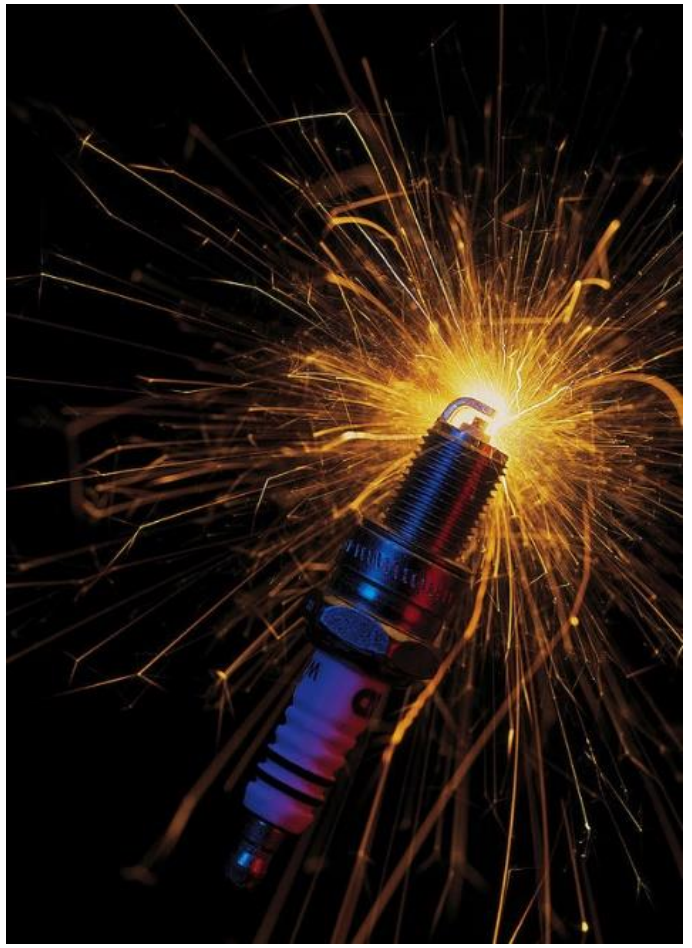
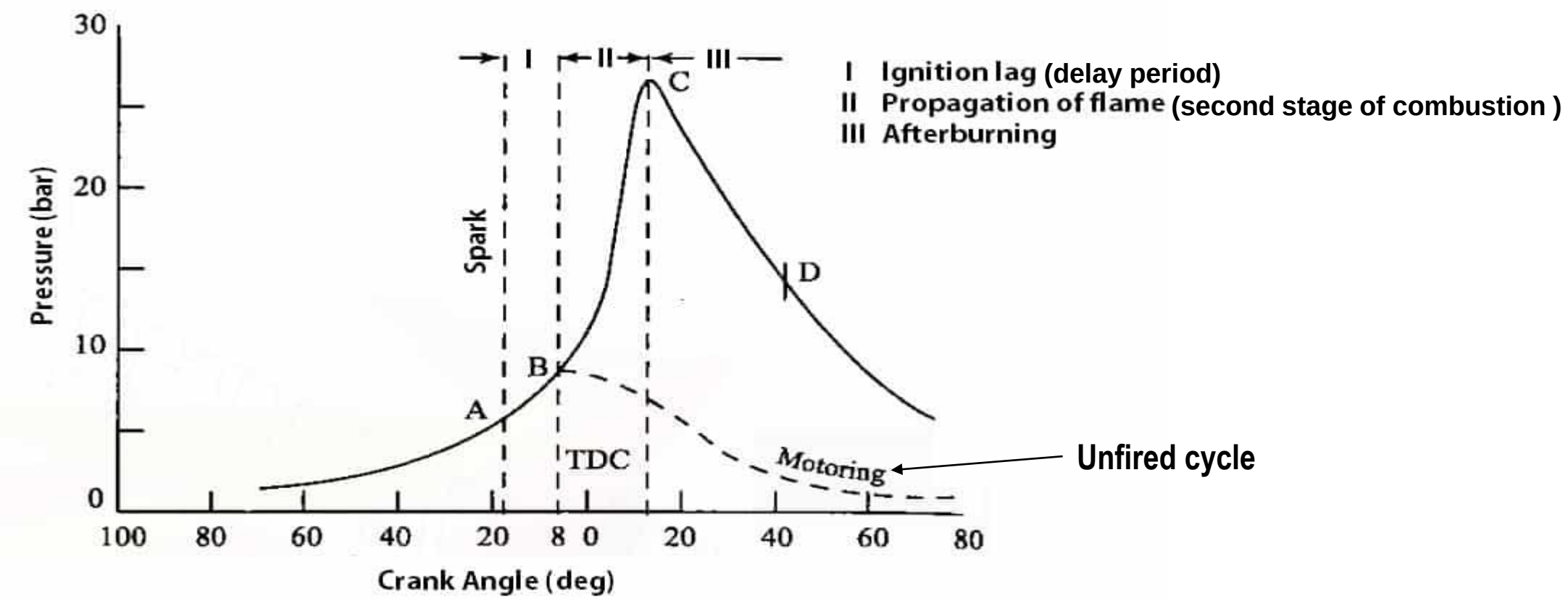
Combustion In Spark Ignition Engine:



