

UNIT - IV: Energy Sources

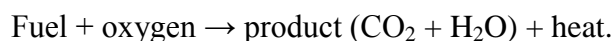
UNIT - IV: Energy Sources:

Introduction, Calorific value of fuel – HCV, LCV- Dulong's formula, Numerical problems.
Classification- Solid fuels: coal – analysis of coal – proximate and ultimate analysis and their significance. Liquid fuels – petroleum and its refining, cracking types – moving bed catalytic cracking. Knocking – octane and cetane rating, synthetic petrol - Fischer-Tropsch's process; Gaseous fuels – composition and uses of natural gas, LPG and CNG, Biodiesel – Trans esterification and advantages.

Fuels are the main energy sources for industry and domestic purposes.

A fuel is a substance containing carbon as the major substituent which provides energy on combustion for industry and domestic purposes.

Combustion is the process of chemical reaction between fuel and oxygen, which provides heat energy.



Classification:

(A) Classification based on the occurrence

(B) Classification based on the physical state

Classification based on the occurrence

Primary or natural fuels: The fuels which occur in nature as such.

Example: wood, coal, peat, petroleum, natural gas etc.

Secondary or artificial fuels: The fuels which are derived from the primary fuels.

Example: coke, kerosene oil, petrol, coal gas, Thiokol, hydrazine, LPG etc.

Classification based on the physical state

i. Solid fuels

ii. Liquid fuels

iii. Gaseous fuels

A complete classification of fuels with suitable examples is represented in Table

Type of Fuel	Natural or primary fuel	Artificial or secondary fuel
Solid fuels	Wood, peat, lignite, brown coal, anthracite	Charcoal, coke
Liquid fuels	Crude oil or petroleum	Petrol, diesel and various other fractions of petroleum
Gaseous fuels	Natural gas	Coal gas, water gas, producer gas, oil gas, bio gas, and LPG

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Characteristics of a good fuel:

While selecting an ideal fuel for domestic or industrial purpose we should keep in mind that the fuel selected must possess the following characteristic properties.

1. It should possess **high calorific value**. If the calorific value of the fuel is high, the fuel is said to be more efficient.
2. It should **not produce harmful combustion products** like CO, SO₂, NO, H₂S, smoke and clinkers during combustion. In other words, it should not cause pollution on combustion
3. It should have **low moisture** and volatile content.
4. Fuel must be **easily available** in abundant and its **cost** must be **minimum**.
5. It should be **easy** to handle and **transport**.
6. It must have **moderate ignition temperature** and should **leave less ash** after combustion. (Ignition temperature is the minimum temperature to which the fuel is to be heated to start combustion.)
7. **Combustion** should be **easily controllable** i.e., combustion of fuel should be easy to start or stop as and when required.
8. **Uniform size**: In the case of a solid fuel, the size should be uniform so that the combustion is regular.
9. The combustion of a good fuel **should not be explosive**.

Calorific value

The calorific value of a fuel can be defined as “the total quantity of heat liberated when a unit quantity (mass or volume) of the fuel is completely burnt in air or oxygen”.

There are different units for measuring the quantity of heat. They are:

- | | |
|----------------------------------|---------------------------------|
| 1. Calorie | 2. Kilocalorie |
| 3. British thermal unit (B.Th.U) | 4. Centigrade heat unit (C.H.U) |

Inter conversion of various units of heat:

$$1 \text{ k.cal} = 1000 \text{ cal} = 3.968 \text{ B.Th.U} = 2.2 \text{ C.H.U}$$

Fuel calorific value is two types:-

- Gross calorific (or) higher calorific value (H.C.V)
- Net calorific value (or) lower calorific value (L.C.V)

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Higher calorific value (HCV) or gross calorific value:

HCV is defined as “the total amount of heat liberated, when unit mass or unit volume of the fuel has been burnt completely and the products of combustion are cooled down to room temperature (60 °F or 15 °C)”.

Lower calorific value (LCV) or Net calorific value (NCV):

LCV is defined as “the net heat produced, when unit mass or unit volume of the fuel is burnt completely and the combustion products are allowed to escape”.

$$LCV = HCV - \text{Latent heat of water vapour formed}$$

N.C.V = gross calorific value – latent heat of vaporization.

latent heat of vaporization = [Mass of hydrogen per unit weight of fuel burnt $\times 9 \times$ latent heat of vaporization of water]

One part of H gives 9 parts of H₂O and latent heat of steam for water is 587 cal/g.

$$N.C.V = G.C.V - 9 \times (H/100) \times 587$$

(Or)

$$N.C.V = G.C.V - 0.09 \times H \times 587 \quad (\text{Where } H = \% \text{ of Hydrogen in the fuel})$$

Dulong's formula

The HCV of fuel is the sum of calorific values of all the constituents present in fuel.

$$GCV \text{ or } HCV = \frac{1}{100} [8080 C + 34500 (H - \frac{O}{8}) + 2240 S] \text{ cal/gm}$$

Where C, H, O and S are the percentage of carbon, Hydrogen, Oxygen and sulphur in the fuel respectively.

