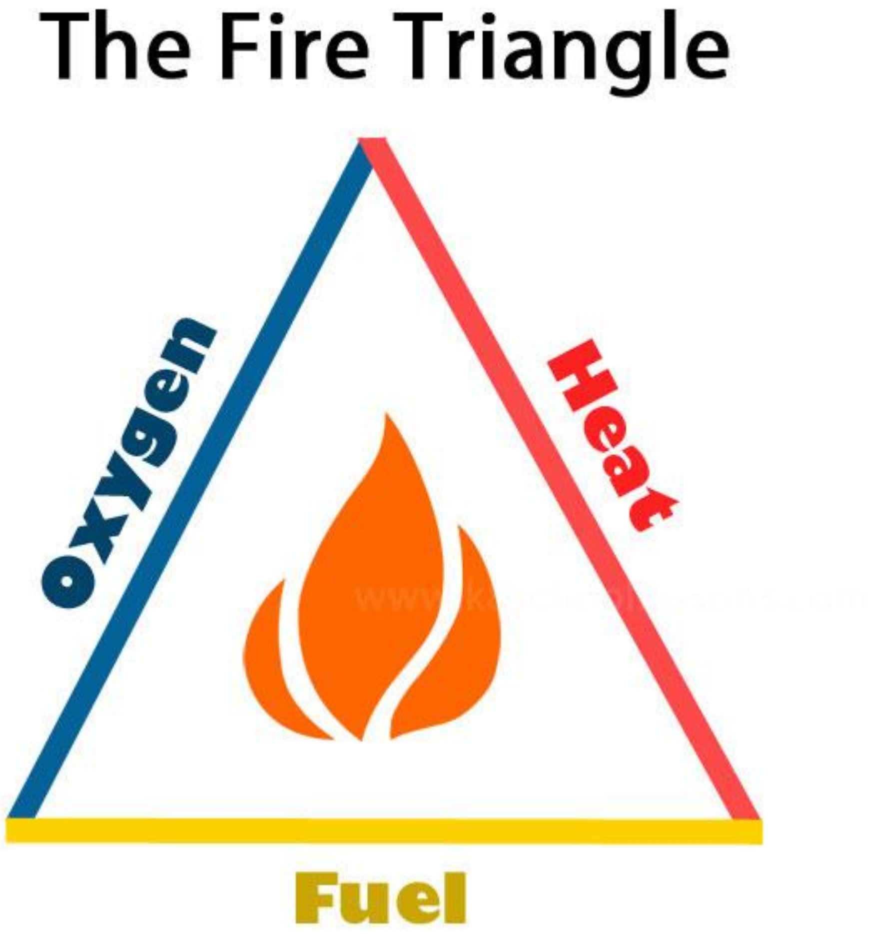
❖ What is Fuel ?

❑ Any material that releases energy (heat) when a change occurs in its physical and chemical structure is generally called fuel. Generally, substances that give heat when burned are called fuel. Fuels can be stored in order to generate energy. They can be used to generate work when necessary, to provide energy. In order for matters to be defined as fuel, they must have features such as not harmful to health when burned, abundant in nature, not posing a danger and also, being cheap.



