MODULE-III

INTRODUCTION TO IC ENGINES:

Components and Working Principles, 4-Strokes Petrol and Diesel Engines, Application of IC Engines.

INSIGHT INTO FUTURE MOBILITY:

Electric and Hybrid Vehicles, Components of Electric and Hybrid Vehicles. Advantages and disadvantages of EVs and Hybrid vehicles.

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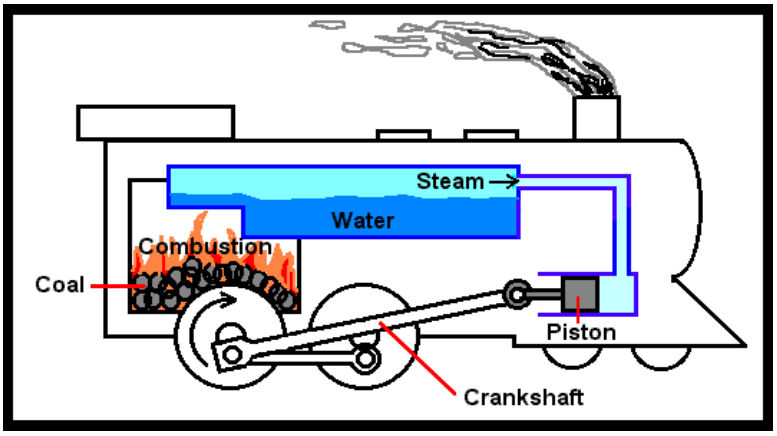
INTRODUCTION TO IC ENGINES:

A heat engine is a machine, which converts heat energy into mechanical energy. The combustion of fuel such as coal, petrol, and diesel generates heat. This heat is supplied to a working substance at high temperature. By the expansion of this substance in suitable machines, heat energy is converted into useful work.

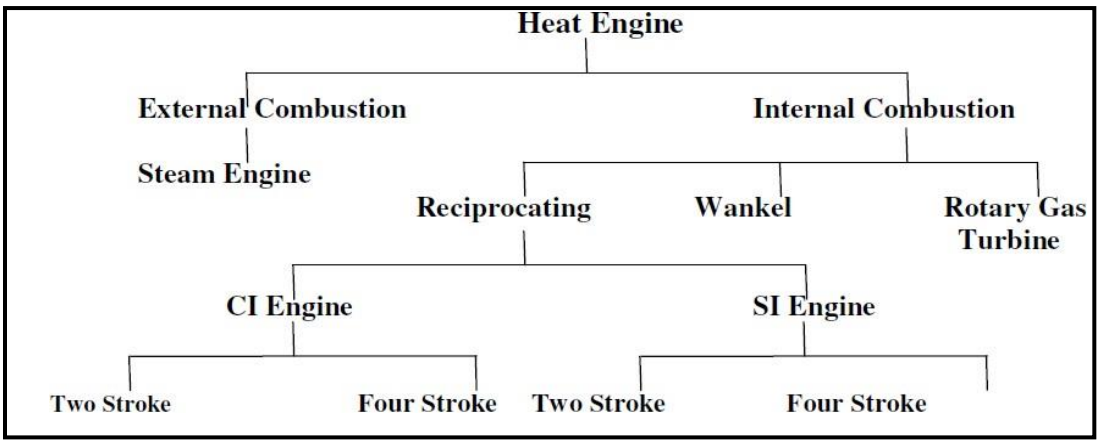
Heat engines can be further divided into two types:

i)External combustion ii) internal combustion.

External combustion Engine: - In a steam engine the combustion of fuel takes place outside the engine and the steam thus formed is used to run the engine. Thus, it is known as external combustion engine.



Internal combustion Engine: - In the case of internal combustion engine, the combustion of fuel takes place inside the engine cylinder itself.



I C ENGINE:

An internal combustion engine (I C Engine) is a heat engine, which converts the heat energy released by the combustion of the fuel taking place inside the engine cylinder into mechanical work.

The advantages of I C Engines compared to External combustion Engines are high efficiency, light weight, compactness, easy starting, suitable for mobile applications and comparatively lower initial cost.

CLASSIFICATION OF IC ENGINES:

According to the type of fuel used:

a) Petrol engine - If the fuel used is petrol, the engine is called as petrol engine.

b) Diesel engine - If the fuel used is diesel, the engine is called as diesel engine.

c) Gas engine - gaseous fuels like bio-gas, natural gas, or liquefied petroleum gas (LPG), etc., are used as fuels.

d) Bi-fuel (Bio-fuel) engine - these engines use a mixture of more than one fuel. For example, mixture of diesel and natural gas, mixture of diesel and neem oil, etc.

According to the number of strokes per cycle:

a) 4-stroke engine - if the engine completes its working cycle in four different strokes of the piston, or two revolutions of the crankshaft, it is called as 4-stroke engine.

b) 2-stroke engine - if the engine completes its working cycle in two different strokes of the piston, or one revolution of the crankshaft, it is called as 2-stroke engine.

