Drivers' Dilemma:

Octane 92 or 95

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Fueling your vehicle with gasoline (Petrol)

Gasoline (Petrol)

- Leaded
  - Octane 92
  - Octane 95
- Unleaded
  - Octane 92 (137 Rs/L)
  - Octane 95 (161 Rs/L)

The fuel gasoline (Petrol)

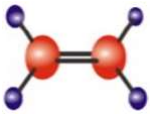
Gasoline is a complex mixture of various hydrocarbons rerived from crude petroleum oil for use as fuel in engines. Additives and blending agents are added to improve the performance and stability of gasoline

Gasoline contains mainly:

- Alkanes (Paraffin)

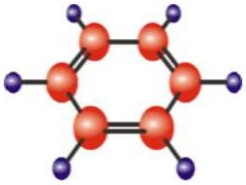
C_nH_{2n+2}

- Alkenes (Olefins)



C_nH_{2n}

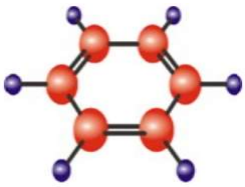
- Aromatics



C_nH_n

The gasoline……

Petroleum composition



100% Aromatic

Young/shallow

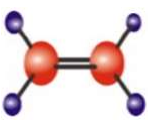
Young/deep

Old/shallow

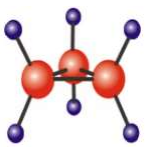
Old/deep

100% Paraffins

100% Naphthenes



Olefins forms during distillation

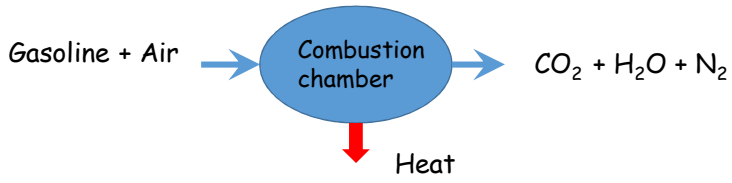


The gasoline……

- The hydrocarbons of gasoline contain typically 4-12 carbon atoms with boiling range between 30 and 210 °C
- Gasoline contains approximately 86% of carbon and 14% of hydrogen on weight basis

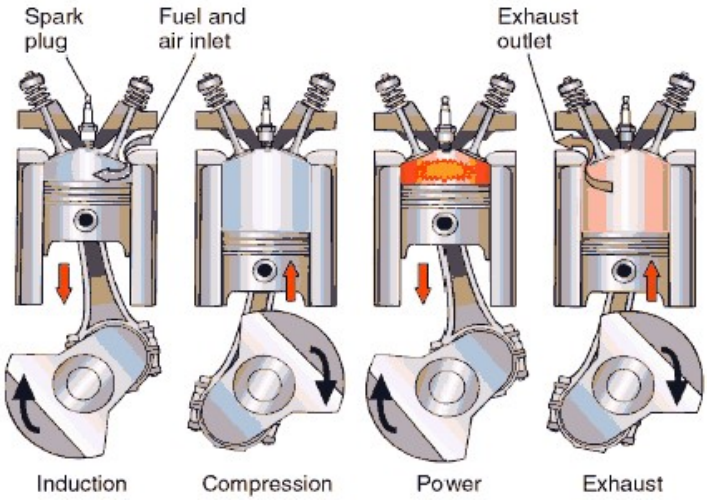
Combustion of gasoline

For a complete or stoichiometric combustion, all carbon is converted to carbon dioxide (CO_2) and all hydrogen is converted into water (H_2O). These two complete combustion reactions are as follows:



Combustion of fuel/air mixture inside the engine

Four stroke spark ignition internal combustion engine (Otto cycle)

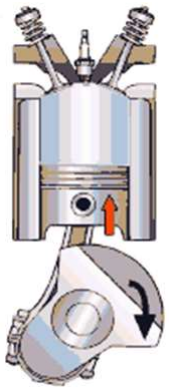


Source: drivers club

Combustion……

The compression stroke

- Both the values closed
- Mixture volume shrinks and pressure increases
- Consumes mechanical energy
- Enhances mixing of air and gasoline
- Increases the mixture temperature
- Makes the mixture ready for a pre-mixed combustion
- Increases the peak cylinder pressure during power stroke
- Increases the engine efficiency/work output



Compression

Higher the compression ratio higher the mixture temperature is

Combustion……

High compression ratio increases the thermal efficiency of the engine

- Carnot cycle efficiency is defined from the ratio of cold to hot temperatures

$$\eta_{th} \leq 1 - \frac{T_C}{T_H}$$

- The engines' thermodynamic efficiency depends on the compression ratio **r** of the engine and the specific heat ratio (C_p/C_v = γ) of the mixture/gas in the combustion chamber