Types of Fuel

❑ **Fuels are generally divided into three groups:**

1. Solid fuels:

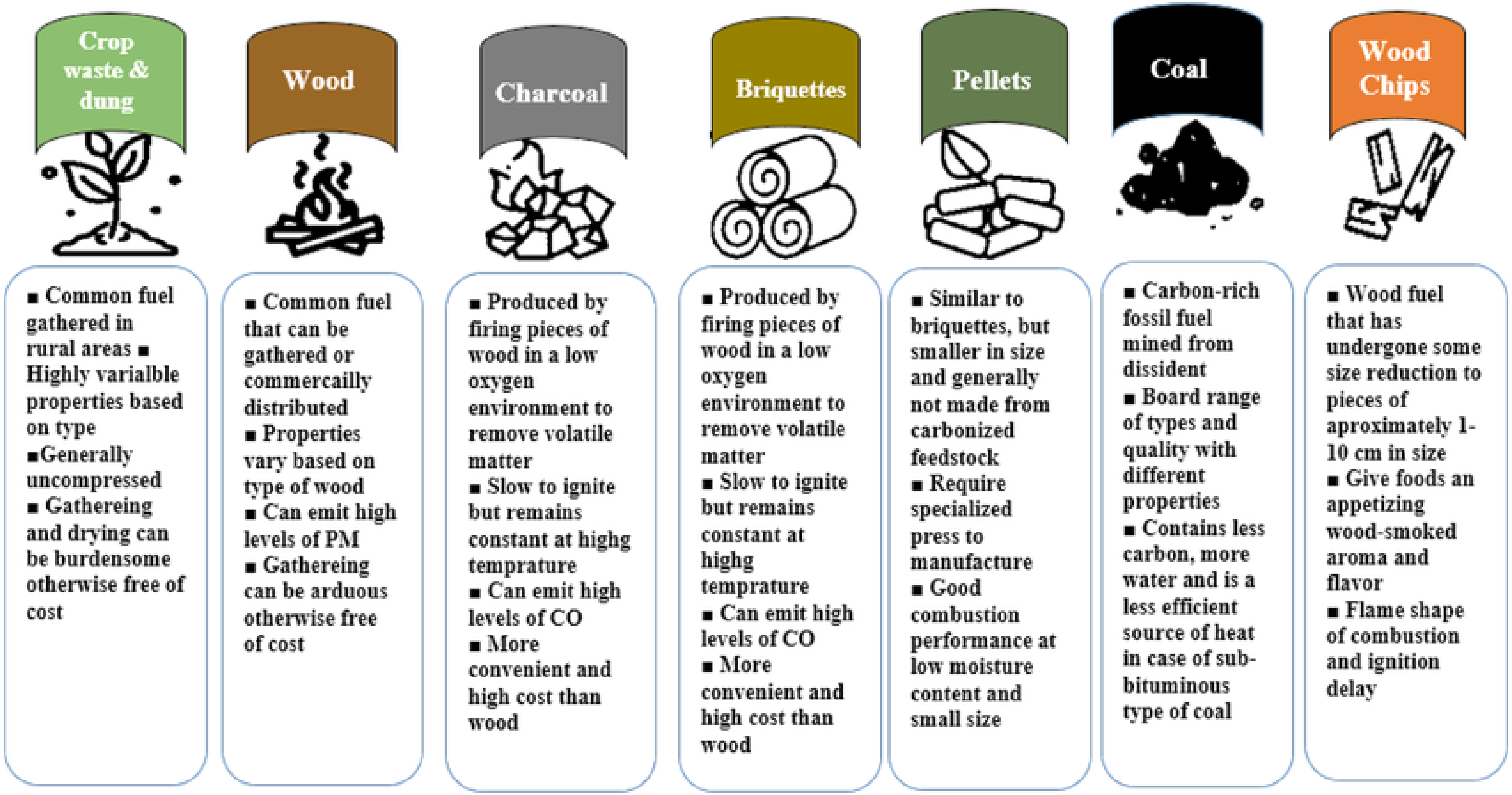
They are divided into three groups.

• ***Natural solid fuels:*** The most important solid fuels are natural solid fuels known as fossil coals. These coals according to the formation stages are; anthracite, hard coal, brown coal, lignite coal, peat follows the order.

• ***Artificial solid fuels:*** Coke and wood coal obtained from natural solid fuels.

• ***Biomass solid fuels:*** Biologically derived fuels, such as wood and biomass briquettes/pellets, obtained from industrial waste processing forest and agricultural products.

Solid fuels



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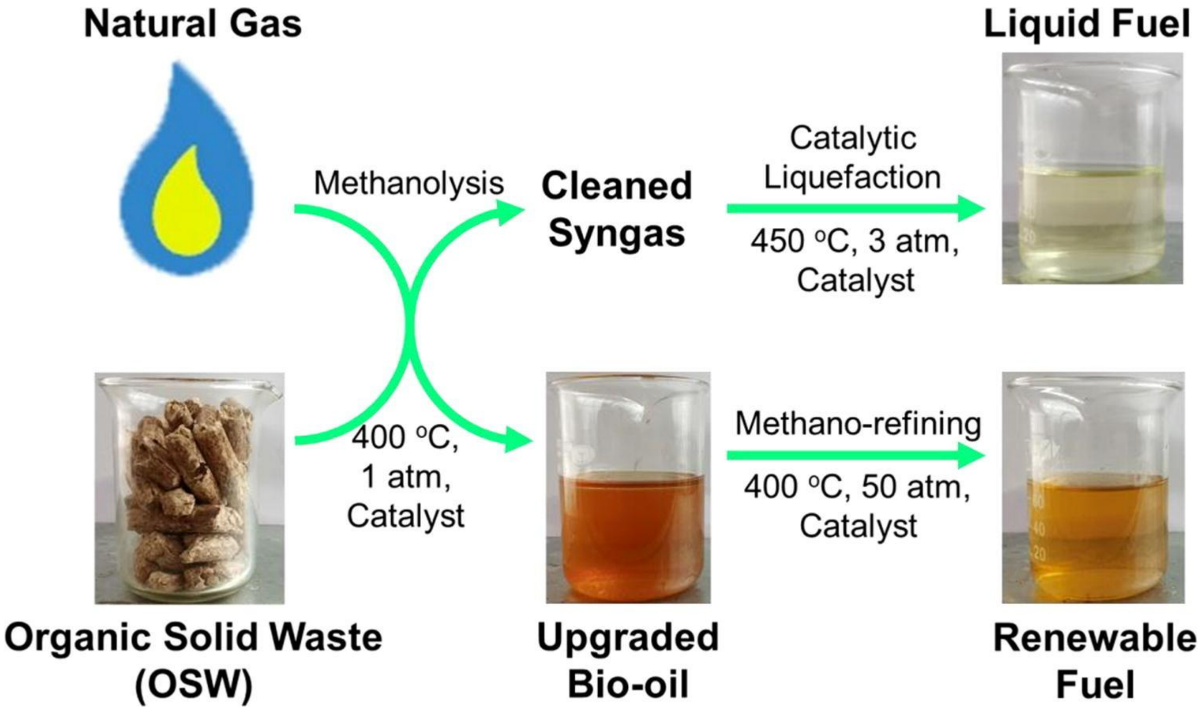
Liquid Fuels