According to the method of ignition:

a) Spark Ignition (SI) engine - If the fuel is ignited by an electric spark generated by a spark plug, the engine is called as spark ignition engine.

b) Compression Ignition (CI) engine - In these engines, the fuel ignites when it comes in contact with the hot compressed air.

According to the cycle of combustion:

a) Otto cycle engine - If the combustion of fuel takes place at constant volume, the engine is called Otto cycle engine.

b) Diesel cycle engine - combustion of fuel takes place at constant pressure.

c) Dual combustion cycle engine - combustion of fuel first takes place partially at constant volume, and then at constant pressure.

According to the number of cylinders used:

a) Single cylinder engine - If the engine consists of only one cylinder, then it is called as single cylinder engine.

b) Multi-cylinder engine - If the engine consists of more than one cylinder, then it is called as multi-cylinder engine.

According to the arrangement of cylinders:

a) Vertical engine - If the cylinder is arranged in a vertical position, the engine is called vertical cylinder engine.

b) Horizontal engine - cylinder is arranged in horizontal position.

c) Inline engine - cylinders are arranged in a line. Most trucks are of inline configuration.

d) Radial engine - cylinders are arranged along the circumference of a circle.

e) V-engine - It is a combination of two inline engines equally set at an angle. Passenger vehicles have V-type configuration.

f) Opposed type engine - cylinders are arranged opposite to each other.

According to the method of cooling:

a) Air cooled engine - If the heated cylinder walls (due to combustion of fuel) are cooled by circulating air, the engine is called air cooled engine.

b) Water cooled engine - water is circulated through the jacket surrounding the healed cylinder walls.

According to their uses:

a) Stationary engine

b) Automobile engine

c) Marine engine

d) Aircraft engine, etc.

PARTS OF AN IC ENGINE:

The following are the main parts of an internal combustion engine.

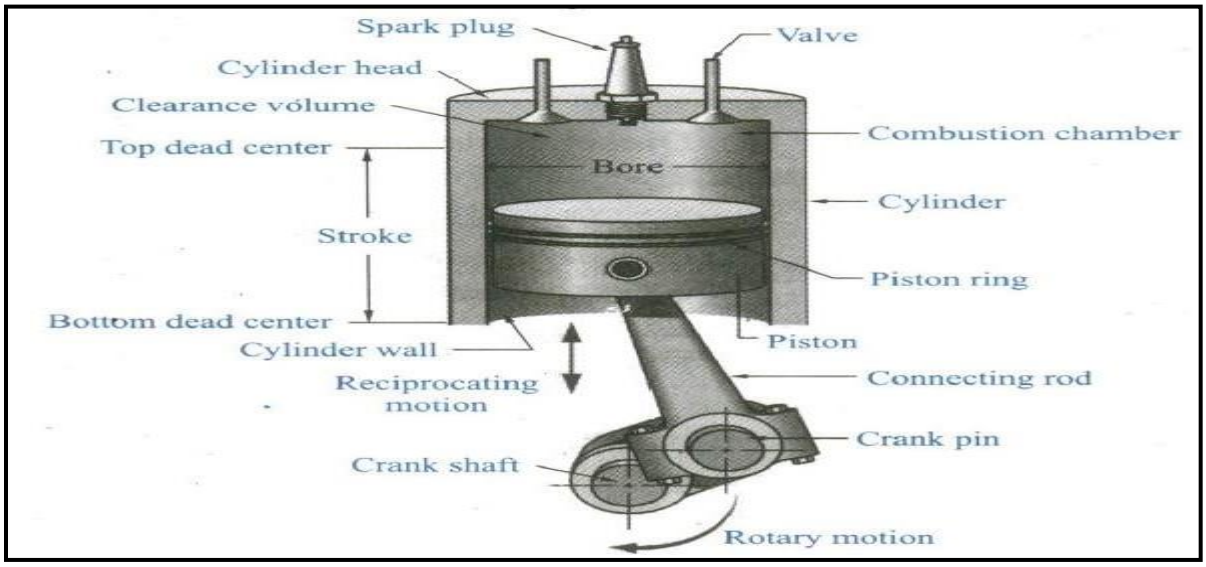
1) Cylinder 2) Piston

3) Piston rings 4) Connecting rod

5) Crank 6) Crankshaft

7) Crankcase 8) Fly wheel

9) Valves



Cylinder:

It is the heart of an I C Engine, as the name indicates is a cylindrical shaped component in which combustion of fuel takes place. The cylinder is usually made from gray cast iron or steel alloys in order to withstand the high pressure and temperature generated inside the cylinder due to combustion of fuel.

Piston:

The piston is a close fitting hollow cylindrical plunger moving to and fro in the cylinder. The power developed by the combustion of the fuel is transmitted by the piston to the crankshaft through the connecting rod.