1- Normal Combustion:

When piston approaches the end of the compression stroke, a spark is discharged between electrodes, then the flame is propagated, but, due to turbulence the propagation cannot be enhanced which causes the delay period.



Delay Period:

Is the time between spark charging and the beginning of combustion, it is 0.5ms which is 7.5 of C.A at 2500 rpm, it depends up on temp, press, and A/F ratio.

BC is the 2^{nd} stage which is the 2^{nd} stage of combustion, it is affected by press, temp, A/F ration and turbulence.

For the best torque the minimum ignition advance (MBT) which is a compromise for the beginning of ignition before TDC;

2- Abnormal Combustion:

In this type of combustion the fuel/air mixture spontaneously ignited without an ignition source due to contact with a hot surface s.a exhaust v/v. The cause is the combustion deposits.

This leads to what is called knock

Knock: is probably caused by vibration of the combustion chamber content at the appropriate resonant frequency.

As a result of knocking the thermal boundary layer at the combustion chamber walls can be destroyed. This causes increase in heat transfer which might then lead to certain surfaces causing pre-ignition.

What Is Knocking ?

- High frequency vibrations giving rise to ping like sound inside an Engine.

- Caused By :

✓ Low Quality Fuel

✓ Deposits on Cylinder Wall

✓ Wrong Spark Plug.

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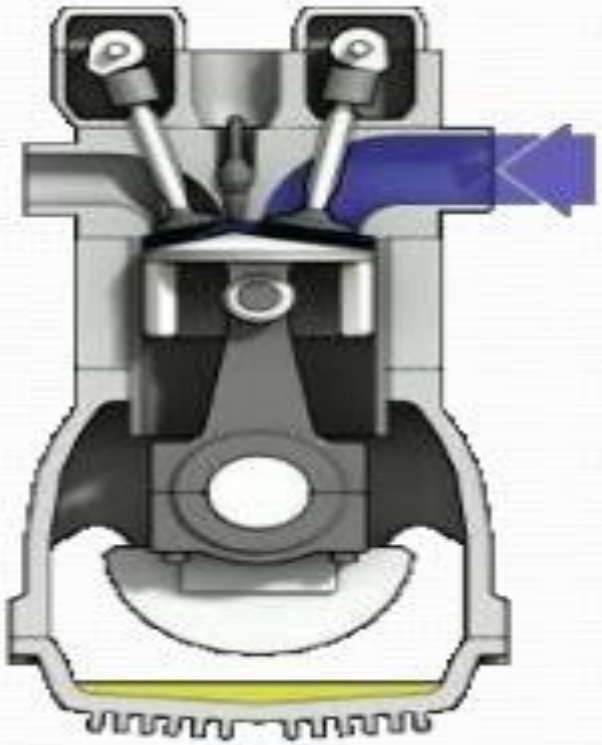


Factor Affecting Knock:

1- Fuel Characteristics:

- Molecular structure.
- Temp of self-ignition.
- Rate of burning.

