19AUB203 AUTOMOTIVE ENGINES AND EMISSION CONTROL

UNIT I INTRODUCTION

Constructional details of spark ignition (SI) engines.

A spark-ignition engine (SI engine) is an internal combustion engine, generally a petrol engine, where the combustion process of the air-fuel mixture is ignited by a spark from a spark plug.

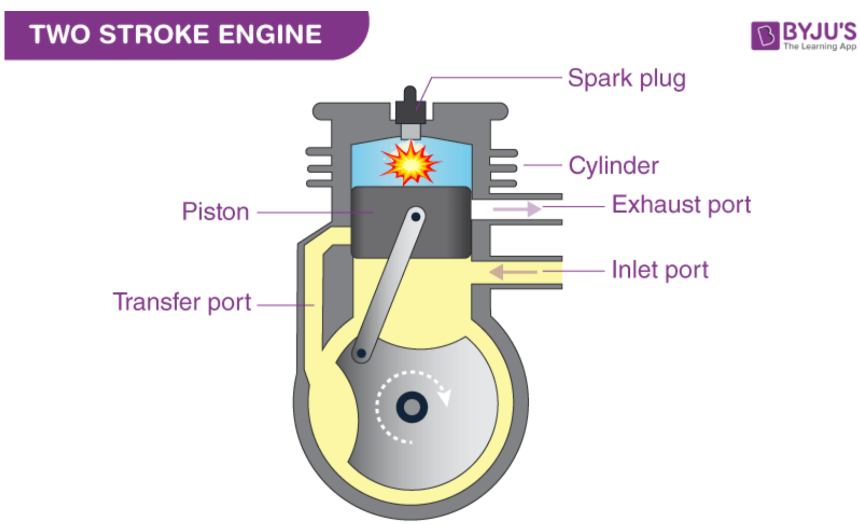
Fuels

Spark-ignition engines can (and increasingly are) run on fuels other than petrol/gasoline, such as autogas (LPG), methanol, ethanol, bioethanol, compressed natural gas (CNG), hydrogen, and (in drag racing) nitromethane.

Working cycle

A four-stroke spark-ignition engine is an Otto cycle engine. It consists of following four strokes: suction or intake stroke, compression stroke, expansion or power stroke, exhaust stroke. Each stroke consists of 180 degree rotation of crankshaft rotation and hence a four-stroke cycle is completed through 720 degree of crank rotation. Thus for one complete cycle there is only one power stroke while the crankshaft turns by two revolutions.

Construction of A Two-Stroke Engine



Piston – The piston transfers the expanding force of gases to the mechanical rotation of the crankshaft through a connecting rod.

Crankshaft – It converts the reciprocating motion to rotational motion.

Connecting Rod – It transfers motion from a piston to the crankshaft and acts as a lever arm.

Flywheel – It is a mechanical device that is used to store energy.

Spark Plug – It delivers electric current to the combustion chamber and in turn ignites the air-fuel mixture leading to abrupt expansion of gases.

Counter Weight – Counterweight on the crankshaft is used to reduce the vibrations due to imbalances in the rotating assembly.

Inlet and Outlet Ports – These ports allow fresh air with fuel to enter and exit from the cylinder.

Four Stroke Engine

A four-stroke engine is an internal combustion engine that utilises four distinct piston strokes (intake, compression, power, and exhaust) to complete one operating cycle. A complete operation in a four-stroke engine requires two revolutions (720^0) of the crankshaft. In this article, let’s study the four-stroke engine.

Parts of a Four Stroke Engine

Piston

In an engine, a piston transfers the expanding forces of gas to the mechanical rotation of the crankshaft through a connecting rod.

Crankshaft

A crankshaft is a part that converts the reciprocating motion to rotational motion.

Connecting Rod

It transfers motion from a piston to a crankshaft, acting as a lever arm

Flywheel

The flywheel is a rotating mechanical device that is used to store energy.

