FUELS

(PART - III)

Brotati Chakraborty
Department of Chemistry
Bejoy Narayan Mahavidyalaya, Itachuna, Hooghly

Sem V General (DSE-1A)

Summary of Fuel (Part I and II)

- Definition of fuel
- Classification of fuel
- Calorific value
- GCV and NCV
- Characteristics of a good fuel
- Solid Fuel: Coal – origin – carbonisation of coal – LTC, HTC
- Secondary gaseous Fuels: Water gas, Producer gas, Coal gas
- Liquid Fuel: Petroleum – refining of petroleum, cracking of petroleum

KNOCKING

• In an internal combustion (IC) engine, a mixture of fuel (gasoline or diesel) and air is ignited in a cylinder. The ignition is brought about by an electric spark (in a petrol engine) or by compressing the air (in a diesel engine). The gases evolved during ignition create high pressure and force the piston down providing the stroke.

• The power output and efficiency of an IC engine depends on a factor called compression ration. It is defined as the ratio of gaseous volume in the cylinder at the end of the suction stroke to the volume at the end of the compression stroke. Higher the compression ratio, higher is the efficiency.

• If the compression ratio exceeds a certain limit, the full air mixture may get heated to temperature greater then its ignition temperature (minimum temperature at which combustion is self supporting) and spontaneous combustion and explosion occurs even before sparking. This is known as pre-ignition.

- It may also happen that the last unburnt portion of the fuel-air mixture after sparking, undergoes self-ignition, resulting in an explosion. This explosion produces a shocking wave, which dissipates its energy by hitting the walls of the cylinder and the piston, producing a characteristic metallic sound termed as **'knocking'**.

- **Knocking** is thus a sharp metallic sound similar to the rattling of a hammer, which is produced in internal combustion engines due to immature ignition of air-gasoline mixture.

- Knocking decreases the efficiency of engines as well as causes huge loss of energy and damage to the piston and cylinder.

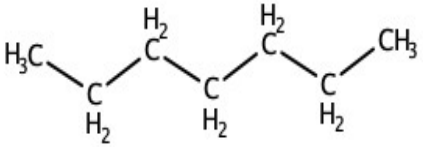
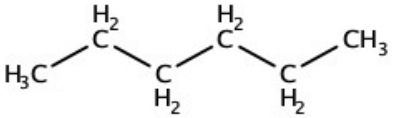
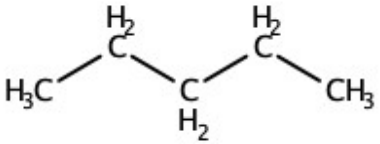
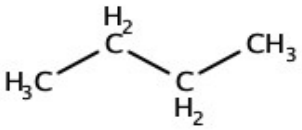
- The cause of knocking is characteristic of the fuel and engine design.

- The order of knocking characteristics of a constituent in a fuel is:

  Straight chain paraffins > branched chain paraffins > olefins > cycloparaffins > aromatics

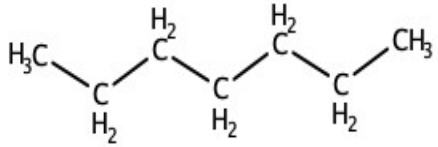
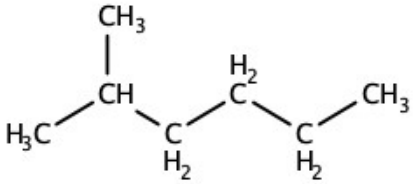
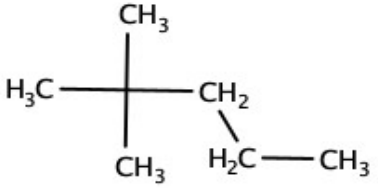
- In normal parrafins, knocking increases with increase in length of the hydrocarbon chain

  n-heptane > n-hexane > n-pentane > n-butane

- In case of branched chain praffins, paraffins having less branch have more knocking characteristics. Thus,

  n-heptane > 2-methyl hexane > 2,2-dimethylpentane

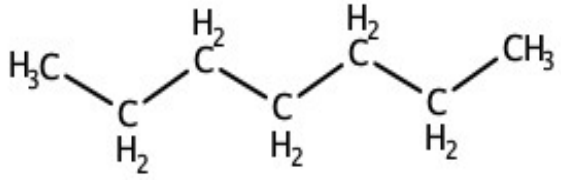




- Aromatic hydrocarbons such as benzene, toluene etc., show less knocking characteristics

