# Liquid fuels

Sem-II (DEE/DCE/DME/DETC)

Prepared by
Smt Sonali Ghosh
Lecturer in Chemistry
Jnan Chandra Ghosh
Polytechnic

# What is fuel?

- Any substance used to produce energy is called Fuel.
- Any combustible substance which may be burnt to supply heat for practical applications without the formation of excessively objectionable byproducts.

# Principles of classification of Fuels

Fuels may broadly be classified in two ways:

- **According to the physical state in which they exist in nautre.**
  - Solid fuels
  - Liquid fuels
  - Gaseous fuels

- **According to the mode of procurement**
  - Natural
  - Manufectured

# Liquid fuel

- **Liquid fuels** are those combustible or energy-generating molecules that can be harnessed to create mechenical energy, usually producing kinetic energy.
- They also must take the shape of their container.

# Properties of liquid fuels

- **Density**
  - Ratio of the fuel's mass to its volume at 15 °C,
  - $kg/m^3$
  - Useful for determining fuel quantity and quality
- **Viscosity**
  - Measure of fuel's internal resistance to flow
  - Most important characteristic for storage and use
  - Decreases as temperature increases

- **Flash point**
  - Lowest temperature at which a fuel can be heated so that the vapour gives off flashes when an open flame is passes over it
  - Flash point of furnace oil: 66°C
- **Pour point**
  - Lowest temperature at which fuel will flow
  - Indication of temperature at which fuel can be pumped

- **Calorific value**
  - Heat or energy produced
  - Gross calorific value (GCV): vapour is fully condensed
  - Net calorific value (NCV): water is not fully condensed
- **Specific gravity**
  - Ratio of weight of oil volume to weight of same water volume at a given temperature
  - Specific gravity of water is 1
  - Hydrometer used to measure

- **Sulphur content**
  - Depends on source of crude oil and less on the refining process
  - Furnace oil: 2-4 % sulphur
  - Sulphuric acid causes corrosion
- **Ash content**
  - Inorganic material in fuel
  - Typically 0.03 - 0.07%
  - Corrosion of burner tips and damage to materials /equipments at high temperatures

- **Carbon residue**
  - Tendency of oil to deposit a carbonaceous solid residue on a hot surface
  - Residual oil: >1% carbon residue
- **Water content**
  - Normally low in furnace oil supplied (<1% at refinery)
  - Free or emulsified form
  - Can damage furnace surface and impact flame

# Classification of liquid fuel

# PETROLEUM

- The single largest source of **liquid fuel is petroleum**.
- Petroleum (petra=rock;olium=oil) is also known as **rock oil** or **mineral oil**.
- Crude oil (petroleum) is a viscous liquid containing hydrocarbons , petroleum also contains small amounts of non-hydrocarbons mineral impurities that we extract from underground deposits at a depth of **500-1500 ft** at various places.
- It is mainly composed of various hydrocarbons (like straight chain paraffins, cycloparaffins or napthenes, olefins, and aromatics) together with small amount of organic compounds containing oxygen nitrogen and sulphur

# Composition of typical crude oil

| | |
|---|---|
| Carbon: | 83-87% |
| Hydrogen: | 11-14% |
| Nitrogen: | 0-0.5% |
| Sulfur: | 0-6% |
| Oxygen: | 0-3.5% |

Plus oxygenated compounds like phenols, fatty acids, ketones and metallic elements like vanadium and nickel.

# Classification of Petroleum

- **Paraffinic Base Type Crude Petroleum**

  This type of petroleum is mainly composed of the saturated hydrocarbons from $\mathbf{CH_4}$ to $\mathbf{C_{35}H_{72}}$ and a little of the napthenes and aromatics. The hydrocarbons from $\mathbf{C_{18}H_{38}}$ to $\mathbf{C_{35}H_{72}}$ are sometimes called Waxes.

- **Asphalitc Base Type Crude Petroleum**

  It contains mainly cycloparaffins or napthenes with smaller amount of parffins and aromatic hydrocarbons.

- **Mixed Base Type Crude Petroleum**

  It contains both paraffinic and asphaltic hydrocarbons and are generally rich in semi-solid waxes.

