

MODULE - 1**Chemical Energy Sources and Engineering materials****CONTENTS**

Fuels- Definition with examples. Characteristics of an ideal fuel. Calorific value- definition, types - Gross and Net calorific values, units in S.I system. Experimental determination of calorific value of a solid fuel using Bomb Calorimeter. Numerical problems on GCV and NCV. Chemical processing of Petroleum: Cracking- Definition. Types of cracking- thermal and catalytic cracking. Fluidized catalytic cracking. Reforming of petrol with reactions (Isomerisation, cyclisation, aromatisation and dehydrogenation). Octane number & Cetane number. Knocking in IC engine.

Prevention of knocking - anti knocking agents (TEL & MTBE).

Green fuels: Power alcohol- introduction, advantages and disadvantages. Biodiesel- introduction, synthesis, advantages and disadvantages.

Alloys: Introduction, classification, composition, properties and applications of Stainless Steel, Solders, Brass and Alnico.

10 hours

Introduction:

Energy: Energy is an important aspect for human activity. large number of energy sources such as animal waste, coal, oil and gas are available. Out of these, coal, oil and gas are called Fossil fuels. As these sources are depleting in nature, after some years availability of fossil fuels may come to end. Hence these sources are called non-renewable sources. But wood, charcoal and animal wastes are renewable because they can be regenerated again in nature in short time.

Today we are facing many energy problems, because the sources of petroleum and natural gas are dwindling or depleting day by day. Hence, there is lot of research work going on to develop new sources of energy, alternative to fossil fuels.

Definition of Fuel: Chemical fuel is “combustible substance, containing carbon as main constituent, which on proper burning gives large amount of heat, which can be used conveniently & economically for domestic and industrial purposes”.

Ex: Wood, coal, charcoal, oil, gas, petrol, diesel, producer gas, etc are some of the fuels.

CHARACTERSTICS OF A GOOD FUEL (OR) IDEAL FUEL

1. A good fuel should possess high calorific value.
2. A good fuel should have moderate ignition temperature. [If ignition temperature is low, the fuel can catch fire easily. Lower ignition temperature is dangareous for storage and transportation of fuel. If ignition temperature is high, it is difficult to ignite the fuel.]
3. Low moisture content. [moisture reduces the heating value].
4. A good fuel should contain low non-combustible matter. [after combustion, the non-combustible matter remains in the form of ash. or clinker. Storage, handling & disposal is problem.]
5. The products of combustion should not be harmful. [on heating, they should not give objectionable & harmful gases like CO_2 , CO , SO_2 , H_2S , etc].
6. A good fuel should be readily available in bulk at a cheap rate.
7. A good fuel should be easy to transport.
8. A good fuel combustion process should be easily controllable. [the combustion of the fuel should be easily start or stoped when required.]
9. Storage cost in bulk should be low.
10. A good fuel should burn in air with efficiency without much smoke.

CALORIFIC VALUE

An important parameter of fuel is Calorific value. It gives useful information about **fuel heating efficiency**. The performance of fuel is expressed in terms of Calorific value.

Hence, it can be defined as “**The total amount of heat is liberated, when a unit mass or volume of fuel is burnt completely in air (oxygen)**”.

It is expressed in terms of *cal per gm (cal/g)*, *kilocal per kg (kcal/kg)*, *Joules per Kg (J/Kg)* or *KiloJoules per Kg (KJ/Kg)* for Solid and liquid fuels.

$$1 \text{ Kcal/Kg} = 4.187 \text{ KJ/Kg}$$

For liquid and gas it is expressed in terms of *Joules per cubic meter* or (J/m^3).

TYPES OF CALORIFIC VALUE: There are two types of calorific values, they are

(a) **Higher or Gross calorific value (HCV/GCV):** Gross or Higher calorific value is “the total amount of heat produced when a unit mass or volume of the fuel has been burnt completely and the products of combustion have been cooled to room temperature”.

(b) **Lower or Net calorific value (LCV/NCV):** Net or Lower calorific value (LCV) can be defined as “the total amount of heat produced when unit mass or volume of the fuel has been burnt completely and the products are permitted to escape”.

$$\text{Alternatively, LCV or NCV} = \text{GCV} - \frac{(9 \times \text{percentage of Hydrogen}) \times \text{latent heat of steam} \times 4.187}{100}$$