Piston Rings:

The piston rings are the metallic rings inserted into the circumferential grooves provided at the top end of the piston. These rings maintain a gas-tight joint between the piston and the cylinder while the piston is reciprocating in the cylinder. They also help in conducting the heat from the piston to the cylinder.

Connecting Rod:

It is a link that connects the piston and the crankshaft by means of pin joints. It converts the rectilinear motion of the piston into rotary motion of the crankshaft.

Crank:

The crank is a lever, with one of its end connected to the lower end of the connecting rod, while the other end connected to the crankshaft.

Crankshaft:

The function of the crankshaft is to transform reciprocating motion into rotary motion. The crankshaft transmits the power developed by the engine through the flywheel, clutch, transmission and differential to drive (move) the vehicle. The crankshafts are made of carbon steel.

Crankcase:

The crankcase is the lower part of the cylinder block that encloses the crankshaft and provides a reservoir for the lubricating oil.

Valves:

The valves are the devices which controls the flow of the intake and the exhaust gases to and from the engine cylinder. They are also called poppet valves. These valves are operated by means of cams driven by the crankshaft through a timing gear or chain.

IC ENGINE TERMINOLOGY:

Top Dead Centre (TDC) or Cover end: The extreme position of the piston near to the cylinder head is called top dead centre. Briefly abbreviated as TDC. In horizontal engines, like the opposed type engine, the term top dead centre becomes irrelevant, and hence the term cover end is used in-place of top dead centre.

Bottom Dead Centre (BDC) or Crank end: The extreme position of the piston near to the crankshaft is called bottom dead centre. Briefly abbreviated as BDC. In horizontal engines, like the opposed type engine, the term bottom dead centre becomes irrelevant, and hence substituted by the term crank end.

Bore: The inner diameter of the cylinder is called bore. It is denoted by

Stroke or Stroke length: The linear distance travelled by the piston when it moves from top dead centre to bottom dead centre is called stroke or stroke length. It is denoted by **L**.

WORKING PRINCIPLE OF FOUR-STROKE PETROL ENGINE (4-S-P-E):-

A four-stroke petrol engine works on Otto cycle. Hence it is also called Otto cycle engine.

The charge used in a 4-Stroke petrol engine is a mixture of air and petrol, and is supplied by the carburettor in suitable proportions. The charge is ignited by the spark generated by a spark plug, and for this reason, petrol engines are also called Spark Ignition (SI) engines.

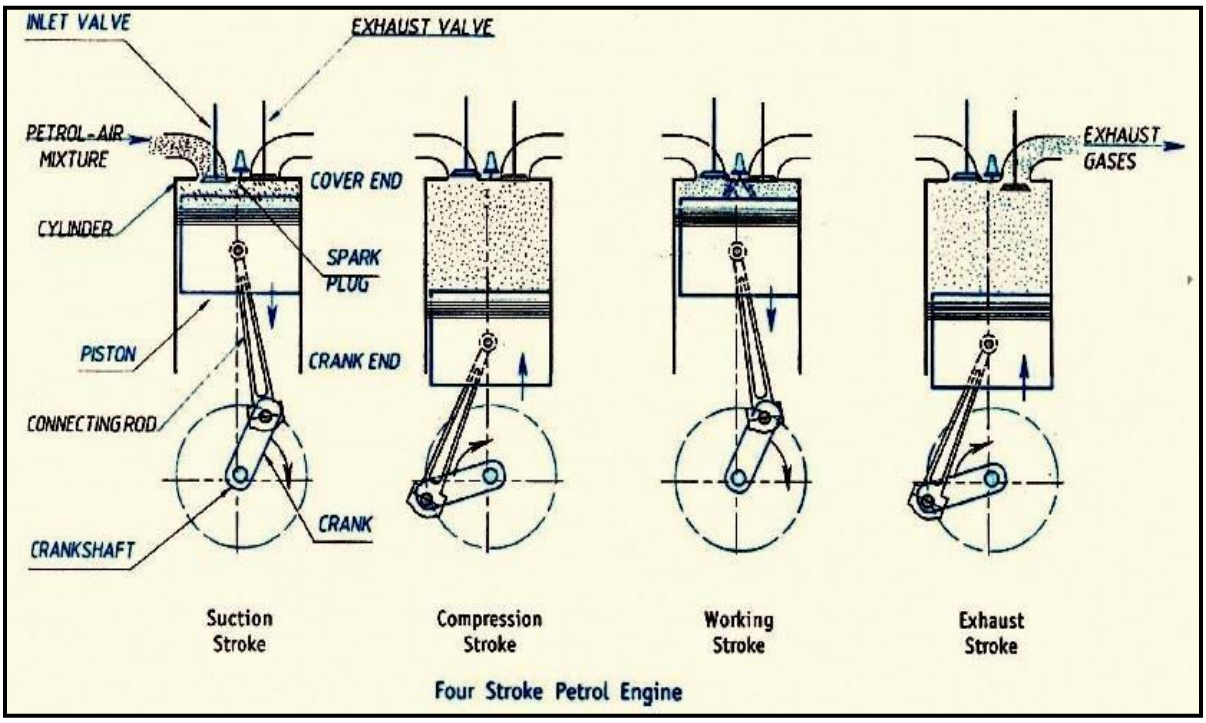
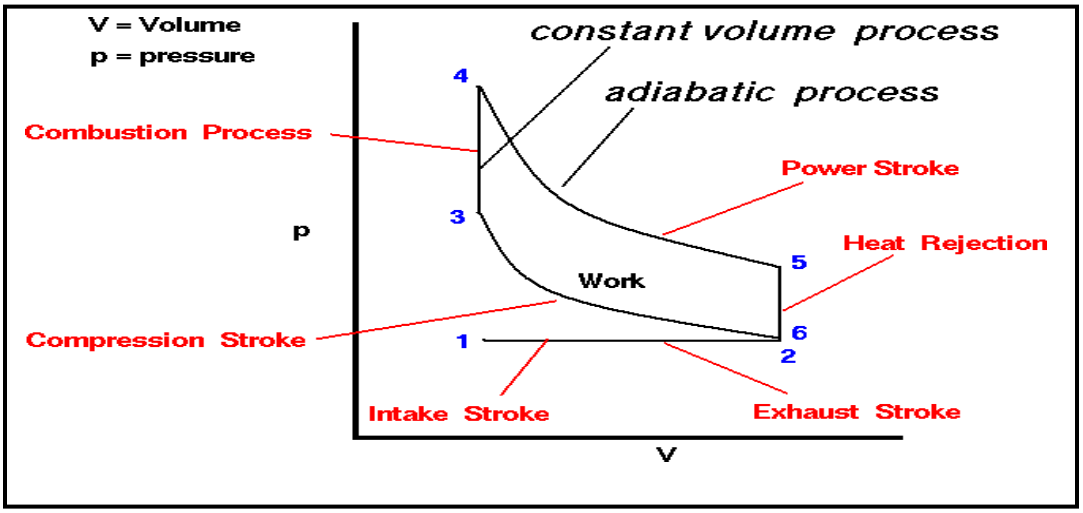


