3. Gaseous Fuels

Gaseous fuels consist of natural gas, blast furnace gas, coal gas, producer gas etc…… The gaseous fuels can be classified as follows:

*1. **Natural** >>>>>>> Natural gas.*

*2. **Prepared** >>>>>> Blast furnace gas , Coal gas , Producer gas.*

Natural Gas:

*Natural gas comes out of **gas wells** and **petroleum wells**. It is mainly composed of:*

Methane (CH4)= 85%

Ethane (C2 H6) = 10% and,

Other hydrocarbons = 5%

It is colourless and non-poisonous.

The calorific value of natural gas is 525 Kcal/m^3

Blast Furnace Gas:

This gas is obtained as a by – product from blast furnace used for producing pig iron. The approximate composition of blast furnace gas is:

Carbon monoxide (CO) = 30%

Carbone dioxide (CO2) = 2%

Nitrogen (N2)= 52%

Hydrogen (H2)= 3% , and

Methane (CH4)= 3%

The calorific value of blast furnace gas is 970 Kcal/m^3

Coal Gas:

Coal gas is a by-product gas obtained during the destructive distribution of coal. The approximate composition of coal gas is:

Carbon monoxide (CO)= 8%

Carbone dioxide (CO2) = 2%

Nitrogen (N2)= 6%

Hydrogen (H2)= 45% , and

Methane (CH4)= 35% , and

Other hydrocarbons = 4%

The calorific value of blast furnace gas is 7600 Kcal/m^3

Producer Gas:

Producer gas is produced during incomplete combustion of coke in current of air; the main constituents are nitrogen and carbon monoxide. The approximate composition of coal gas is:

Carbon monoxide (CO)= 23%

Carbone dioxide (CO2) = 5%

Nitrogen (N2)= 62 %

Hydrogen (H2)= 6% , and

Methane (CH4)= 4% , and

Other hydrocarbons = 4%

The calorific value of blast furnace gas is 1200 Kcal/m3

Advantages of Gaseous fuels over solid fuels:

1. *It is easy to control the length and nature of the flame, then easily control on the temperature.*
2. *Gaseous fuels do not contain ash and other foreign matter and burn completely. Their used is economical as compared to solid and liquid fuels. No ash removal is required.*
3. *Handling of gaseous fuel is not required as they can be easily piped into the furnace.*
4. *Lesser amount of excess air is needed to burn them completely.*
5. *Greater cleanliness is assured as the soot and smoke is practically nil.*

Calorific Value of Fuel (Heating Value):

Calorific Value:

*The **calorific value** of the fuel is defined as the amount of heat produced when unit quantity (one kilogram of solid or liquid fuel or one cubic meter of gaseous fuel) if fuel is completely burnt under standard conditions*. It is the most important characteristic property of any fuel.

Calorific value may be defined as ***"the amount of heat liberated by the complete combustion of a unit mass of a fuel".***

The quantity of heat can be measured by the following units.

i. Calorie

ii. Kilocalorie

iii. British thermal units

iv. Centigrade heat units

Calorie

The amount of the heat required to raise the temperature of 1gm of water through 1OC (15 to 16 OC). *The calorific value is expressed as Kcal per kg or Kcal per cubic meter of gaseous fuel. The calorific value of a fuel can be classified in two ways:*

1. Higher Calorific Value (H.C.V.)

2. Lower Calorific Value (L.C.V.)

***1. The higher or grass of calorific value** (HCV or GCV):*

It is the total amount of heat produced when unit quantity of fuel is burnt completely and the products of combustion have been cooled to the room temperature, generally taken as 15 oC.

Dulong's formula (Theoretical calculation)

Dulong's formula for the theoretical calculation of calorific value is:

According to dulong formula, the calorific value of a fuel is given by the following relation:

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

*Where **C, H, O,** and **S** represent the % by weight of carbon, hydrogen, oxygen and sulphur respectively. It is based on the assumption that the calorific values of C, H & S are found to be 8080, 34500 and 2240 kcal, when 1 kg of the fuel is burnt completely.*

However, all the oxygen in the fuel is assumed to be present in combination with hydrogen in the ratio H : O as 1 : 8 by weight.

2. Net or The lower calorific value *(NCV or LCV):*

It is the net amount of heat produced when unit quantity of fuel is completely burnt and the products of combustion are not cooled to room temperature but are allowed to escape.

