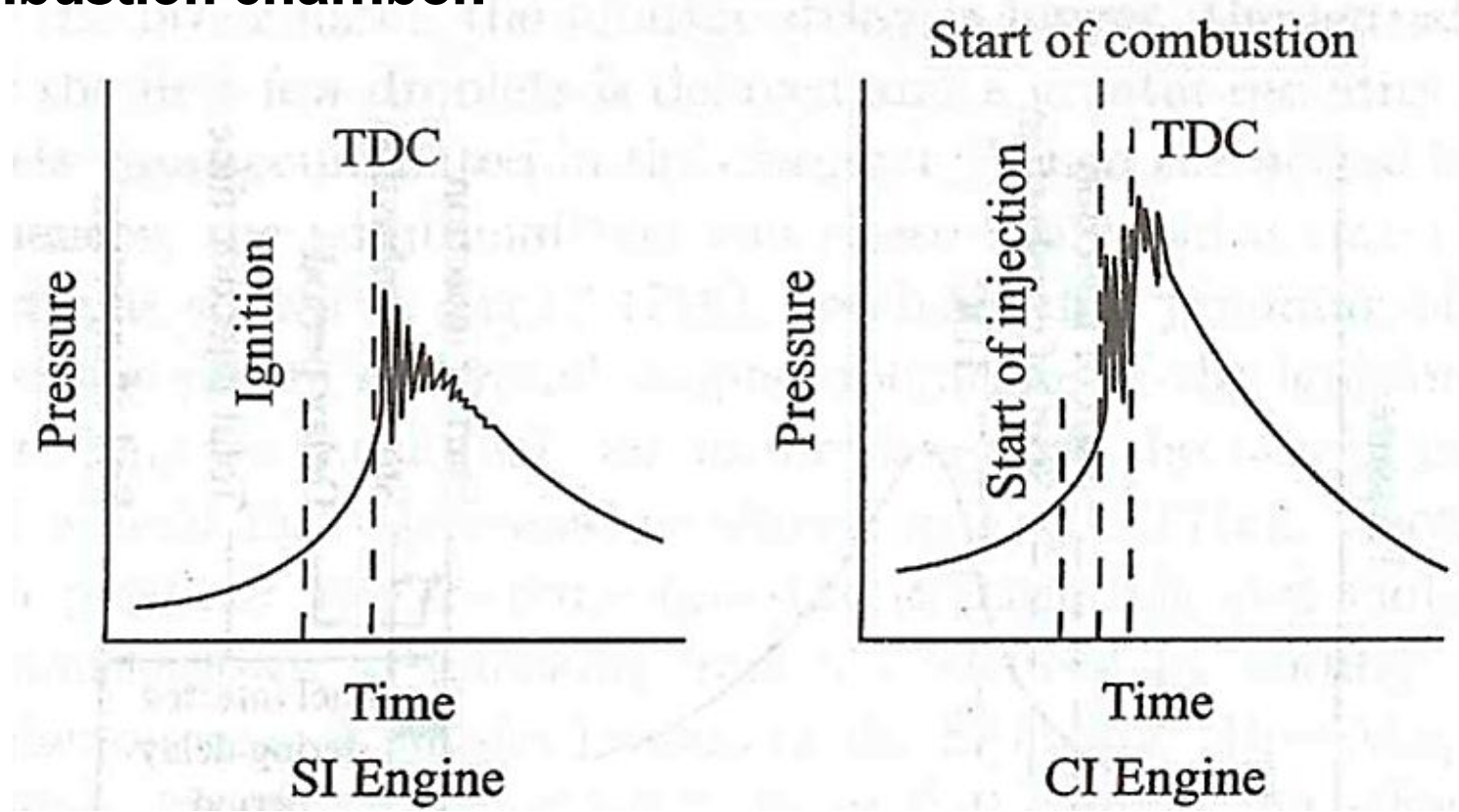
Knock in SI and CI Engines

Knock in SI and CI engines are fundamentally similar. In SI engines, it occurs near the end of combustion; whereas in CI engines, it occurs near the beginning of combustion.