The calorific values of fuel constituents

Constituent	Carbon	Hydrogen	Sulphur
Calorific value (k. cal/kg)	8080	34500	2240

Problems:

1. Calculate the gross and net calorific value of a coal sample having the following percentage composition. C= 75%, H= 5.2%, O= 12%, S =2%, N= 3.2% and ash =2.5%.

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Solution:

We know that Dulong's formula

$$\text{GCV or HCV} = \frac{1}{100} [8080 C + 34500 (H - \frac{O}{8}) + 2240 S] \text{ cal/gm}$$

$$\text{Then GCV} = \frac{1}{100} [8080 \times 75 + 34500 (5.2 - \frac{12}{8}) + 2240 \times 2] \text{ cal/gm}$$

$$\text{GCV} = \frac{1}{100} [606000 + 34500 (3.7) + 4480] \text{ cal/gm}$$

$$\text{GCV} = \frac{1}{100} [606000 + 127650 + 4480] \text{ cal/gm}$$

$$\text{GCV} = 7381.3 \text{ cal/gm} = 7381.3 \text{ kcal/kg}$$

$$\text{and NCV} = \text{G.C.V} - 0.09 \times H \times 587$$

$$\text{NCV} = 7381.3 - 0.09 \times 5.2 \times 587$$

$$\text{NCV} = 7106.6 \text{ cal/gm} = 7106.6 \text{ kcal/kg}$$

2. Calculate the gross and net calorific value of a coal sample having the following percentage composition. C= 80%, H= 7%, O= 3%, S =3.5%, N= 2% and ash =5%.

Answer: GCV = 8828 kcal/kg, NCV = 8458 kcal/kg.

Solid Fuels:-

The main solid fuels are wood, peat, lignite, coal and charcoal.

Coal: - Coal is a fossil fuel which occurs in layers in the earth's crust. It is formed by the partial decay of plant materials accumulated millions of years ago and further altered by action of heat and pressure. The process of conversion of wood into coal can be represented as

Wood → Peat → Lignite → Bituminous Coal → Anthracite

Fuel	Percentage of carbon	Calorific value (k.cal/kg)	Applications
Wood	50	4000-4500	Domestic fuel
Peat	50-60	4125-5400	Used if deficiency of high rank coal is prevailing
Lignite	60-70	6500-7100	For steam generation in thermal power plants
Bituminous	80-90	8000-8500	In making coal gas and Metallurgical coke
Anthracite	90-98	8650-8700	In households and for steam raising

Analysis of Coal

Two types of analysis: Proximate and Ultimate

Proximate Analysis of Coal

In this analysis, the percentage of carbon is indirectly determined. It is a quantitative analysis of the following parameters.

1. Moisture content
2. Volatile matter
3. Ash content
4. Fixed carbon

- I. **Moisture Content:** About 1 gram of finely powdered air-dried coal sample is weighed in a crucible. The crucible is placed inside an electric hot air-oven, maintained at 105 to 110 °C for one hour. Then the coal is cooled in a desiccator and weighed out. Loss in weight is reported as moisture.

$$\text{Moisture \%} = \frac{\text{Loss in weight}}{\text{Weight of coal sample}} \times 100$$

- II. **Volatile matter:** Moisture free coal left in the crucible in first experiment (I) is covered with a lid loosely. Then it is heated at 925°C in a muffle furnace for 7 minutes. The crucible is taken out and cooled in a desiccator. Then it is weighed. The loss in weight is due to loss of volatile matter of the coal sample. (Volatile matter is the thermally decomposed coal during burning of coal, which escapes without combustion, in the form of smoke).

$$\text{Volatile matter \%} = \frac{\text{Loss in weight}}{\text{Weight of coal sample}} \times 100$$

- III. **Ash content:** The residual coal in the crucible in (II) is then heated without lid in muffle furnace for half an hour at 700±50 °C. The crucible is taken out, cooled first in air, then in a desiccator and weighed. Heating, cooled and weighing is repeated until a constant weight is obtained. The residue is reported as ash on percentage basis. Thus,

$$\text{Ash \%} = \frac{\text{weight of ash}}{\text{Weight of coal sample}} \times 100$$

- IV. **Fixed carbon:** The sum total of the percentage of moisture, volatile matter and ash content subtracted from 100 gives the percentage of fixed carbon.

$$\text{Fixed carbon \%} = 100 - \% \text{ of (Moisture + Volatile matter + ash)}$$

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Significance or Importance of proximate analysis:

Proximate analysis provides following valuable information's in assessing the quality of coal.

