3.ENERGY SOURCES

A Battery is a device consisting of one or more electro chemical cells that convert chemical energy into electrical energy. Battery consists of group of two or more electrochemical cells connected in a series.

There are 3 main components: [-] Anode, Cathode [+], Electrolyte

Batteries are classified into a two categories depending on their recharging capabilities.

✓Primary batteries (or) primary cells

✓Secondary batteries (or) secondary cells

✓Fuel cells

PRIMARY BATTERIES

- The cell is not rechargeble(Cell reaction is not reversible).
- The cell becomes dead after use.(Only one time)
- These are less expensive and are used in ordinary gadgets like torch lights, watches and toys
- These batteries are used as source of DC power.
- Eg. Lithium cell, Dry cell (Leclanche cell) and Alkaline cell,Zn-air battery etc..

- **SECONDARY BATTERIES**
- The cell is rechargable(Cell reaction is reversible).
- The cells in which the cell reaction is reversible by passing direct current in opposite direction and can be used again and again.
- The secondary batteries can be used through a large number of cycles of discharging and charging. They are used as a source of DC power.
- Eg. Lead –acid storage cell, Lithiumion batteries and Ni-Cd battery.

Difference between primary and secondary cells:

Primary cells	Secondary cells
Cell reaction is irreversible	Cell reaction is reversible
Must be discarded after use.	May be recharged.
Have relatively short shelf life.	Have long shelf life.
Function only as galvanic cells.	Functions both galvanic Cell & as electrolytic cell.
They cannot be used as storage devices	They can be storage used as energy devices
They cannot be recharged	They can be recharged.
Eg. Dry cell, Alkaline cell and Li- battery,Zn-air battery.	Eg. Lead acid storage cell, Ni-Cd-battery,Lithium- ion cell

RESERVE BATTERY

- A reserve battery, also called stand-by battery, is a primary battery where part is isolated until the battery needs to be used.
- When long storage is required, reserve batteries are often used, since the active chemicals of the cell are segregated until needed, thus reducing self-discharge.
- Reserve batteries are special purpose primary batteries usually designed for emergency use.
- A reserve battery is distinguished from a backup battery, in that a reserve battery is inert until it is activated, while a backup battery is already functional, even if it is not delivering current.

Some reserve batteries are:

- Aluminium battery
- Silver-zinc battery
- Thermal battery,
- Water-activated battery

Applications:

- radiosondes, missiles, projectile and bomb fuzes, and various weapon systems.
- These batteries have many marine and military applications and find extensive use with the emergency service

Basic Requirements of Commercial Batteries:

- Cost ,Temperature range
- Physical size &shape
- Voltage
- Energy and power
- Service life
- Sufficient capacity
- Cycle life, Discharge curve
- Ability to deep discharge
- Power density, Physical requirements. Etc

Construction, working and applications of Zn -air

- It is primary battery
- Non rechargeable
- Model of metal air
- Metal air battery
- Active material at cathode is O2 from air
- High energy density

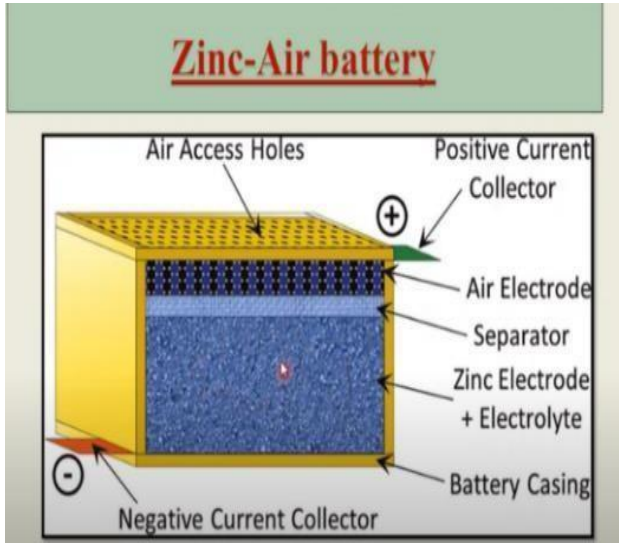
Construction:

