UNIT – IV

FUELS AND COMBUSTION

4.4 Liquid fuel

Liquid fuels are combustible or energy-generating molecules that can be harnessed to create mechanical energy, usually producing kinetic energy.

They must also take the shape of their container; the fumes of liquid fuels are flammable, not the fluids.

Most liquid fuels in widespread use are derived from the fossilized remains of dead plants and animals by exposure to heat and pressure inside the Earth's crust.

However there are several types such as hydrogen

fuel for automotive uses, ethanol, jet fuel and bio-diesel, which are all categorized as liquid fuels.

Emulsified fuels of oil in water, such as orimulsion, have been developed as a way to make heavy oil fractions usable as liquid fuels. Many liquid fuels play a primary role in transportation and the economy.

Some common properties of liquid fuels are that they are easy to transport and can be handled easily.

They are also relatively easy to use for all engineering applications and in home use. Fuels like kerosene are rationed in some countries, for example in government-subsidized shops in India for home use.

Conventional diesel is similar to gasoline in that it is a mixture of aliphatic hydrocarbons extracted from petroleum.

Kerosene is used in kerosene lamps and as a fuel for cooking, heating, and smallengines.

Natural gas, composed chiefly of methane, can only exist as a liquid at very low temperatures (regardless of pressure), which limits its direct use as a liquid fuel in most applications.

LP gas is a mixture of propane and butane, both of which are easily compressible gases under standard atmospheric conditions.

It offers many of the advantages of compressed natural gas (CNG) but is denser than air, does not burn as cleanly, and is much more easily compressed.

Commonly used for cooking and space heating, LPG gas and compressed propane are seeing increased use in motorized vehicles. Propane is the third most commonly used motor fuel globally.

Petroleum:

Petroleum or crude oil is dark greenish brown viscous liquid found deep inearth's crust. It is a mixture of various hydrocarbons.

Composition of Crude oil (petroleum):

Constituents	Percentage (%)
C	80- 87
H	11-15
S	0.1 – 3.5
N + O	0.1 – 0.5

Refining of Petroleum or crude oil:

The crude oil is a mixture of oil, water and unwanted impurities.

The process of removing impurities and separating crude oil into various fractions iscalled as refining of petroleum.

Steps of refining:

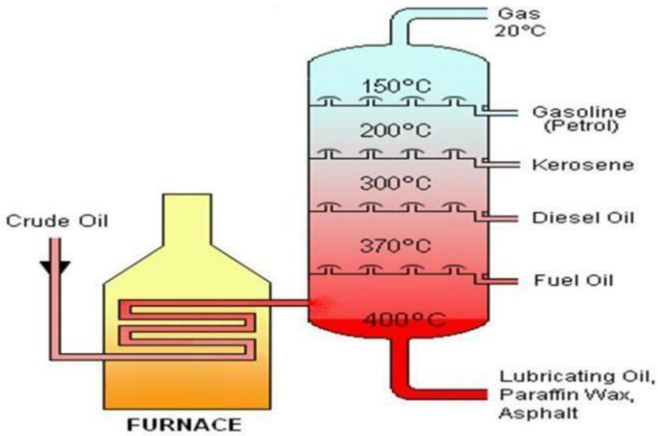
Separation of water (Cottrell's process):

The crude oil is an emulsion of oil and salt water. The crude oil is allowed to flow between two highly charged electrodes. Here the water droplets combine to form large drops which separate out from oil.

Removal of sulphur compounds:

Sulphur compounds are removed by treating crude oil with copper oxide. Thecopper sulphide formed is separated by filtration.

Fractional distillation:



Purified crude oil is heated to 400˚C in an iron retort. The oil gets vapourised. The hot vapours are passed up a 'fractionating column'. The fractionating column is a tall cylindrical tower containing a number ofhorizontal steel trays at short distances. As the vapours go up they become cooler and get condensed at different trays.

Various fractions obtained during fractional distillation:

Name of the fraction	Boiling point	Range of C- atoms	Uses
Uncondensed gases	Below 30˚C	C1 – C4	Fuel as LPG
Gasoline or petrol	40 – 150	C5 – C9	Fuel for IC engine
Kerosene	180 – 200	C10 – C16	Fuel
Diesel	250 - 300	C15 – C18	Diesel engine fuel
Heavy oil	320 - 400	C17 – C30	Fuel for ship

Fractions of heavy oil:

No	Name of the fraction	Uses
1	Lubricating oils	As lubricants.
2	Petroleum jelly(Vaseline)	Medicines and cosmetics.
3	Grease	As lubricant.
4	Paraffin wax	Used in candles, boot polishing.
5	Pitch	Making road, water proof roofing.