1. **Moisture content:** High percentage of moisture is undesirable because it reduces the calorific value of coal. Lesser, the moisture content, better the quality of coal as a fuel.
2. **Volatile matter:** volatile matter escapes un-burnt, High percentage of volatile matter is undesirable because high volatile matter burns with long flame with high smoke and reduces the calorific value of fuel. Hence, lesser the volatile matter, better the rank of the coal.
3. **Ash content:** In good quality coal, the ash content should be low. High percentage of ash content is undesirable because it causes hindrance to heat flow as well as produces clinkers which blocks the air supply through fuel and reduces the calorific value of fuel, Increases transport, handling, storage and disposal costs.
4. **Fixed carbon:** High percentage of fixed carbon is desirable because higher the percentage of fixed carbon in a coal, greater is its calorific value.

Ultimate Analysis of Coal

This is the elemental analysis and often called as qualitative analysis of coal. This analysis involves the determination of carbon and hydrogen, nitrogen, sulphur and oxygen.

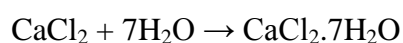
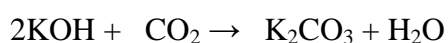
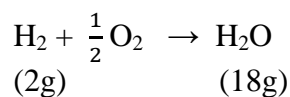
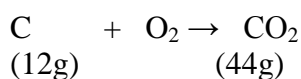
Determination of Carbon and Hydrogen

A known weight of powdered and air dried coal sample is burnt in the presence of pure oxygen, in a combustion apparatus. C and H are converted to CO₂ and H₂O vapours respectively.

The gaseous products are allowed to pass through first the pre-weighed U-tube containing anhydrous CaCl₂ (absorbing H₂O vapours) and then through the KOH in a pre-weighed U-tube (absorption of CO₂).

The increase in weight of U-tube containing anhydrous CaCl₂ corresponds to weight of H₂O formed and increase in weight of U-tube containing KOH solution corresponds to CO₂ formed, by combusting the coal sample.

Reactions



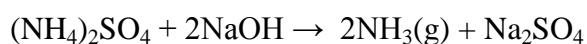
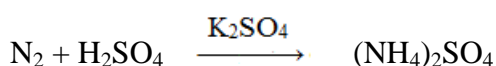
$$\text{Percentage of C} = \frac{\text{Increase in weight of KOH tube} \times 12}{\text{Weight of coal sample} \times 44} \times 100$$

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$$\text{Percentage of H} = \frac{\text{Increase in weight of CaCl}_2 \text{ tube} \times 2}{\text{Weight of coal sample} \times 18} \times 100$$

Determination of Nitrogen:

Percentage of nitrogen in coal determined by kjeldahl method. About 1 gram of accurately weighed powdered coal is heated with concentrated H_2SO_4 along with K_2SO_4 (catalyst) in a long-necked Kjeldahl's flask. After the solution becomes clear i.e. when whole N is converted to $(\text{NH}_4)_2\text{SO}_4$, it is treated with excess of NaOH to liberate ammonia (NH_3) and added a known volume of standard HCl. The unused acid is then determined by back titration with standard NaOH solution. From the volume of acid used by ammonia liberated, the percentage of N in coal is calculated as follows:

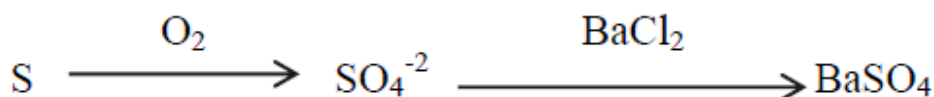


$$\% \text{ of nitrogen} = \frac{\text{Volume acid used} \times \text{Normality of acid} \times 14}{\text{Weight of coal sample} \times 1000} \times 100$$

$$= \frac{\text{Volume acid used} \times \text{Normality of acid}}{\text{Weight of coal sample}} \times 1.4$$

Determination of Sulphur:

Known amount of powdered coal is taken and it is burnt in oxygen at high pressure in bomb calorimeter. Sulphur in coal gets oxidized to sulphates. This upon treated with BaCl_2 solution to precipitate sulphate as BaSO_4 . The precipitate is filtered and washed, dried and weighed.