Fig: Otto cycle (P-V diagram)



Working:

In a 4-Stroke petrol engine, the working cycle is completed in four different strokes of the piston.

1) Suction stroke: At the beginning of the suction stroke, the piston is at the top dead centre (TDC), and is about to move towards the bottom dead centre (BDC). At this instance, the inlet valve is opened and the exhaust valve is closed. The downward movement of the piston produces suction (partial vacuum) in the cylinder, due to which fresh charge of air and petrol mixture is drawn into the cylinder through the inlet valve.

When the piston reaches the BDC, the suction stroke ends and the inlet valve is closed. With this stroke, the crankshaft rotates through 180° or half-revolution.

The energy required for the piston movement is taken from a battery. The suction of air takes place at atmospheric pressure, and is represented by the line AB on p-v diagram.

2) Compression stroke: During the compression stroke, the piston moves from BDC to TDC. Both the inlet and exhaust valves remain closed. As the piston moves upwards, the air-petrol mixture in the cylinder gets compressed (squeezed), due to which the pressure and temperature of the mixture increases.

The compression process is adiabatic [Adiabatic - It is a process in which there is no heat transfer from the system to the surroundings or vice-versa.] in nature and is shown by the curve BC on p-v diagram. When the piston is about to reach the TDC, the spark plug

initiates a spark that ignites the air-petrol mixture. Combustion of fuel takes place at constant volume as shown by the line CD on p-v diagram.

Since combustion of fuel takes place at constant volume, 4-Stroke petrol engines are also called as constant volume cycle engines. With this stroke, the crankshaft rotates by another 180° or half revolution. The energy required for the piston movement is taken from a battery.

3) Power stroke (Expansion stroke or Working stroke): During this stroke, both the valves will remain closed. As the combustion of fuel takes place, the burnt gases expand and exert a large force on the piston causing it to move rapidly from the TDC to BDC. The force (or power) is transmitted to the crankshaft through the connecting rod.

As a result, the crankshaft rotates at high speeds. The crankshaft then transmits the power through clutches, gears, chains, etc... To turn the wheels of the vehicle and cause it to move. The expansion of gases is adiabatic in nature and is shown by the curve DE on p-v diagram.

Since the actual power or work is produced by the engine in this stroke, it is also called as power stroke or working stroke. Also, expansion of gases occurs during this stroke, and hence the name expansion stroke.

4) Exhaust stroke: Towards the end of the expansion stroke, the exhaust valve opens, while the inlet valve remains closed. A part of the burnt gases due to their own expansion escapes out of the cylinder through the exhaust valve.