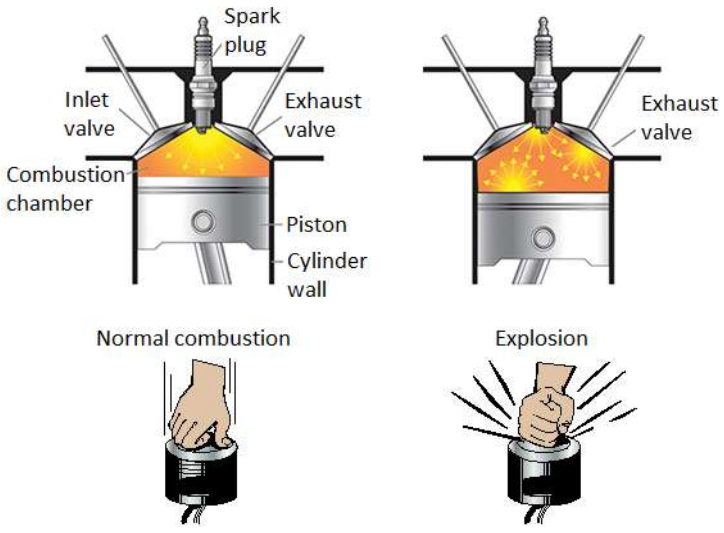
$$\eta_{th} = 1 - \frac{1}{r^{\gamma-1}}$$

So, higher the compression ratio higher the thermal efficiency is

Combustion……

- The maximum compression ratio usable is limited by the need to prevent pre-ignition (Detonation)
- At higher compression ratios, the air/fuel mixture ignites by itself before the spark plug fires
- Compression ratios for Otto engines range from 9.1:1 to 14:1 including racing engines (with and without detonation sensors)
- Alcohol powered cars can go even up to 15:1

Pre-ignition (Detonation)



Pre ignition……

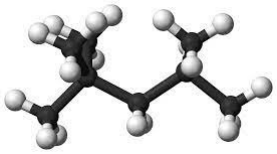
- ***Detonation*** occurs when the fuel ignited beyond the flame front initiated by the sparkplug burns
- The combustion characteristics of different hydrocarbons are not the same when burned inside an engine
- Otto engines can burn most of the hydrocarbon fuels that can mix with air by evaporation (low boiling point)
- If an Otto engine is designed for a particular fuel, it would not perform similarly with a fuel that has a different chemical composition

How do we specify a fuel for an Otto engine with known pressure ratio

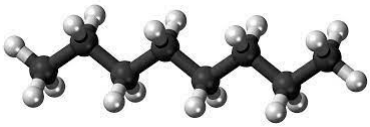
The Octane number

The tendency of a particular gasoline to detonate is expressed by its octane number (ON)

- The engine designers learned that straight-chain paraffin have a much higher tendency to detonate than do branched-chain paraffin



Iso-octane

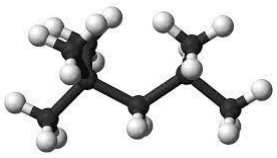


n-octane

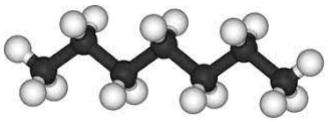
The Octane…..

Based on the composition and tendency to detonate,

- Tri-methyl-pentane, C_8H_{18} (iso-octane) is assigned an ON of 100



- The straight-chain paraffin n-heptane, C_7H_{16} is given an ON of zero



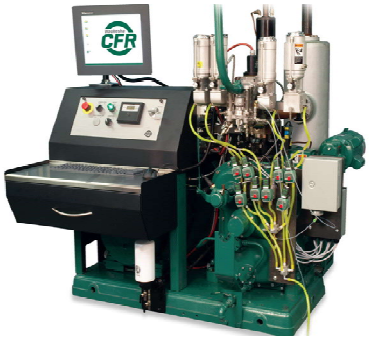
The Octane…..

- Hence, a fuel sample containing 90% iso-octane and 10% n-heptane is said to have an ON of 90
- Gasoline is made up of a mixture of mostly branched-chain paraffin with suitable additives to give an ON in the range 90 –100
- Octane rating proportional to the detonation temperature
- Higher octane allows higher compression
- It was also learned through experiments that the ON of a gasoline blends (e.g. gasoline and ethanol) can be calculated by using weighted average ON of each component in the mixture

The Octane…..

How is octane determined?

Numerical rating of knock resistance for a fuel obtained by comparing its detonation intensity with that of primary reference fuels of known octane number when tested in a standard Cooperate Fuel Research (CFR) engine or variable compression engine operating under conditions specified in International Standards



Source: CFR Engines, Inc. (copyrighted)

The Octane…..