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They are obtained from crude oil and coal tar.

- ***Natural liquid fuels:***
  - They are produced by distillation of crude oil.
- ***Artificial liquid fuels:***

Theyaredividedinto3groupsaccordingtothesource they are produced from:

- Fuels produced by distillation from fuels such as coal.
- Liquid fuels produced by cracking heavy petroleum. products,
- Liquid fuels produced by synthesis process.

Types of Fuel

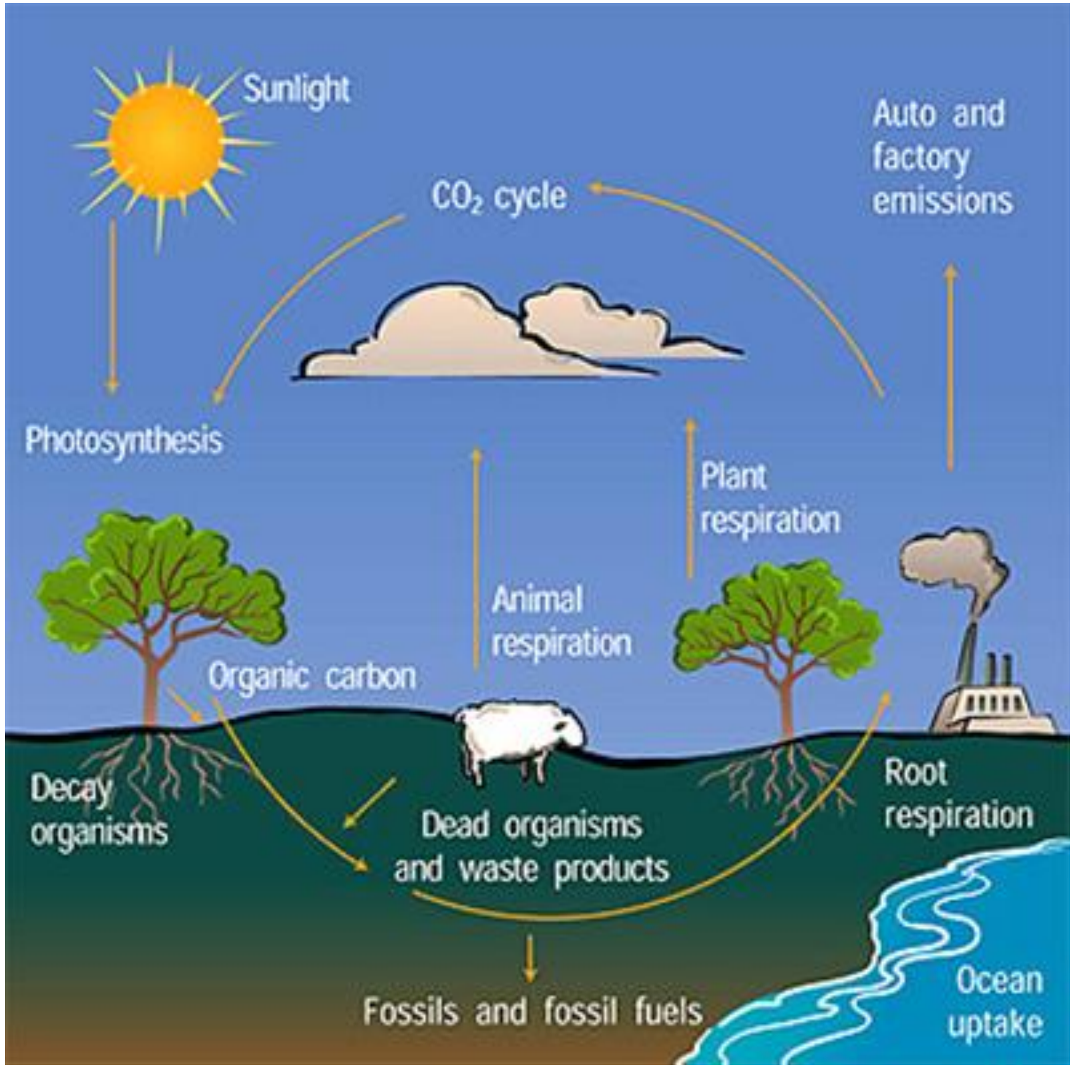
❖ **Gaseous fuels:**

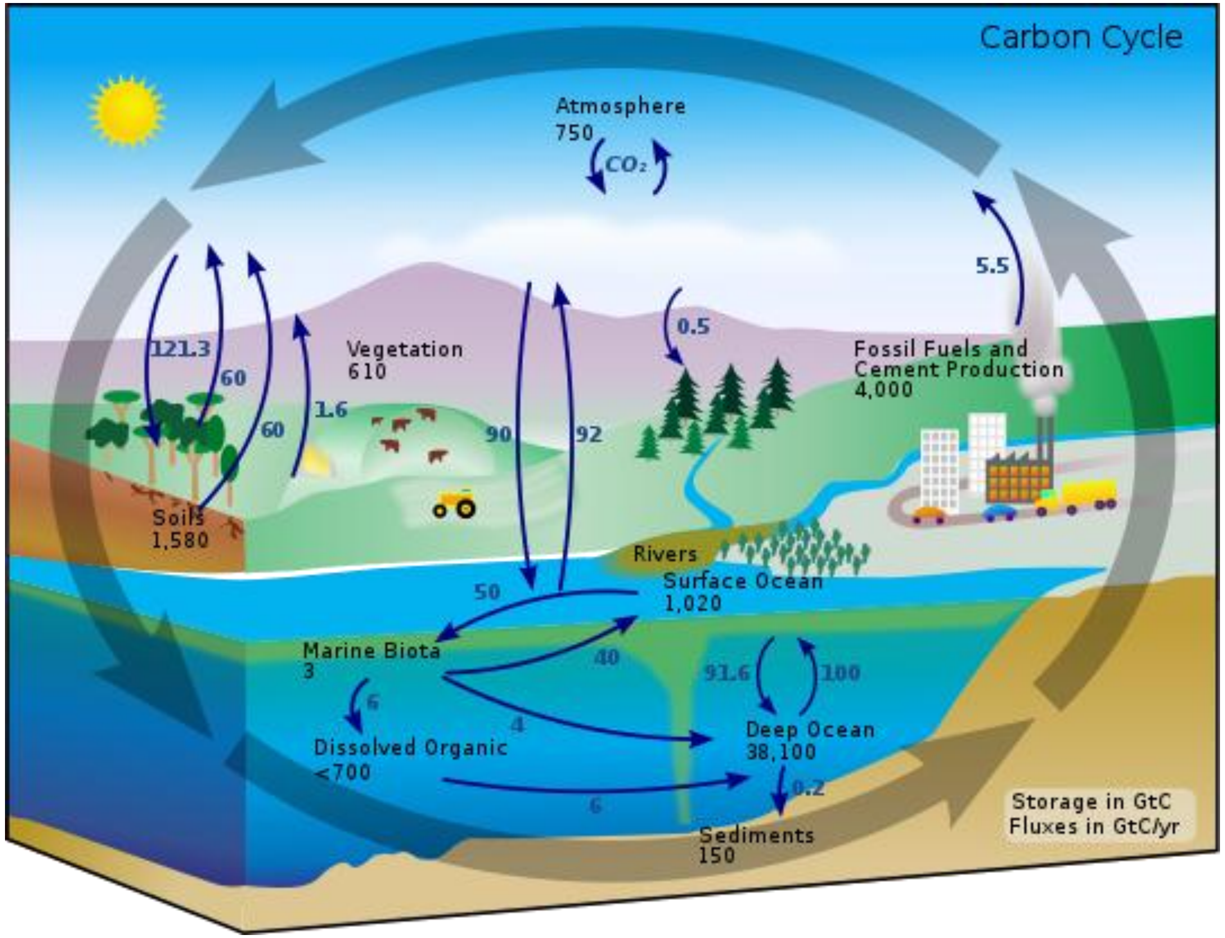
- The gas obtained as a result of the distillation of fossil coals is the gases in the structure of small molecule hydrocarbon mixture which is the product of petroleum distillation and natural ground gases. Gaseous fuel is produced by fermentation (biogas) or gasification of organic materials.

❖ Fossil Fuels

- ❑ Fossil fuels are fuels such as coal, oil, and natural gas. Most of the energy we use today comes from fossil fuels.
- ❑ For millions of years, fossil fuels have been formed with the decay of plants and animals.
- ❑ Fossil fuels can be drilled (drilled) or excavated. Currently, these fuels are formed underground with heat and pressure.
- ❑ However,therateatwhichfossilfuelsareproducedismuchlowerthantheir consumption rate.
- ❑ Therefore, fossil fuels can be considered as non-renewable energy sources in a short time.
- ❑ In particular, population growth, urbanization, and industrialization lead to an increase in the energy requirements of these fuels.
- ❑ In addition to the depletion of fossil fuels and the steady increase in prices, the damage they cause to the environment as a result of their combustion and their impact on human health is also important.