$$\% \text{ of sulphur} = \frac{\text{Weight of BaSO}_4 \text{ obtained} \times 32}{\text{Weight of coal sample taken} \times 233} \times 100$$

Determination of oxygen

The percentage of oxygen is determined indirectly by subtracting sum of the percentage of C, H, S and Nitrogen from 100

$$\% \text{ of Oxygen} = 100 - \% \text{ of (C + H + N + S)}$$

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Significance of ultimate analysis

- I. Carbon and Hydrogen contents: Higher the percentage of carbon and hydrogen, better is the quality of coal and higher is its calorific value. Higher percentage of carbon in coal reduces the size of combustion chamber required.
The hydrogen is combustible and present in combination with oxygen in water. On heating, it changes into steam. The calorific value of any fuel containing hydrogen is only due to hydrogen present in Free State and not in combined form as water. so lesser the percentage of hydrogen better is the quality of coal.
- II. Nitrogen content: Nitrogen does not have any calorific and its presence in coal is undesirable. Good quality coal should have very little nitrogen content.
- III. Sulphur: Sulphur, when present in coal adds to its calorific value as the oxidation of S is an exothermic process. But its presence in coal is undesirable because the combustion products of sulphur i.e SO_2 and SO_3 are harmful and have corrosion effects on equipments.
- IV. Oxygen content: Lower the percentage of oxygen higher is its calorific value. As the oxygen content increases its moisture holding capacity increases and the calorific value of the fuel reduces.

Liquid fuels

Liquid fuels are the important commercial and domestic fuels used these days. Most of these fuels are obtained from the naturally occurring petroleum or crude oil as primary fuel.

Examples are: Petrol, Kerosene, diesel, cooking oil, etc.

On average the composition of petroleum is

C = 79.5-87.1% H = 11.5-14.8%

S = 0.1-3.5% N and O = 0.1-0.5%

Refining of Petroleum:

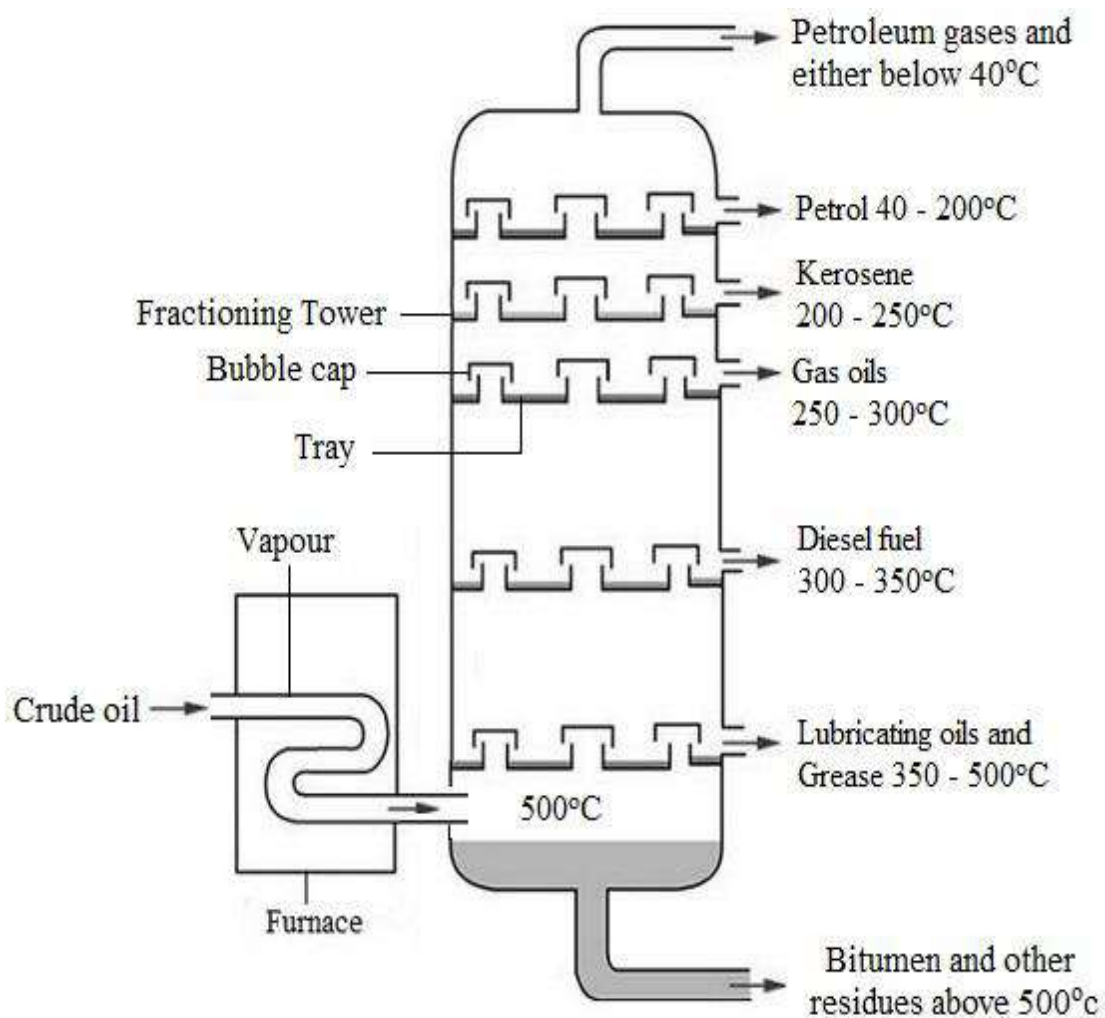
The process of purification and separation of crude oil or petroleum into different fractions on the basis of their boiling points is known as refining or fractionation of petroleum. Refining is done in oil refineries.