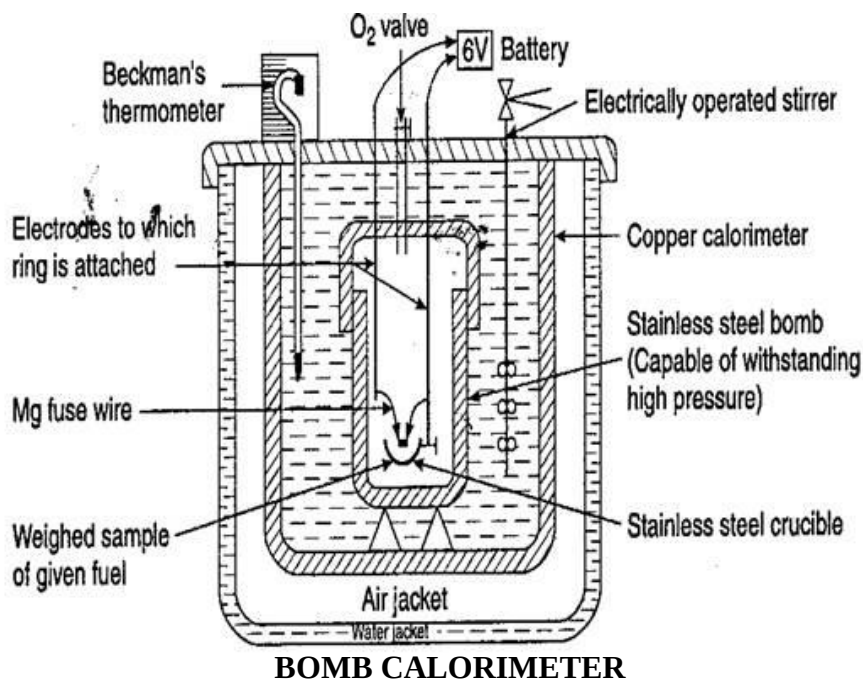
$$\begin{aligned} \text{NCV} &= \text{GCV} - 0.09 \times \% \text{ Hydrogen} \times \text{latent heat of steam} \times 4.187 \\ &= \text{GCV} - 0.09 \times \% \text{ Hydrogen} \times 587 \times 4.187 \end{aligned}$$

Because, 1 part by mass of Hydrogen produces 9 parts by mass of water and the latent heat of steam is 587 cal/gm or kcal/kg.

DETERMINATION OF CALORIFIC VALUE OF SOLID FUEL BY BOMB CALORIMETER

This apparatus is used to find the *calorific value* of solid or liquid fuel. The bomb calorimeter consists of a strong cylindrical vessel made of stainless steel. The combustion of fuel is allowed to take place in this bomb. It is provided with a lid, which can make a perfect gas tight seal. The lid is also provided with two stainless steel electrodes and an inlet valve for entry of oxygen used for combustion. A small ring is also attached with one of the electrode. This brings supports to the crucible made either of Ni or stainless steel.

The bomb is placed in a copper calorimeter, which is surrounded by air jacket and water jacket in order to avoid losses due to radiation. The calorimeter is provided with an electrically operated stirrer and Beckmann's thermometer, which can read accurately temperature difference upto $1/100^{\text{th}}$ of a degree.



A known amount ('m' gm) of the fuel whose calorific value is determined is placed in the Ni or stainless steel crucible. A 'Mg' fuse wire is immersed in fuel sample. The bomb lid is tightly screwed and filled with oxygen at about 25 atm pressure. The bomb is then placed carefully in the copper calorimeter containing a known amount of water ('w' gm). The stirrer is driven and initial temperature of water ($t_1^{\circ}\text{C}$) is noted. The electrodes are then connected to a battery and circuit is completed. The combustion of the fuel sample takes place and heat is liberated because all combustion reactions are exothermic. Stirring of water is continued and final temperature ($t_2^{\circ}\text{C}$) of water is recorded.

OBSERVATION AND CALCULATIONS:

- (a) Mass of fuel = m gm = 'm' kg
- (b) Initial temperature of water = $t_1^{\circ}\text{C}$
- (c) Maximum temperature attained by water in the calorimeter = $t_2^{\circ}\text{C}$
- (d) Rise in temperature of water = $(t_2 - t_1) = t^{\circ}\text{C}$
- (e) Weight of water taken in calorimeter = w_1 kg
- (f) Water equivalent of calorimeter = w_2 kg
- (g) Specific heat of water (S) = $4.187 \text{ KJ/Kg}^{\circ}\text{C}$

There fore,

$$\text{HCV of fuel} = \frac{[w_1 + w_2] \times S \times (t_2 - t_1)}{m} \text{ KJ Kg}^{-1}$$

Lower calorific value is calculated using the equation

LCV = HCV - Heat released by the condensation of steam

$$\text{LCV} = \text{GCV} - \frac{9}{100} \times \% \text{H}_2 \times \text{latent heat of steam}$$

$$\text{LCV} = \text{GCV} - 0.09 \times \% \text{H}_2 \times 587 \times 4.187 \text{ KJ kg}^{-1}$$

(**Note:** If the mass of fuel is given in grams, convert that into kg. For example, 0.2 g = 0.2×10^{-3} kg. If specific heat of water is given in $\text{J kg}^{-1} \text{ } ^\circ\text{C}^{-1}$, calorific value will be in J kg^{-1} . If the specific heat is given in $\text{kJ kg}^{-1} \text{ } ^\circ\text{C}^{-1}$, then the calorific value will be in kJ kg^{-1} .) Specific heat of water is 1 cal/gm, but 1 cal = 4.187 J).