Synthetic petrol (Synthetic liquid fuel):

Hydrogenation of coal:

Coal is hydrogen deficient compound. If coal is heated with hydrogen at high temperature and high pressure, it is converted into gasoline. This process of preparation of liquid fuel from solid coal is called hydrogenation of coal.

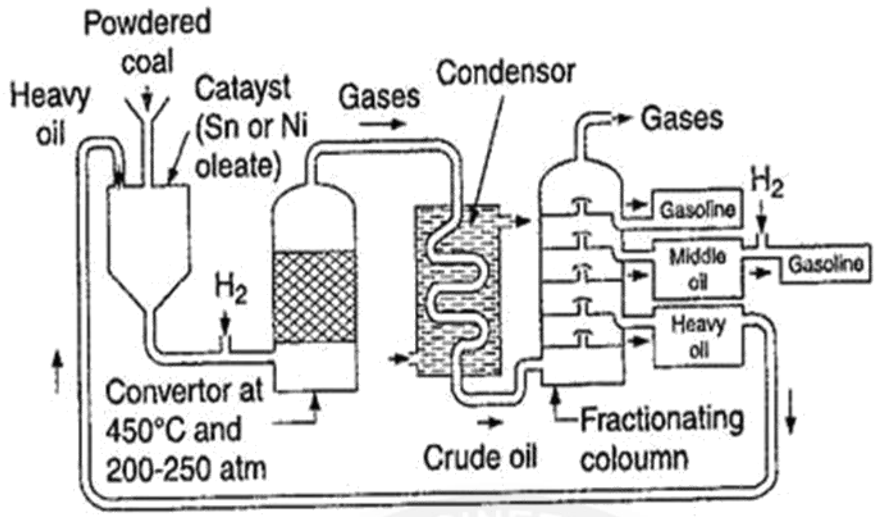
Two methods are available for hydrogenation of coal. They are

Bergius process (direct method):

Fischer – Tropsch Method (indirect method) Bergius process:

In this process, the finely powdered low ash coal, heavy oil, and catalyst powder (tin oleate or nickel oleate) is mixed to form a paste.

The paste is heated with hydrogen at a temperature of 400 -450˚C and a pressure of200 – 250 atmospheres for about 1.5 hours in a convertor.



During this process, hydrogen combines with coal to form saturated higher hydrocarbons which further decomposes to yield low – boiling liquid hydrocarbons (crude oil) while passing through a condenser.

Crude oil obtained is subjected to fractional distillation to yield i) Gasoline ii) Middle oil iii) Heavy oil.

The yield of gasoline is about 60% of coal used.

The middle oil is further hydrogenated yield more gasoline. The heavy oil is recycled for making paste with fresh coal dust.

4.4. Knocking:

What is knocking:

Knocking is the term related to internal combustion engine working on petrol In internal combustion engine a mixture of gasoline vapours and air is used as afuel.

The combustion or burning of fuel is initiated by a spark in cylinder. Due to combustion gases are formed which move piston down the cylinder.

The rate of combustion and movement of piston depends upon the combustion of fuel, temperature and design of engine.

The movement of piston must be uniform without vibration. But sometimes rate of combustion become so great that the fuel on ignitation, instantaneously produces sudden increase in gaseous volume which causes uneven movement of piston with rattling noise in engine. It is called as knocking of the engine

- The knocking results in the loss of efficiency of I.C. engine.

Thus Knocking is defined as ,A sharp metallic sound similar to rattling of hammer, which is produced in the internal combustion engine due to immature ignition of the air gasoline mixture.

- Knocking causes loss of energy & damage to piston & cylinder.

The knocking tendency of fuel increases with the composition. It is observed thatthe straight chain saturated hydrocarbons have more knocking tendency than unsaturated hydrocarbons.

- The cyclic compounds have low tendency to knock than the straight chain compounds. Aromatic hydrocarbon burns uniformly if double bond is near the centre of chain have less knocking property.
- Ant knocking Agent: The high compression ratio used in internal combustion engines, demands petrol of high quality with least knocking tendency.
- The octane rating of many fuels can be increased by adding certain antiknock agents to petrol. These compound which are added to vehicular or aviation petrol to improve their knocking property are called antiknock agents.

The commonly used antiknock agents are

- Tetraethyl lead
- Tetra methyl lead

Mixed methylene lead Working of TEL among the antiknock agents,

TEL is more commonly used, since it is cheap and more effective in increasing octane number of fuel.

Generally it is used with ethylene dibromide or ethylene dichloride. During combustion TEL forms PbO. These species acts as free radical chain inhibitors and thus prevent propagation of explosive chain and thereby minimizing knocking.