The net or lower calorific value (L.C.V.) is obtained by subtracting from H.C.V. the heat carried by the products of combustion especially by steam which can be taken as 588.76 Kcal/kg of water vapors formed due to burning of 1 kg of fuel.

$$\therefore L.C.V. = (H.C.V. - 587 * W)\ cal/kg$$

Where W is the amount of water vapors formed by the combustion of 1 kg of fuel.

Where, $W = (m + 9H_2)\ g$
m = *mass of moisture, / kg of fuel*
H_2 = *mass of* H_2 */ kg of fuel.*

The specific enthalpy of evaporation per kg of steam which leaves with the combustion products is taken as 2442.0 kJ/kg ***(587 cal/gm)*** *of steam at 25 ◦C From this then,*

$$L.C.V. = {}^{*}H.C.V._{at\ 15^{\circ}C} - 2442(m + 9H_2) + \frac{kJ}{kg}\ of\ fuel$$

NCV = GCV – Latent heat of condensation of steam produced

1 part by weight of H_2 produces 9 parts by weight of H_2O as follows.

The latent heat of steam is 587 cal/gm.

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$$

2gms 16gms 18gms

1 8 9

Thus,

$$LCV = HCV - \frac{9}{100}H \times 587 \qquad kcal/kg$$

$$LCV = HCV - 0.09\,H \times 587 \qquad kcal/kg$$

$$where\ H = \%\ of\ H_2\ in\ the\ fuel$$

Example 1:

The % composition by the weight of a sample of coal is given as below:

C= 65.5% ; H2 =6.65% ; O2 = 17.5% ; S = 1.8%

Using Dulong formula, calculate the calorific values of coal?

Solution:

According to Dulong formula, the higher calorific value (H.C.V.) is given by the following relation:

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

$$H.C.V. = \frac{1}{100}[8080 * 65.5 + 34500\,(6.65 - \frac{17.5}{8}) + 2240 * 1.8]\ kcal/kg$$

$$H.C.V. = \frac{1}{100}, 529240 + 153956 + 4032-$$
$$= 6872.22 kcal/kg$$

Steam produced =0.0665× 9 = 0.5985 kg of steam/ kg of fuel

to find Lower Calorific Value (L.C.V.)

$$\therefore L.C.V. = (H.C.V. - 587 * W)\ cal/kg$$

$$\therefore L.C.V. = (6872.22 - 587 * 0.5985)\ Kcal/kg$$

$$\therefore L.C.V. = (6871.92 - 351.31) = 6520.61\ Kcal/kg$$

Example 2:

Calculate the Gross and Net calorific values of a coal having the following compositions, C = 80 %, H2 =08 %, O2 = 08 %, S = 2 % and ash=2. Latent heat of steam is = 587 cal/gm.

Solution:

(i) Gross Calorific Value (GCV):

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

$$H.C.V. = \frac{1}{100}[8080C + 34500\,(8 - \frac{8}{8}) + 2240 \times 2]\ kcal/kg$$

$$H.C.V. = \frac{1}{100}, 646400 + 241500 + 4480\text{-}\ kcal/kg$$

$$H.C.V. = \frac{1}{100}, 892380\text{-}kcal/kg$$

$$H.C.V. = 8923.8\ kcal/kg$$

(ii) Net Calorific Value (NCV):

$$LCV = HCV - \frac{9}{100}\,H\ \times 587 \qquad kcal/kg$$

$$LCV = 8923.8 - \frac{9}{100} \times 8\ \times 587\ \ kcal/kg$$

$$LCV = 8923.8 - 422.64\ kcal/kg$$

$$LCV = 8501.16\ kcal/kg$$

Homework:

1. Calculate the Gross and Net calorific values of a coal having the following compositions, C = 63 %, H2 = 19 %, O2 = 03 %, S = 13 % and ash=2. Latent heat of steam is = 587 cal/gm.

[Ans. ***HCV= 11807.22 kcal / kg; LCV= 10803.45 kcal / kg***]

2. Calculate the Gross and Net calorific values of a solid fuel having 80% of carbon & 20% of hydrogen. Latent heat of steam is = 587 cal/gm.

[Ans. *HCV=* ***13364 kcal / kg.****; LCV=* ***12307.4 kcal / kg***]