Chapter-12 Fuel

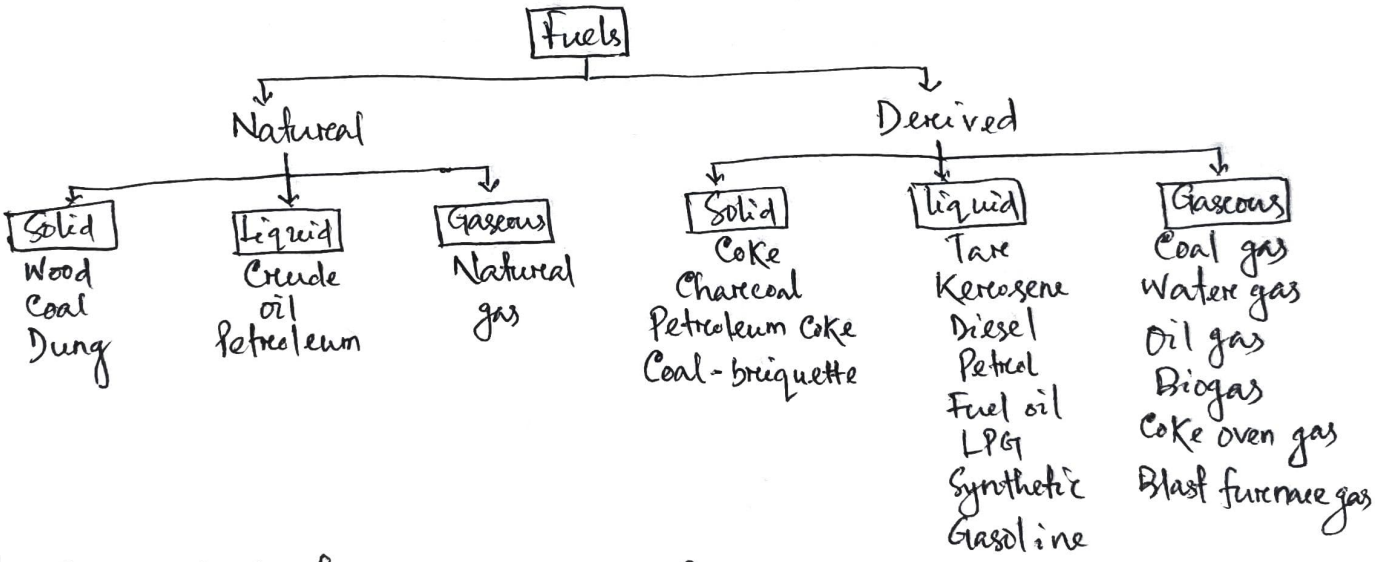
Introduction: A fuel is a source of heat energy. Fuels may be Chemical fuels or nuclear fuels. A chemical fuel produces heat energy as a result of chemical reaction like oxidation. The heat energy produced in a chemical reaction is only limited. On the other hand, nuclear fuels produce a tremendous amount of energy as a result of nuclear fusion and fission.

We know fuels are required for burning purposes. Examples of such fuels include wood, coal, Kerosene, gasolin etc. Chemical fuels are combustible substances. Generally, carbon and hydrogen in the fuel produce carbon dioxide and water alongwith a large quantity of heat.

$$\text{Fuel} + O_2 \longrightarrow \text{Products} + \text{Heat}.$$

Definition: Fuel may be defined as any substance which on combustion release a large amount of heat energy without producing excess residue or by-products.

Classification of Fuels:



A. On the basis of their occurence, fuels may be classified into two categories

1. **Natural Fuels:** Such fuels are found in nature.
   Ex:- Wood, Coal, Petroleum, natural gas etc.
2. **Artificial Fuels:** Such fuels are prepared from natural fuels.
   Ex:- Coke, Kerosene, Petrol, Water gas, Producer gas etc.

B. Based on their physical state, fuels may be classified into three categories:

1. **Solid fuels:** Fuels which are found in their solid state at room temperature are generally referred to as solid fuels.
   Ex:- Wood, Coal, Charcoal, Straw etc.

2. Liquid Fuels: Most of the liquid fuels are derived from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust.

Ex:- Petroleum, Kerosene, Petrol, Diesel, Alcohol etc.

3. Gaseous Fuels: Most of the gaseous fuels are composed of hydrocarbons, carbon monoxide, hydrogen, or a mixture of them all.

Ex:- Natural gas, Coal gas, Producer gas, Water gas, Hydrogen etc.

* Calorific value of fuel:

It may be defined as "the amount of heat energy produced by the complete combustion of a unit mass or unit volume of fuel in air."

Units of Calorific value are: Cal/gm, Kcal/kg, KJ/kg, B.Th.U/lb (British Thermal Unit / Pound)

or "the amount of heat energy released by the complete combustion of one gram of the fuel".