Anode: Granulated Zn powder

Cathode: porous carbon plate (blended with catalyst with Mno+Teflon)

Electrolyte: KOH

Separator: Polyethylene



Working:

Reactions:

at anode: $Zn+2OH^- \rightarrow Zno+H2O+2e^-$

at cathode: $1/2\ 02+H20+2e^- \rightarrow 2OH^-$

Over all reaction:$Zn+1/2O2 \rightarrow ZnO+1.4V$ & 100Wh/Kg

When air passes through the cell Zn is oxidised to ZnO at the anode during the discharging.

Applications:

- Military radio receivers
- Power sources in hearing
- Medical devices

Secondary cells:Lithium-ion cell :

- It is a Secondary Cell.It can be recharged.
- As the name suggest movement of lithium ions are responsible for charging and dis charging.
- lithium cobalt oxide – $LiCoO_2$ act as Anode
- Porous carbon (Graphite) act as Cathode
- Electrolyte is a polymer gel,act as separator between the electrodes.
- The separater allows the passage of ions but not that of electrons.
- Provide lightweight, high energy density power sources for variety of devices.

- Li+CoO2 → Li(1-x)+CoO2+xLi+Xe-

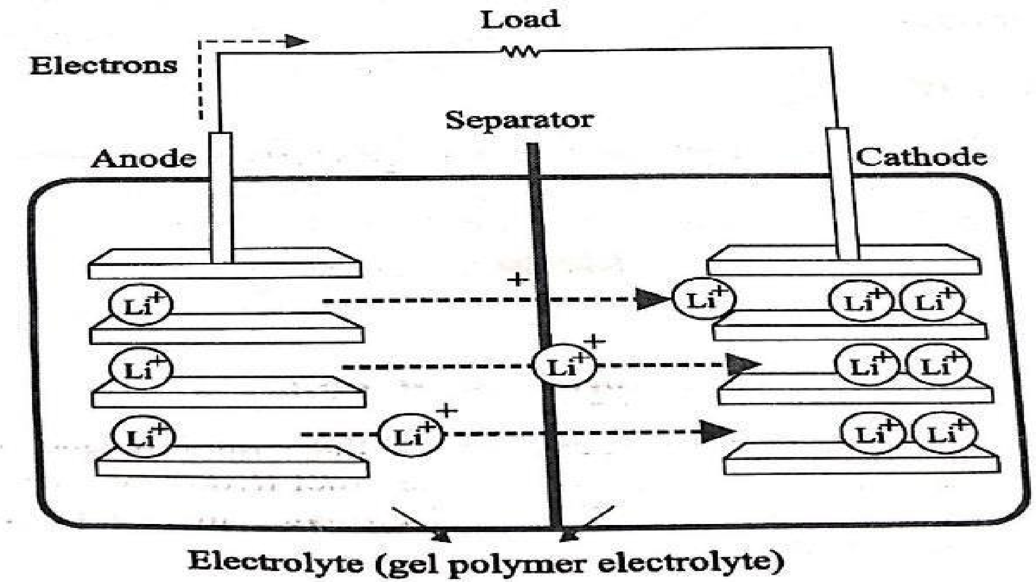


Fig. 4.6 Lithium-ion cell during discharging

Advantages:

1. Lithium-ion batteries are high voltage and light weight batteries.
2. It is smaller in size.
3. It produces three time the voltage of Ni-Cd batteries.
4. It is used in cell phone, note PC, portable LCD TV, semiconductor driven audios.

Applications of Li-ion battery to electrical vehicles:

- Lithium-ion batteries are commonly used for portable electronics and electric vehicles and are growing in popularity for military and aerospace applications.
- High energy efficiency.
- Good high temperature performance.
- Low self-discharge
- Cheaper.
- Smaller and even lighter.

- A fuel cell is a electrochemical cell ,which converts the chemical energy into electrical energy from fuel with out combuston. It converts the energy of the fuel directly into electricity.
- In these cells, reactants, products and electrolytes pass through the cell.
- Fuel Oxygen $\longrightarrow$ Oxidation products + Electricity
- Examples: Hydrogen-oxygen fuel cell,Methyl alcohol(Methanol)-oxygen fuel cell .