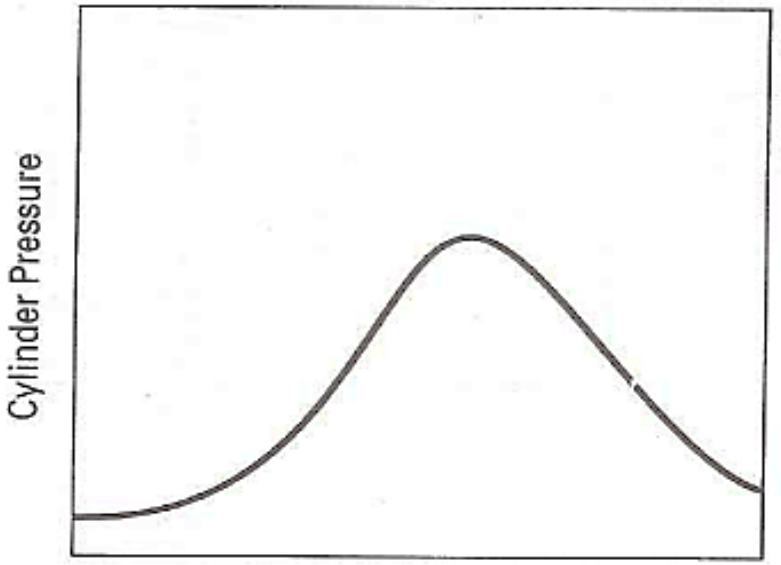
- **Knock in CI engines is related to delay period.**
- **When DP is longer, there will be more and more accumulation of fuel droplets in combustion chamber.**
- **This leads to a too rapid a pressure rise due to ignition, resulting in jamming of forces against the piston and rough engine operation.**
- **When the DP is too long, the rate of pressure rise is almost instantaneous with more accumulation of fuel.**



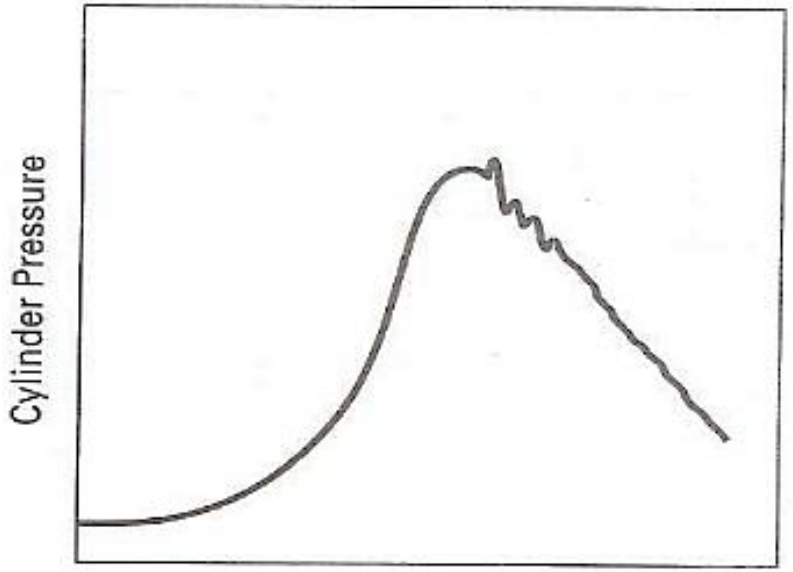
Antiknock Quality of Fuel

Abnormal burning/detonation in SI engine causes a very high rate of energy release, temperature and pressure. This adversely affects the thermal efficiency. The fuel characteristics should resist this tendency. This property of fuel is called its antiknock quality.