* Example: In the combustion of octane, C_8H_{18}, a component of gasoline, the thermochemical equation is:

$$2\,C_8H_{18(l)} + 25\,O_{2(g)} \longrightarrow 16\,CO_{2(g)} + 18\,H_2O_{(l)} \; ; \; \Delta H = -10,920\,KJ$$

2×114

Therefore, calorific value of $C_8H_{18(l)}$ is $= \frac{10,920}{2\times114} = 47.9\ KJ/gm$.

* Characteristics of good fuel/Choice of good fuel:-

1. It should have high calorific value.
2. It should be cheap and readily available.
3. It should leave only small amount of residue or ash when burent.
4. It should have a controllable combustion rate.
5. It should not produce harmful combustion products.
6. It should not produce much smoke.
7. It should have moderate ignition temperature.
8. It should not be explosive in nature.
9. It should have low moisture content.
10. It should require low storage volume.
11. It should be easy to transport.

* Composition and uses of some liquid fuels:

1. Diesel:
   - It contains a mixture of hydrocarbons between pentadecane to octadecane ($C_{15}H_{32}$ to $C_{18}H_{38}$).
   - Average Composition: C = 85%, H = 12%, Rest = 3%.

→ Calorific value = 11,000 Kcal/Kg.

Uses: It is used as a fuel in diesel engine.

2. Petrol or Gasoline:

→ It contains a mixture of hydrocarbons between pentane to octane. (C_5H_{12} to C_8H_{18})

→ It is volatile and inflammable.

→ Average composition: C = 84%, H = 15%, O + S + N = 1%.

→ Calorific value = 11,250 Kcal/Kg.

Uses:

→ It is used as a fuel for internal combustion engines of automobiles.

→ It is used as a dry-cleaning agent.

3. Kerosene:

→ It consists of hydrocarbons between decane to hexadecane ($C_{10}H_{22}$ to $C_{16}H_{34}$)

→ Average composition, C = 84%, H = 16%, S < 0.1%.

→ Calorific value = 11,100 Kcal/Kg.

Uses:

→ It is used as a domestic fuel in stoves.

→ It is used as a jet engine fuel for making oil gas.

* Composition and uses of some gaseous fuels:

1. Water gas:

(i) It is a mixture of combustible gases; CO and H_2 with a little quantity of non-combustible gases like CO_2 and N_2.

(ii) The average composition of water gas is:

H_2 = 51%, CO = 41%, CO_2 = 4% and N_2 = 4%.

(iii) Its calorific value is 2800 Kcal/m^3.

Uses: It is used:

→ as a source of H_2 gas.

→ as a fuel.

→ as an illuminating gas.

→ for welding purposes.

2. Producer gas:

(i) It is a mixture of combustible gases; CO and H_2 with large quantities of non-combustible gases; CO_2 and N_2.

(ii) The avg. composition of producer gas is:

CO = 22-30%, H_2 = 8-12%, N_2 = 52-55% & CO_2 = 3%.

(iii) Its calorific value is 1,300 Kcal/m^3.

Uses: It is used:
⇒ for heating open-hearth furnaces in steel and glass manufacture, muffle furnace in coke and coal gas manufacture.
⇒ As a reducing agent in metallurgical operations.

3. Coal gas:
(i) It is a mixture of a no. of hydrocarbons along with H_2, N_2, CO and CO_2.
(ii) It is a colourless gas and burns with a sooty flame.
(iii) The avg. composition of coal gas is:
H_2 = 40%, CH_4 = 32%, CO = 7%, C_2H_2 = 2%, C_2H_4 = 3%, N_2 = 4%, CO_2 = 1% and reest = 11%.
(iv) Its calorific value is 4900 Kcal/m^3.

Uses: It is used:
⇒ as a fuel.
⇒ as a reducing agent in metallurgical operations.
⇒ as an illuminant.

4. LPG (Liquified Petroleum gas):
(i) It is mainly C3, C4 hydrocarbons of alkane and alkene.
(ii) It is highly inflammable.
(iii) It is colourless and odourless but a smelling agent called ethyl mercaptan (C_2H_5SH) is added to it to detect the leakage.
(iv) The avg. composition of LPG is:
n-butane = 27%, iso-butane = 25%, butene = 43%, propene = 2.5% & propane = 2.5%.
(v) Its calorific value is 27,800 Kcal/m^3.

Uses: It is used:
⇒ As a domestic fuel.
⇒ As an industrial fuel.
⇒ As a vehicular fuel.

5. CNG (Compressed Natural Gas):
(i) It is a colourless, odourless gas and burns with a pale blue flame.
(ii) The avg. composition of CNG is:
CH_4 = 70-90%, C_2H_6 = 4-9% and traces of propane and butane.
(iii) Its calorific value is 12,500 Kcal/m^3.

Uses: It is used:
⇒ as a fuel in low emissive vehicles like ULEV (Ultra-Low emission vehicles).
⇒ as a domestic and industrial fuel.
⇒ as a source of carbon in tyre industry.
⇒ for the production of H_2 gas needed in fertilizer industry.