Sustainability numericals

GCV/NCV - Calorific Value Numericals

Calorie :- Amount of heat required to raise the temperature of one gram of water through one degree centigrade.

1000 cal = 1 K cal.

2 Types :-

→ GCV or HCV

→ LCV or NCV

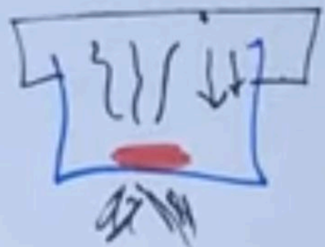
Gross or High Calorific Value

Low or Net Calorific Value.

HCV or GCV.

Defination :-

Total Amount of heat produced when a unit mass of fuel is burned completely & the products of combustion are cooled down to room Temperature usually 60°F or 15°C



LCV or NCV

Net amount of heat produced when a unit mass of fuel is burned completely & the products of combustion are allowed to escape into the atmosphere. ~~In~~

** If fuel does not contain hydrogen then HCV = LCV **

Dulong's Formula :-

Oxygen

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

NCV/LCV = GCV − latent heat of condensation of water vapour formed.

= GCV − (weight of H × 9 × latent heat of steam)

$$= GCV - \left[\frac{H}{100} \times 9 \times 587\right]$$

Dulong's Formula :- $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ (18)

$\frac{1}{2} \rightarrow \frac{9}{18}$

Oxygen

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

Kcal/kg

NCV/LCV = GCV − latent heat of condensation of water vapour formed.

$= GCV - (\text{weight of } H \times 9 \times \text{latent heat of steam})$

$= GCV - \left[\frac{H}{100} \times 9 \times 587\right]$ Kcal/Kg

Find the GCV & NCV of a value, which an ultimate analysis gave following results $C = 68.3\%$, $N = 0.25\%$, $H = 5\%$; $O = 25.6\%$, $S = 0.3\%$,

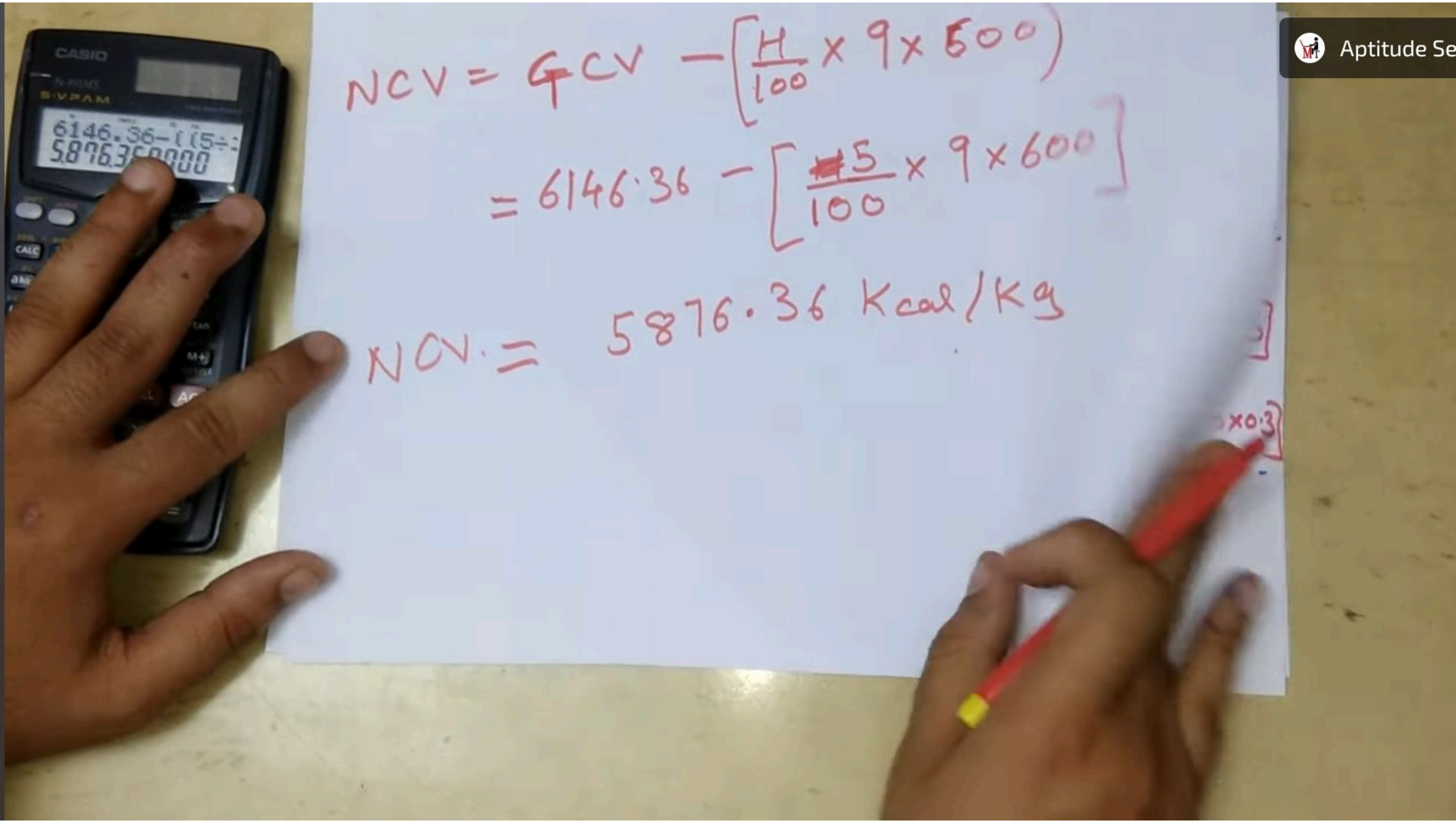
Assume latent heat of steam is 600 cal/gm.