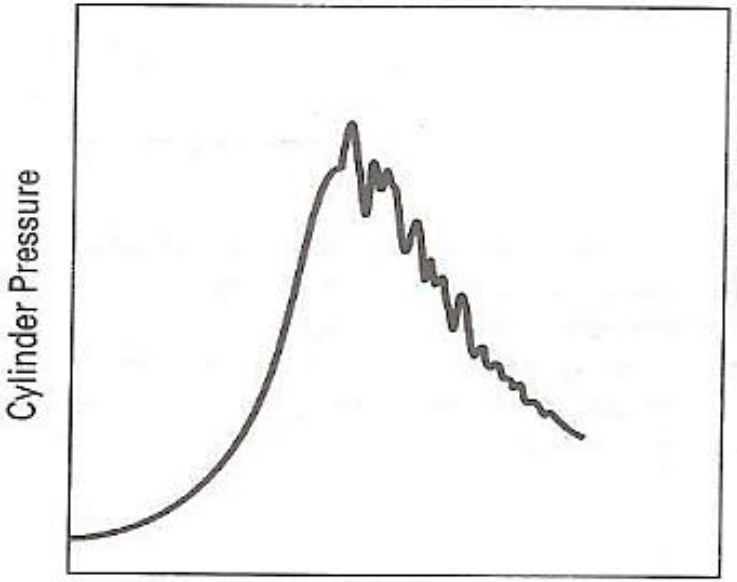
With no self-ignition, the pressure force on piston follows a smooth curve, resulting in smooth engine operation. When self-ignition occurs, pressure forces on piston are not smooth and engine knock occurs.



(a) Normal Combustion with No Knock



(b) Combustion with Light Knock



(c) Combustion with Heavy Knock

Antiknock Quality and Rating of Engine Fuel s

Fuels are rated for their **antiknock qualities**.

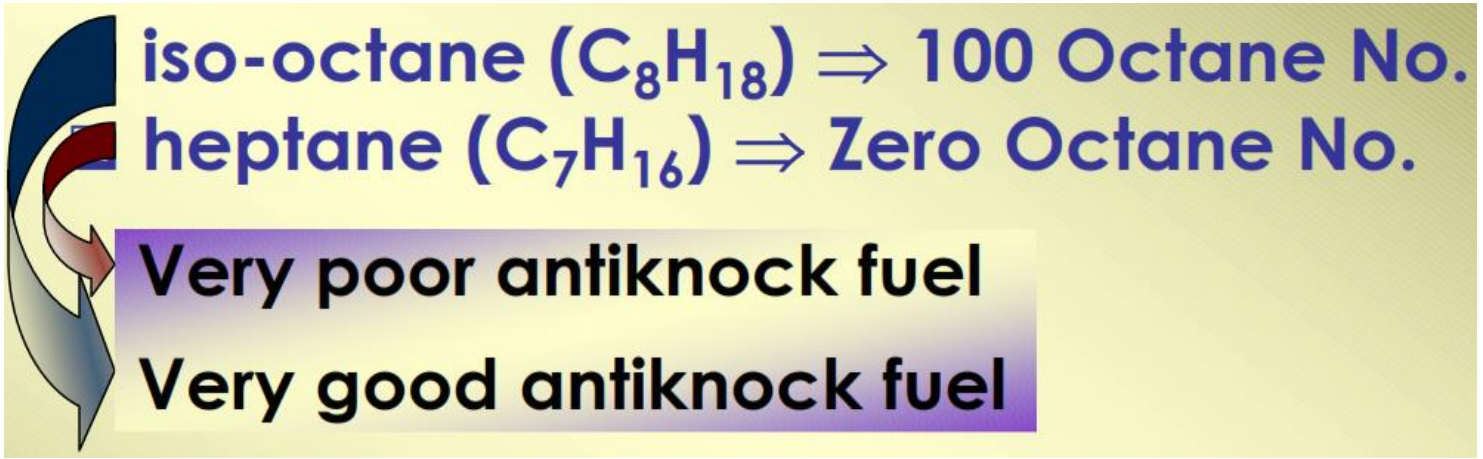
Gasoline : Octane number

Diesel : Cetane number

Resistance to knock depends upon the chemical composition of fuel (or characteristics of hydrocarbon in the fuel). Other operating parameters:

i. **AF ratio**; ii. **Ignition timing**; iii. **Engine speed**; iv. **Shape of combustion chamber**; v. **Compression ratio** etc.