Inlet and Outlet Valves

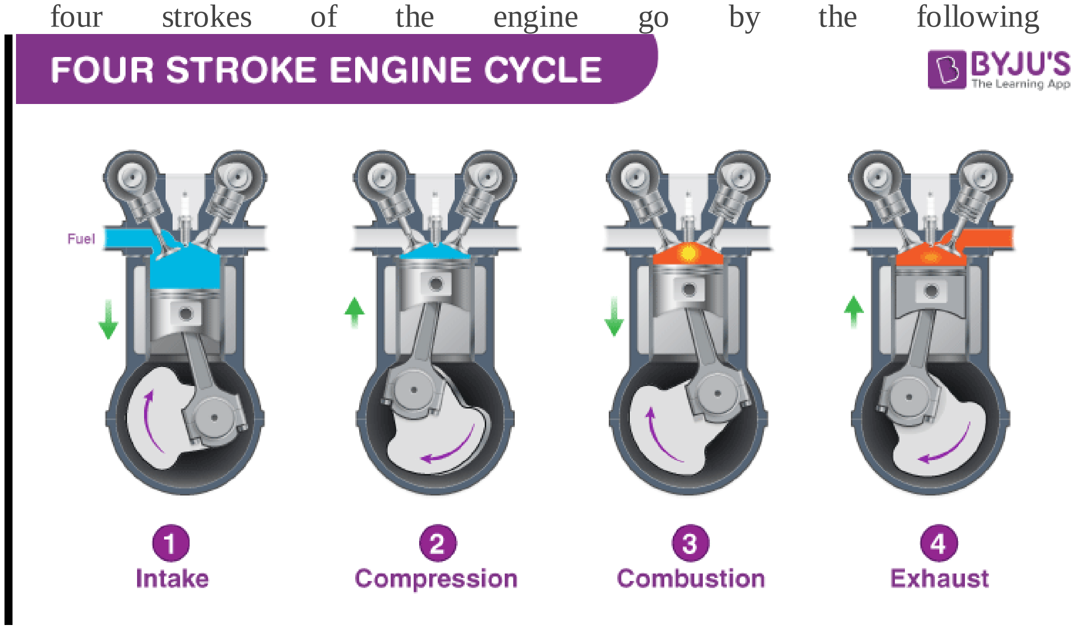
It allows us to enter fresh air with fuel & to exit the spent air-fuel mixture from the cylinder.

Spark Plug

It is a device that delivers electric current to the combustion chamber, which ignites the air-fuel mixture leading to the abrupt gas expansion.

<u>Four Stroke Engine Cycle</u>

The four strokes of the engine go by the following names:



Suction/Intake Stroke

Intake stroke occurs when the air-fuel mixture is introduced to the combustion chamber. In this stroke, the piston moves from TDC (Top Dead Center – the farthest position of the piston to the crankshaft) to BDC (Bottom Dead Center – the nearest position of the piston to the crankshaft.) The movement of the piston towards the BDC creates a low-pressure area in the cylinder. The inlet valve remains to open a few degrees of crankshaft rotation after BDC. The intake valve then closes, and the air-fuel mixture is sealed in the cylinder

- **Key points**
- **Inlet Valve – Open**
- **Outlet Valve – Closed**
- **Crankshaft Rotation – 180^0**

Compression Stroke

In compression stroke, the trapped air-fuel mixture is compressed inside the cylinder. During the stroke, the piston moves from BDC to TDC, compressing the air-fuel mixture. The momentum of the flywheel helps the piston move forward. Compressing the air-fuel mixture allows more energy to be released when the charge is ignited. The charge is the volume of compressed air-fuel mixture trapped inside the combustion chamber ready for ignition. The inlet and outlet valves must be closed to ensure that the cylinder is sealed, resulting in compression.

- **Key points**
- **Inlet Valve – Closed**
- **Outlet Valve – Closed**
- **Crankshaft Rotation – 180^0 (Total 360^0)**

Power/Combustion Stroke

The second rotation of the crankshaft begins when it completes a full rotation during the compression stroke. The power stroke occurs when the compressed air-fuel mixture is ignited with the help of a spark plug. Ignition or Combustion is the rapid, oxidizing chemical reaction in which a fuel chemically combines with oxygen in the atmosphere and releases energy in the form of heat. The hot expanding gases force the piston head away from the cylinder head.