2- Conditions of the cylinder charge:

- A/F ratio.
- Charge-distribution.
- Temp of charge.
- Density of the charge.

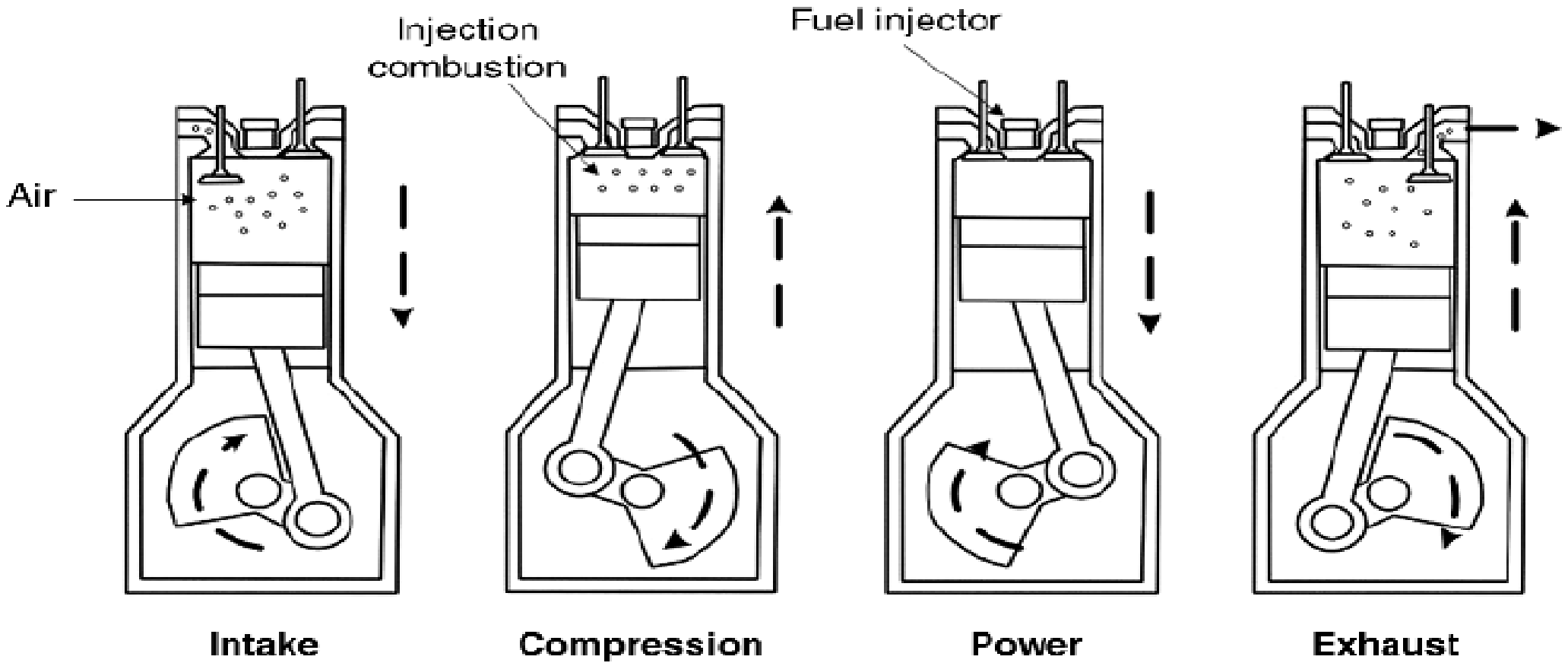
3- Compression Ratio:

- Comp pressure.
- Comp temp.
- Dilution by residual gases.
- Valve timing.

4- Combustion Chamber.