PROBLEMS

1. Calculate the calorific value of a sample of coal from the following data

Solution:

Mass of coal = 0.6gm

Water equivalent of calorimeter = 2200gm

Specific heat of water = $4.187 \text{ KJ Kg}^{-1} \text{ } ^\circ\text{C}^{-1}$

Rise in temperature = 6.52°C

$$\begin{aligned} \text{HCV} &= \frac{w \times s \times t}{m} \\ &= \frac{(2.2 \times 4.187 \times 6.52)}{0.0006} \end{aligned}$$

$$\text{HCV} = 1.0 \times 10^5 \text{ KJ /Kg}$$

2. On burning 0.85 gm of coal sample (Carbon = 90%, Hydrogen = 5% and ash = 5%) was subjected to combustion in a Bomb calorimeter. Mass of water taken in the calorimeter was 2000 gm and water equivalent of calorimeter was 600 gm. The rise in temperature was found to be 3.5°C . Calculate gross and net calorific value of the sample. (given latent heat of steam = 2457 KJ/Kg and specific heat of water = $4.187 \text{ KJ Kg}^{-1} \text{ } ^\circ\text{C}^{-1}$)

Solution:

Mass of the fuel	= 0.85 g	= $0.85 \times 10^{-3} \text{ Kg}$
Weight of the water in copper calorimeter	= 2000 gm	= $2000 \times 10^{-3} \text{ Kg}$
Water equivalent of calorimeter	= 600 gm	= $600 \times 10^{-3} \text{ Kg}$
Specific heat of water	= $4.187 \text{ KJ/Kg/}^\circ\text{C}$	
Latent heat of steam	= 2457 KJ/Kg	
Raise in temperature	= 3.5°C	
% of Hydrogen	= 5 %	
GCV = $\frac{(W_1 + W_2) S (t_2 - t_1)}{m}$		

$$= \frac{(2000+600) \times 10^{-3} \times 4.187 \times (3.5)}{0.85 \times 10^{-3}}$$

$$\text{GCV} = 44,825 \text{ KJ/Kg}$$

$$\text{NCV} = \text{GCV} - 0.09 \times \% \text{H}_2 \times 587 \times 4.187$$

$$= 44825 - 0.09 \times 5 \times 587 \times 4.187$$

$$\text{NCV} = 43,719 \text{ KJ/Kg}$$

3. Calculate GCV and NCV from the following data

Mass of the fuel	= 0.84 gm = 0.84×10^{-3} Kg
Weight of the water in copper calorimeter	= 2800 gm = 2800×10^{-3} Kg
Water equivalent of calorimeter	= 350 gm = 350×10^{-3} Kg
Specific heat of water	= $4.187 \text{ KJ Kg}^{-1} \text{ C}^{-1}$
Latent heat of steam	= 2457 KJ/Kg
Raise in temperature	= 3.5°C
% of Hydrogen	= 5.2%

Solution:

$$\begin{aligned} \text{GCV} &= \frac{(W_1+W_2) S (t_2-t_1)}{m} \\ &= \frac{(2800+350) \times 10^{-3} \times 4.187 \times (3.5)}{0.84 \times 10^{-3}} \end{aligned}$$

$$\text{GCV} = 54,954.375 \text{ KJ/Kg}$$

$$\text{NCV} = \text{GCV} - 0.09 \times \% \text{H}_2 \times 587 \times 4.187$$

$$= 54,954.375 - 0.09 \times 5.2 \times 587 \times 4.187$$

$$\text{NCV} = 53,804.139 \text{ KJ/Kg}$$

4. Calculate the gross and net calorific value of a sample from the following data obtained from a bomb calorimeter experiment. Weight of coal = 0.73 g. Weight of water in the calorimeter is 1500g, water equivalent of calorimeter = 470 g. Initial temperature of water = 25°C .

Final temperature = 27.3°C , percentage of hydrogen in coal sample = 2.5%. Latent heat of steam = $587 \times 4.187 \text{ KJ/Kg}$. Specific heat of water = $4.187 \text{ KJ/Kg}^{\circ}\text{C}$.

Solution:

$$\text{Mass of the coal fuel} = 0.73 \text{ gm} = 0.73 \times 10^{-3} \text{ Kg}$$

$$\text{Weight of the water in copper calorimeter} = 1500 \text{ gm} = 1500 \times 10^{-3} \text{ Kg}$$

Water equivalent of calorimeter	= 470 gm = 470 x 10 ⁻³ Kg
Specific heat of water	= 4.187 KJ Kg ⁻¹ C ⁰⁻¹
Latent heat of steam	= 587x4.187 KJ/Kg
Raise in temperature	= 2.3 ⁰ C
% of Hydrogen	= 2.5%

$$\text{GCV} = \frac{(W_1+W_2) S (t_2-t_1)}{m}$$

$$= \frac{(1500+470) \times 10^{-3} \times 4.187 \times (2.3)}{0.73 \times 10^{-3}}$$

$$\text{GCV} = 25,988.078 \text{ KJ/Kg}$$

$$\text{NCV} = \text{GCV} - 0.09 \times \% \text{H}_2 \times 587 \times 4.187$$

$$= 25,988.078 - 0.09 \times 2.5 \times 587 \times 4.187$$

$$\text{NCV} = 25,435.08 \text{ KJ/Kg}$$

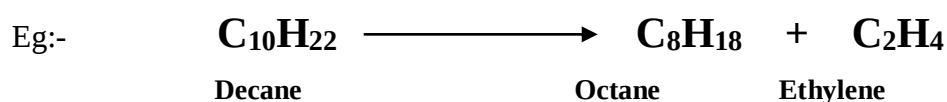
PETROLEUM CRACKING

Petroleum is a dark viscous liquid which consists of a complex mixture of many hydrocarbons. The word petroleum is derived from Greek word: (Petra = rock, oleum = oil) or crude oil.