- **Key points**

- **Inlet Valve – Closed**
- **Outlet Valve – Closed**
- **Crankshaft Rotation – 180^0 (Total 540^0)**

Exhaust Stroke

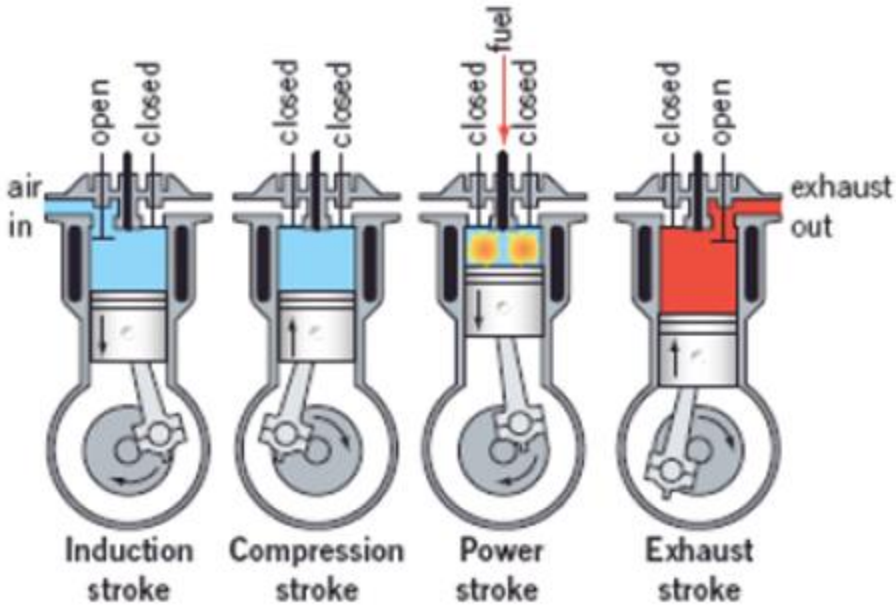
As the piston reaches BDC during the power stroke, combustion is complete, and the cylinder is filled with exhaust gases. The exhaust valves open during this stroke, and the inertia of the flywheel and other moving parts push the piston back to TDC, forcing the exhaust gases through the open exhaust valve. At the end of the exhaust stroke, the piston is at TDC, and one operating cycle has been completed.

- **Key points**
- **Inlet Valve – Closed**
- **Outlet Valve – Open**
- **Crankshaft Rotation – 180^0 (Total 720^0)**

Comparison Between a 2-stroke engine and a 4-stroke engine

1. A 4-stroke engine weighs 50% heavier than a 2-stroke engine.
2. A 4-stroke engine is more efficient than a 2-stroke engine because fuel is consumed once every 4 strokes.
3. A 2-stroke engine creates more torque at a higher RPM, while a 4-stroke engine creates a higher torque at a lower RPM.
4. A 4-stroke engine is quieter than a 2-stroke engine.
5. 2-stroke engines tend to wear out fast because they are designed to run at a higher RPM.
6. 2-stroke engines are easier to fix because of their simple construction. 4-stroke engines have complex designs with more parts, making them more expensive, and repairs cost more.

<u>Diesel Engine: Working Principle of Four Stroke Diesel Engine</u>



In a diesel engine, diesel oil, light, and heavy oil are used as fuel. This fuel is ignited by being injected into the engine cylinder containing air compressed to very high pressure.

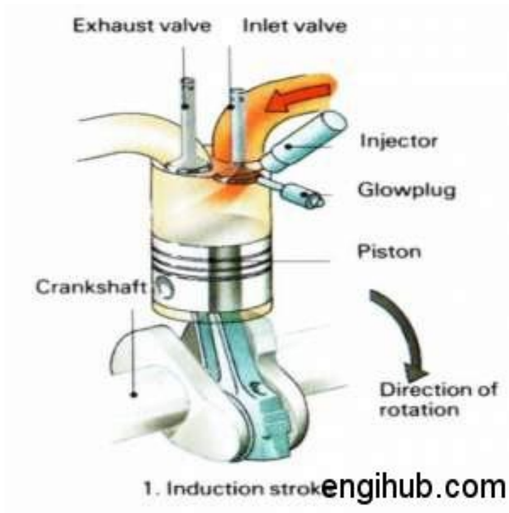
The temperature of this compressed air is sufficiently high to ignite the fuel. Hence there is no spark plug used in the diesel engine.

This high-temperature compressed air used in the form of very fine spray is injected at a controlled rate. So, the combustion of fuel proceeds at constant pressure.

