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Analysis of Solid and Liquid Fuel Calorific Value

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Abstract: *Fuel gives a large amount of heat which can be used for domestic and industrial Purposes. Wood, coal, petrol, oil, gas, diesel, kerosene, charcoal etc. are common example of fuel. Any naturally occurring or manufactured substance which act as a source of energy is called a fuel . thus ,afuel is a substance which is fissionable material ,chemical or reactant which combust in presence of oxygen to produce energy . the bomb calorimeter is used for the determination of calorific value of solid and liquid fuels. The calorific value of uel can be appoximatelly of computed by noting the amount of the components constituting the fuel.*

Analysis of fuel sample calorific value are HCV = 1,000 kcal/kg
GCV =9,650.4 kcal/kg , NCV = 9,227.8 kcal/kg

In all combustion reaction ,dfinite exist between the masses of relationships the fuel fired, they are used and the flue gases fomed as well as the amount of heat evolved or absorbed during the reaction.

Keywords*: Good Fuel, Inter conversion, Bomb Calorimeter, examples*

I. Introduction

Any naturally occurring or manufactured substance which act as a source of energy is called a fuel. Fuel give a large amount of heat which can be used for domestic and industrial purpose . wood,coal,oetrol,oil,diesel,kerosene ,charcoai ,etc. are common example of fuel .Thus,a fuel is a substance which fissionable material ,chemical or reactant which combust in presence of oxygen to produce energy. During the process of combustion the rearrangement of valancy electron of the atoms of carbon ,hydrogen occurs and result in combination of 02 to from CO2 and H20 etc. The difference of energy content of the product and the reactant appears in the form of heat i.e.,

$$\underset{\text{High energy content}}{\text{Fuel} + 0_2} \longrightarrow \underset{\text{low energy content}}{\text{products}} + \text{Heat}$$

Classification of Fuel: Fuel can be classified:

A on the basis of their occurrence:

- Natural or primary fuel: fuel which are found in nature as such are called natural fuel e.g wood, coal, peat, petroleum and natural gas.
- Artificial or secondary fuel : fuel which are prepared artificially Generally from primay fuel are called artificial fuel e.g. coke, kerosene oil, petrol, coal gas etc.

B on the basis of physical state of aggregation:

It can be classified in three group:

Solid fuels, Liquid fuels, Gaseous fuels

Characteristics of a Good Fuel:

- Good fuel must have high calorific value .
- An ideal fuel must have moderate ignition temperature .
- The moisture content in a fuel should be low because it reduce the combustion process of a fuel .
- For regular combustion of a solid fuel ,the size should be uniform .
- A combustion of fuel provide non-combustible matter content which reduces the heating value and heat loss occurs. So a good fuel should have a low non- combustible matter content.

- There should not be spontaneous combustion because it causes fire hazardus.
- It is necessary that the combustion of a fuel should be easily controllable.
- The solid and liquid fuel can be easily transported from one place to another but the transportation of gaseous fuel is typical and costly and can even cause fire hazards. Therefore,a fuel should be easily transportable.
- A fuel should be readily available in bulk at a low cost value.
- It should have low ash content.
- Fuel on burning should not pollute the environment with some toxic gases as combustion product.

Unit of Heat:

- calories –

  The amount of heat required to raise the temperature of 1 gm of water through 10c.

  1 cal = 4.185 × 107 erg =4.185 joule

  1 kcal = 1000 calories
- killocaloric or kilogram caloric **-** The amount of heat required to raise temperature of 1 kg of water 10c 1 kcal = 1ooo cal
- British thermal unit –It is the amount of heat required to raise the temperature of 1 ib of water through 1oc.
- Centrigrade heat unit –The centrigrade heat unit is the amount of heat required to raise the temperature of 1 ib water through 1oc .

  1 kcal = 3.968 B.T.U. =2.2 C.H.U.

Interconversion of various unit of heat –

The various units of heat can be easily interconverted on the basis that 1kg = 2.2 ib and 1oc = 1.8 oF Accordingly,

1 cal/g = 1 kcal/kg = 1.8 B.Th.U./ib

1 kcal/m3 = 0.1077 B.Th.U/ft3

1 B.Th.U/ft3 = 9.3 kcal/m3

Calorific Value: calorific value of a fuel is defined as the amount of heat obtainable by the complete combustion of a unit mass of the fuel.