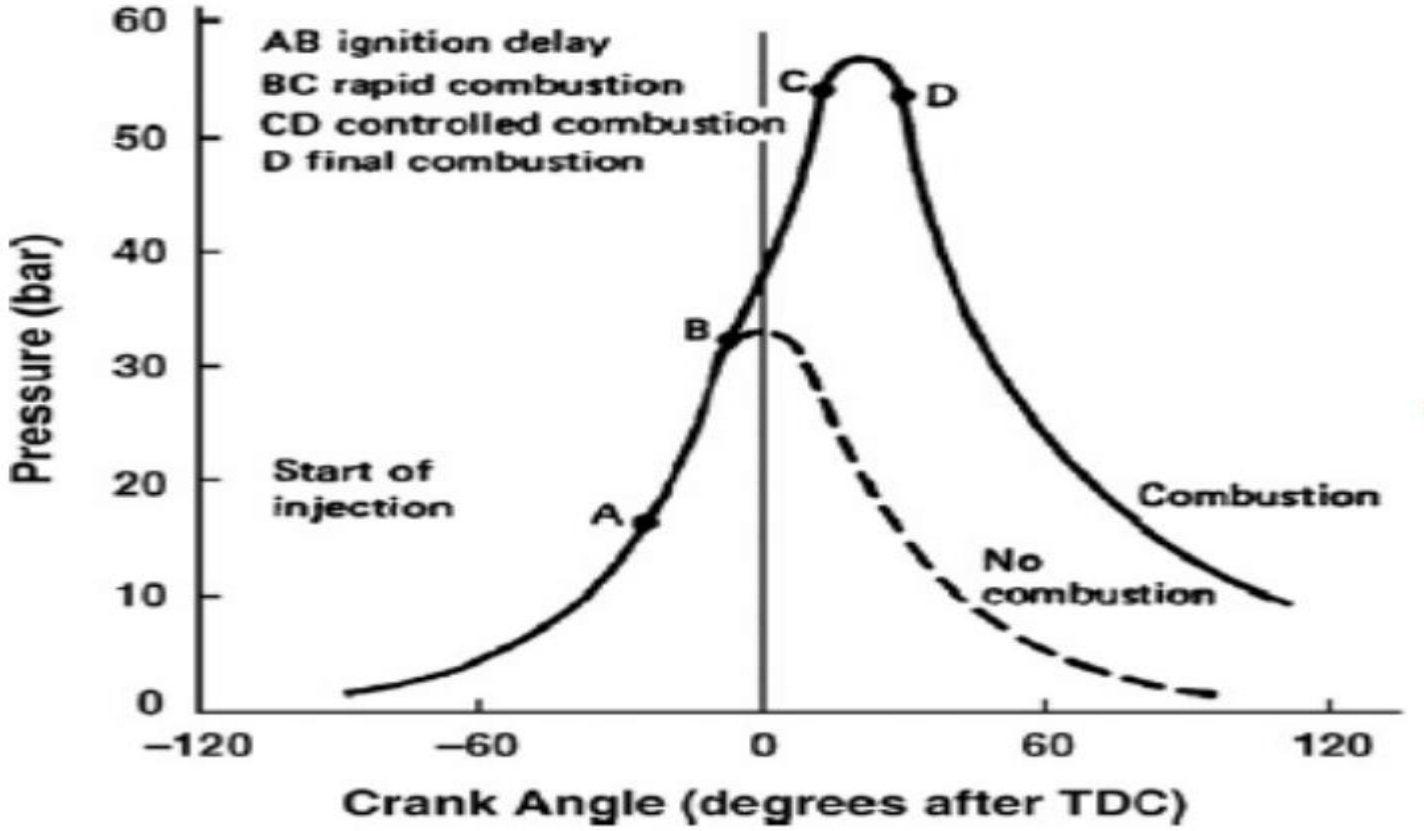
- Shape.
- Material.
- Surface conditions.

Combustion in C.I.E :



Combustion in C.I.E :

1- Ignition delay AB, during this period the fuel is breaking up into droplets being vaporized, and mixing with air. Chemical reactions will be starting.



Combustion in C.I.E :

2- Rapid or uncontrolled combustion BC, a very rapid increase in pressure caused by ignition of the fuel air mixture prepared during the ignition delay period.

3- Controlled combustion CD, Combustion occurs at a rate determined by the preparation of fresh air/fuel mixture.