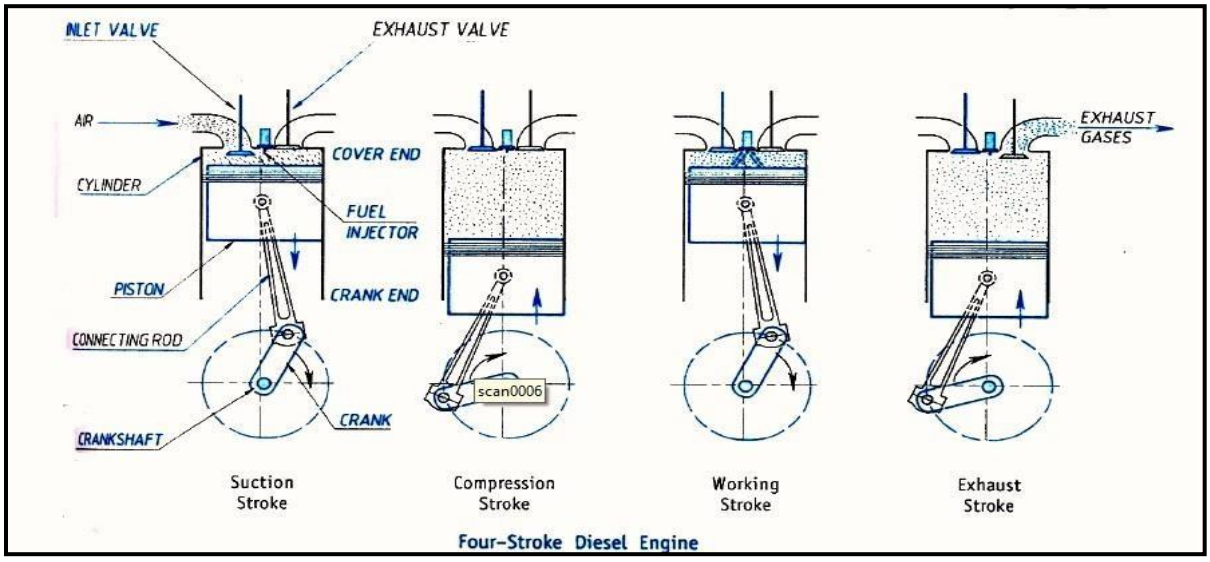
This drop in pressure at constant volume inside the cylinder is represented by the line EB on p-v diagram. The exhaust stroke begins when the piston starts moving from the BDC to TDC. The energy for this stroke is supplied by the flywheel, which it had absorbed in the previous stroke. As the piston moves upwards, it forces the remaining burnt gases to the atmosphere through the exhaust valve. The exhaust taking place at atmospheric pressure is shown by the line BA on p-v diagram.

When the piston reaches the TDC, the exhaust valve closes and the working cycle is completed. In the next cycle, the piston starts moving from TDC to BDC, the inlet valve opens allowing fresh charge to enter into the cylinder, and the process continues. Thus it is

clear that, the four different strokes or one working cycle is completed when the crankshaft rotates through 720° or two revolutions.

Four-stroke petrol engines are commonly used in scooters, motor bikes, cars, large boats, etc.

WORKING PRINCIPLE OF FOUR STROKE DIESEL ENGINE (4-S-D-E):



A 4-stroke diesel engine works on Diesel cycle. Hence it is also called Diesel cycle engine. The working principle is similar to that of 4-stroke petrol engine, except a fuel injector is used in place of spark plug, and only air enters the cylinder during the suction stroke and gets compressed in the compression stroke.

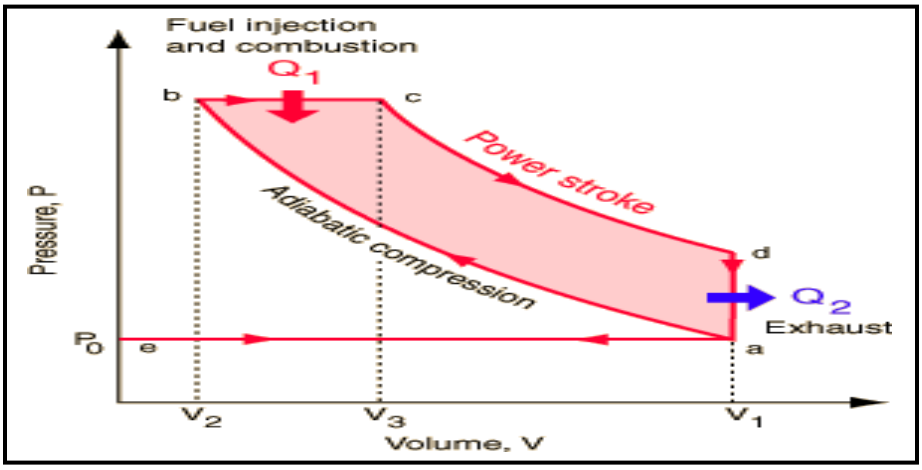


Fig: Diesel cycle (P-V diagram)

Working:

1) Suction stroke: At the beginning of the suction stroke, the piston is at the top dead centre (TDC), and is about to move towards the bottom dead centre (BDC). At this instance, the inlet valve is opened and the exhaust valve is closed.