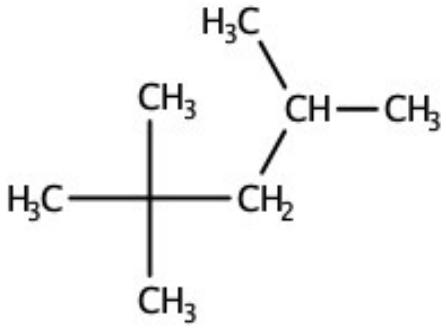
OCTANE NUMBER

- To classify fuels according to their knocking property, an arbitrary scale known as **octane rating** or **octane number** was established.

- n-heptane has good knocking characteristics and hence it was assigned an anti-knock value of zero.



- iso-octane (2,2,4-trimethylpentane) has a high resistance to knocking and was assigned a value of 100.



- **Octane number** of a fuel is defined as the percentage of iso-octane present in a mixture of iso-octane and heptane, which has the same knocking characteristics as that of the fuel under investigation, under the same set of conditions.

- A fuel with octane number 80, would give the same knocking as a mixture of iso-octane and n-heptane, containing 80% of iso-octane by volume.

- Greater the octane number, greater is the anti-knock property of the fuel.

- Octane number of some hydrocarbons are:

  n-pentane – 62

  iso-pentane – 90

  cyclohexane – 77

ANTI-KNOCK AGENTS

- The octane number of a fuel can be increased by adding certain additives known as **anit-knock agents**.

- Tetra ethyl lead (TEL) $Pb(C_2H_5)_4$, is an anti-knock agent.

- TEL produces, Pb and PbO, which acts as free radical chain inhibitors that arrest the propagation of explosive chain reaction responsible for knocking.

- *Disadvantage of TEL:* Pb and PbO causes atmospheric pollution and decreases engine efficiency. They are thus removed by adding ethyl bromide.

- Petrol whose octane number is increased without addition of lead compounds is called unleaded petrol. This can be achieved by:

  [1] addition of methyl tertiary butyl ether (MTBE) which supplies oxygen from the ether group for combustion of petrol

  [2] reforming, i.e. increasing the contents of molecules having branched structures (iso-octane, iso-pentane) and aromatic ring structures (ethyl benzene, isopropyl benzene).

- Advantages of unleaded petrol:

  [1] Environment will be free from lead pollution

  [2] It allows the use of catalytic converter to be attached to the exhaust in the automobiles as the exhaust will not poison the catalyst like leaded petrol.

KEROSENE OIL

- This fraction is obtained between 180 ºC to 250 ºC on fractional distillation of petroleum during the refining process.
- It is mixture of C_{10} to C_{16} hydrocarbons.
- The approximate elemental composition is C – 85%, H – 15% and S < 0.1%.
- Calorific value is 11000 kcal/kg.
- Used as a domestic fuel (fuel in stove) as well as jet engine fuel.

LIQUEFIED PETROLEUM GAS (LPG)

- Derived from the refinery process, crude oil stabilization and natural gas processing plants.
- The main constituents of LPG are lower hydrocarbons upto C4, like n-butanes, iso-butane, propane, isobutylene.
- It can exist as a gas under atmospheric pressure, but can be readily liquefied under pressure and is done so for easy transportation and storage.
- It is mostly used a domestic and industrial fuel.
- It is cheap, highly knock-resistant and burns clearly without leaving any residue.
- Calorific value is 28000 kcal/kg.

LIQUFIED NATURAL GAS (LNG)

- LNG is 80 – 85% methane along with a few percent of ethane, propane and butane and small amount of nitrogen.
- LNG is odorless, colourless, non-corrosive and non-toxic.
- Natural gas is condensed to a liquid by cooling it to about -162 ^{o}C. This process reduces its volume by a factor of more than 600. This makes it possible to transport natural gases to places where pipelines do not reach.
- As a liquid LNG will cannot explode and is not flammable.
- LNG will freeze any material it contacts.

PETROCHEMICALS

- Petrochemicals refer to all those compounds that can be derived from petroleum refinery products.

- C1 compounds: methane
- C2 compounds: ethylene and acetylene
- C3 compounds: propylene