4-Final combustion D. As with controlled combustion the rate of combustion is governed by diffusion until all the fuel or air is utilized.

To avoid knock in diesel engines in the rapid uncontrolled combustion period, the injection of too much fuel too quickly should be reduced, some systems inject a small quantity of fuel before the main injection, a system known as pilot injection.

Characteristics of Petrol:

There are two main properties of petrol oil:

- Volatility.
- Octane number.

1- Volatility:

The volatility is the percentage by volume that is distilled at or below fixed temperature.

If Petrol is too volatile, when it is used at high ambient temperatures the petrol is liable to vaporize in the fuel lines and form vapor locks.

If Petrol is not sufficiently volatile the engine will difficult to start, especially at low ambient temperatures the volatility also influences the cold start fuel economy.

SIE's are started on very rich mixtures, and continue to operate on rich mixtures until the normal operating temperature, this is to insure adequate vaporization of fuel.

Increasing the volatility of petrol at low temperatures will improve fuel economy during and after starting.

2- Octane Number:

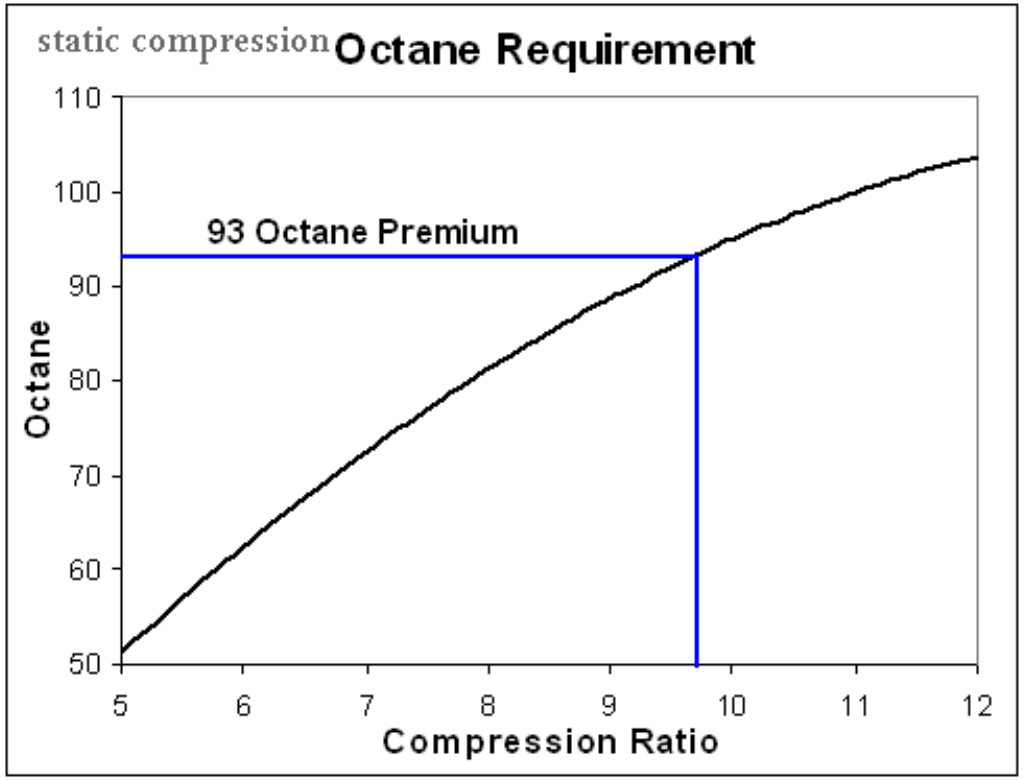
The octane number of a fuel is a measure of its anti-knock performance. A scale of 0- 100 is devised by assigning value of 0 to n heptane (a fuel prone knock) and a value of 100 to iso-octane (a fuel resistant to knock).

A 95 octane fuel has the performance equivalent to that of a mixture of 95 percent iso-octane and 5 percent n- heptane by volume.

The octane requirements of an engine varies with C.R, geometrical and mechanical considerations and also operating conditions.