Formation of fossil fuels





Properties of Fuels

❖ **Density**

❑ This is defined as the ratio of the mass of the fuel to the volume of the fuel at a reference tem perature of 15°C. Density is measured by an instrument called hydrometer. The knowledge of density is useful for quantity calculations and assessing ignition quality. The unit of density is kg/m3

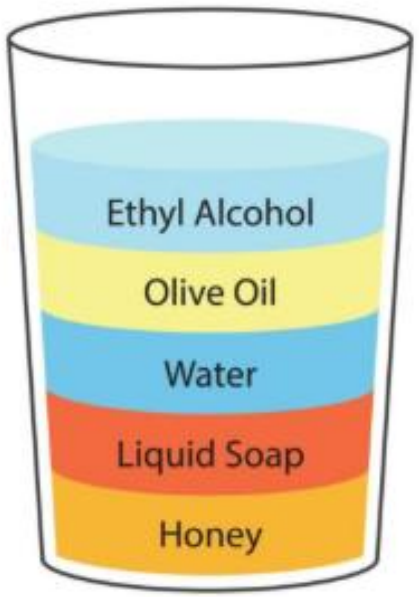
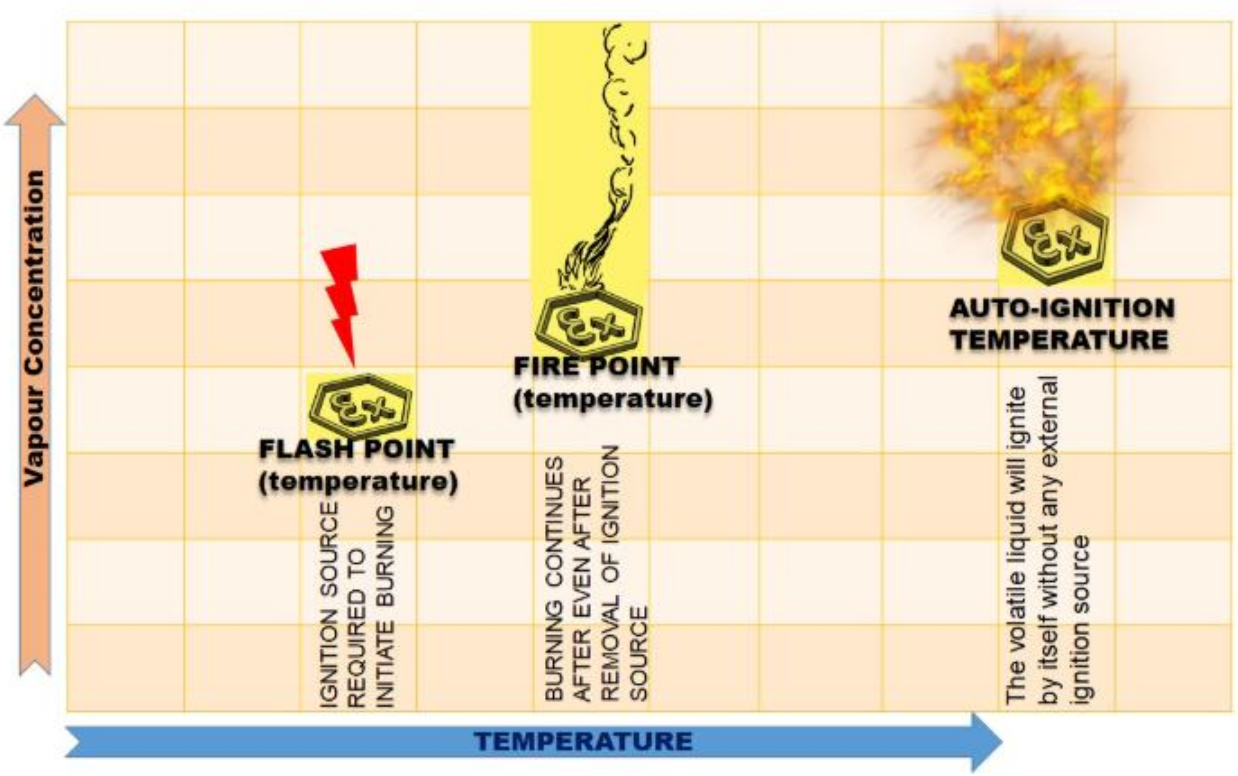


Fig: Density

❑ Density plays a very important part on a ship because the fuel we get on ship has a lot of water content, we can’t take that oil into the main engine so we separate them. The more the density difference between water and fuel the better the separation takes place in a tank called settling tank. Density of oil needs to be 991 kg/m cube and density of water is 1000 kg/m cube.

Properties of Fuels



- ❑ ***Ignition temperature:*** Minimum temperature required to start combustion. Good fuels have moderate ignition temperatures (not too low to avoid accidental ignition, not too high to make ignition difficult).