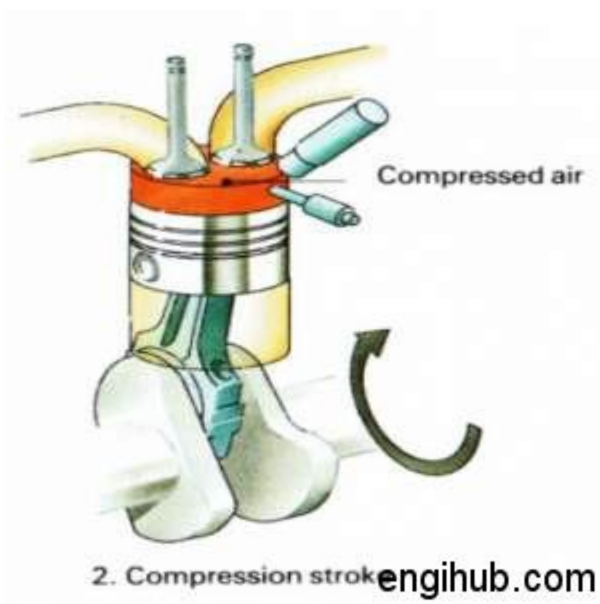
A fuel Injector or fuel injection pump, or fuel atomizer is used for this operation. The power is generated by completing a working stroke.

Working strokes of Diesel Engine

Suction Stroke



Compression Stroke



In this stroke, the piston moves up from the bottom dead center to the top dead center. During this stroke, both inlet and exhaust valves are closed.

The air drawn into the cylinder during the suction stroke is entrapped inside the cylinder and compressed due to the upward movement of the piston.

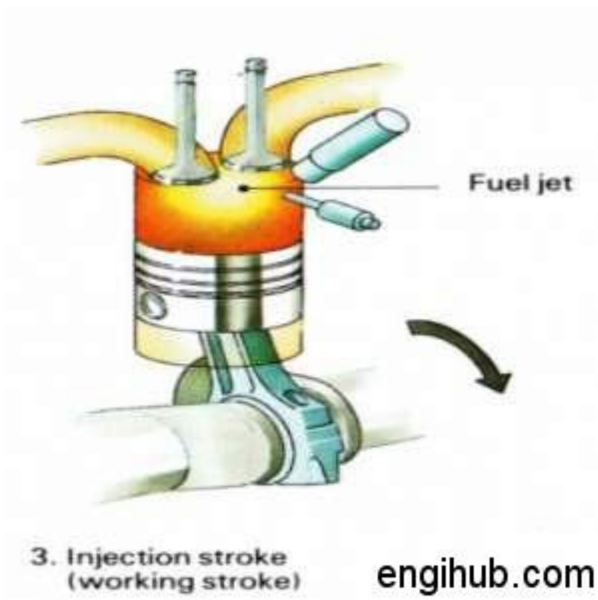
In a diesel engine, the compression ratio used is very high as a result, the air is finally compressed to a very high-pressure up-to 40 Kg/cm², at this pressure, the temperature of the air is reached 1000° centigrade which is enough to ignite the fuel.

Constant Pressure Stroke

In this stroke, the fuel is injected into the hot compressed air where it starts burning, at constant pressure. When the piston moves to its top dead center, the supply of fuel is cut off.

It is to be said that the fuel is injected at the end of the compression stroke and injection continues until the point of cut-off, but in actual practice, the ignition starts before the end of the compression stroke to take care of the ignition tag.

Working or Power Stroke

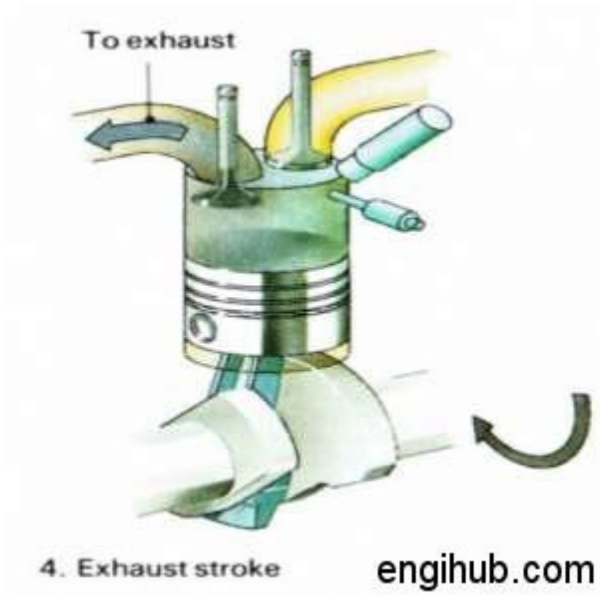


In this stroke, both the inlet and exhaust valve remain closed.