Antiknock property for SI Engine Fuels is compared with reference to



For example Fuel with Octane Number of 70 indicates:

70 % Octane, and

30 % Heptane

Octane Number (ON)

Definition: It indicates the % by volume of iso-octane in a mixture of iso-octane and heptane which exhibit the same characteristics of the fuel in a standard engine under a set of operating conditions.

Common octane numbers for gasoline fuels used in automobile range from 87 to 95, with higher values for special high performance and racing cars.

Tests for Rating Octane Number (ON)

Two most common methods of rating gasoline and other SI engine fuels are the Motor Method and the Research Method. These give the motor octane number (MON) and research octane number (RON).

Gasoline Additives and Octane Number (ON)

There are a number of gasoline additives that are used to raise the octane number. For many years, the standard additive was tetraethyl lead (TEL). A few millilitres of TEL in several litres of gasoline could raise the ON several points.

Gasoline additives

Additives	Type	Function
Oxidation inhibitors	Aromatic amines and phenols	Inhibit gum formation and oxidation
Corrosion inhibitors	Carboxylic acids and carboxylates	Inhibit corrosion of ferrous metals
Metal deactivators	Chelating agent	Inhibit gum formation Catalyzed by certain metals
Anti-icing additives	Surfactants and glycols	Prevent icing in carburetor and fuel system
Detergents	Amines and amine carboxylates	Prevent deposits in carburetor throttle body
Deposit control additives	Polybutene amines Polyether amines	Remove and prevent deposits throughout carburetor intake ports and valves
Blending agents	Ethanol, methanol, tertiary butyl alcohol, methyl tertiary ether	Extend gasoline supply, increase apparent octane quality with some loss in mileage
Antiknock compounds	Lead alkykl, organo-manganese compounds	Increase octane quality

Rating of CI Engine Fuels

- Ignition delay (ID) is the prime factor for auto-ignition/knock.
- ID is the time between start of injection and initiation of combustion.
  - Long ID ⇒ Rapid pressure rise ⇒ Knock
  - Short ID ⇒ incomplete mixing/smoke production

- Ignition quality : Cetane Number

- Reference Fuels
  - Cetane ($C_{16}H_{34}$) ⇒ 100 Cetane No.
  - α-methyl naphthalene ($C_{11}H_{10}$) ⇒ Zero Cetane No.

- Fuel with Cetane Number of 60 indicates
  - 60 % $C_{16}H_{34}$
  - 40 % $C_{11}H_{10}$

Cetane Number (CN)

Definition: It indicates the % by volume of normal cetane in a mixture of Cetane and α-methyl naphthalene which exhibit the same ignition characteristics (ID) as the test fuel when combustion is carried out under specified operating conditions.

Cetane number of a fuel is a measure of its ability to auto-ignite quickly when the fuel is injected into the combustion chamber.

Higher the CN, lesser is the tendency to knock. Further, too high a Cetane number may induce pre-ignition.

Diesel usually has a Cetane number between 40 - 60, whereas gasoline has a Cetane number of 10 - 20. This is why it is not suitable as diesel fuel due to its poor auto-ignition quality. A good diesel engine fuel is a bad gasoline engine fuel.

Qualities of CI Engine Fuel

- ❑ It should have good antiknock quality. Must have short ignition delay.
- ❑ Must be sufficiently volatile in the operating range to ensure proper mixing and complete combustion.
- ❑ Should not promote smoke in the exhaust.
- ❑ Should not cause corrosion/wear in the engine components.
- ❑ Easy handling/availability.

- ➢ In terms of combustion considerations, the major factors are viscosity and cetane number.
- ➢ Although the primary effect of low cetane number is to cause cold starting problems, reduction of cetane number can also increase engine roughness, peak pressure, and NO emissions.
- ➢ Typically, highly turbocharged engines are more tolerant to low cetane number during steady-state operation.