Unit of calorific value: Calorific value of solid liquid and liquid fuel are usually expressed in calories per gram or kilocalories/kilogram or british thermal unit per pound whereasthe calorific value of gases are expressed as kilocalories per cubic meter or British thermal unit per cubic foot or C.H.U./1b or C.H.U./ft3

Gross calorific value: It may be defined as the amount of heat librated by complet combustion of One unit of a fuel and the prodcct of combustion are cooled down to room Temperature.

Nat calorific value: It may be defined as " The amount of heat librated by complete combustion of one Unit of a fuel and products of combustion are allowed to escape out".

In actual use, the water vapour and moisture , etc. are not condensed and Escape as such along with hct combustion gases. Hence,a lesser amount of heat is available.

Therefore,it is called as Net or lower calorific value

LCV =HCV –Latent heat of water vapour formed

= HCV – Mass of hydrogen × 9 × Latent heat of steam

II. Methods and Procedure

The bomb calorimeter is used for the determination of calorific value of solidAnd liquid fuels.

Constructions: It consists of a strong cylindrical bomb made of stainless steel. It is resistant to acid and corrosion. It is of 250-300 ml capacity .The bomb has A lid ,which can be screwed to the body of bomb so as to make a perfect gas Tight seal.The lid is provided with two stainless steel electodes and an oxygen Inlet value. To one of the electodes, a small ring is attached. In this ring, A platinum nickel or stainless steel crucible can be supported. The bomb is Placed in a copper calorimeter which is surrounded by an air jacket and water jacket to Prevent heat losses due to radiation. The calorimeter is provide with an Electrically operated stirrer and beckmann's thermometer which can read Accurately temperature difference upto 1/100 of a degree.

Procedure: A known amount of fuel between 0.5 to 1.0 g is kept in crucible supportedOver a ring. A fine Mg wire touching the sample of the fuel is then stretched Across the electrode. The bomb is placed carefully in acopper calorimeter Containing wg water. After stirring the water, the temperature t1 is noted.

The electrode are then connected with battery and circuit is completed.T hus, Combustion of fuel take place and heat is librated .Now, stirring of water Continued and the final temperature of water t2 is noted.