- ❑ ***Calorific value:*** Amount of heat produced by complete combustion of 1 kg (solid/liquid) or 1 m^3 (gas) of fuel.

❖ *Viscosity*

variety of capillary viscometers

- The viscosity of a fluid is a measure of its internal resistance to flow. Viscosity depends on temperature and decreases as the temperature increases. Any numerical value for viscosity has no meaning unless the temperature is also specified. Viscosity is measured in Stokes / Centistokes. Sometimes viscosity is also quoted in Engler, Saybolt or Redwood. Each type of oil has its own temperature - viscosity relationship. The measurement of viscosity is made with an instrument called Viscometer.

- Viscosity is the most important characteristic in the storage and use of fuel oil. It influences the degree of pre-heat required for handling, storage and satisfactory atomization. If the oil is too viscous, it may become difficult to pump, hard to light the burner, and tough to operate. Poor atomization may result in the formation of carbon deposits on the burner tips or on the walls. Therefore pre-heating is necessary for proper atomization.

Properties of Fuels

Fig: **Flash point**

Fig: **Pour point**

Flash Point :

- The flash point of a fuel is the lowest temperature at which the fuel can be heated so that the vapour gives off flashes momentarily when an open flame is passed over it. Flash point for furnace oil is 66°C.

Pour Point:

- The pour point of a fuel is the lowest temperature at which it will pour or flow when cooled under prescribed conditions. It is a very rough indication of the lowest temperature at which fuel oil is readily pumpable.

Properties of Fuels

FLASH POINT, FIRE POINT, AND AUTO IGNITION TEMPERATURE

FLASH POINT
The minimum temperature at which a flammable liquid gives off sufficient vapour which ignite 'MOM-ENTARILY"

FIRE POINT
The minimum temperature at which a flammable liquid will generate enough vapors above it which in presence of an ignition source Can 'CONINUE THE COMBUSTION

AUTO IGNITION TEMPERATURE
The minimum temperaturæ at which a flammable liquid can ignite without any source of ignition

ALWAYS AUTO IGNITION TEMPERATURE > FIRE POINT TEMPERATURE > FLASH POINT TEMPERATURE

FLASH POINT, FIRE POINT, AUTO IGNITION TEMPERATURE OF DIFFERENT CHEMICALS

CHEMICAL	FLASH POINT (°C)	FIRE POINT (°C)	AUTO IGNITION TEMPERATURE (°C)
Gasollne	−43	~-40	apro. 280-470
Ethanol	13	~ 16	363
Acetone	−20	~-17	465
Diesel	52 -96	~ 62	210
Kerosene	apro.-72	~ 42	~ 220

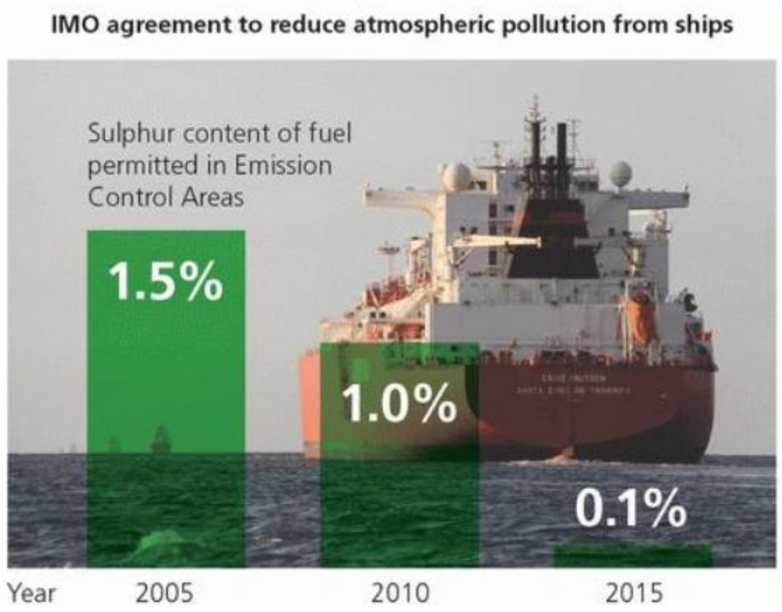
Properties of Fuels

❖ Sulfur content

The amount of sulfur in the fuel oil depends mainly on the source of the crude oil and to a lesser extent on the refining process. The normal sulfur content for the residual fuel oil (furnace oil) is in the order of 2-4 %.

Fuel oil	Percentage of Sulphur
Kerosene	0.05 – 0.2
Diesel Oil	0.05 – 0.25
L.D.O	0.5 – 1.8
Furnace Oil	2.0 – 4.0
LSHS	< 0.5

- ➢ Sulfur Content Should be low to prevent corrosion and pollution (SO_2 emissions).



- ❑ **Ash content:** Non-combustible residue; low ash improves combustion efficiency.
- ❑ **Combustion products**: Good fuels should produce minimal harmful gases like CO, SO_2, or unburnt hydrocarbons.