Refining of petroleum is done in different stages:

- a. **Removal of solid impurities:** The crude oil is a mixture of solid, liquid and gaseous substances. This is allowed to stand undisturbed for some time, when the heavy solid particles settle down and gases evaporate. The supernatant liquid is then centrifuged where in the solids get removed.

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- b. **Removal of water (Cottrell's process):** The crude oil obtained from the earth's crust is in the form of stable emulsion of oil and brine (salt water). To separate water from crude oil, the crude oil is allowed to flow between two highly charged electrodes. The colloidal water droplets combine to form large drops and get separated from oil.
- c. **Removal of sulphur compounds:** To remove sulphur from the crude oil or petroleum, the crude oil is treated with copper oxide. The sulphur gets precipitated as copper sulphide and is separated by filtration.
- d. **Fractional distillation:** Heating of crude oil around 400°C in an iron retort, produces hot vapours which is allowed to pass through fractionating column. It is a tall cylindrical tower containing a number of horizontal stainless trays at short distances and is provided with small chimney covered with loose cap. As the vapours go up they get cooled gradually and fractional condensation takes place. Higher boiling fractions condense first later the lower boiling fractions.



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Cracking types – moving bed catalytic cracking.

Cracking is defined as the process of decomposition of higher molecular weight hydrocarbons (higher boiling) into lower molecular weight hydrocarbons (low boiling).

Example: Decane is cracking into pentane and pentene



Cracking is mainly divided into two types - 1. Thermal cracking 2. Catalytic cracking

Thermal cracking: If the cracking takes place at high temperature then it is thermal cracking.

Catalytic Cracking:

In this type of cracking catalysts are used. The suitable catalysts used are Al_2O_3 and $\text{Al}_2(\text{SiO}_3)_3$.

Catalytic cracking is of 2 types.

