FUELS AND COMBUSTION

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FUELS

Definition:

A combustible substance which when combusted completely produces large amount of heat energy which can be utilised economically for domestic as well as industrial purposes

During the process of combustion of a fuel, the elements carbon, hydrogen, etc combine with oxygen with simultaneous liberation of heat.

$$C + O_2 \text{ -----> } CO_2 + \text{energy}$$

$$2H_2 + O_2 \text{ -----> } 2H_2O + \text{energy}$$

FUELS

Classification:

- <u>On the basis of physical state -</u>

1. Solid fuels
2. Liquid fuels
3. Gaseous fuels

- <u>On the basis of source -</u>

1. Primary fuels – obtained from natural source
2. Secondary fuels – obtained from primary fuels

	SOLID	LIQUID	GASEOUS
PRIMARY	Wood, Coal	Petroleum (Crude oil)	Natural gas
SECONDARY	Charcoal, Metallurgical Coke	Petrol, Diesel, Kerosene	LPG, Water gas, Producer gas

Characteristics of a good fuel

- High Calorific Values
- Moderate Ignition Temperature
- Low Moisture Content
- Low Ash Content
- Moderate Velocity of Combustion
- Should not produce harmful products
- Low Cost
- Easy Storage & Transportation
- Easily Controllable

Calorific Value (C.V.)

Definition:

Calorific value is defined as the amount of heat energy generated when a unit quantity of fuel is completely oxidized (combusted).

Units of Calorific Value:

System	Solid/Liquid Fuels	Gaseous Fuels
CGS	Calories/gm	Calories/cm^3
MKS	k cal/kg	k cal/m^3
B.T.U	BTU/lb	BTU/ft^3

Higher and Lower Calorific Value

- **Higher Calorific Value or Gross Calorific Value (HCV or GCV)**

Higher Calorific value is defined as the total amount of heat energy generated when a unit quantity of fuel is completely oxidized (combusted) and products of combustion are allowed to cool to room temperature. (Latent heat of water vapour is taken into consideration)

- **Lower Calorific Value or Net Calorific Value (LCV or NCV)**

Lower Calorific value is defined as the total amount of heat energy generated when a unit quantity of fuel is completely oxidized (combusted) and products of combustion are allowed to escape to atmosphere. (Latent heat of water vapour is not taken into consideration)

- **LCV = HCV - Latent heat of condensation of water vapour produced**

Relation between HCV & LCV

Let the % of Hydrogen in fuel sample = H

Therefore amount of hydrogen in unit quantity of fuel

= H/100

Therefore amount of water vapour produced by unit quantity of fuel on complete combustion

= 9H/100 -------- ($H_2 + ½ O_2$ -----> H_2O)

Now, Latent heat of water Condensation = 587 kcal/kg

Therefore amount of heat energy liberated when water vapour from unit quantity of fuel is condensed

= 587 x 9H/100

$$\boxed{LCV = HCV - (587 \times 9H/100)}$$

Dulong's formula for calculation of HCV (kcal/kg)

$$HCV = 1/100\ [8080\ C + 34500\ (H - O/8) + 2240\ S]\ \text{kcal/kg}$$

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

- In this formula, oxygen is assumed to be present in combination with hydrogen as water
- $LCV = [\,HCV - 9H/100 \times 587]\ \text{kcal/kg}$

  $= [\,HCV - 0.09\ H \times 587]\ \text{kcal/kg}$

Numericals (Dulong's formula)

1. Calculate the higher and lower calorific value of a coal which analyses: C = 74%, H = 6%, N = 1%, O = 9%, S = 0.8%, moisture = 2.2% and ash = 8%.

Solution:

HCV = 1/100 [8080 C + 34500 (H – O/8)+ 2240 S] kcal/kg

= 1/100 [8080 x 74 + 34500 (6 – 9/8)+ 2240 x 0.8] kcal/kg

= 1/100 [597920 + 168187.5 + 1792] kcal/kg

= 7678.995 kcal/kg

LCV = HCV – (587 x 9H/100)

= 7678.995 – 316.98

= 7362.015 kcal/kg

Numericals (continued…)

2. A sample of coal has following analysis:

LCV = 8277.80 kcal/kg, C = 70 %, O = 8 %, N = 3%, S = 2% and Ash = 7 %. Calculate %H & HCV.

Solution:

$$HCV = 1/100\ [8080\ C + 34500\ (H - O/8) + 2240\ S]\ kcal/kg \qquad \text{-------}\ 1$$

$$HCV = LCV + (587 \times 9H/100) \qquad \text{-------}\ 2$$

Solving above equations simultaneously,

H = %

HCV = kcal/kg