Advantages of Fuel cells:

- Fuel cells are efficient (75%) and take less time for operation.
- It is pollution free technique.
- It produces electric current directly from the reaction of a fuel and an oxidiser.
- It produces drinking water.

Disadvantages of Fuel cells

- Fuel cells can not store electric energy as other cells do.
- Electrodes are expensive and have short life time.
- Storage and handling of hydrogen gas is dangerous.

Difference Between Battery And Fuel Cell

Batteries	Fuel cells
A Battery is a device Cantaing one or more electrochemical cells that convert chemical energy into electrical energy	A fuel cell is a device that can converts the chemical energy into electrical energy
Battery stores chemical Energy	Fuel Cells do not stores chemical Energy
They Can be Recharged	They Can not be Recharged
Products remain in the cell	Products removed from the cell
Reactants are with in the cell	Reactants are continuously supplied
Harmful Waste Products are Not Formed	Harmful Waste Products are Formed
Efficency is Less	Efficency is More
Chemical changes occur in batteries	No changes occur in chemical

DIRECT METHANOL FUEL CELL:

- It is a type of a cell that generates electricity by directly oxidizing liquid methanol with oxygen.
- DMFC use a readily available liquid fuel,which specify storage and transport.
- The fuel cells are composed of an anode made of pt/Ru where methonal is oxidised.
- A proton exchange membrane (PEM) that allows proton to pass through and a cathode,where protons and oxygen combine to form water.
- Chemical Reactions:
- At anode : CH3OH+ H2O → CO_2 + 6 H+ +6e-
- At cathode :1/2 O2+2H+ → H2O
- Overall reaction: CH3OH + 1/2O2 → $CO_2 + 2H_2O$

Working:

At anode a methanol water mixture is passed and methanol reacts with oxygen in presence of catalyst to produce carbon dioxide,protons and electrons.

The protons pass through the proton exchange membrane to the cathode.

The electrons travel through an external circuit producing an electric current.

At cathode ,the protons,electrons and oxygen react to form water.

Advantages:

1.As methanol is a liquid at room temperature and easy to transport.

2.Methanol is an energy dense fuel,produces long lasting power in small system.

3.Direct methanol fuel cell is suitable for low temperature operations

FUELS:

INTRODUCTION

A fuel is a combustible substance, containing carbon as the main constituent, which on burning gives large amount of heat. During the process of combustion of a fuel, the atoms of carbon, hydrogen. etc., combine with oxygen simultaneous liberation of heat.

$$C + O_2 \longrightarrow CO + 94k\ cals.$$

$$2H_2 + O_2 \longrightarrow 2H_2O + 68.5\ kcals.$$

The main source of fuel is coal and crude petroleum oil. These are stored fuels available in earth's crust and are generally called fossil fuels, because they were formed from fossilised remains of plants and animals.

CLASSIFICATION OF FUELS

Fuels are classified into two types as

(i) Primary fuels which occur in nature as such, eg. Coal, petroleum, natural gas

(ii) Secondary fuels which are derived from primary Fuels, eg, coke, gasoline, coal gas.

Both primary and secondary fuels may be further based on their physical state into

(i) Solid fuels

(ii) Liquid fuels and

Applications:

- Direct methanol fuel cells are primarily used for lower-power.
- Portable applications such as charging electronic devices and military and defence sectors.

DEFINITION

Combustion is a process of rapid exothermic oxidation, in which a fuel burns in the presence of oxygen with the Evolution of heat and light

CALORIFIC VALUE

The efficiency of a fuel can be understood by its calorific value. The calorific value of a fuel is defined as “the total amount of heat liberated, when a unit mass of fuel is burnt completely.”

