

# **FUELS AND COMBUSTION**

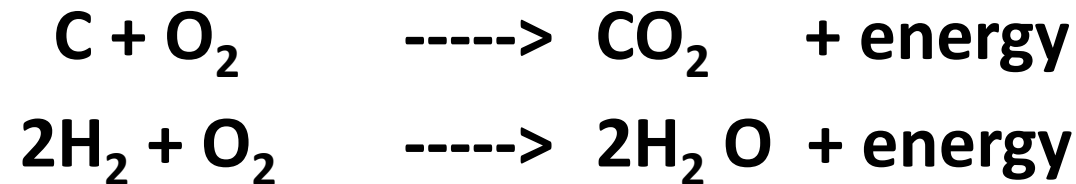
**DR. ANUPAMA SAWANT**

# 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.**



# FUELS

## Classification:

- On the basis of physical state -

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

- On the basis of source -

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 <sup>3</sup>
MKS	k cal/kg	k cal/m <sup>3</sup>
B.T.U	BTU/lb	BTU/ft <sup>3</sup>

# 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)

- $LCV = HCV - \text{Latent heat of condensation of water vapour produced}$

## 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

$$= 9H/100 \quad \text{-----} (H_2 + \frac{1}{2} O_2 \text{ -----} \rightarrow H_2 O)$$

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

$$= 587 \times 9H/100$$

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

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

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

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
- $\text{LCV} = [\text{HCV} - 9\text{H}/100 \times 587] \text{ kcal/kg}$   
 $= [\text{HCV} - 0.09 \text{ H} \times 587] \text{ kcal/kg}$



## 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:

$$\begin{aligned}\text{HCV} &= 1/100 [8080 \text{ C} + 34500 (\text{H} - \text{O}/8) + 2240 \text{ S}] \text{ kcal/kg} \\ &= 1/100 [8080 \times 74 + 34500 (6 - 9/8) + 2240 \times 0.8] \text{ kcal/kg} \\ &= 1/100 [597920 + 168187.5 + 1792] \text{ kcal/kg} \\ &= 7678.995 \text{ kcal/kg}\end{aligned}$$

$$\begin{aligned}\text{LCV} &= \text{HCV} - (587 \times 9\text{H}/100) \\ &= 7678.995 - 316.98 \\ &= 7362.015 \text{ kcal/kg}\end{aligned}$$

## 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:

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

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

Solving above equations simultaneously,

$$\text{H} = \quad \%$$

$$\text{HCV} = \quad \text{kcal/kg}$$