Crude petroleum is a dark brown or greenish viscous liquid possessing usually an offensive odour. Petroleum is essentially a mixture of alkane hydrocarbons which are present in it, right from methane up to the higher members containing as many as thirty five carbon atoms. It is also containing varying amounts of aromatic hydrocarbons & cycloalkanes. Besides the various types of hydrocarbons petroleum organic compound containing Nitrogen & Sulphur. [Average composition of crude petroleum is C = 75 - 85%, H = 11-14%, S = 0.1- 4%, N + O = 0.1 - 0.5%].

WHY CRACKING: of all the fractions obtained by fractionation of petroleum, gasoline or petrol has the largest demand as MOTOR FUEL., but the yield of this fraction is only about 20-30% of the crude. Also, the quality of so-called “**Straight-run**” gasoline is not high. It has to be properly treated or blended. Moreover, there is surplus of heavier fractions. To overcome these difficulties, the middle and heavier fractions are subjected to cracking to get petrol. The petrol obtained from cracking has far better than “straight-run” petrol. So, in order to improve the quality and quantity i.e to produce more petrol having high octane number. Heavier fractions are converted into smaller fractions suitable for automobile by 2 important chemical methods. They are, (a) Cracking (b) Reforming

Cracking is defined as “The process of breaking higher hydrocarbon molecules of higher molecular weight (high boiling point) into lower hydrocarbons of lower molecular weight (High boiling hydrocarbons into low boiling hydrocarbons) with the intention of increasing the quality and high yield of petrol”.



There are two types of cracking

1. Thermal cracking
2. Catalytic cracking

1. Thermal cracking:- it is the older technique, where temperature is used to break the molecules. The heavy oil fraction is heated to around 600°C maintaining it either in liquid phase (liquid phase cracking, yield is about 45%) or in vapour phase (vapour phase cracking, yield is about 50%) under pressure. In this process, time taken for cracking is more, and percentage of gasoline is less (< 50%).

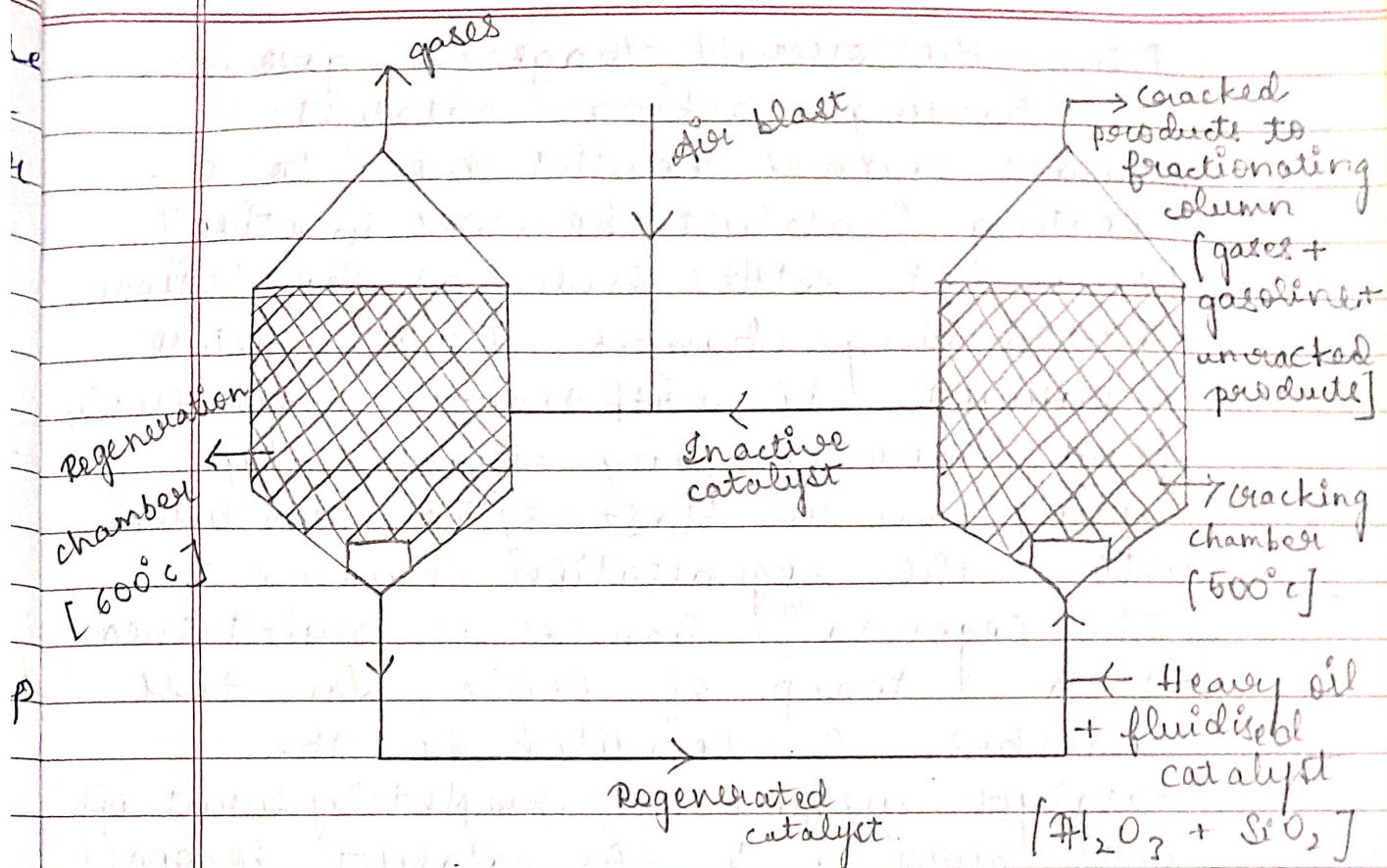
2. Catalytic cracking:- This is widely used technique where cracking is done in presence of catalyst. Use of catalyst not only decreases the temperature (about 500°C) and time, but also increases the yield (about 60 - 70%). The important catalyst used during catalytic cracking process are, Alumina (Al₂O₃), SiO₂, mixture of synthetic alumina and silica, Natural clays, etc.