UNITS OF CALORIFIC VALUES:

The quantity of heat can be measured by the following Units:

1. Calorie
2. Kilocalorie
3. British Thermal Unit (B.T.U)
4. Centigrade Heat Unit (C.H.U)

Calorie: It is defined as the amount of heat required to raise the temperature of 1 gram of water through 1°C (15 to 16°C)

Types of calorific values

1. **Higher (or) Gross calorific value (GCV)**

It is defined as the total amount of heat produced, when a unit quantity of the fuel is completely burnt and the products of combustion are cooled to room temperature.

Lower (or) Net Calorific Value (NCV)

- It is defined as the net heat produced, when a unit quantity of the fuel is completely burnt and the products of combustion are allowed to escape.
- **NCV = GCV--Latent heat of condensation of water vapour produced.**
- **NCV = GCV-- Mass of hydrogen x 9 x Latent heat of condensation of water vapour**.
- 1 part by weight of H produces 9 parts by weight of H2O as follows. The latent heat of steam is 587 cal/gm

FOSSIL FUELS:

I. LIQUID FUELS

❖ PETROLEUM

- Petroleum or crude oil is naturally occuring liquid fuel.
- It is a dark brown or black coloured viscous oil found deep in earth's crust.
- The oil is usually floating over a brine solution and above the oil, natural gas is present.
- Crude oil is a mixture of paraffinic, olefinic and aromatic hydrocarbons with small amounts of organic compounds like N, O and S.

The overage composition of crude oil is as follows

CONSTITUENTS	PERCENTAGE (%)
C	80-87
H	11-15
S	0.1-3.5
N+O	0.1-0.5

CLASSIFICATION OF FUELS:

Petroleum is classified into three types.

1. Paraffinic-Base type crude oil

   It contains saturated hydrocarbons from CH_4 to $C_{35}H_{72}$ with a smaller amount of naphthenes and aromatics

2. Naphthenic (or) Asphaltic Base type crude oil

   It contains cycloparaffins or naphthenes with a smaller amount of paraffins and aromatics.

3. Mixed Base type crude oil

   It contains both paraffinic and asphaltic hydrocarbons.

REFINING OF PETROLEUM (OR) CRUDE OIL

- The crude oil obtained from the earth is a **mixture of oil, water and unwanted impurities**.
- After the removal of water and other impurities, the crude oil is subjected to fractional distillation. During fractional distillation, the crude oil is separated into various fractions.
- Thus, the process of removing impurities and separating the crude oil into various fractions having different boiling points is called Refining of Petroleum.

The process of refining involves the following steps.

Step 1 Separation of water (Cottrell's process)

The crude oil is allowed to flow between two highly charged electrodes, where colloidal water droplets combine to form large drops, which is then separated out from the oil.

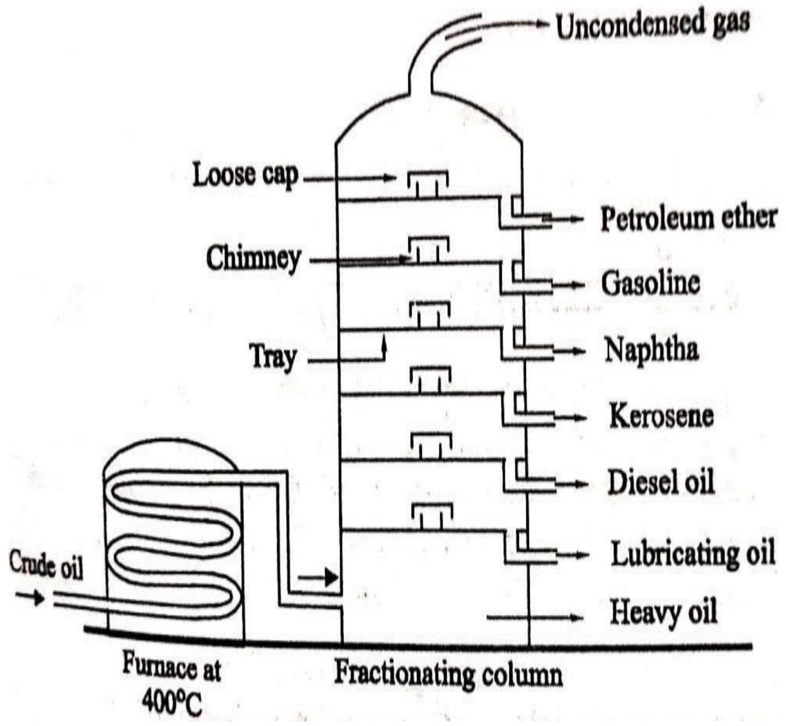
Step 2 Removal of harmful sulphur compounds

