FUELS

(PART - I)

Brotati Chakraborty
Department of Chemistry
Bejoy Narayan Mahavidyalaya, Itachuna, Hooghly

Sem V General (DSE-1A)

Definition: A fuel can be defined as a combustible substance containing carbon as the major constituent which is capable of releasing a large amount of heat that can be used for domestic and industrial needs.

Example: wood, charcoal, coal etc.

CLASSIFICATION OF FUELS

on the basis of occurrence

primary/natural

occur in nature

Eg: wood, coal, petroleum, natural gas etc.

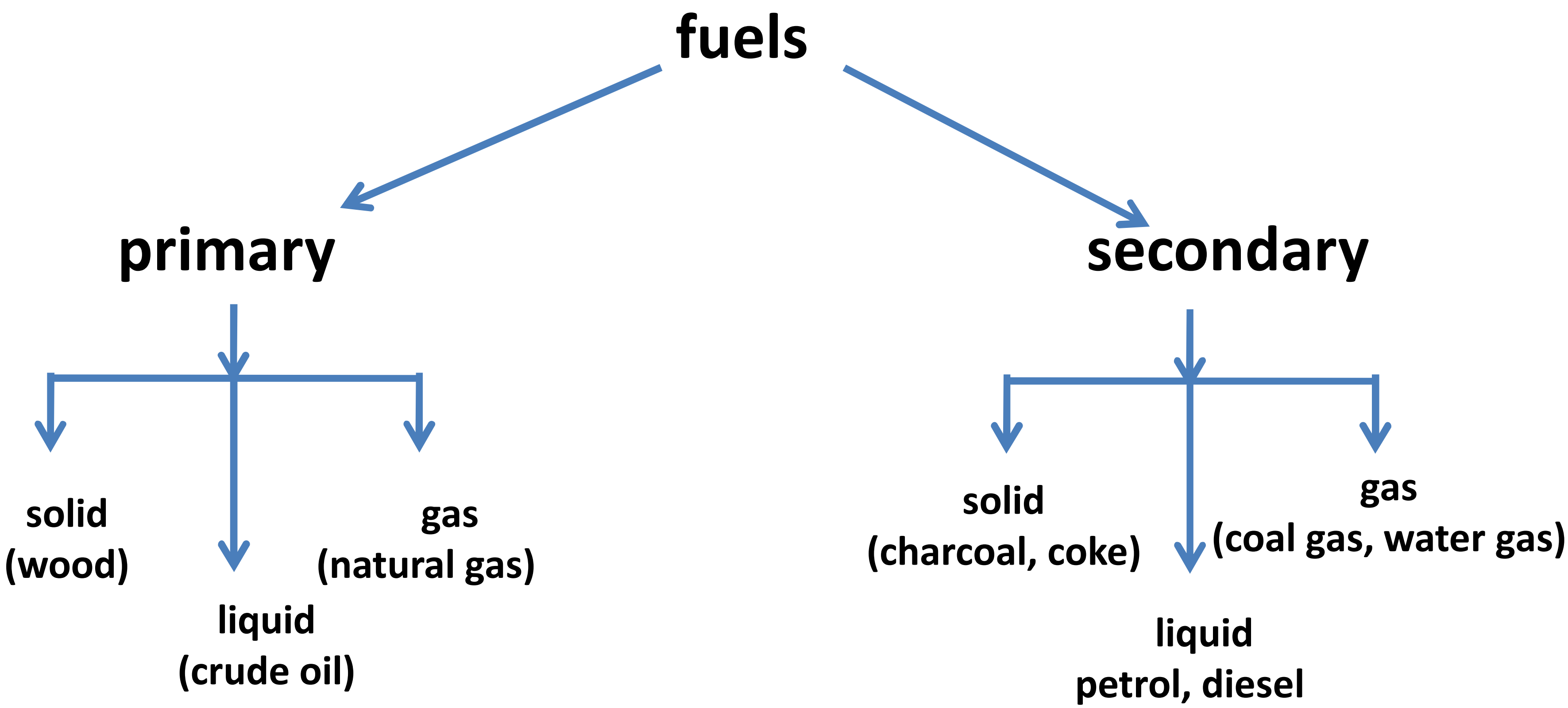
secondary /artificial

derived from primary fuel by chemical processing

Eg: coke, kerosene oil, petrol, coal gas, producer gas etc.

CLASSIFICATION OF FUELS

on the basis of state of aggregation



Calorific value

- Calorific value of a fuel is defined as the total quantity of heat liberated from the complete combustion of a unit mass or unit volume of the fuel in sufficient air or oxygen.

- It determines the efficiency of a fuel.

- Calorific value of solid and non-volatile liquids are determined by 'bomb calorimeter'.

- Calorific values of gaseous and volatile liquids are determined by 'Boy's gas calorimeter'.

- Two types of calorific values are there. They are:

1. Gross Calorific Value(GCV)/Higher Calorific Values (HCV)
2. Net Calorific Value (NCV)/ Lower Calorific Value (LCV)

Gross Calorific Value(GCV)/Higher Calorific Values (HCV)

It is the total amount of heat liberated when a unit quantity (unit mass or unit volume) of fuel is completely burnt in oxygen or air, and the products of the combustion *are cooled down to that room temperature*.