Octane Number:

The octane number requirements for a given C.R vary widely, but typically a CR of 7.5 requires 85 octane fuel, while a compression ratio of 10 would require 100 octane fuel.



It was found that lead additives can improve the octane ratings of fuels, either tetra methyl lead (CH3)4 Pb or tetra ethyl lead (C2H5)4Pb.

Characteristics of Diesel

The main characteristic of diesel oil is the cetane number, it is an indication for the oil to show how it is ready for self-ignition. A scale of 0-100 is constructed by making a value of 0 to α methyl naphthalene ($C_{10}H_{17}CH_3$), a naphthalene compound with poor self-ignition qualities, and a value of 100 to n- cetane ($C_{16}H_{34}$, a straight chain alkane with good self-ignition qualities). A 60 cetane fuel would have ignition delay performance equivalent to that of blend of 60 percent n-cetane and 40 percent α methyl naphthalene by volume.

Characteristics of Diesel:

Diesel knock occur due to fuel has low cetane number, it is caused by too rapid combustion and is the result of a long ignition delay period, since during this period fuel is injected and mixes with air to form a combustion mixture.

The flash point of diesel oil is relatively higher than these of petrol or kerosene, this makes it safer to be stored its flash point is at least 55°C.

Characteristics of Diesel:

Additives in diesel fuel to improve the cetane number are referred to as ignition accelerator. Adding 1 percent of amyl nitrate, $C_5H_{11}ONO_2$ will improve cetane number by 6 percent. Other additives are ethyl nitrate $C_2H_5ONO_2$ and ethyl nitrite C_2H_5ONO

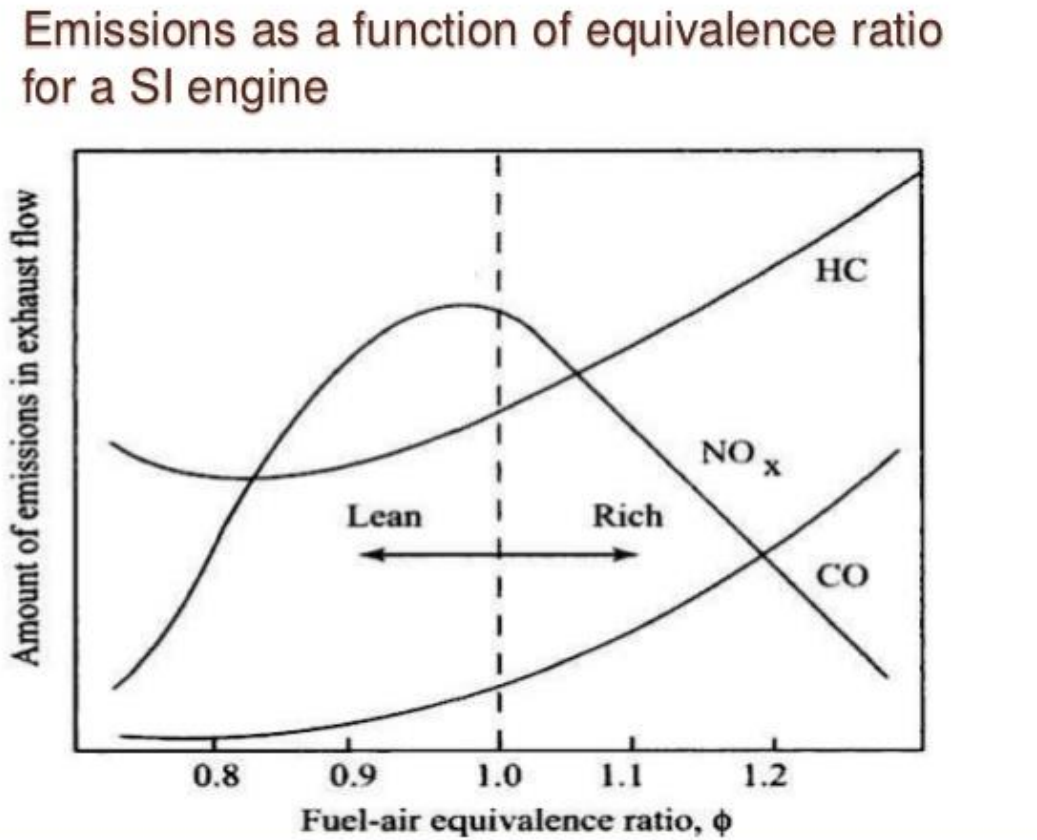
To overcome cold-starting a facility on the injector pump to inject excess fuel, or starting aids such as heaters, or volatile fuels with high CN such as ether can be added to the intake air.