# Differences Between Coal and Petroleum

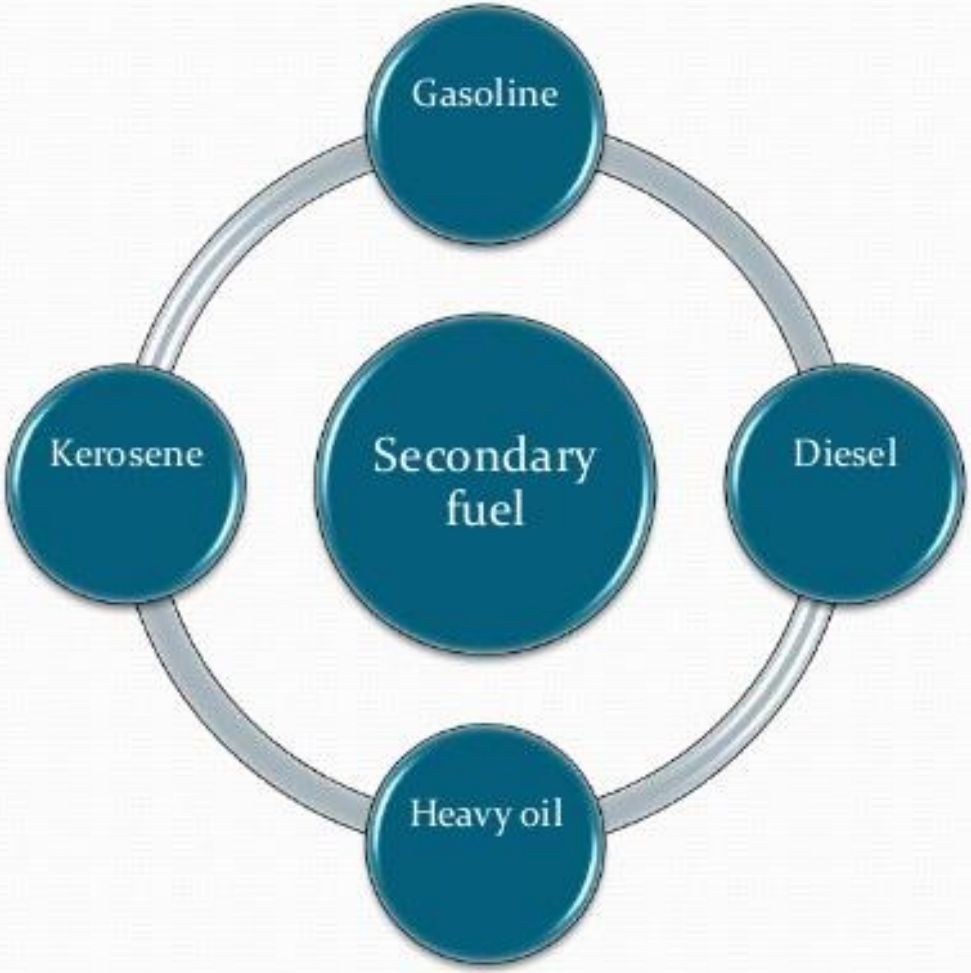
| Coal | Petroleum |
|---|---|
| Formed from land plants decaying under mildly reducing conditions | Formed mainly from sea plants and animals decaying under strongly reducing conditions |
| Seams remain where deposited, i.e., location of existing deposits are usually same as the location of accumulation of debris | Can migrate under effects of temperature and pressure, i.e., location of existing deposits may not be the same as location of accumulation of debris |

# Oil Shales

- Oil shales contain a solid combustible mixture of hydrocarbons called ***kerogen***.

# Heavy Oils from Oil Shale

- Heavy and tarlike oils from oil shale could supplement conventional oil, but there are environmental problems.
  - **High sulfur content**.
  - **Extracting and processing produces:**
    - Toxic sludge
    - Uses and contaminates larges volumes of water
    - Requires large inputs of natural gas which reduces net energy yield.