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

Step 3 Fractional distillation

- The purified crude oil is then heated to about 400°C in an iron retort, where the oil gets vapourised. The hot vapours are then passed into the bottom of a "fractionating column" (Fig).
- The fractionating column is a tall cylindrical tower containing a number of horizontal stainless steel trays at short distances. Each tray is provided with small chimney covered with a loose cap.

S.NO	Name of the fraction	Boiling range 0C	Range of C-Atoms	Uses
1	Uncondensed gases	Below 30	C1-C4	As a fuel under name of LPG
2	Petroleum ether	30-70	C5-C7	As a solvent
3	Gasoline or petrol	40-120	C5-C9	Fuel for IC engines
4	Naptha or aolvent spirit	120-180	C9-C10	As a solvent in paints and in dry cleaning
5	Kerosine oil	180-250	C10-C16	Fuel for stoves and jet engines
6	Diesel oil	250-320	C15-C18	Diesel engine fuel
7	Heavy oil	320-400	C17-C30	Fuel for ships and for production of gasoline by cracking



- When the vapours of the oil go up in the fractionating column, they become cooler and get condensed at different trays.
- The fractions having higher boiling points condense at lower trays whereas the fractions having lower boiling points condense at higher trays.
- The gasoline obtained by this fractional distillation is called straight-run gasoline.
- Various fractions obtained at different trays are given in table

CRACKING:

CRACKING

Defination

- Cracking is defined as "the decomposition of high boiling hydrocarbons of high molecular weight into simpler, low boiling hydrocarbons of low molecular weight."

C10H22	$\longrightarrow$	C10H22	+	C10H22
Decane		n-Pentane		Pentene
B.Pt: 174°C		B.Pt: 36°C		

