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Topic 1

It is simple to answer the problem in simply two lines. However with a view to share the knowledge base with the readers of this site I would like to explain the full process as under:

Coal is a sedimentary rock composed of the altered remains of plants. Plants are mostly made of carbon, hydrogen and oxygen; these elements are preserved in the organic part of coal. The physical and chemical structure undergoes massive changes in the coal development process, caused by the pressure of later sediments from above, and by geothermal heat from below.

Coal burns because it contains large amounts of carbon, hydrogen and sulfur. During combustion, these elements combine with oxygen from the air to form carbon dioxide (CO_2), steam (H_2O) and sulfur dioxide (SO_2) respectively, releasing large amounts of energy as heat as detailed below:

C + O2	CO_2 + Heat (8084 K Cal / Kg of C)
$2H_2 + O_2$	$2H_2O$ + Heat (28922 K Cal / Kg of H_2)
$S + O_2$	SO_2 + Heat (2224 K Cal / Kg of S)

1. C: Carbon
2. H: Hydrogen
3. S: Sulfur
4. N: Nitrogen
5. A: Ash
6. M: Moisture

Gross Calorific Value (GCV or HCV) of the coal is the amount of total heat obtained by the complete combustion of 1 Kg of coal. To determine the amount of this heat the products of combustions are cooled to the air temperature (usually taken as 15^oC). From the above chemical reactions it is also obvious that the quantity of heat contained in the coal has empirical relation with its chemical composition and can be determined as under (Dulong's Formula):

GCV or HCV = 33800 C + 144000 H_2 + 9270 S kJ/Kg

If the fuel contains oxygen then it is assumed that the whole amount is combined with hydrogen having mass equal to 1/8th of that of oxygen. Thus the hydrogen is reduced by 1/8th and the formula is modified as under:

GCV or HCV = 33800 C + 144000 (H_2 - O_2/8)+ 9270 S kJ/Kg

Net of Lower Calorific Value In fact the products of combustion are released into atmosphere at a higher temperature than the ambient temperature. Also the water formed during the process of combustion also carries away some amount of heat as latent heat. Thus a lower amount of heat is released by combustion of coal than the total amount of heat actually contained in the coal, which is termed as Net calorific value of the coal. It is determined by subtracting the heat taken away by steam formed during combustion from the total heat actually contained in the coal.

The latent heat of vaporization of water corresponding to standard temperature of 15^oC is 2466 kJ/kg. Also above equation explains that the mass of steam formed = 9 H_2. Thus the LCV or NCV can be determined as under

NCV or LCV = HCV – 9 H_2 x 2466 kJ/Kg

Thus in case of chemical analysis of dried coal LCV can be determined by knowing hydrogen content only. However in the industries on field coal also contains moisture (in addition to inherent in coal sprayed to prevent fire). Thus these formulas have further been simplified for industrial convenience and in practice used as under:

UHV: Useful heat value = 8900 - 138(A+M)
GCV: Gross Calorific Value = (UHV + 3645 -75.4 M)/1.466
NCV: Net Calorific Value = GCV - 10.02M

We can determine the NCV from GCV, if total moisture content is known.