PbO formed may get deposited on engine parts and cause mechanical damage. In order to minimize damage caused to the engine parts, TEL is always used with ethylene bromide. The function of these halogen compounds is to convert the less volatile Pb and PbO into more volatile PbBr2, and PbCl2 which escape into air along with exhaust gas

Cause for knocking:

In an internal combustion engine, a mixture of gasoline vapour and air at 1:17 ratio is used as a fuel.

Due the presence of some impurities in gasoline the rate of oxidation becomes high and the final portion of the fuel – air mixture ignites instantaneously, producing an explosive sound. This is known as knocking.

Effects of knocking:

- Carbon deposits on the combustion chamber.
- Mechanical damage.
- Noise and roughness.
- Decreases the power output and efficiency.
- Ways to reduce knocking
- Adding Tetra – Ethyl Lead (TEL) as anti- knocking agent.
- Adding aromatic phosphates as anti- knocking agent.
- Retarding spark.

Octane number:

Octane number is defined as the percentage of iso-octane present in a mixtureof iso-octane and n-heptane.

Iso-octane has antiknock value (octane number) – 100 (less knocking). n-heptanehas antiknock value (octane number) – 0 (more knocking)

It expresses the knocking characteristics of petrol.

An octane rating, or octane number, is a standard measure of an engine or aviation gasoline capability against compression.

The higher the octane number, the more compression the fuel can withstand before detonating.

Octane rating does not relate directly to the power output or the energy content of the fuel per unit mass or volume, but simply indicates gasoline's capability against compression.

In broad terms, fuels with a higher octane rating are used in higher- compression gasoline engines that potentially yield higher power. Note that such higher power comes from the fuel's higher compression by the engine, and not necessarily from the gasoline.

In contrast, fuels with lower octane numbers (but higher cetane numbers) are ideal for diesel engines, because diesel engines (also referred to as compression-ignition engines) do not compress the fuel, but rather compress only air and then inject fuel into the air which was heated by compression.

Gasoline engines rely on ignition of air and fuel compressed together as a mixture, which is ignited near the end of the compression stroke using electrically activated spark plugs.

Therefore, high compressibility of the fuel matters mainly for gasoline engines.

Use of gasoline with lower octane numbers may lead to the problem of engine knocking

Effects

Higher octane ratings correlate to higher activation energies: the amount of applied energy required to initiate combustion.

Since higher octane fuels have higher activation energy requirements, it is less likely that a given compression will cause uncontrolled ignition, otherwise known as auto ignition or detonation.

Because octane is a measured and/or calculated rating of the fuel's ability to resist auto ignition, the higher the octane of the fuel, the harder that fuel is to ignite and the more heat is required to ignite it.

The result is that a hotter ignition spark is required for ignition. Creating a hotter spark requires more energy from the ignition system, which in turn increases the parasitic electrical load on the engine.

The spark also must begin earlier in order to generate sufficient heat at the proper time for precise ignition.

As octane, ignition spark energy, and the need for precise timing increase, the engine becomes more difficult to "tune" and keep "in tune".

The resulting sub-optimal spark energy and timing can cause major engine problems, from a simple "miss" to uncontrolled detonation and catastrophic engine failure.

The octane number of fuel can be improved by,

- ✓ blending petrol of high octane number with petrol of low octane number.
- ✓ the addition of antiknock agents like tetra ethyl lead (TEL)

Cetane number:

The knocking property of diesel is expressed by cetane number.

Cetane number is defined as the percentage of cetane present in a mixture of cetane and 2 – methyl naphthalene.

The cetane number (or CN) of a fuel is defined by finding a blend of cetane and heptamethylnonane with the same ignition delay.

Cetane has a cetane number defined to be 100, while heptamethylnonane's measured cetane number is 15, replacing the former reference fuel alpha- methylnaphthalene, which was assigned a cetane number of 0. Once the blend is known, the cetane number is calculated as a volume-weighted average, rounded to the nearest whole number, of cetane's 100 and heptamethylnonane's 15.

Cetane number = % *n*-cetane + 0.15(% heptamethylnonane)

Cetane number is an inverse function of a fuel's ignition delay, the time period between the start of ignition and the first identifiable pressure increase during combustion of the fuel.

In a particular diesel engine, higher cetane fuels will have shorter ignition delay periods than lower Cetane fuels. Cetane numbers are only used for the relatively light distillate diesel oils.

The cetane number of diesel oil can be increased by, adding additives called pre- ignition dopes. (e.g.) Ethyl nitrite, Iso – amyl nitrite etc.