There are two types of catalytic cracking :-

(a) Fixed-bed catalytic cracking:- In this method, vapours of heavy oils are passed through a bed of porous catalyst. The cracked vapours are separated to get gasoline or petrol. (not included in our syllabus).

(b) Moving bed or Fluidised-bed catalytic cracking (FCC) :-

This is the most common and widely used method for catalytic cracking.



In this method, a fine powder of $\text{Al}_2\text{O}_3 + \text{SiO}_2$ is used as a catalyst. The powdered catalyst behaves like a fluid & hence the name fluidised catalytic cracking.

Heavy oil is mixed with fluidised catalyst & this mix up is then forced up into the cracking chamber. The cracking chamber is maintained at a temp. of about 500°C , in which cracking of heavy oil takes place. The cracked products are withdrawn continuously from the top of the cracking chamber.

The cracked products are then passed through a fractionating column to separate gases, gasoline & other uncracked products. The uncracked products may be cracked in the 2nd stage of cracking, thereby

↑ing the overall %age of gasoline.
During cracking, catalyst powder becomes heavier due to c-coating [catalyst becomes inactive]. Hence, it settles down at the bottom of cracking chamber. This inactive catalyst is withdrawn continuously from the cracking chamber by using an air blast & is introduced into the regeneration chamber.

The regenera.ⁿ chamber is maintained at a temp. of 600°C . In this chamber C deposited on the catalyst surface is completely burnt off. After burning C, the catalyst becomes active (or) regenerated. Thus, the regenerated catalyst is used again by mixing with fresh heavy oil. In this process, it is possible to produce more gasoline having high octane no.

Reforming of Petrol

Petrol (or) gasoline is mainly used as a fuel in I.C engines of automobiles. Petrol is obtained by 1^o fractional distillation of petroleum which contains straight chain H.C. & has low octane no. of about 60. But, I.C engines of automobiles req.^d a gasoline having an octane no. of about 75 - 90. Therefore, petrol obtained by 1^o fractional distillation of petroleum

Advantages of Fluidised catalytic cracking:-

1. Good quality of petrol with high yield is obtained.
2. Catalyst can be regenerated and reused.
3. Very efficient and almost 70% cracking occurs in one stage in 3-4 sec.
4. Can be carried out at lower temperature and pressure.
5. Minimum amount of gaseous products are formed as by-products.
6. The process is continuous and controllable. So that the desired products can be obtained.

REFORMATION OF PETROL

In order to increase the anti-knock properties (octane number) of petrol or gasoline obtained by distillation of crude petroleum. It is subjected to a special type of cracking called reforming. Reforming process is important in the production of high octane petrol. **“The process involves a molecular rearrangement of hydrocarbons without any change in the number of carbon atoms to form new compounds”**. Reforming is usually brought about by passing the petroleum fraction at about 600°C over anhydrous aluminium chloride or platinum catalyst in the presence of hydrogen.

The main reactions during reforming are

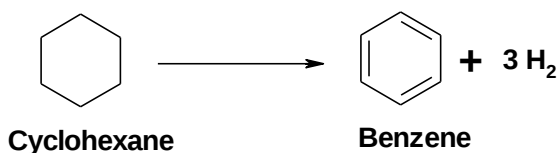
(a) Isomerization:- The straight chain HCs are converted into branched chain hydrocarbons.

Example: n – Hexane → 2 - Methyl pentane

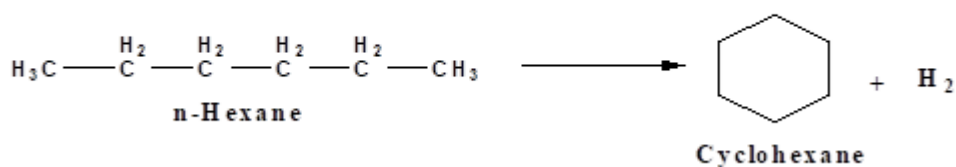


(b) Dehydrogenation:- Cycloalkanes undergo dehydrogenation to form aromatic compounds.