The downward movement of the piston produces suction (partial vacuum) in the cylinder, due to which air from the atmosphere is drawn into the cylinder through the inlet valve. When the piston reaches the BDC, the suction stroke ends and the inlet valve is closed. With this stroke, the crankshaft rotates through 180° or half-revolution.

The energy required for the piston movement is taken from a battery. The suction of air takes place at atmospheric pressure, and is represented by the line AB on p-v diagram.

2) Compression stroke: During the compression stroke, the piston moves from BDC to TDC. Both the inlet and exhaust valves remain closed. As the piston moves upwards, the air in the cylinder gets compressed (squeezed), due to which the pressure and temperature of the air increases.

The compression process is adiabatic in nature and is shown by the curve BC on p-v diagram. When the piston is about to reach the TDC, a quantity of diesel is injected in the form of fine sprays into the hot compressed air by a fuel injector.

Combustion of fuel takes place at constant pressure as shown by the line CD on p-v diagram. Since combustion of fuel takes place at constant pressure, 4-Stroke diesel engines are also called as constant pressure cycle engines.

With this stroke, the crankshaft rotates by another 180° or half revolution. The energy required for the piston movement is taken from a battery. Since the heat of compression ignites the diesel injected into the cylinder, diesel engines are also called as compression ignition engines.

3) Power stroke (Expansion stroke or Working stroke): During this stroke, both the valves will remain closed. As the combustion of fuel takes place, the burnt gases expand and exert a large force on the piston causing it to move rapidly from the TDC to BDC.

The force (or power) is transmitted to the crankshaft through the connecting rod. As a result, the crankshaft rotates at high speeds. The crankshaft then transmits the power through clutches, gears, and other transmission elements to turn the wheels of the vehicle and cause it to move. The expansion of gases is adiabatic in nature and is shown by the curve DE on p-v diagram.

4) Exhaust stroke: During this stroke, the inlet valve remains closed and the exhaust valve opens. The greater part of the burnt gases escapes because of their own expansion. The drop in pressure at constant volume is represented by the vertical line EB.

The piston moves from bottom dead centre to top dead centre and pushes the remaining gases to the atmosphere. When the piston reaches the top dead centre the exhaust valve closes and the cycle is completed.

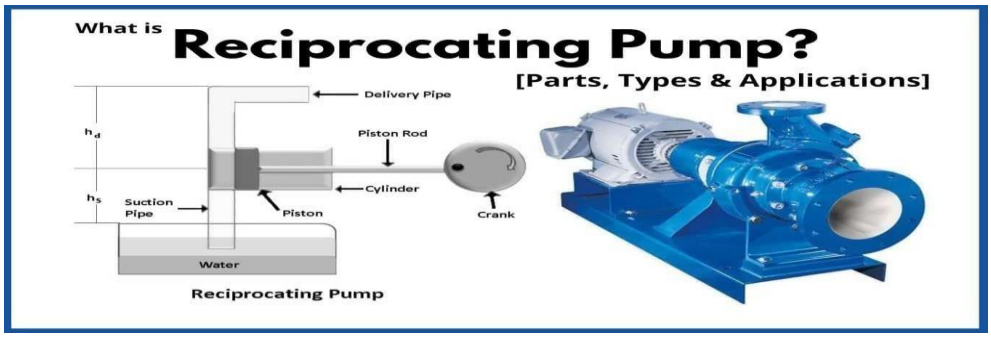
APPLICATIONS OF I.C ENGINE

1. In Automotive –
   i. Two stroke engine – Mopeds, Scooters.
   ii. Four stroke engine – Light vehicles, Heavy vehicles.
2. Marine Application – Ships, Boat.
3. Locomotive s – Railways.
4. Stationery engines – For lifting water, Generator,
5. Agriculture

1. A lawn mower (also known as a mower, grass cutter or lawnmower) is a machine utilizing one or more revolving blades (or a reel) to cut a grass surface to an even height. The height of the cut grass may be fixed by the design of the mower, but generally is adjustable by the operator, typically by a single master lever, or by a lever or nut and bolt on each of the machine's wheels. The blades may be powered by manual force, with wheels mechanically connected to the cutting blades so that when the mower is pushed forward, the blades spin or the machine may have a battery-powered or plug-in electric motor. The most common self-contained power source for lawn mowers is a small (typically one cylinder) internal combustion engine.