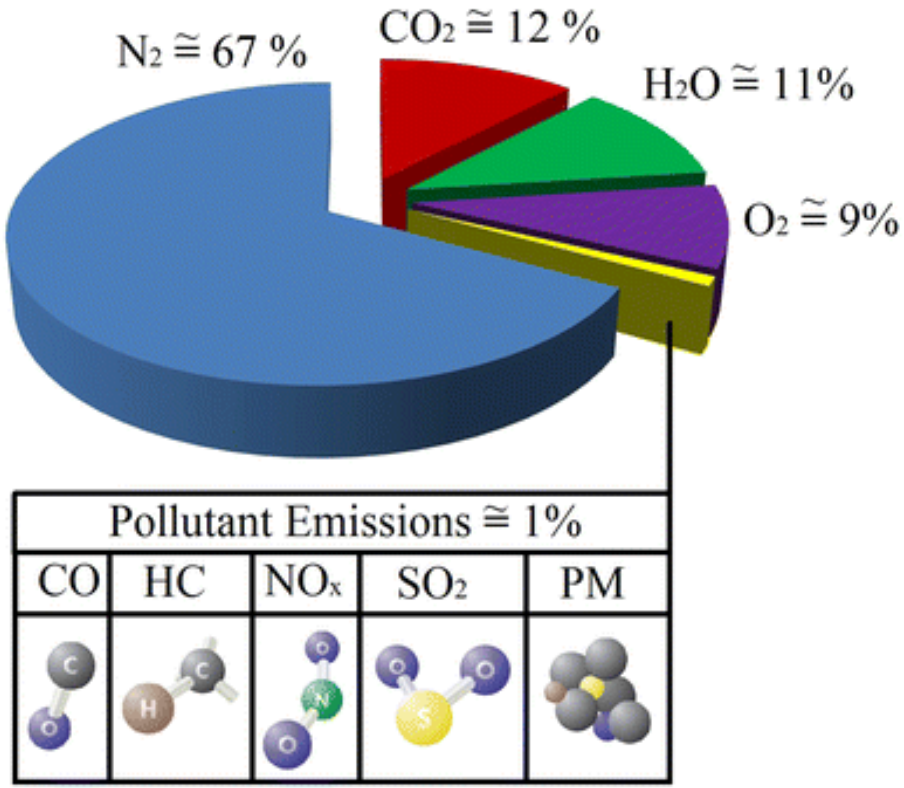
Engine Emissions:

The main emissions in the engine exhaust gases are carbon monoxide CO, various oxides of nitrogen NOx, and unburned hydrocarbons HC.

To compare between diesel and petrol engine the petrol engine has much more emissions than diesel engine the main cause is that the petrol engine works on rich mixtures while in diesel engine combustion occurs at lean mixture.

comparison of emissions for Diesel and Petrol:





Diesel emissions

comparison of emissions for Diesel and Petrol:

	Diesel Engine	Petrol Engine
Particulate Matter	0.5 g/m3	0.01 g/m3
Carbon Monoxide	<0.1% by volume	<10% by volume
Hydrocarbons	<300 ppm	<1000 ppm
Oxides of Nitrogen	1000-4000 ppm	2000-4000 ppm

Engine Emissions:

CIE produces black smoke or soot, it is a particulate matter that can be seen and smelt. To reduce such particulates a Diesel Particulate Filter is used in modern CIE's.

CO is always present in exhaust gases due to the dissociation process, with rich mixtures the CO concentration is further increased due to the incomplete combustion to carbon dioxide.

NO and hydrocarbon emissions react in sunlight to cause photochemical smog which causes pollution problems.