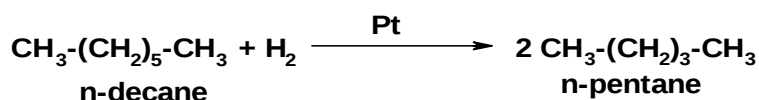
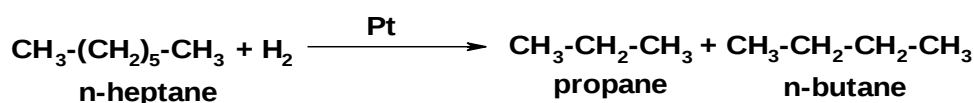
Example: Cyclo hexane → Benzene + Hydrogen



(c) **Cyclisation:-** Straight chain HC undergo cyclisation followed by dehydrogenation to produce aromatic hydrocarbon.



(c) **Hydro-cracking:** - Long chain hydro carbons are converted small chain hydro carbons in presense of Pt and H₂



KNOCKING IN IC ENGINE

In an internal combustion engine, a mixture of gasoline or petrol vapour and air is used as a fuel. This mixture is compressed and ignited by a spark in the cylinder. The ratio of original volume of the fuel mixture to that of the final volume obtained after compression is called compression ratio. The efficiency of internal combustion engine depends upon this compression ratio and higher the compression ratio, higher is the efficiency of the engine. However, there is a limit to this, beyond particular compression ratio the petrol-air mixture suddenly bursts in to flames (pre-ignition) and flame propagation increases nearly 200 times more. This process is accompanied by a sharp knock in the engine (metallic sound) & a black smoke issues out from the exhaust. The knocking increases fuel consumption and engine wear & reduces engine power.

Definition: Explosive combustion of air-petrol vapour mixture produces shock waves which hit the cylinder wall and piston of IC engine, creating rattling sound is known as Knocking in IC engine.

Octane Number (ON)

For modern high speed petrol engines a high compression is essential for efficiency. But a straight run air gasoline mixture ignites prematurely under high compression and burns in an explosive and disorderly fashion producing a sharp metallic sound called knocking. Knocking causes a great loss of power, a part of energy is converted in to metallic rattle. High fuel is consumed in this manner and also causes damages to the engines. In order to classify fuels according to the knocking property the scientist Edger (1927) introduced an arbitrary scale for rating the fuels called octane number. It has been found that n-heptane knocks very badly and hence its anti-knock value has been given zero and on the other hand iso-octane (2,2,4-trimethyl pentane) gives very little knocking. So its anti-knock value has been given as 100. Thus octane number (or rating) of a fuel (or any other internal combustion fuel), may be defined as the percentage of iso-octane in a mixture of iso-octane and n-heptane, which matches the fuel under test in knocking characteristics.

Now a days gasoline with octane number rating as high as 135 & even more have been produced and they are used for aviation purpose.

Cetane number (CN): Diesel engine fuel

Diesel engine fuels consists of longer chain hydrocarbons than IC engine fuel. The suitability of a diesel fuel is determined by its cetane value(CN), which is the percentage of hexadecane (Cetane) in a mixture of hexadecane and 2-methyl naphthalene which knocks at the same compression ratio as the fuel under examination. Diesel engine normally requires a fuel of cetane number greater than 50.

Prevention of knocking

Knocking of gasoline can be decreased by adding certain compounds and these compounds are known as anti-knocking compounds/ agents. This anti knocking agent increases the octane number and decreases knocking.

Tetra Ethyl Lead(TEL)

Tetra ethyl lead (TEL) is $\text{Pb}(\text{C}_2\text{H}_5)_4$ a very important anti knocking agents for gasoline. According to the most accepted theory, TEL is converted in to a lead oxide particles in the cylinder and these particles react with any hydrocarbon peroxide molecules formed, thereby slowing down the chain oxidation reaction and thus decreases the knocking. However, the deposit of lead oxide is harmful to the engine life. Consequently, in order to stop this small amount of ethylene di bromide is also added

to petrol. The added ethylene di bromide removes lead oxide as volatile lead bromide along with the exhaust gases.

Now a days, Tetra methyl lead (TML) has been used instead of TEL, because of higher anti knocking qualities and stability at higher temperature.

Unleaded petrol

Octane value may also be increased by mixing straight chain hydrocarbons with the high octane components such as iso-pentene, iso-octane, ethyl benzene and iso propyl benzene. Methyl tertiary butyl ether (MTBE) is also used to increase the octane value. MTBE contains oxygen in the form of ether group and supplies oxygen for the combustion of the petrol in IC engine. Thus reducing the formation of peroxide compounds. Petrol where in the knocking tendency can be reduced without the addition of lead compounds is called as unleaded petrol.

POWER ALCOHOL

Power alcohol is gasoline blends containing ethanol which can be used as a fuel in internal combustion engines. Blend containing up to 25% of alcohol with petrol are used. The main objective of the power alcohol is to reduce oil imports and provide an alternative to non-renewable energy source like gasoline.

Definition- Blending of ethanol to the petrol is know as power alcohol.