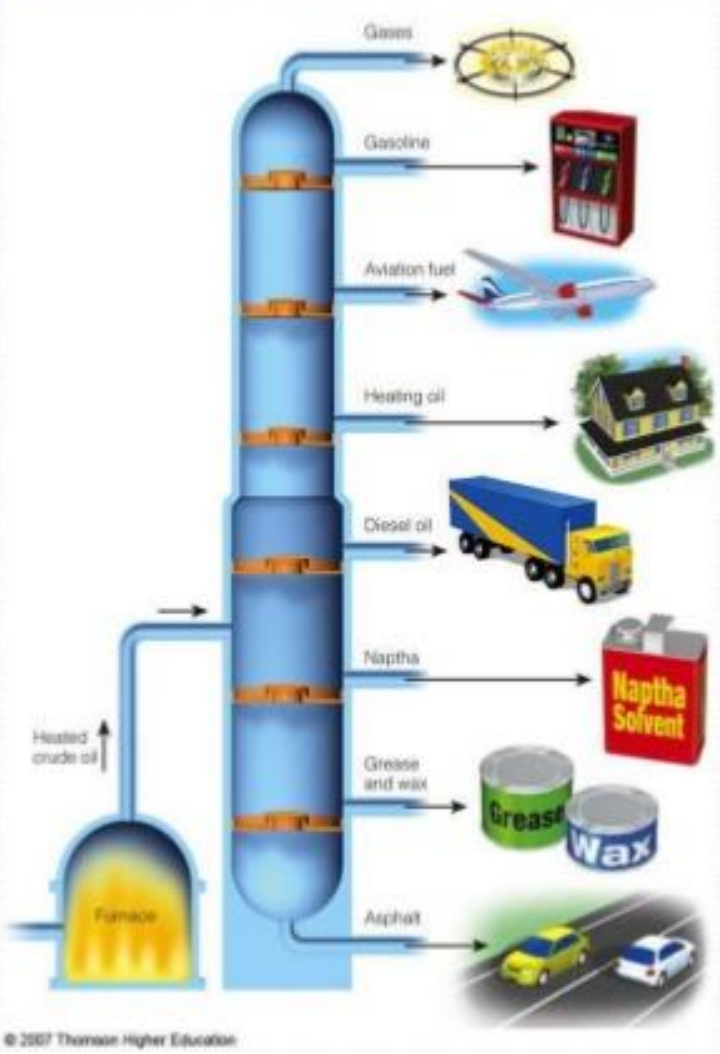



**Note:** Gasoline is known as PETROL in our country

# Refinery processes

1. **Distillation:** Continuous, Atmospheric, and Vacuum.
2. **Cracking:** Thermal, Catalytic and Hydro.
3. **Reforming:** Thermal, Catalytic and Hydro.
4. **Polymerization**
5. **Alkylation**
6. **Isomerization**
7. **Hydrogenation**

# OIL




- **Refining crude oil:**
  - Based on boiling points, components are removed at various layers in a giant distillation column.
  - The most volatile components with the lowest boiling points are removed at the top.

# Gasoline or Petrol and its Characteristics

- **Gasoline** is the most widely used liquid fuel.
- Production of gasoline is achieved by distillation of crude oil. The desirable liquid is separated from the crude oil in refineries. It contains some undesirable unsaturated straight chain hydrocarbons and sulphur compounds. It has boiling range of 40-120°C.
- Liquid gasoline itself is not actually burned, but its fumes ignite, causing the remaining liquid to evaporate and then burn. Gasoline is extremely volatile and easily combusts, making any leakage potentially extremely dangerous.

# Characteristics of ideal Gasoline (Petrol)

- It must be cheap and readily available.
- It must burn clean and produce no corrosion.
- It must be knock resistant.
- It should be pre-ignite easily.
- It must have a high calorific value

# Kerosene Oil

- Kerosene oil is obtained between 180-250°C during fractional distillation of crude petroleum.
- When kerosene is used in domestic appliances, it is always vaporized before combustion.
- By using a fair excess of air it burns with a smokeless blue flame.

**USES**

- ✓ Illuminant
- ✓ Jet engine fuel
- ✓ Tractor fuel (TVO)
- ✓ Additives

# Diesel Fuel and its Characteristics

- Conventional **diesel** is similar to gasoline in that it is a mixture of aliphatic hydrocarbons extracted from petroleum.
- The diesel fuel is obtained between 250-320°C during the fractional distillation of crude petroleum.
- Diesel generally contains 85% C and 12% H.
- Diesel fuels consist of longer hydrocarbons and have low values of ash, sediment, water and sulphalt contents.
- Calorific value is about **11,000** kcal/kg.
- Deisel easily ignite below compression temperature.
- It is used in diesel engine.