Net Calorific Value (NCV)/ Lower Calorific Value (LCV)

It is the net heat produced when a unit quantity (unit mass or unit volume) of fuel is completely burnt and the products of combustion *are allowed to escape*.

- Almost all fuels contain hydrogen. During combustion, hydrogen gets converted to steam. Now when the products of combustion are cooled down to room temperature, the steam gets condensed into water and latent heat is evolved. Thus, GCV includes latent heat of steam.

- When the combustion products are allowed to escape, steam also escapes with the hot combustion gas.

$$NCV = GCV - \text{latent heat of water vapour formed}$$

$$NCV = GCV - 0.09\ \mathrm{H} \times 587$$

where, H is the % of hydrogen in the fuel

latent heat of steam is 587 kcal/kg

$$GCV = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S\right] Kcal/kg$$

where C, H, O and S are the percentages of carbon, hydrogen, oxygen and sulphur in the fuel.

Q1. Calculate the GCV and NCV of a coal sample having the following compositions: C=83%, H=6%, O=5%, S=2.5%, N=2% and ash =1.5%.

$$GCV = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S\right]$$

$$GCV = \frac{1}{100}\left[8080 \times 83 + 34500\left(6 - \frac{5}{8}\right) + 2240 \times 2.5\right]$$

$$GCV = 8616.8 Kcal/kg$$

$NCV = GCV - 0.09\ \text{H} \times 587$

$= 8616.8 - (0.09 \times 6 \times 587)$

$= 8300$ Kcal/kg

Q2. A sample of coal has the following composition by weight: C = 90%, O= 4%, S = 0.5%, N =1 % and ash = 1%. NCV of coal was found to be 9450 Kcal/kg. Calculate the percentage of hydrogen and GCV of coal.

$$GCV = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S\right]$$

$$GCV = \frac{1}{100}\left[8080\times 90 + 34500\left(H - \frac{4}{8}\right) + 2240\times 0.5\right]$$

$$GCV = [7110.7 + 345H]Kcal / kg$$

GCV = [Net calorific value + ($0.09H \times 587$)] Kcal/ kg

= [9450 + ($0.09H \times 587$)] Kcal/ kg

= [9450 + 52.83 H] Kcal/ kg

Therefore, 7110.7 + 345 H = 9450 + 52.83 H

$H = 2339.3/292.17 = 8\%$

GCV = 7110.7 + (345×587) = 9870.7 Kcal/ kg

Characteristics of a good fuel

1. High calorific value
2. Moderate ignition temperature
3. Low moisture content
4. Moderate rate of combustion
5. Harmless combustion product
6. Low cost
7. Controllable combustion
8. Low smoke value
9. Uniform size
10. Low non-combustible matter (like ash) content

COAL (SOLID FUEL)

- Naturally occurring
- It is a *fossil fuel* as it is formed from fossilised remains of animals and plants.
- The transformation of vegetable debris to coal takes place in two stages.

1. Biochemical/Peat stage: The cellulosic plant materials are attacked by various microorganism and under anaerobic conditions, transformed into peat.

$$\underset{\text{cellulose}}{2(C_6H_{10}O_5)_n} \rightarrow \text{peat}$$

2. Chemical stage: Peat buried under sedimentary deposits lose moisture and volatile components under high temperature (>300 ºC) and pressure over a very long time.

- With due course of time the peat gets enriched in carbon and oxygen content gets decreased and spongy peat turns into coal. Time required is of the order $10^7 – 10^8$ years.

- The rank is the qualitative measure of carbon content in coal and is defined as *the extent of maturation*.

- Soft coal (*Low rank coal*): Low % of carbon – peat, lignite etc.

- Hard coal (*High rank coal*): High % of carbon – bituminous, anthracite etc.

- vegetation $\rightarrow$ cellulose $\rightarrow$ peat $\rightarrow$ lignite $\rightarrow$ bituminous $\rightarrow$ anthracite

Carbonisation of coal

- The process of converting coal into *coke* is called carbonisation.

- Coal is heated in absence of air to a sufficiently high temperature, under which coal undergoes decomposition and yield lustrous, dense, porous and coherent mass richer in carbon content than the original coal known as *coke*.

- Properties of coke depends on:

1. Type of coal used
2. Temperature of carbonisation
3. Rate of carbonisation

- Objectives of carbonisation:

1. Coal does not possess as much porosity and strength as coke.
2. Undesirable S is removed.
3. Coke burns with a short flame.

- Depending on temperature, there are two types of carbonisation:

1. Low temperature carbonisation (LTC)
2. High temperature carbonisation (HTC)

Characteristics	LTC	HTC
Heating temperature	500 - 700 ℃	900 - 1200 ℃
Yield of coke	75 – 80 %	65 – 75 %
Volatile matter content in coke	5 – 15 %	1 – 3 %
Mechanical strength of coke	Poor	Good
Use of coke	Domestic	Metallurgical purpose
Hardness of coke	Soft	Hard
Smoke produced on burning coke	Smokeless	Smoky
Calorific value of gas	6500 – 9500 kcal/m^3	5400 – 6000 kcal/m^3