The importances of power alcohol as fuel are

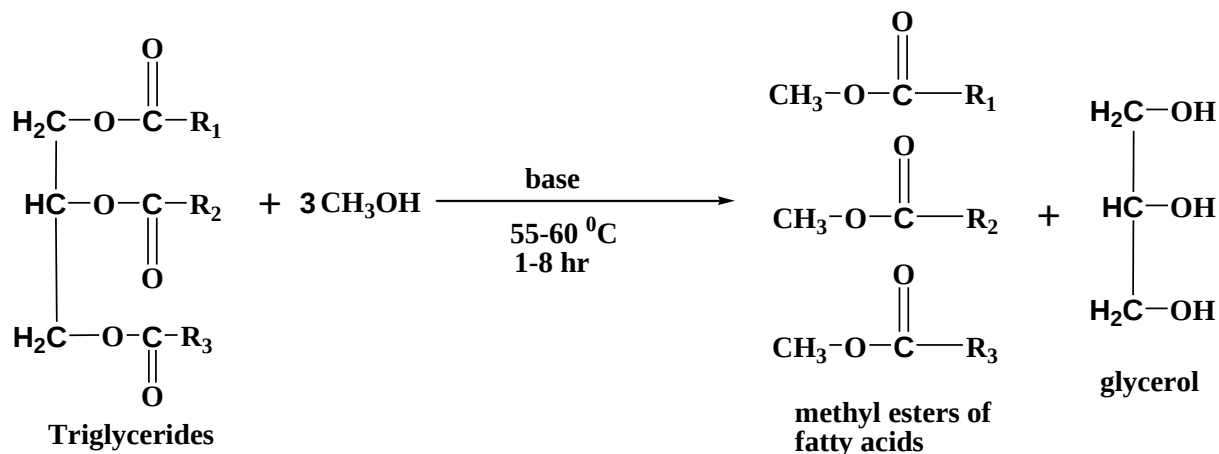
1. Alcohol has an octane number of 90; while petrol has octane number of 60-70. Addition of power alcohol to petrol increases the octane number. Hence alcohol blended petrol possesses better anti-knock properties.
2. There are no starting difficulties with alcohol-petrol blend.
3. Lubrication in case of alcohol-petrol blend and pure petrol is the same.
4. Ethanol is biodegradable.

Disadvantages

1. It lowers the calorific value of petrol (7000 Kcal/Kg, petrol 10,000kCal/Kg)
2. Due to considerable surface tension, alcohol does not atomize at low temperature.
3. Due to oxidation of alcohol in storage tanks, corrosion can occur.

BIO-DIESEL

Biodiesel is prepared from the process of transesterification of vegetable oils such as soyabean, jatropha, sunflower, peanut, rope seeds, mustard, rice bran, cotton seed, palmoil etc, that contain triglycerides. The transesterification process involves treatment of the triglycerides in these oils with excess of methanol in the presence of NaOH (Catalyst) to give monomethylesters of long chain fatty acids and glycerine [used cooking oil, rendered animal fat etc could also be converted to biodiesel].



Where R₁, R₂ and R₃ are long chain fatty acids. Transesterification is carried out above the boiling point of alcohol i.e. 55-60°C for 1-8 hr. The mixture of methyl esters are called biodiesel and have desired characteristics of diesel fuel with cetane number in the range of 50-62. So, this biodiesel can be used as alternative fuel for compression ignition engines or can be blended with petro-diesel and used.

Advantages

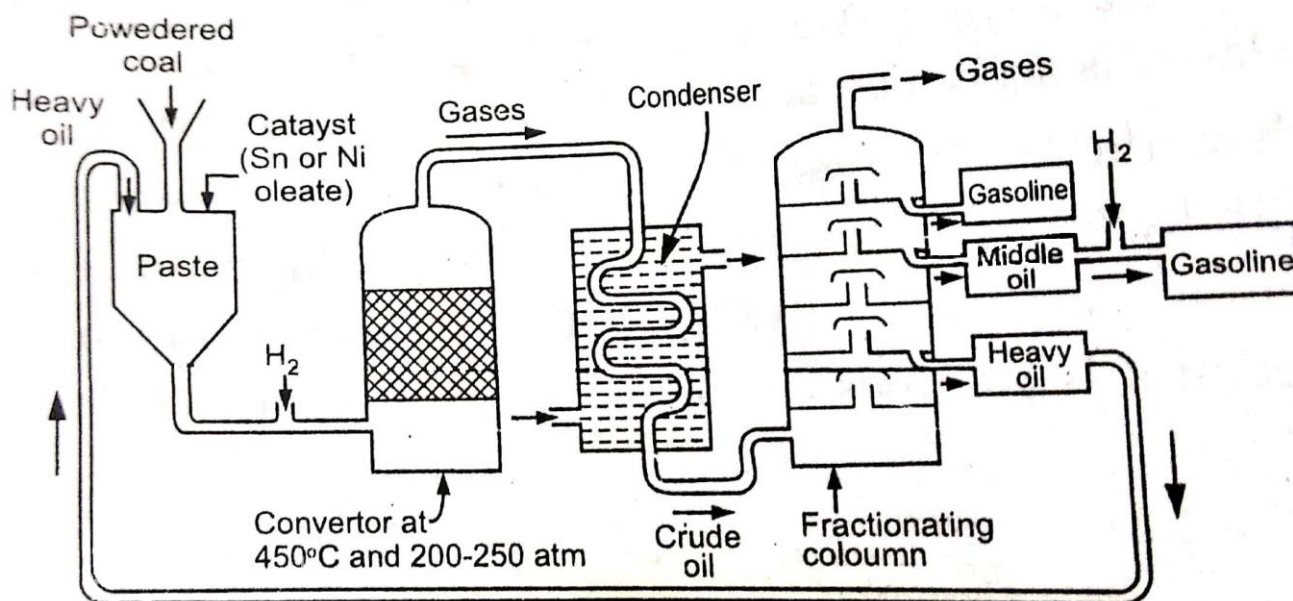
1. It is made using renewable sources.
2. Readily undergoes bio degradation .
3. Biodiesel has a higher cetane number (50-60) compare to diesel (40 – 55).
4. Use of biodiesel reduces green house gases.
5. It is non toxic.