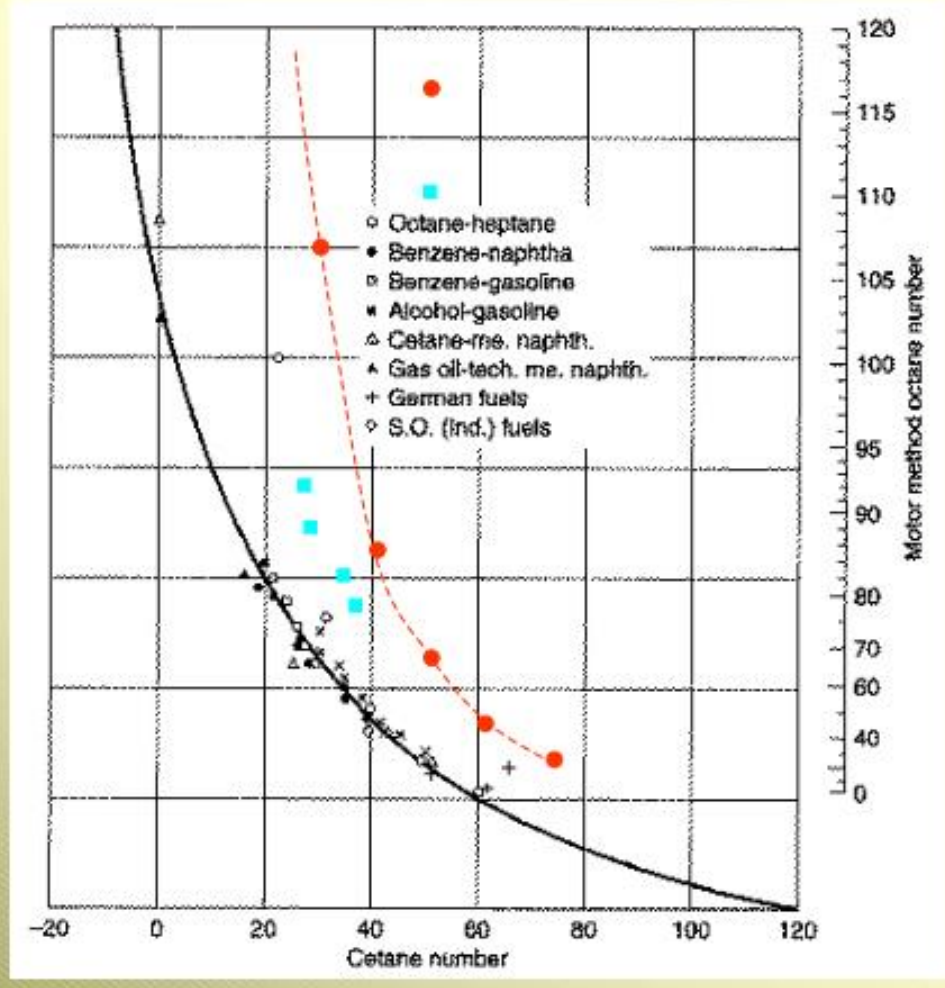
Diesel fuels can also be improved by addition of fuel-additives.

Automotive diesel fuel additives

Additive	Type	Function
Detergents	Polyglycols, basic nitrogen-containing surfactants	Prevent injector deposits, increase injector life
Dispersants	Nitrogen-containing surfactants	Peptize soot and products of fuel oxidant; increase filter life
Metal deactivators	Chelating agents	Inhibit gum formation
Rust and corrosion inhibitors	Amines, amine carboxylates, and carboxylic acids	Prevent rust and corrosion in pipelines and fuel systems
Cetane improvers	Nitrate esters	Increase cetane number
Flow improvers	Polymers, wax crystal	Reduce pour point modifiers
Antismoke additions or smoke suppressants	Organic barium compounds	Reduce exhaust smoke
Oxidation inhibitors	Low–molecular weight amines	Minimize deposits in filters and injectors
Biocides	Boron compounds	Inhibit growth of bacteria and microorganisms

Cetane vs Octane Number

The octane number and cetane number of a fuel are inversely correlated.



Gasoline is a poor diesel fuel and vice versa.