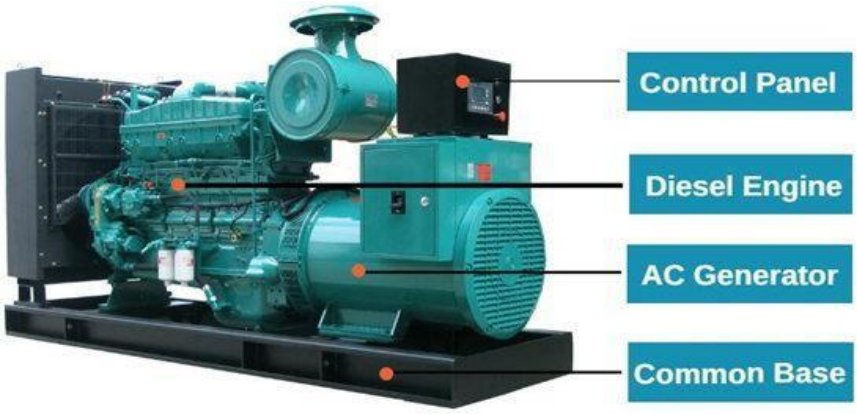
2. Power Tiller helps in preparing the soil, sowing seeds, planting seeds, adding & spraying the fertilizers, herbicides & water.

Reciprocating Pumps are used to lift water in agricultural purpose where the delivery pressure of the fluid is quite large. In this article, we will discuss on Single-acting Reciprocating Pump. As the name itself indicates that it has a single component of the suction valve, delivery valve, suction pipe, and delivery pipe along with a single-piston.



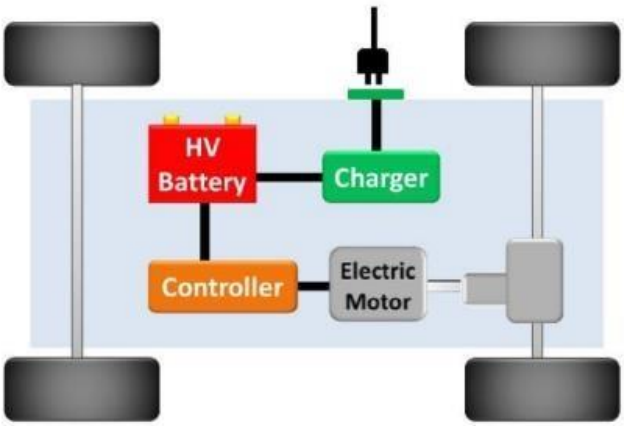
6. In power generation

Gensets : In a power plant, diesel ICEs are grouped into blocks called generating sets. Every engine is connected to a shaft which is connected to its electric generator. Generator produces rotation of shaft into electricity.



Electric Vehicles

All-electric vehicles (EVs), also referred to as battery electric vehicles, have an electric motor instead of an internal combustion engine. The vehicle uses a large traction battery pack to power the electric motor and must be plugged in to a wall outlet or charging equipment, also called electric vehicle supply equipment (EVSE). Because it runs on electricity, the vehicle emits no exhaust from a tailpipe and does not contain the typical liquid fuel components, such as a fuel pump, fuel line, or fuel tank.



What are the inner parts of an EV?

EVs have 90% fewer moving parts than an ICE (Internal Combustion Engine) car. Here's a breakdown of the parts that keep an EV moving:

Electric Engine/Motor - Provides power to rotate the wheels. It can be DC/AC type, however, AC motors are more common.

Inverter - Converts the electric current in the form of Direct Current (DC) into Alternating Current (AC)

Drivetrain - EVs have a single-speed transmission which sends power from the motor to the wheels.

Batteries - Store the electricity required to run an EV. The higher the kW of the battery, the higher the range. Charging - Plug into an outlet or EV charging point to charge your battery

How Does An Electric Car Work?

When pedal of the car is pressed, then:

➢ Controller takes and regulates electrical energy from batteries and inverters

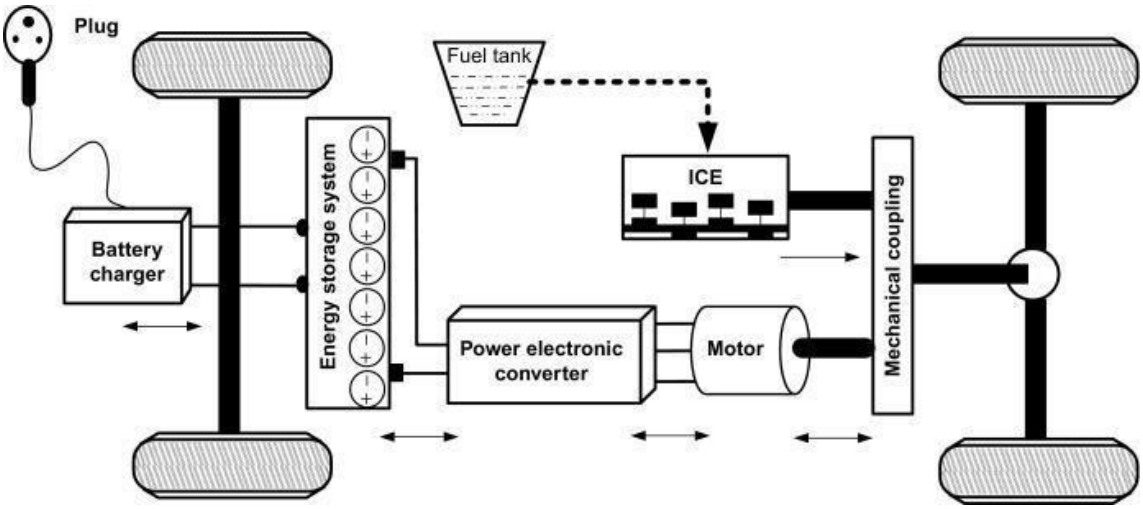
➢ With the controller set, the inverter then sends a certain amount of electrical energy to the motor (according to the depth of pressure on the pedal)

