JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Year & Sem. – B. Tech I year, Sem.-I

Subject –Engineering Chemistry

Unit – II (Lecture No. 13 Bomb Calorimeter)

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Determination of Calorific Value

- **The amount of heat released/ liberated by unit mass or volume of a fuel is known as calorific value**

There are two types of calorific values:

1. **Higher / Gross Calorific Value (HCV/GCV)**
2. **Lower/Net Calorific Value**

Gross or Higher calorific value (G.C.V or H.C.V): It is the total quantity of heat liberated when one unit of fuel is burnt completely and products of combustion has been cooled to room temperature.

Net or Lower calorific value (N.C.V or L.C.V)): It is the total quantity of heat liberated when one unit of fuel is burnt completely and products of combustion has been permitted to escape.

L.C.V= H.C.V – Latent heat of water vapour formed

Latent heat of steam= 537 cal/gm

LCV=HCV-0.09H x 587 Cal/g

Determination of Calorific Value by Bomb Calorimeter

<u>Principle:</u> A known unit mass of the fuel is brunt and the quantity of heat produced is absorbed in water and measured. Then the quantity of heat produced by burning a unit mass of the fuel is calculated.

Construction: It consists of the following parts as shown in figure.

(1) A strong cylindrical bomb made up of chromium nickel-molybdenum steel, resistant to corrosion and capable of withstanding high pressures up to 50 atmospheres. It is provided with a lid which can be screwed firmly on the bomb. The lid in turn is provided with two electrodes and an oxygen inlet valve. A small ring is attached to one of the electrode which acts as a support for the crucible.

(2) A copper calorimeter vessel with a known weight of water and in which the bomb stands.

(3) The calorimeter is surrounded by an air jacket and a water jacket to prevent the loss of heat due to radiation.

(4) The calorimeter is provided with an electrically operated stirrer and a Beckmann thermometer which can read accurately temperature difference up to 0.01 of a degree.

(5) The crucible used is made up of nickel, stainless steel or fused silica.

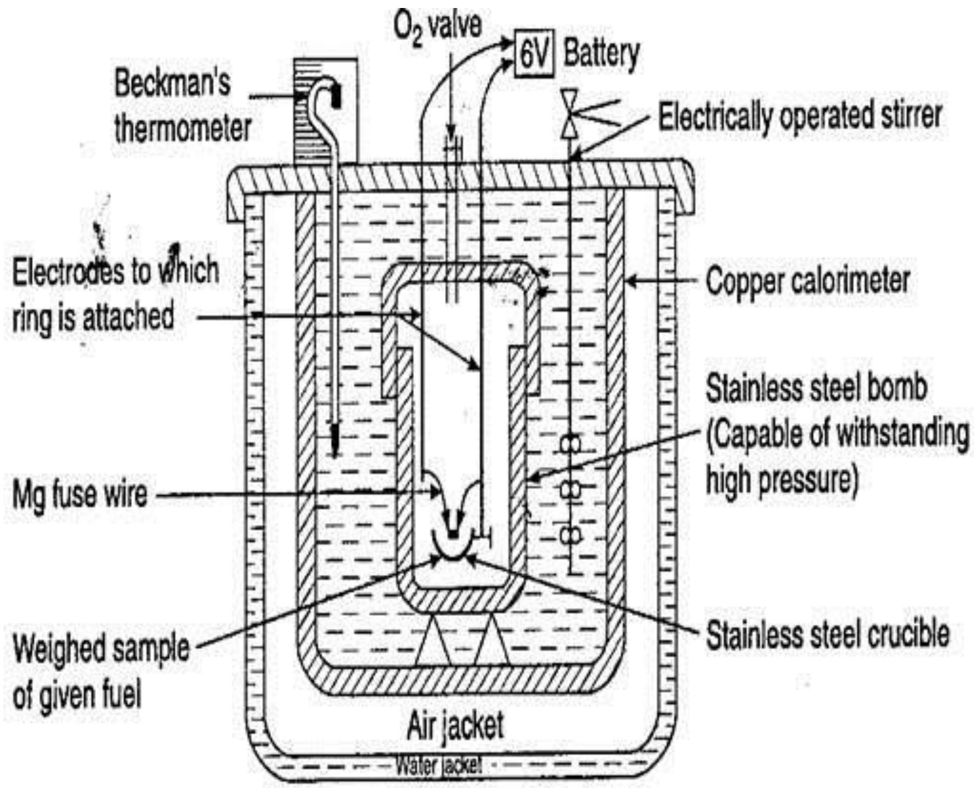

Figure: Bomb calorimeter

Working:

A weighed amount of the fuel is placed in the silica crucible supported over the ring. A fi ne magnesium wire touching the sample of the fuel is stretched across the electrodes. About 10 mL of distilled water is introduced into the bomb to absorb vapors of sulfuric acid and nitric acid formed during the combustion. Oxygen supply is forced into the bomb to a pressure of 25–30 atmosphere. The bomb is then carefully placed in the calorimetric vessel containing a known amount of water. The stirrer is driven and the initial temperature of water is noted. The electrodes are then connected to a battery and circuit is completed. The combustion of the fuel take place with the evolution of heat. The heat produced by burning is transferred to the water which is stirred throughout the experiment by the electric stirrer Maximum temperature shown by the thermometer is recorded. The calorific value of fuel can be calculated as follows:

Observation: Weight of the fuel taken in crucible = x g

Weight of water in the calorimeter = W g

Water equivalent of the calorimeter, stirrer, thermometer and bomb = w g

Initial temperature of water in calorimeter = t_1 °C

Final temperature of water in calorimeter = t_2c °C

Let the higher or Higher calorific value of the fuel = L cal/g

Calculation:

Heat Gained by Water = $W (t_2-t_1)$ Cal

Heat gained by calorimeter = $w (t_2-t_1)$ Cal

Total heat gained = $W (t_2- t_1) + w (t_2- t_1)$ Cal

Heat liberated by fuel = x L

Now Heat Liberated by Fuel = Heat gained by water and calorimeter

$$xL = (W + w)(t_2- t_1)$$

$$(HCV)L = (W + w)(t_2- t_1)/x \quad Cal/g$$

$$LCV=HCV-0.09H \times 587 \ Cal/g$$

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Corrections:

(i) Fuse wire correction: The heat liberated includes the heat given out by ignition of the fuse wire used.

(ii) Acid correction: Fuels containing sulphur and nitrogen are oxidized under high pressure and temperature of ignition to sulphuric acid and nitric acid.

$$S + O2 \rightarrow SO2$$

$$2O_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4 \quad \Delta H = -144000\ \text{Cal}$$

$$2N_2 + 2H_2O + 5O_2 \rightarrow 4HNO_3 \quad \Delta H = -\ 57160\ \text{Cal}$$

Formation of these acids is an exothermic reaction, thus the measured heat also includes the heat given out during acid formation.

Amount of these acids can be analyzed from the washings. Sulphuric acid is precipitated as $BaS0_4$. Correction for 1 mg sulphur is 2.25 Cal while for 1 ml N/10 HNO_3 is 1.43 cal.

(iii) Cooling correction: Time taken to cool the water from maximum temperature to room temperature is noted. From the rate of cooling (dt° /min) and actual time for cooling (t min), the cooling correction dt x t is added to rise in temperature.

$$L\ (HCV) = \frac{(W-w)(t2-t1+\text{cooling correction})-(\text{Acid}+\text{fuse wire correction})}{X\ (\text{Mass of fuel sample taken})}\ \text{Cal/g}$$

Question Bank

Q1. Define calorific value of coal?
Q2. Write the formula to calculate LCV and HCV of liquid fuel.
Q3. Differentiate between HCV and LCV
Q4. Give principle of Bomb Calorimeter.
Q5. Name the equipment used to determine the CV of Solid fuel.
Q6. What is Cooling correction?
Q7. Explain acid and fuse wire corrections in bomb calorimeter.
Q8. Draw labeled diagram of bomb calorimeter.

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Thank you!