The hot gases (which are produced due to ignition of fuel during compression stroke) and compressed air now expand adiabatically, in the cylinder pushing the piston down, and hence work is done.

At the end of a stroke, the piston finally reaches the bottom dead center.

Exhaust Stroke



in this stroke, the piston again moves upward. The exhaust valve opens, while the inlet and fuel valve is closed. A greater part of the burnt fuel gases escapes due to their own expansion.
The upward movement of the piston pushes the remaining gases out through the open exhaust valve. Only a small quantity of exhaust gases stay in the combustion chamber.
At the end of an exhaust stroke, the exhaust valve closes and the cycle is thus completed.

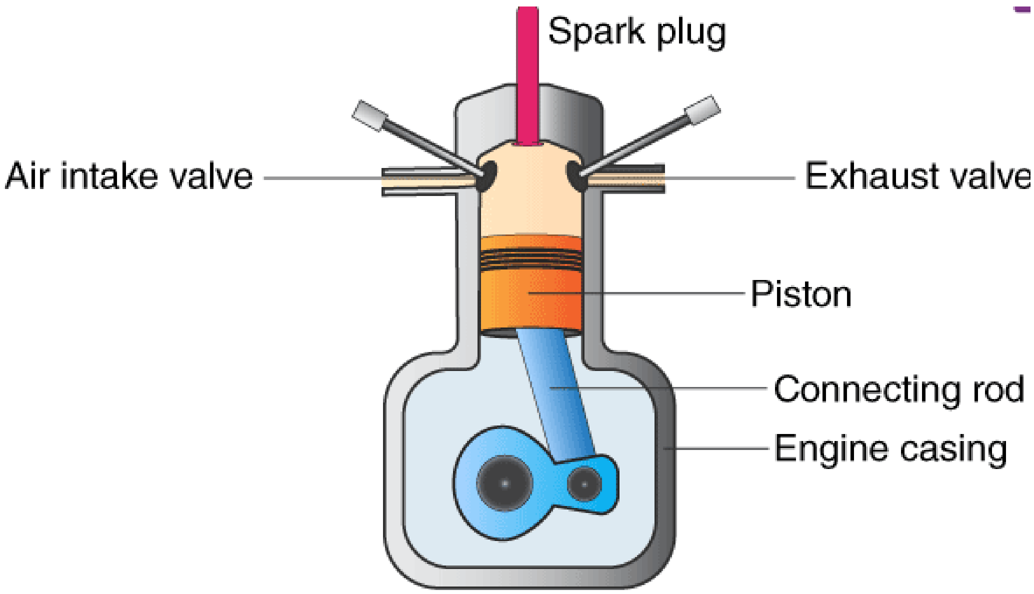
Difference between Petrol and Diesel Engine

The primary difference between Petrol and Diesel engines is that the Petrol engine works on the Otto cycle whereas the Diesel engine works on the Diesel cycle. Other differences can be attributed to the structure, types, and uses of these engines. The main parameter they are classified on is the type of fuel they use. Generally, Engines run on the principle of heat transfer.

Petrol Engine

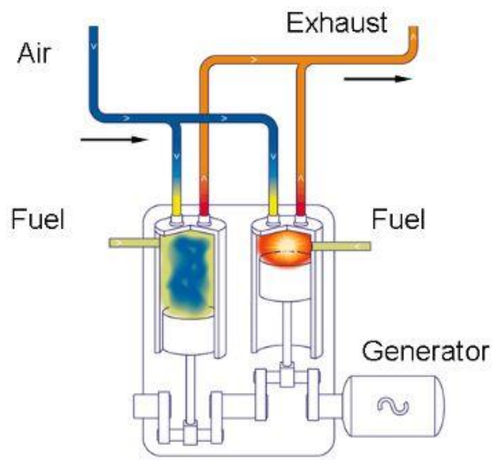
- Petrol engines are internal combustion engines which have spark-ignition. They run on relatively volatile fuels such as petrol.
- In these engines, air and fuel are generally mixed post-compression.
- Petrol engines work on the Otto cycle, which consists of two isochoric processes and two isentropic processes.
- In petrol engines, air and petrol are usually mixed in a carburettor before being introduced to the cylinder.

- Once the air and petrol are compressed, the fuel is ignited via an electric spark.