➢ Electric motor converts electrical energy into mechanical energy (rotation)

➢ Rotation of the motor rotor rotates the transmission so the wheels turn and then the car moves.

Hybrid electric vehicles

Hybrid electric vehicles are powered by an internal combustion engine and an electric motor, which uses energy stored in batteries. A hybrid electric vehicle cannot be plugged in to charge the battery. Instead, the battery is charged through regenerative braking and by the internal combustion engine. The extra power provided by the electric motor can potentially allow for a smaller engine. The battery can also power auxiliary loads and reduce engine idling when stopped. Together, these features result in better fuel economy without sacrificing performance.



Key Components of a Plug-In Hybrid Electric Car

Battery (auxiliary): In an electric drive vehicle, the low-voltage auxiliary battery provides electricity to start the car before the traction battery is engaged; it also powers vehicle accessories.

Charge port: The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.

DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

Electric generator: Generates electricity from the rotating wheels while braking, transferring that energy back to the traction battery pack.

Exhaust system: The exhaust system channels the exhaust gases from the engine out through the tailpipe.

A three-way catalyst is designed to reduce engine-out emissions within the exhaust system.

Internal combustion engine (spark-ignited): In this configuration, fuel is injected into either the intake manifold or the combustion chamber, where it is combined with air, and the air/fuel mixture is ignited by the spark from a spark plug.

Power electronics controller: This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.

Transmission: The transmission transfers mechanical power from the engine and/or electric traction motor to drive the wheels.

Advantages of electric vehicles

1) No fuel, no emissions: No petrol or diesel is needed in a fully electric vehicle, which is great for your carbon footprint.

2. More Convenient: The electric vehicle is easy to recharge, and the best part is you will no longer need to run to the fuel station to recharge your car before hitting the road! Even a normal household socket could be used for charging an electric car.

3. Savings: These cars can be fuelled for very low prices, and many new cars will offer great incentives for you to get money back from the government for going green. Electric cars can also be a great way to save money in your own life.

4. No Emissions: The biggest advantage of an electric vehicle is its green credential. Electric cars are 100 percent eco-friendly as they run on electrically powered engines.

5. Safe to Drive: Electric cars undergo the same fitness and testing procedures test as other fuel powered cars. An electric car is safer to use, given their lower center of gravity, which makes them much more stable on the road in case of a collision.

6. Cost-Effective: The mass production of batteries and available tax incentives further brought down the cost, thus, making it much more cost-effective.

7. Reduced Noise Pollution: Electric cars put a curb on noise pollution as they are much quieter. Electric motors are capable of providing smooth drive with higher acceleration over longer distances.

Disadvantages of electric vehicles

1. Recharge Points: Electric fuelling stations are still in the development stages. Not a lot of places you go to on a daily basis will have electric fuelling stations for your vehicle, meaning that if you're on a long trip or decide to visit family in a rural or suburban area and run out of charge, it may be harder to find a charging station. You may be stuck where you are.

2. Electricity isn't Free: Electric cars can also be a hassle on your energy bill if you're not considering the options carefully. If you haven't done your research into the electric car you want to purchase, then you may be making an unwise investment.

3. Short Driving Range and Speed: Electric cars are limited by range and speed. Most of these cars have a range of about 50-100 miles and need to be recharged again. You just can't use them for long journeys as of now, although it is expected to improve in the future.

4. Longer Recharge Time: While it takes a couple of minutes to fuel your gasoline-powered car, an electric car takes about 4-6 hours and sometimes even a day to get fully charged.**5.**

5. Silence as a Disadvantage: Silence can be a bit disadvantage as people like to hear the noise if they are coming from behind them. An electric car is, however, silent and can lead to accidents in some cases.

6. Battery Replacement: Depending on the type and usage of battery, batteries of almost all electric cars are required to be changed every 3-10 years.

What Are the Advantages and Disadvantages of Hybrid Cars?Advantages

- Environment-friendly
- Financial benefits due to lesser fuel cost incurred
- Less dependence on fossil fuels
- Regenerative braking system
- Built from lightweight materials
- Electric motor assistance
- Smaller engines
- Automatic start and stop

Disadvantages

- Lesser power generation
- Hybrid car price is on the higher side
- Poor handling
- High maintenance cost
- High voltage batteries can cause accidents
- Expensive battery replacement charges
- Inconvenience of battery disposal and recycling