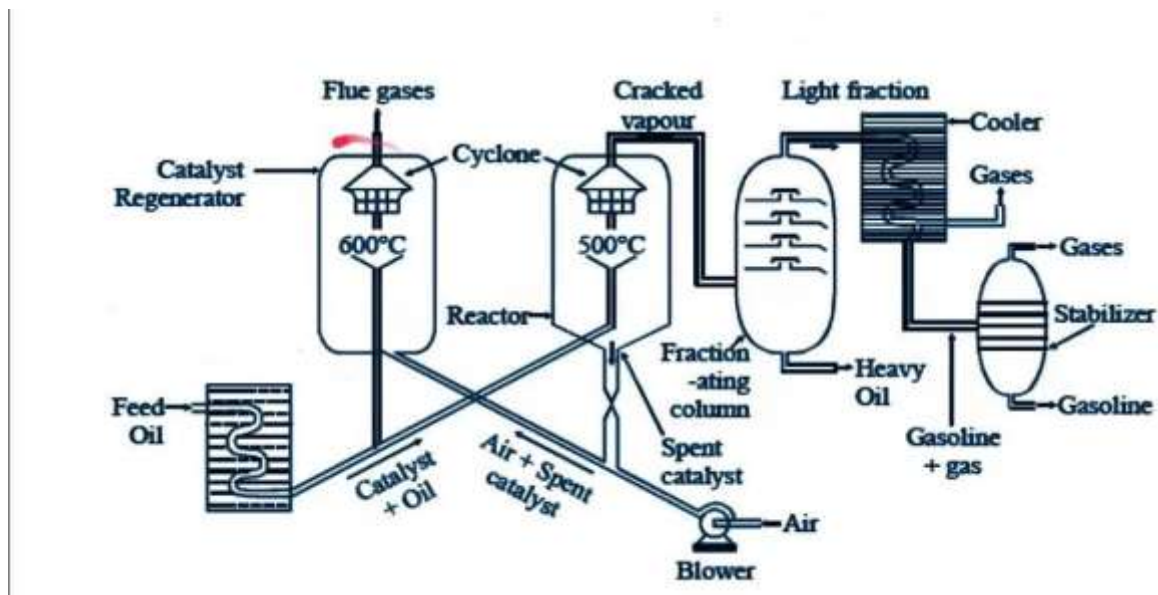
(i) Fixed bed cracking

(ii) Moving bed catalytic cracking

Moving bed catalytic cracking or Fluid bed catalytic cracking

In this method the finely divided catalyst bed is fluidized by passing heavy oil or gas oil vapours, in a cracking chamber. The cracked vapours are sent into fractionating column to separate into gases, gasoline and un-cracked gases.

- In this process the solid catalyst ($\text{Al}_2\text{O}_3 + \text{SiO}_2$) is finely powdered which act as a liquid and is circulated in gas stream.
- Heavy oil vapours and catalyst fluid are allowed into reactor at 500°C , cracking takes place, near top of the reactor there is centrifugal separator, which can allow only cracked vapours but not catalyst powder and carbon dust
- Cracked vapours passed through fractionating column and products are fractionated into gases, gasoline, gas oils and residual oils (unconverted).
- The un-cracked oils are further subjected to cracking.
- The deactivated catalyst is reached at bottom of reactor and regenerated by burning off (at 600°C), the carbon deposited and is mixed with fresh heavy oil and returned to the cracking chamber.



Knocking –

Premature and instantaneous ignition of petrol-air (fuel-air) mixture in a petrol engine, leading to the production of explosive violence known as knocking.

or

Knocking is defined as the rattling noise or sharp metallic noise produced in an internal combustion engine and which results into the loss of energy.

The order of knocking tendencies is,

Straight chain paraffins (n-alkanes) > branched chain paraffins > olefins > cycloparaffins > aromatics.

Reasons for knocking:

- (1) Faulty engine design.
- (2) Running conditions of engine
- (3) Chemical structure of fuel.

Adverse effects of knocking:

- (1) Early ignition
- (2) Mechanical damage due to overheating.
- (3) Decrease in efficiency and increase in fuel consumption.
- (4) Noise and roughness.

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Preventing the knock:

1. Good quality of fuel with higher octane number
2. By adding anti knocking reagents
3. by the retarding sparkplug ignition

Octane number:-

The performance of gasoline in internal combustion has been rated on the basis of octane number.

The knocking tendency of petrol is expressed in terms of octane number

- The higher the octane number, lower is knocking, better the quality of petrol, and hence the vehicle gives higher efficiency.
- The knocking is maximum for n-heptane and has lowest antiknock value and its octane number is assigned as zero
- Knocking is minimum for **iso-octane (2,2,4-trimethyl pentane)**, has highest anti-knocking value and its octane number is given as 100.
- **Octane number of gasoline is defined as the percentage of iso-octane in the mixture of isooctane and n-heptane which has same knocking as the gasoline itself**
- *The higher the octane number, lower is knocking*

Anti-Knocking agents are the additives which improve the octane value of the fuel used in internal combustion engines & prevent or reduces knocking of the engines.

Alcohols, Toluene, Tetraethyl lead (TEL) are typical anti knocking agents.

cetane number

The quality or rating of diesel is expressed by cetane number. *Cetane is n- Hexadecane ($C_{16}H_{34}$).*

If branched or cyclic hydro carbon chain present in diesel shows bad knocking but it contain straight chain hydrocarbon does not exhibit the knock.

Cetane number is defined as the percentage of hexadecane (n-cetane) present in a mixture of **hexadecane** and **2-methyl naphthalene**, which has the same ignition characteristic of diesel fuel in test. Generally diesel fuels with cetane numbers of 70-80 are used.

Ex: cetane number 60 means - 60% cetane 40 % 2methyl naphalene

It gives 40% knocking

The order of cetane number for the following is given as:

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n-alkanes > naphthalenes > alkenes > branched alkanes > aromatics

The cetane number of fuel may be increased by the addition of pre-ignition dopes such as ethyl nitrite, iso amyl nitrite, acetone peroxide.

Synthetic petrol - Fischer-Tropsch's process

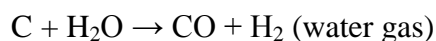
Synthesis of petrol from coal can be made from coal by 2 methods.