Calorific value

- Organic carbon (C) is the main substance of fuels. The reaction of organic carbon with oxygen (O2) produces heat. The reaction heat released in this way is utilized in various processes. The energy value per unit mass or volume of fuels is called the heating (calorific) value. The heating value of the fuel is defined as the heat energy produced when the combustion products are brought to ambient temperature as a result of the complete combustion of the fuel in mass or volume. In practice, the heat is divided into upper and lower heating values (LHV).

- The higher heating value (HHV) is the amount of heat released when 1 kg or m3 of fuel at a given temperature is mixed with the minimum air required for full combustion, without any heat loss, and the combustion products are cooled to the initial degree and condensed water vapor in the mixture.

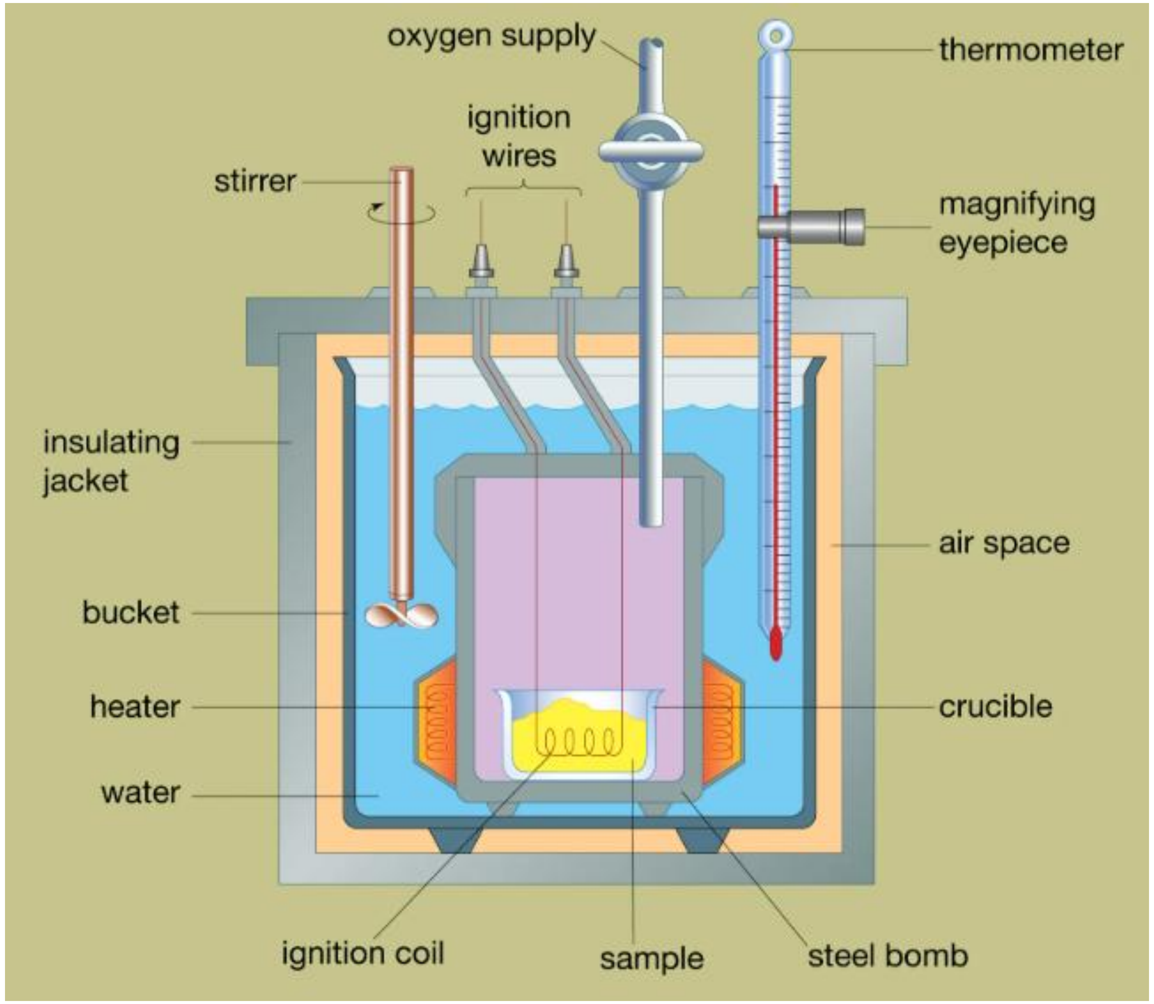
- ***Higher Calorific Value (HCV or GCV):*** Includes latent heat of condensation of water vapor.

- ***Lower Calorific Value (LCV or NCV):*** Excludes latent heat; hence, always lower than HCV.

    - **Units:** kJ/kg (solids & liquids)
      kJ/m^3 (gases).