SYNTHETIC PETROL

During World War II, US govt stopped the supply of petrol and petroleum products to Germany. As a result of it, the scientist was asked to come up with some methods to prepare or produce synthetic petrol by the great dictator Hitler. In this context, two scientists came up with two different methods to synthesize petrol starting from coal. They are:-

- (1) BERGIUS PROCESS
- (2) FISCHER-TROPSCH PROCESS (not included in our syllabus).

SYNTHETIC PETROL BY BERGIUS METHOD



In this process, the low grade coal is finely powdered and made into a paste with heavy oil. A catalyst composed of Tin oleate or Ni oleate is mixed with it. It is then pumped along with hydrogen into the converter where the paste is heated to 450⁰ C under 200-250 atm pressure for about 1.5 hr. The hydrogen combines with coal to form saturated hydrocarbons which decompose to yield mixture of lower hydrocarbons. Since the reaction is exothermic, the vapours leaving the converters are condensed in the condenser to give synthetic petroleum or crude oil. The crude oil is then fractionated to get (a) Gasoline or Petrol, (b) Middle oil and (c) heavy oil.

The top fraction is condensed and synthetic gasoline or petrol is recovered. The middle oil is hydrogenated in presence of a solid catalyst to give more gasoline. The heavy oil is recycled for making a paste with fresh coal powder which is required for this process. The yield of gasoline is about 60% of coal used.

Alloys

Introduction to Alloys

An alloy is a mixture of two or more elements, where at least one is a metal. Alloys are designed to have properties that are different from the pure metals, often enhancing strength, durability, corrosion resistance, or other desirable characteristics. They play a crucial role in various industries, including construction, transportation, electronics, and manufacturing.

Classification of Alloys

Based on the Number of Elements

- **Binary Alloys:** Composed of two elements. Example: Brass (copper and zinc)
- **Ternary Alloys:** Composed of three elements. Example: Stainless steel (iron, chromium, and nickel)
- **Quaternary Alloys and Higher-Order Alloys:** Composed of four or more elements. Example: Some high-strength steels (iron, chromium, nickel, and molybdenum)

Based on the Base Metal

- **Ferrous Alloys:** Contain iron as the principal element. Example: Stainless steel, Cast iron
- **Non-Ferrous Alloys:** Do not contain iron as the main element. Example: Aluminum alloys, Copper alloys (Brass and Bronze), Nickel alloys

Specific Alloys

1. Stainless Steel

Composition: Primarily iron, with a minimum of 10.5% chromium. Other elements may include nickel, molybdenum, and manganese.

Properties:

- High corrosion resistance due to the chromium content.
- High strength and durability.
- Good temperature resistance.
- Non-magnetic in some grades.
- Easy to clean and sterilize.

Applications:

- Kitchen utensils and appliances.
- Medical instruments.
- Construction materials (e.g., bridges, buildings).
- Automotive and aerospace components.

2. Solders

Composition: Traditionally, a mixture of lead (Pb) and tin (Sn). Lead-free solders often include tin with silver (Ag), copper (Cu), or bismuth (Bi).

Properties:

- Low melting point, suitable for joining electrical and electronic components.
- Good wettability, allowing it to spread and adhere well to surfaces.
- Adequate mechanical strength for holding components in place.

Applications:

- Electronics assembly (soldering of circuit boards).
- Plumbing (for joining pipes).
- Jewelry making.
- Stained glass window creation.

3. Brass

Composition: Primarily copper (Cu) and zinc (Zn). The ratio can vary to create different types of brass with varying properties.

Properties:

- Good corrosion resistance.
- Attractive golden color.
- High malleability and ductility.
- Good acoustic properties.

Applications:

- Musical instruments (e.g., trumpets, saxophones).
- Decorative items (e.g., jewelry, ornaments).
- Plumbing fittings and valves.
- Bearings and gears.

4. Alnico

Composition: An alloy of aluminum (Al), nickel (Ni), and cobalt (Co), often with iron (Fe) and sometimes other elements like copper or titanium.

Properties:

- Excellent magnetic properties, high coercivity.
- High resistance to demagnetization.
- Good thermal stability.

- Durable and resistant to corrosion.

Applications:

- Permanent magnets.
- Electric motors and generators.
- Sensors and relays.
- Loudspeakers and microphones.

TEXT BOOKS

1. Engineering Chemistry by M.M.Uppal, Khanna Publishers (2001 edition).
2. A text Book of Engineering Chemistry- by P C Jain and Monica Jain, Dhanapatrai Publications, New Delhi.(2015 edition)