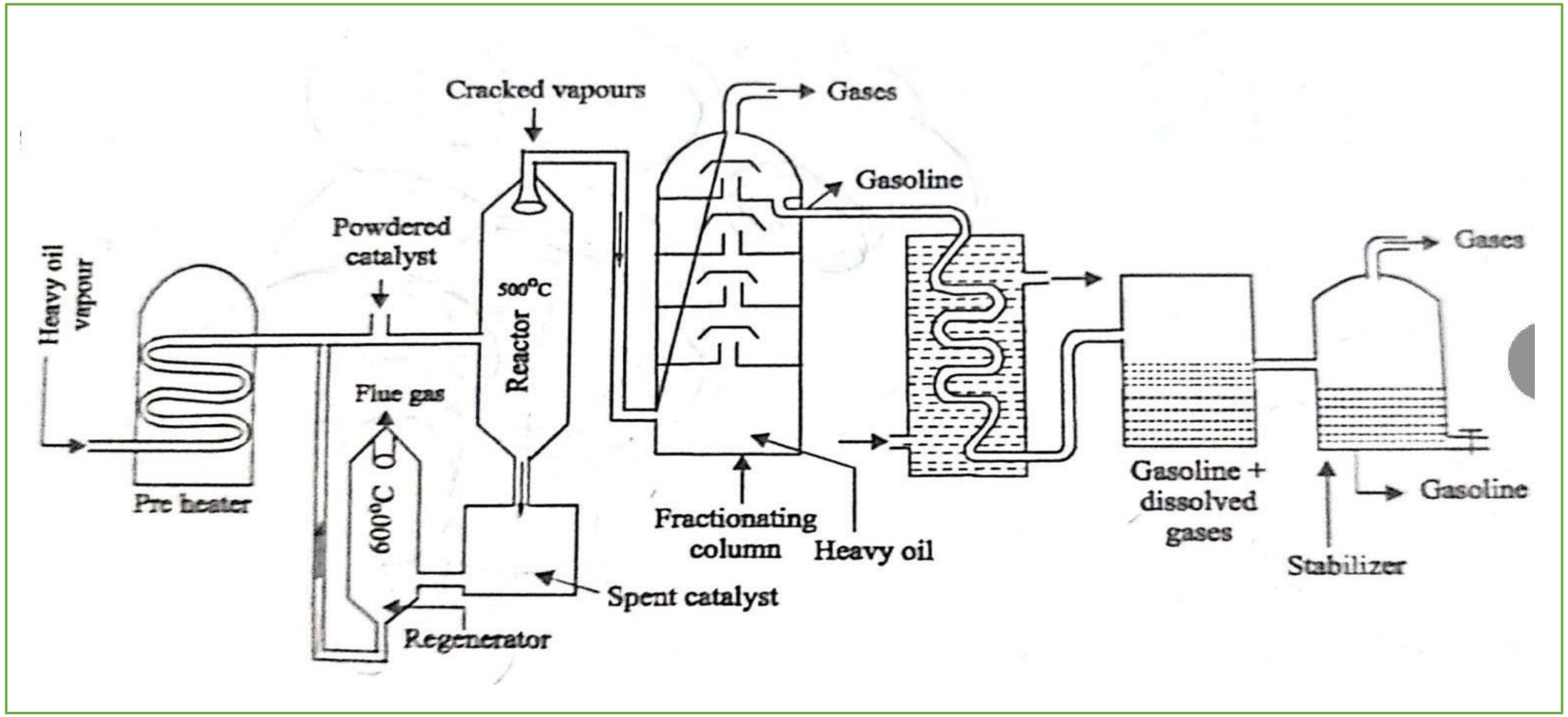
CATALYTIC CRACKING

- If the cracking is carried out at lower temperature and pressure in the presence of catalyst, it is called catalytic cracking.
- The catalyst used are aluminium silicate Or alumina.
- There are two types of catalytic cracking.

MOVING BED (OR) FLUID BED CATALYTIC CRACKING

- In this process, the solid catalyst is finely powdered, so that it behaves as a fluid, which can be circulated in oil vapour.
- The heavy oil vapour is heated to 420-450°C in a preheater and it is mixed with the catalyst powder.
- Then this mixture is forced into the reactor, which is maintained at a temperature of 500°C and a pressure of 5 kg/cm^2, where cracking takes place.
- Near the top of the reactor, there is a centrifugal separator (called cyclone), which allows only the cracked oil vapours to pass on to the fractionating column leaving behind the catalyst powder in the reactor itself.
- The catalyst powder gradually becomes heavier, due to coating of carbon and it settles down at the bottom of the reactor.
- Then it is forced into the regenerator maintained at 600°C, where carbon is burnt and the regenerated catalyst is again recirculated along with the heavy oil vapour.

- From the reactor the cracked oil vapours are passed into the fractionating column, where heavy oil settles down and the vapours are then passed through the cooler where gasoline condenses along with some gases



ADVANTAGES OF CATALYTIC CRACKING

- The yield of petrol is higher.
- The quality of petrol produced is better.
- The production cost is very less, since high Temperature and high pressure are not required.
- No external fuel is necessary for cracking. The heat required for cracking is derived by burning the carbon deposited on the catalyst.
- The percentage of gum and gum form.ag compounds is very low.
- he products contain less sulphur compounds.
- The octane number of cracked gasoline is higher when compared to straight-run gasoline. This is due to the presence of branched paraffins and aromatic hydrocarbons in cracked gasoline.

- The cracking process can be easily controlled, so The desired products can be maintained

COMPRESSED NATURAL GAS (CNG)

- When the natural gas is compressed, it is called Compressed Natural Gas (CNG).
- The primary component present in CNG is methane. It is mainly derived from natural gas.
- The natural gas can either be stored in a tank of a vehicle as compressed natural gas (CNG) at 3,000 or 3,600 psi or as Liquified natural gas (LNG) at typically 20-150 psi.
- The average composition of CNG is as follows

CONSTITUENTS	PERCENTAGE (%)
Methane	88.5
Ethane.	5.5
Propane	3.7
Butane	1.8
Pentane	0.5

USES:

- CNG produces less pollutants than LPG.
- CNG is cheaper and cleaner than LPG.
- The octane rating of CNG is high, hence the thermal efficiency is more.
- It does not evolve sulphur and nitrogen gases.
- It mixes very easily with air than the other gaseous.
- Noise level is much less than diesel.
- CNG vehicle limit 40% less of nitrogen oxide, 90% less Of hydrocarbons, 25% less of CO_2.