1. Polymerization (from lower hydrocarbons)
2. Fischer-Tropsch method (from water gas)
3. Bergius Process (from coal)

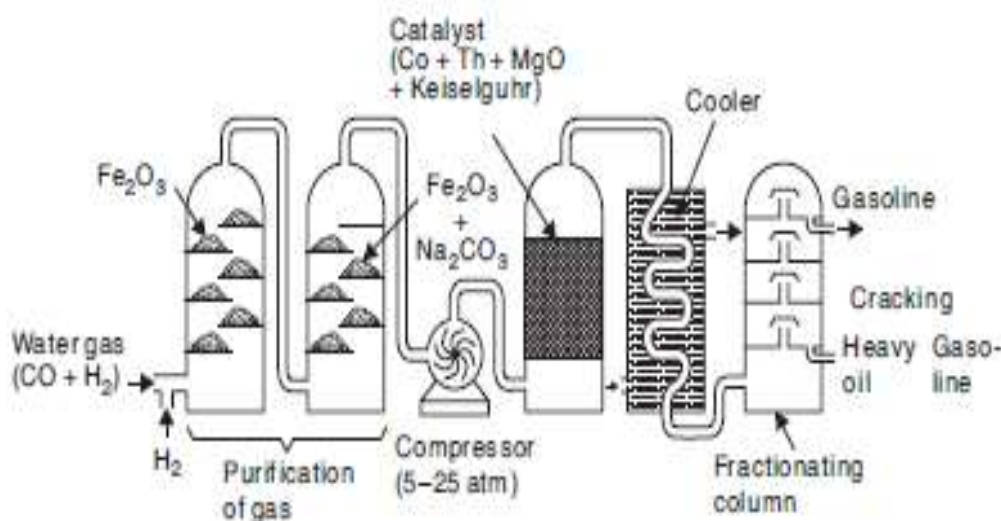
Fischer-Tropsch's process

This method was developed by two German scientists Franz Fischer and Hans Tropsch.

The raw material i.e. hard coke is converted into water gas ($\text{CO} + \text{H}_2$) by passing steam over red hot coke.

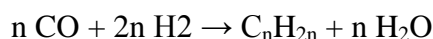


A mixture of hydrogen and water gas is first purified by passing through Fe_2O_3 (to remove H_2S) and then into a mixture of $\text{Fe}_2\text{O}_3 + \text{Na}_2\text{CO}_3$ (to remove organic sulfur compounds).

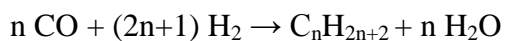


The purified gas is compressed to 5-25 atm and then passed through a converter maintained at about $200-300^\circ\text{C}$. The converter is packed with a catalyst consisting of a mixture of cobalt (Co, 100 parts), thoria (5 parts), magnesia (MgO , 8 parts) and keiselguhr earth (200 parts).

Mixtures of saturated and unsaturated hydrocarbons are formed.



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The reaction is exothermic as such the hot gaseous mixture is led to a cooler, where a liquid resembling crude oil is obtained. The crude oil obtained is then fractionated to yield: (i) Gasoline, and (ii) high-boiling heavy oil. The heavy oil is reused for cracking to get more gasoline.

Gaseous fuels

The gaseous fuels are most preferred because of their ease of storage, transport, handling and ignition. These are classified into two types.

- a) Primary fuels Ex:- Natural gas
- b) Secondary fuels ex: - Coal gas, producer gas, water gas.

Composition and uses of natural gas

Natural gas is obtained from the wells dug in the earth during mining of petroleum. It is mainly composed of methane and small quantities of ethane along with other hydrocarbons.

If the lower hydrocarbons are present, the gas is called dry gas or lean gas but if the hydrocarbons having the higher molecules are present, the gas is known as rich or wet gas.

The average **composition** of natural gas is as follows.

Methane – 88.5%, Ethane – 5.5%, Propane – 3.7%

Butane – 1.8%,

Pentane, hydrogen and higher hydrocarbons – 0.5%

The calorific value of natural gas varies from 8000-14000 K.cal/m³.

Uses:

1. It is used as a very good domestic fuel and industrial fuel.
2. It is used in the preparation of ammonia
3. It is used to prepare carbon black for rubber industry, methanol, formaldehyde etc.
4. It is used to prepare some synthetic proteins which are used as animal feed
5. It is also used for the generation of electricity in fuel cell.

Composition and uses of LPG (Liquefied Petroleum Gas)

Nowadays LPG has been a common fuel for domestic work and also in most of the industries. The main components of LPG are **n-butane, isobutane, butene and propane**.