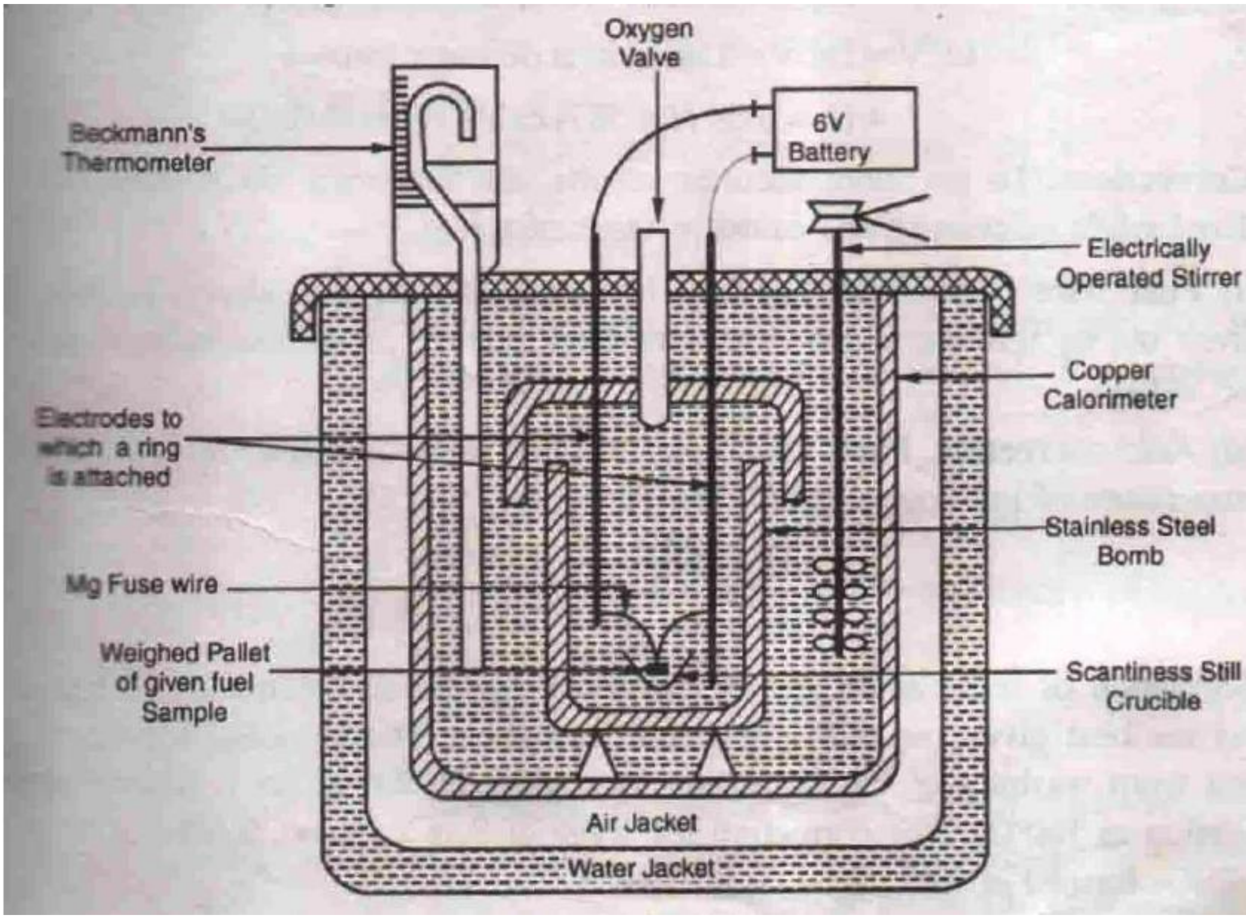

Figure No. 1: Bomb Calorimeter

Calculation:

Let X = mass in g of fuel sample taking in crucible, W = mass of water in the calorimeter. W = water equivalent in g of calorimeter, stirrer, thermometer bomb Etc. t_1 = initial temperature of water in calorimeter, t_2 = final temperature of water in Calorimeter. L = higher calorific value in fuel in cal/g

Heat librated by burning of fuel = XL

And heat absorbed by the apparatus etc.

$$=(W+w)\,(t_2-t_1)$$

But, heat librated by the fuel = Heat absorbed by water apparatus etc.

$$XL = (W+w)\,(t_2-t_1)$$

$$\text{HCV of fuel} \quad (L) = \frac{(W+w)(t_2-t_1)}{X} \text{cal/g (or kcal/kg)}$$

Note: The water equivalent of the calorimeter is determined by burning a fuel of known calorific value and using the above equation. The fuel used for this purpose are benzoic acid (HCV = 6.325 kcal/kg) and Napthalene (HCV = 96.88 kcal/kg).

If H = percentage of hydrogen in fuel = 0.09 H grams

Heat taken by water in forming steam

= 0.09 H × 587 cal (Latent heat of steam = 587 cal/kg).

LCV = HCV –Latent heat of water formed

= (L=0.09H× 587)cal/g (or kcal/kg)

Theoretical Calculation of calorific value: The calorific value of fuel can be approximately computed by noting the amount of the components constituting the fuel. The higher calorific value of some of the chief combustible constituent of fuel are as given below:

Constituent	→	H	C	S
HCV(K Cal/kg)	→	34500	8080	2240

The oxygen if present in the fuel is assumed to be present combined form
With hydrogen in form of fixed hydrogen(water, H2O so if hydrogen in also present in the fuel the amount of available hydrogen for combustion).
= Total mass of hydrogen in fuel – fixed hydrogen.
= Total mass of hydrogen in fuel – (1.8) oxygen in the fuel because
8 parts of Oxygen combine with one part of hydrogen to form water.
Dulong's Formula: For calorific value from the chemical composition of fuel is