# Heavy Oil and its Characteristics

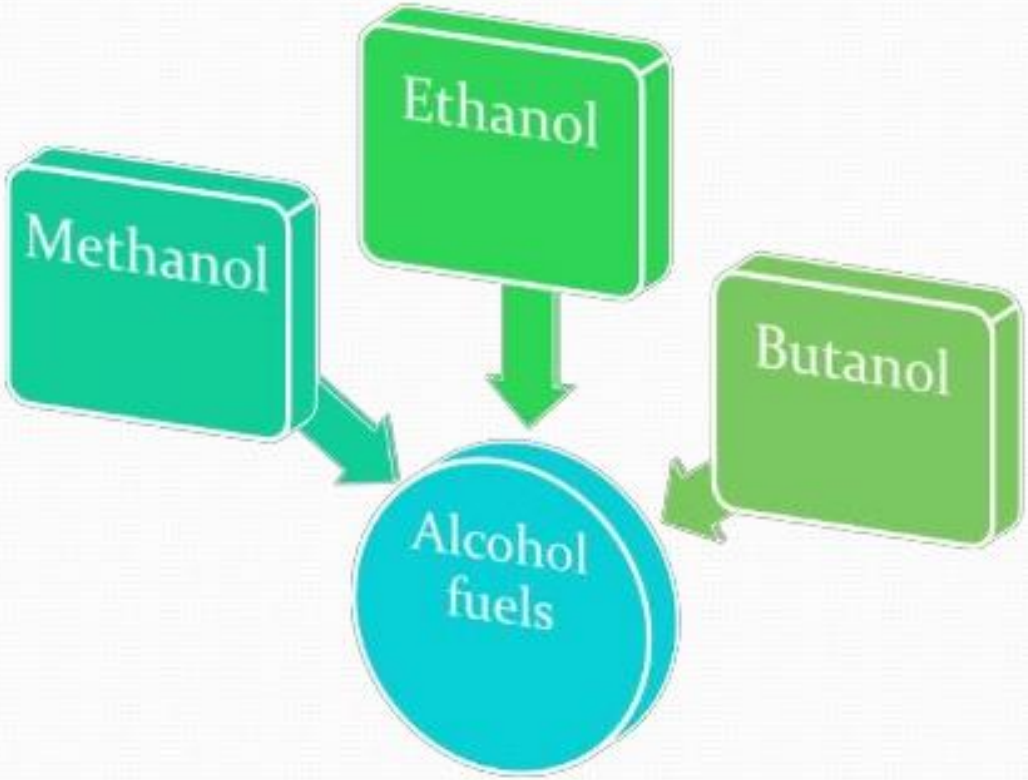
- It is a fraction obtained between 320-400°C during fractional distillation of crude petroleum.
- **This oil on refractionation gives :**
- **Lubricating oils** which are used as lubricants.
- **Petroleum-jelly** (Vaseline) which is used as lubricants in medicines and in cosmetics.
- **Greases** which are used as lubricants.
- **Paraffin wax** which is used in candles, boot polishes, wax paper and for electrical insulation purposes.

# Synthetic liquid fuel

- Liquid fuel from coal and/or natural gas.
- When petroleum is not easily available, chemical processes such as the Fischer-Tropsch process can be used to produce liquid fuels. These are known as non-petroleum fossil fuels.

# Biodiesel

- Biodiesel is an alternative fuel similar to conventional or 'fossil' diesel.
- Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil.
- The process used to convert these oils to Biodiesel is called transesterification.
- The Transesterification process is the reaction of a triglyceride (fat/oil) with an alcohol to form esters and glycerol.


Ethanol
Methanol
Butanol
Alcohol fuels

# Alcohol fuel

- **Methanol**
  - Methanol is the lightest and simplest alcohol, produced from the natural gas component methane and by distillation of wood.
  - Its application is limited primarily due to its toxicity.
  - Used in some race cars and model airplanes.
- **Ethanol**
  - Used as a fuel, most often in combination with gasoline.
  - There is increasing interest in the use of a blend of 85% fuel ethanol blended with 15% gasoline. This fuel blend called E85.
- **Butanol**
  - It is formed by fermentation of biomass by bacterium *Clostridium acetobutylicum*.
  - It has high energy content about 10% lower than gasoline.
  - Major disadvantages of butanol fuel are high flash point, toxicity and foul odour.

## Advantages

- Possesses higher calorific value.
- Combustion without the formation of dust, clinker or ash.
- Firing easier & easily extinguishable.
- Less excess furnace space.
- No wear & tear on furnace parts like solid fuels.
- Low sulphur content.
- For equal heat output lesser space & weight then solid.

## Disadvantages

- Costlier than solid fuels.
- Requirs costly storage tanks.
- High risk of fire hazards especially of volatile liquids.
- Requirement of especially designed burners for efficient burning.
- They give bad odour.