroke Cycle Engine Operation



- Exhaust Stroke
  - Piston moves from BDC to TDC.
  - Exhaust valve is open.
  - Burnt air-fuel mixture is scavenged from combustion chamber.

Firing order

Means the sequence of power strokes occurring in the cylinder of an engine.

In a four cylinder engine the firing order may be 1-2-4-3, or 1-3-4-2.

In a six cylinder engine it will be 1-5-3-6-2-4

Comparison between diesel and petrol engine

S.No.	Parameter	Diesel engine	Petrol engine
1.	Fuel used	Diesel	Vapourizing fuel- Petrol or Kerosene
2.	Intake during suction stroke	Air alone	Mixture of air and fuel
3.	Fuel ignition	Due to high compression of air (heated)	By an electric spark.

S. No.	Parameter	Diesel engine	Petrol engine
4.	Air fuel ratio	Not constant (the quantity of air drawn into the cylinder is always the same but the quantity of fuel injection is to be changed as per load and speed.)	Air and fuel ratio is constant (15:1). To vary the engine power, quantity of mixture is varied.
5.	Compression ratio	14:1 to 20:1.	4.5:1 to 8:1.
6.	Specific fuel consumption	About 0.2 kg per BHP per hour.	About 0.29 kg per BHP per hour.

Comparison between diesel and petrol engine

S.No.	Parameter	Diesel engine	Petrol engine
7.	Thermal efficiency	32 and 38%.	25 and 32%.
8.	Engine weight per horse power	Comparatively more heavily loaded.	Comparatively less
9.	Torque characteristics	more uniform (Better top gear performance)	Comparatively less uniform
10.	Initial cost	High.	Low

S. No.	Parameter	Diesel engine	Petrol engine
11.	Operating cost	Low	High
12	Operating pressure	Ranges from 30 to 50 bar. The maximum BMEP is about 20 bar.	Ranges between 17 and 15 bar. The maximum BMEP is about 10 bar.
13.	Fire risk	Minimum due to the absence of the ignition system	Comparatively more

Comparison between two stroke and four stroke engine

S.No.	Parameter	Two stroke engine	Four stoke engine
1.	Power impulse or working stroke	There is one power impulse for every two strokes of piston.	There is one power impulse for every four strokes of piston.
2.	Power developed by same size engine	About twice than 4 stroke engine.	About half the power of 2 stroke engine.
3.	Valve mechanism	Valves are not required for intake and exhaust operations. (Ports instead of valves.)	Valves are essential.

Comparison between two stroke and four stroke engine

S.No.	Parameter	Two stroke engine	Four stoke engine
4.	Weight per bhp	Low	Comparatively higher
5.	Fuel consumption	High (about 15% more) because some of the fuel passes directly to the exhaust.	Comparatively less
6.	Size of fly wheel	Comparatively smaller	Comparatively larger
7.	Thermal efficiency	Low	Comparatively higher

Comparison between two stroke and four stroke engine

S.No.	Parameter	Two stroke engine	Four stoke engine
8.	Construction and cost	Simple, cheap	Complicated and expensive
9.	Lubrication system	Not much effective, lubricating oil is mixed with the fuel. It consumes more lubricating oil because of the greater amount of heat generated.	Effective system, has a separate lubricating system. less tear and wear of engine parts
10.	Direction of engine operation	Both, clockwise and anticlockwise	In only one direction
11.	Carbon deposit inside cylinder	Much because of mixed fuel	Not so much