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

Where C,H,O and S are percentage of carbon,hydrogen, oxygen and sulphur in the fuel. In this formula, oxygen is assumed to be present in combination withhydrogen as water and

LCV = [HCV -9/100 H × 587] K cal/kg

This is based on the fact that 1 part of H by mass gives 9 parts of H2O and latent Heat of steam is 587 K cal/kg
Example 1. 0.72 g of fuel containing 80% carbon, when burnt in a bomb calorimeter increased the temperature of water from 27.30 to 29.10 C. the calorimeter 250 g of water and its water equivalent is 150 g. calculate the HCV of fuel in kj/kg.
Solution. X = 0.72 g, W = 250 g, w = 150 g, t1 = 27.3 0C, t2 = 29.1 0C

HCV (L) = (W+w)(t2-t1)/x kcal/kg

$$HCV\ (L) = \frac{(250+150)(29.1-27.3)}{0.72}\ kcal/kg$$

= 1,000 kcal/kg

Example 2. Calulate the gross net calorific value of coal having the following composition : C = 85%, H = 8%, S = 1%, N = 2%, ash = 4%,latent heat of steam = 587 cal/g.
Solution. Gross calorific value

$$= \frac{1}{100}\left[8080 \times C + 34500\left(H - \frac{O}{8}\right) + 2240 \times 5\right] Kcal/kg$$

$$= \frac{1}{100}\left[8080 \times 85 + 34500\left(H - \frac{O}{8}\right) + 2240 \times 1\right] Kcal/kg$$

$$= \frac{1}{100}[\ 686{,}800 + 276.000 + 2{,}240\ ]\ kcal/kg$$

$$= \frac{1}{100}[\ 965{,}040\ ]\ kcal/kg = 9{,}650.4\ \ kcal/kg$$

Net clorific value (NCV) = (GCV – 0.09 H × 987) kcal/kg
= (9,650.4 – 0.09 × 8 × 587) kcal/kg
= 9,227.8 kcal/kg
Correction. To get more accurate results, the following correction must be Considered while calculating the calorific value of a fuel.
Fuse wire correction. The heat librated, as measured above, include the heat given out by ignition of the fuse wire used. Hence, it must be subtracted from the total value.
Acid correction. Fuel containing S and N are oxidized under high pressure and temperature of ignition to H2SO4 and HNO3 respectiviely.

$$S + H + 2O_2 \longrightarrow H_2SO_4 + Heat$$

$$2N + H_2 + 3O_2 \longrightarrow 2HNO_3 + Heat$$

Formation of these acid are exothermic reaction measured heat also includes the heat given out during the acid formation. The amount of these acid is analysed from washing of bomb by titration, while H2SO4 alone is determined. By precipitation as BaSO4. The correction for 1 mg of S is 2.25 cal, while for 1 ml of N/10 HNO3 formed is 1.43 cal.
Cooling correction. The time taken to cool the water in calorimeter from maximum temperature to room temperature is noted. From the rate of cooling (dT 0/minute) and the actual time taken for cooling (t-minutes).
The cooling correction of dT × t is added to the rise in temperature .
Cotton thread correction. The correction for the cotton thread used for firing is calculated from the weight of dry cotton thread actually used and on the basis that the calorific value of cellulose is 4140 cal per gram

Hence, the above equation become:

$$L= \frac{(W+w)(t2-t1 + \text{cooling correction}) - [\text{Acid} + \text{Fuse} + \text{Cotton thread correction}]}{Maas\ of\ fuel\ (X)}$$

III. Conclusion

The bomb calorimeter is used for the determination of calorific value of Solid and liquid fuels.Fuel gives a large amount of heat which can be used fordomestic andIndustrial purposes.In all combustion reaction, definite relationships exit between the massesOf the fuel fired, are used and the flue gases formed as well as the Amounts of heat evolved or absorbed during the reaction. Calculate the higher calorific value, gross and net calorific value of fuel

Higher calorific value (HCV)	1,000 kcal/kg
Gross calorific value (GCV)	9,650.4 kcal/kg
Net calorific value (NCV)	9,227.8 kcal/kg

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