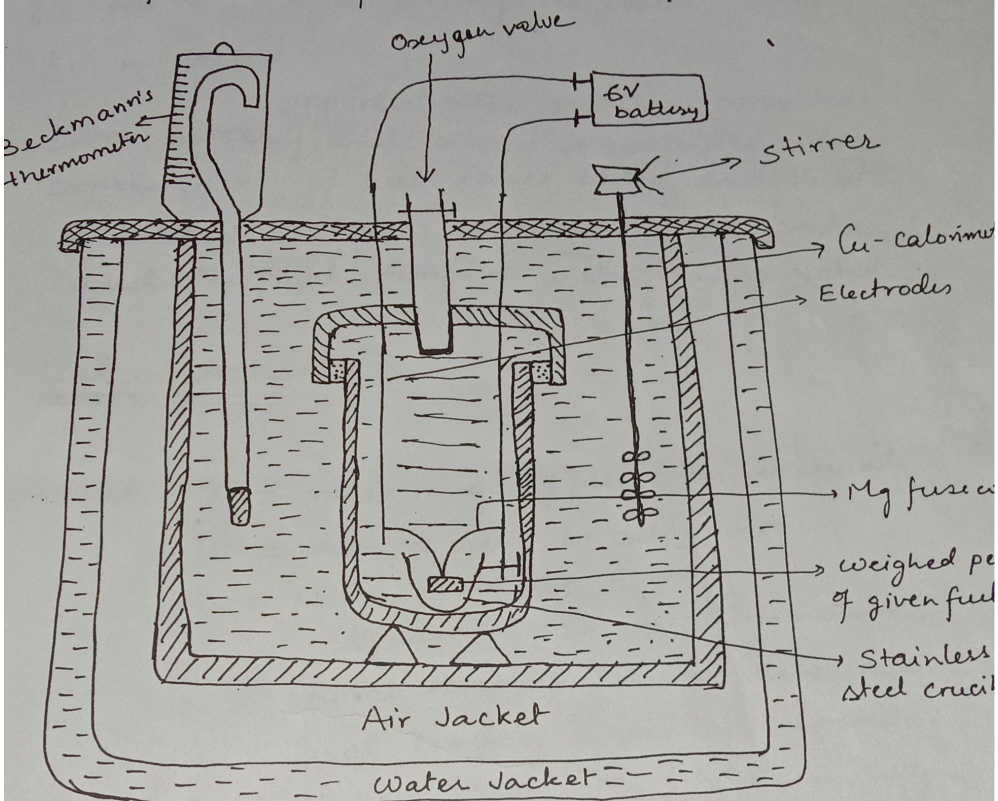
Determination of calorific value by Bomb Calorimeter

Bomb Calorimeter is used for determination of calorific value of solid and liquid fuels.



Apparatus :-

A known amount of fuel (between 0.5 – 1.0 gm) is kept in crucible supported over a ring. A fine-Mg wire touching the sample of the fuel is then stretched across the electrode. The bomb is placed carefully in a Cu-calorimeter containing W gm water. After stirring the water temp. t_1 is noted.

The electrodes are then connected with battery and circuit is completed. Thus combustion of fuel takes place and heat is liberated. Now stirring of water continued and the final temp. of water (t_2) is noted.

Calculations :–

Let X = mass in gm of fuel taken in crucible

W = mass of water in calorimeter.

w = water equivalent in gm (of Calorimeter, stirrer, thermometer etc.)

t_1 = initial temp. of water in Calorimeter

t_2 = Final temp. of water in calorimeter.

L = Higher Calorific value of fuel in Cal/gm

Now Heat liberated by burning of fuel = XL.

Heat absorbed by water and apparatus etc

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

ow

Heat liberated by fuel = Heat absorbed by water apparatus etc.

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

$$\text{H.C.V. of fuel } (L) = \frac{(W + w)(t_2 - t_1)}{x} \text{ Cal/gm or kCal/kg}$$

Note :- Water equivalent of the calorimeter is determined by burning a fuel of known calorific value and using the above equation.

{Fuels used for this purpose are -
benzoic acid (HCV = 6.325 kCal/kg)
& Naphthalene (HCV = 96.88 k Cal/kg)

Let H be the % of hydrogen in fuel then

$$LCV = HCV - 0.09H \times 587 \text{ Cal/gm}$$

Corrections:

To get more accurate results the following corrections are needed.

(i) Fuse wire correction (CF) :- The heat measured in above described case includes the heat given out by ignition of fuse wire used, hence it must be subtracted from the total value.

(ii) **Cooling correction** (C_c) :- The time taken to cool water in calorimeter from maximum temp. to room temp. is noted. From the rate of cooling (dT °/min) and actual time taken for cooling (t-minutes). The cooling correction of $[dT \times t]$ is added to rise in temp.

(iii) **Cotton thread correction** (C_{CT}) :- The correction for cotton thread used for firing is calculated from wt. of dry cotton thread actually used and on the basis of calorific value of cellulose which is 4140 Cal/gm.

(iv) **Acid correction** (C_A) :- Due to high pressure and temprature, N & S present in fuels are oxidised into HNO_3 and H_2SO_4

~~S + H + 2 O → H₂S~~ $S + O_2 \rightarrow SO_2$

$$2SO_2 + O_2 + H_2O \rightarrow 2H_2SO_4 + Heat \quad \text{— (1)}$$

$$2N + 2H + 3O_2 \rightarrow 2HNO_3 + Heat \quad \text{— (2)}$$

Equations (1) & (2) are exothermic reactions and so these heat liberated must be subtracted.

Therefore

$$H.C.V. = \frac{(W+w)(t_2 - t_1 + C_c) - (C_A + C_F + C_{CT})}{m} \quad \text{kCal/kg or Cal/gm.}$$

———— x ———— x ————

Coal : Coal is primary fuel and is highly carbon containing compound which is formed due to alteration of ~~veb~~ vegetable matter under favourable conditions

decreasing → Moisture content, H, O, N & S content & Volatile matter.

Wood → Peat → Lignite → Bituminous coal → Anthracite

%C → Peat 57%, Lignite 60-70%, Bituminous coal 75 - 90%, Anthracite 92 - 98%

increasing → C-content, calorific value & hardness

Analysis of coal :

$$\% \text{ Moisture} = \frac{\text{Loss in weight}}{\text{wt. of coal taken}} \times 100$$

$$\% \text{ Volatile matter} = \frac{\text{Loss in wt. due to removal of volatile matter}}{\text{wt of coal taken}} \times 100$$

$$\% \text{ Ash} = \frac{\text{Weight of Ash left}}{\text{wt. of coal taken}} \times 100$$

$$\% \text{ Carbon} = 100 - \% (\text{Moisture} + \text{Volatile matter} + \text{Ash})$$