Diesel Engine

- The Diesel engine is also an internal combustion engine which is also known as the compression-ignition engine. It is named after Rudolf Diesel.
- In these engines, the fuel is injected into a combustion chamber and is then ignited by the high temperature of the air in the chamber.
- The high temperature of the air in the cylinder is due to the adiabatic compression. These engines only compress the air and not the fuel.
- When injected into the combustion chamber, the Diesel fuel undergoes spontaneous ignition.
- These engines work on the Diesel cycle, which consists of a constant pressure process, a constant volume process, and two isentropic processes.



Difference between Petrol and Diesel Engine

Apart from the type of fuel used, the engines are also divided on the basis of a lot of things, such as the presence of a spark plug in Petrol engines and a fuel injector in Diesel engines. We also know that lighter vehicles such as motorcycles, scooters, and cars typically use petrol in their engines whereas Diesel is used in much heavier machinery such as tractors, trucks, and buses. Thus, the types of fuel used also plays a major role in defining the major difference between Petrol and Diesel engines. More differences between these types of engines are listed in the tabular column below.

Difference Between Petrol(SI) and Diesel(CI) Engine	
Diesel Engine	**Petrol Engine**
These engines work on the Diesel cycle	Works on the Otto cycle
The fuel is mixed with air inside the cylinder	Air and the fuel are mixed in a carburettor
Ignition is achieved with the help of the hot, compressed air.	Fuel is ignited with an electric spark
High compression ratio	Relatively low compression ratio
High power production	Relatively low amounts of power are produced in a Petrol engine
These engines work with fuels that have low volatilities	Highly volatile fuels are used in these internal combustion engines
Generally used in heavy vehicles such as trucks and buses	Used in light vehicles such as motorcycles and cars.
Relatively low fuel consumption	High fuel consumption.

High initial and maintenance costs	Comparatively low initial cost and maintenance cost

Difference between Two Stroke and Four Stroke:

Two Strokes	**Four Strokes**
It has one revolution of the crankshaft during one power stroke.	It has two revolutions of the crankshaft during one power stroke.
It generates high torque.	It generates less torque.
It uses a port for the fuel's outlet and inlet.	It uses valves for the fuel's outlet and inlet.
Its engines result in lesser thermal efficiency.	Its engines result in higher thermal efficiency.
It has a larger ratio in terms of power to weight.	It has a lesser ratio in terms of power to weight.
It generates more smoke and shows less efficiency.	It generates less smoke and shows more efficiency.
Requires more lubricating oil as some oil burns with the fuel.	Requires less lubricating oil.
Due to poor lubrication, more wear and tear occurs.	Less wear and tear occurs.
Engines are cheaper and are simple to manufacture.	Engines are expensive due to lubrication and valves and are tough to manufacture.
Engines are basically lighter and noisier.	Engines are basically heavier because their flywheel is heavy and less noisy.

Indicated Power

Indicated power is the total power of engine which is graphically represented by area of cycle on P-V chart. As the actual P-V diagram of an engine is drawn by an indicator mechanism, this power is called indicated power.

Indicated Power: It is the power developed inside the engine cylinder. I . P = p m L A N K 60.

Brake Power

The power developed by an engine at the output shaft is called brake power and is given by Power = NT/60,000 in kW where T= torque in Nm = WR W = 9.81 * Net mass applied in kg.

Indicated thermal efficiency

Indicated thermal efficiency (ηt): Indicated thermal efficiency is the ratio of energy in the indicated power to the fuel energy.

Indicated thermal efficiency (ηi) : Is is a ratio of Heat equivalent of indicated power per unit time to heat supplied to the engine in unit time. =Indicated power / (mf * C. V.) Indicated power is power developed inside cylinder.

Brake thermal efficiency (ηbth): A measure of overall efficiency of the engine is given by the brake thermal efficiency.
The brake thermal efficiency shows the amount of power taken by the engine crankshaft out of total power generated by the combustion of the fuel.
η_{brake} = Brake power/Fuel power

The volumetric efficiency of an engine is the extent to which the cylinder is completely filled by the air/ fuel mixture that enters on each exhaust stroke.

It is defined as the ratio of the equivalent volume of the fresh air drawn into the cylinder during the intake stroke to the volume of the cylinder itself.

Measurement of friction
F.P = I.P - B.P

Measurement of Engine CC
Cubic Centimeter is the volume and also the capacity of the engine. It is calculated as the Product of the Number of Cylinders in the engine, the Cross-sectional area of the engine, and the length of the piston stroke.