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The gas can be compressed under pressure in container and sold trade flames like Indian, hp, bharat gas etc---

LPG has special odour due to the presence of organic sulphides which are added specially for safety measure

It has high calorific value: $27,800 \text{ kcal/m}^3$

- It gives less CO and least un-burnt hydrocarbons. So it causes least pollution
- It gives moderate heat which is very useful for cooking
- It has a tendency to mix with air easily, it is colourless
- Even though it is toxic, on combustion it gives no toxic gases
- It neither gives ash or smoke content
- It is cheaper than gasoline. Hence used as motor fuel
- It is dangerous when leakage is there. It is highly knock resistant
- LPG is used as domestic fuel and as a fuel in internal combustion engines

Composition and uses of CNG

Natural gas contains mainly CH_4 . When natural gas is compressed at high pressure (1000atm) or cooled to -160°C , it is converted to CNG.

It is stored in cylinder made of steel

It is now replacing gasoline (petrol) as it releases less pollutants during combustion c.n.g vehicles are used to reduce the pollution

Advantages of CNG:

- Due to higher temperature of ignition, CNG is better fuel than petrol and diesel.
- Operating cost of CNG is less. Cost of production is less. It can be easily stored.
- It releases least pollutants like CO and unburnt hydrocarbons.
- It undergoes regular combustion.
- The calorific value of CNG is 900KJ/mole
- It was used to generate electricity, heat buildings, fuel vehicles, power industrial furnaces and air conditioners.
- CNG vehicles are used to reduce pollution.

Biodiesel – Trans esterification and advantages.

“Biodiesel is a renewable, biodegradable fuel that is manufactured from vegetable oils, and animal fats.”

Bio diesel is chemically very similar to diesel and is produced by transesterification of vegetable oil

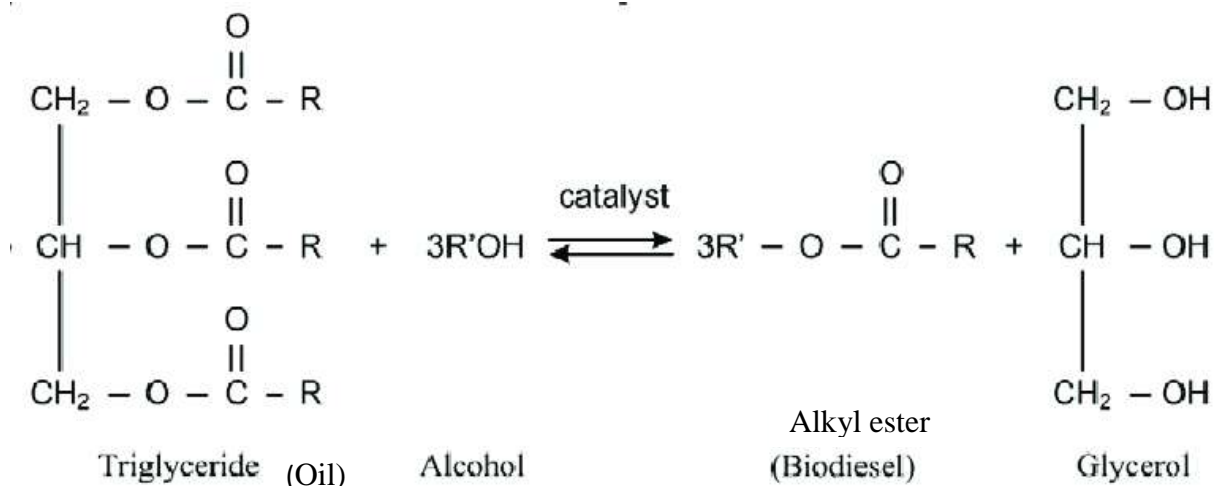
Transesterification is the chemical process, which converts natural fats and oils into Fatty Acid Methyl Esters (FAME) or Biodiesel.

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Biodiesel molecules are long chain carbon atoms containing an ester group at one end. But diesel molecules does not have ester group

Vegetable oil molecules is three times larger than normal diesel molecules

Alcohol and catalyst react with fatty acid/oil (triglyceride), trans esterification reaction takes place and produces biodiesel.



Advantages of Biodiesel

- It is an eco-friendly fuel and does not produce remarkable waste.
- It is safe to use as it does not create any toxic residue.
- This fuel has a lower emission rate, making it reliable for longer use.
- It also finds use in alteration with petroleum diesel oil.
- This is also used as a heating fuel in specific boilers.
- Diesel engines can burn biodiesel fuel with no modification.