Its calorific value is about 25,000

LIQUEFIED PETROLEUM GAS (LPG)

- It is obtained as a by-product during fractional distillation of crude petroleum oil or by cracking of heavy oil.
- It consists of propane and butane. It can be readily liquefied under pressure,
- so it can be economically stored and transported in cylinders.
- The average composition of LPG is as follows.

CONSTITUENTS	PERCENTAGE (%)
n-Butane	38.5
Iso butane	37
Propane	24.5

SYNTHETIC FUELS:

- The gasoline, obtained from the fractional distillation of crude petroleum oil, is called straight run petrol. As the use of gasoline is increased, the amount of straight run gasoline is not enough to meet the requirement of the present community. Hence, we are in need of finding out a method of synthesizing petrol.
- Synthetic petrol is synthesized by the following method

1.Fischer-Tropsch process (or) (indirect method)

In this process (Fig 6.3) coal is first converted into coke. Then water gas ($CO+H_2$) is produced by passing steam over red hot coke.

$$\underset{\text{(Coke)}}{C} + \underset{\text{(Steam)}}{H_2O} \xrightarrow{1200^{\circ}C} \underset{\text{(Water Gas)}}{CO + H_2O}$$

- The water gas is mixed with hydrogen and the mixture is purified by passing through Fe_2O_3, (to remove H_2S) and then into a mixture of $Fe_2O_3 + Na_2CO_3$ (to remove organic sulphur compounds).
- The purified gas is compressed to 5 to 25 atm and then led through a converter, which is maintained at a temperature of 200-300°C.
- The converter is provided with a catalyst bed consisting of a mixture of 100 parts cobalt, 5 parts thoria. 8 parts magnesia and 200 parts keiselghur earth.
- A mixture of saturated and unsaturated hydrocarbon is produced as a result of polymerisation

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(Coke) (Steam) (Water Gas)

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HYTHANE:

Hythane is a blended fuel, natural gas enriched with a small percentage of hydrogen, used in internal combustion engines.

It is deginated to improve engine efficiency and reduce emissions like carbon dioxide and nitrogen dioxide, acting as a transitional step towards a hydrogen based economy.

PRODUCTION:

The natural gas and hydrogen are passed into the blender to mix up the gases and the resulting mixture of gases is hythane which is compressor and passed into the storage tanks.

The composition of hythane is a blend of natural gas and hydrogen 10-30% by volume.

Advantages:

1.Hythane possess improved combustion due to the addition of hydrogen, expands the fuel flammability and better engine efficiency.

2.Low CO2 emission due to lower carbon content in the fuel.

Applications:

1.Hythane is used as an automotive fuel, especially buses and heavy-duty trucks.

GREEN HYDROGEN:

- Green hydrogen is a sustainable, carbon neutral fuel produced by using renewable energy sources such as solar and wind to split water through electrolysis.
- Green hydrogen offers a significant opportunity to decarbonise the sectors like transportation, fertilisers and iron and steel and can be used for long duration energy sources.

ADVANTAGES:

Decarbonisation is the major advantage of green hydrogen to replace fossil fuels in the sectors like heavy duty transport, aviation and some industrial processes.

Hydrogen is a excellent sources for storage of renewable energy for longer duration and helping the intermittency of sources like solar and wind.

APPLICATIONS:

- 1.As a fuel-Green hydrogen is a fuel for heavy transport vehicle like ships and air planes,replacing fossil fuel in many sectors.
- 2. Chemicals& Fertilisers- Green hydrogen is used in producing Ammonia and Methanol .
- 3. Steel production-It replaces the coal in steel making process making the industry environmentally friendly.