Calorific value Determination

❖ **Bomb Calorimeter**



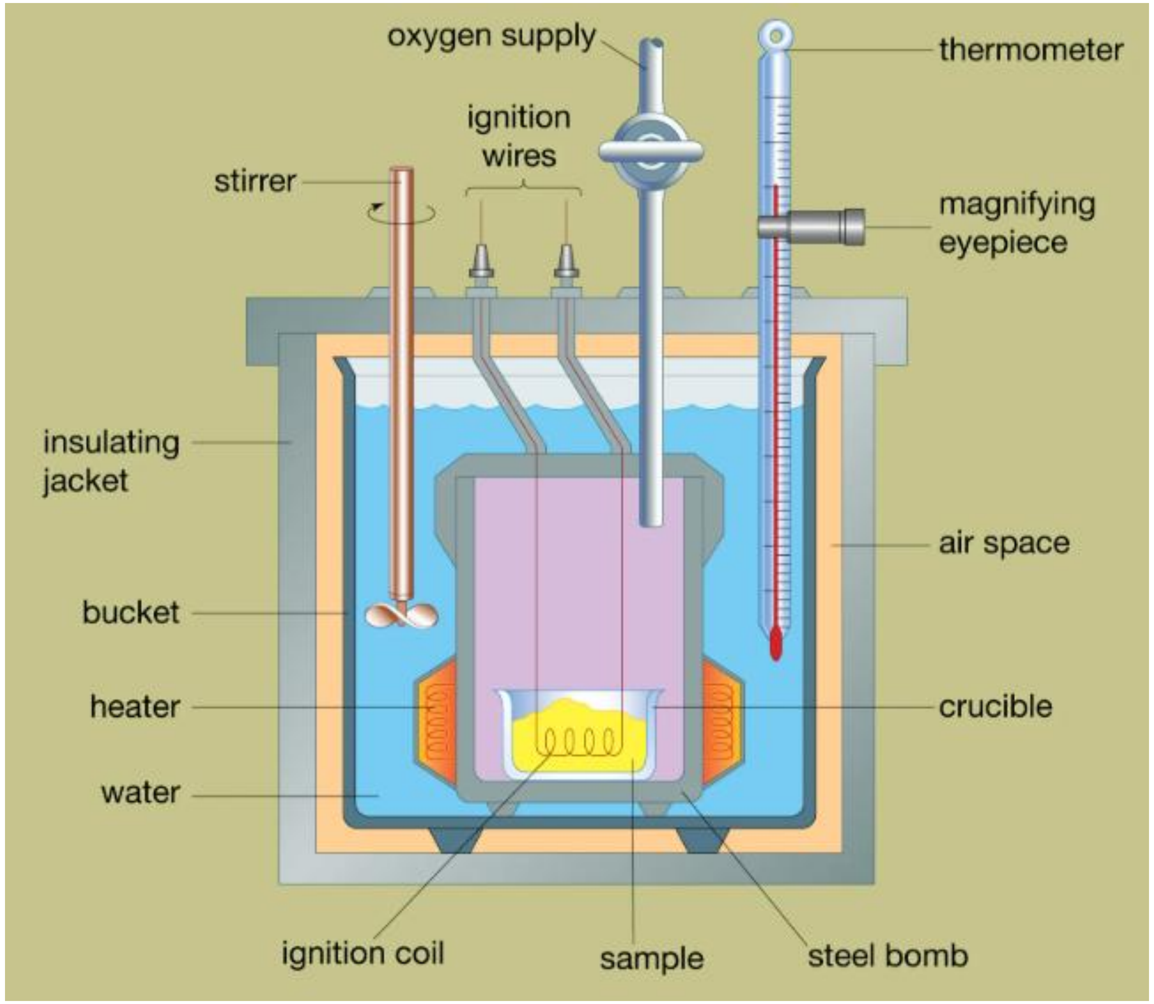
- ***Bomb Calorimeter*** (for solid & liquid fuels).
- ***Boy's Calorimeter*** (for gaseous fuels).

- A **Bomb Calorimeter** is a laboratory device used to measure the **higher calorific value (HCV)** of solid and liquid fuels.
- It works by burning a known mass of fuel in a sealed chamber (bomb) under controlled conditions and measuring the heat released.
- Named "bomb" because combustion occurs in a **strong, thick-walled steel vessel** that can withstand high pressures.

https://www.sciencedirect.com/topics/engineering/bomb-calorimeter

Bomb calorimeter

❖ **Bomb Calorimeter**



Principle

- The principle is based on the **First Law of Thermodynamics** (energy conservation).
- Heat released by combustion of fuel = Heat absorbed by water + Heat absorbed by calorimeter parts.

Mathematically:

$$Q_{fuel} = (m_w \cdot C_w + W) \cdot \Delta T$$

Where:

- m_w = mass of water (kg)
- C_w = specific heat of water (kJ/kg·K)
- W = water equivalent of calorimeter (kJ/K)
- ΔT = temperature rise (°C or K)

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