Research octane number (RON):

Complying with International Standard EN ISO 5164, the engine operates at 600 rpm and 49°C air/fuel mixture temperature. The RON is usually higher than the specified required minimum.

Motor octane number (MON):

Similar to the RON but complying with different International Standard EN ISO 5163. The motor octane number (MON) reflects more severe conditions (at 900 rpm and 149°C air/fuel mixture temperature).

The Octane…..

Most importantly, the octane number has nothing to do with the heating value (Calorific value) or the purity of the fuel

Example

The calorific value of iso-octane = 48.119 MJ/kg

The calorific vale of n-heptane =48.438 MJ/kg

The calorific value of 92 Octane of a blend = 48.145 MJ/kg

The calorific value of 95 Octane of a blend = 48.135 MJ/kg

The Octane…..

- Enormous researches found lead in the form of tetraethyl lead $Pb(C_2H_5)_4$ inhibits detonation

<u>Fuel Lead</u>

Blending lead with n-heptane (cheap gasoline), higher octane gasoline can be produced

210 mg of Pb per Liter produces 100 octane fuel

105 mg of Pb per Liter produces 90 octane fuel

The Octane…..

Detonation can be prevented by following techniques:

- Reducing peak cylinder pressure
- Use of a fuel with high Octane rating
- Retarding ignition timing
- Enriching the air/fuel mixture
- Decreasing the manifold pressure by reducing the throttle opening
- Reducing the load on the engine

Octane boosters

- Methyl Tertiary Butyl Ether (MTBE)
- Benzene, Toluene, Ethyl-benzene and Xylene (BTEX)
- Methylcyclopentadienyl Manganese Tricarbonyl (MMT)
- Ethanol
- Oxygenators (Octane enhancers) such as CH_3OH or C_2H_5OH

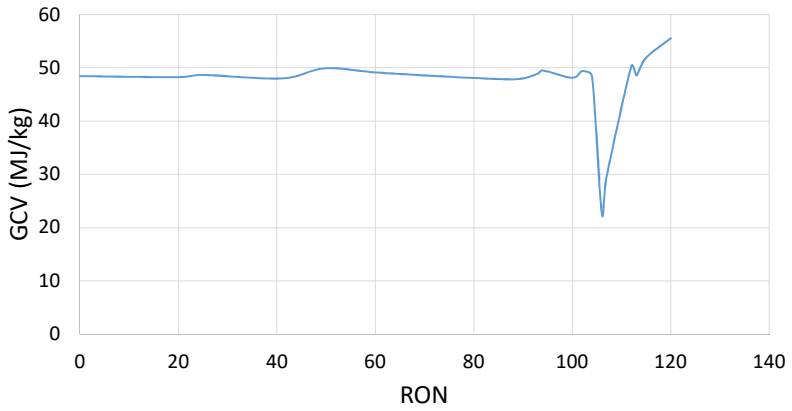
The Octane…..

Properties of several hydrocarbons

Hydro carbon	Chain	GCV (MJ/kg)	RON
Methane	CH_4	55.536	120
Acetylene	C_2H_2	49.923	50
Ethane	C_2H_6	51.902	115
Propane	C_3H_8	50.322	112
n-Butane	C_4H_{10}	49.511	94
iso-Butane	C_4H_{10}	49.363	102
n-Pentane	C_5H_{12}	49.003	62
iso-Pentane	C_5H_{12}	48.909	93
n-Hexane	C_6H_{14}	48.674	25
iso-Hexane	C_6H_{14}	48.454	104
n-Heptane	C_7H_{16}	48.438	0
n-Octane	C_8H_{18}	48.254	20
iso-Octane	C_8H_{18}	48.119	100
n-Decane	$C_{10}H_{22}$	48.002	41
iso-Decane	$C_{10}H_{22}$	48.565	113
n-Dodecane	$C_{12}H_{26}$	47.838	88
Methanol	CH_4O	22.663	106
Ethanol	C_2H_6O	29.668	107

The Octane…..

Randomness of GCV Vs RON



Extracts from owners' manuals

Toyota Prius

■ **Fuel types**

Use unleaded gasoline. (Octane rating 87 [Research Octane Number 91] or higher)

Toyota Prius - C

Fuel type	Unleaded gasoline only
Octane rating	87 (Research octane number 91) or higher

Honda Fit

■ **Fuel recommendation**

Unleaded gasoline, pump octane number 87 or higher

Use of lower octane gasoline can cause a persistent, heavy metallic knocking noise that can lead to engine damage.

Mitsubishi eclipse cross

Your vehicle is designed to operate on unleaded gasoline having a minimum octane number of 87 [(MON+RON)/2] or 91 RON.

Thank you