Find the GCV & NCV of a value, which an ultimate analysis gave following results $C = 68.3\%$, $N = 0.25\%$, $H = 5\%$; $O = 25.6\%$, $S = 0.3\%$,
Assume latent heat of steam is 600 cal/gm.

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

$$= \frac{1}{100}\left[8080 \times 68.3 + 34500\left(5 - \frac{25.6}{8}\right) + 2240 \times 0.3\right]$$

$$GCV = 6146.36 \text{ Kcal/Kg}$$


Aptitude Series for Be
NCV = GCV − [H/100 × 9 × 600]
= 6146.36 − [5/100 × 9 × 600]
NCV = 5876.36 Kcal/Kg

A sample of coal contains C = 76%, N = 1.5%, H = 5%, O = 16.2%; S = 0.3% & ash = 1.0%. Calculate the HCV & GCV of coal.

$$\Rightarrow GCV = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S\right]$$

$$= \frac{1}{100}\left[8080 \times 76 + 34500\left(5 - \frac{16.2}{8}\right) + 2240 \times 0.3\right)$$

$$GCV = 7173.895 \text{ Kcal/kg}$$

$$LCV = GCV - \left[\frac{H}{100} \times 9 \times 587\right]$$

$$= 7173.895 - \left[\frac{5}{100} \times 9 \times 587\right]$$

$$LCV = 6909.745 \text{ kcal/kg}$$

A coal having following composition by weight:-
$C = 90\%$, $O = 0.3\%$, $N = 0.5\%$, $Ash = 2.5\%$, $S = 0.5\%$.
The NCV = 8925.28 Kcal/Kg. Calculate % H & GCV.

$$\Rightarrow GCV = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S\right]$$

$$= \frac{1}{100}\left[8080\times 90 + 34500\left(H - \frac{0.3}{8}\right) + 2240\times 0.5\right]$$

$$= \frac{1}{100}\left[727200 + 34500(H - 0.0375) + 1120\right]$$

$$= \frac{1}{100}\left[72526.25 + 34500H\right]$$

$$GCV = [725.2625 + 345H]$$

$$NCV = GCV - \left[\frac{H}{100} \times 9 \times 587\right]$$

$$8925.28 = (725.2625 + 345H) - \left(\frac{H}{\cancel{100}} \times 52.83\right)$$

$$= 725.2625 + 345H - 52.83H$$

$$292.17H = 8925.28 - 725.2625$$

$$H = \frac{8200.0175}{292.17} = \underline{28.0659\,\%}$$

$$GCV = [725.2625 + 345H]$$

$$GCV = 725.2625 + 345 \times 28.065 = \underline{\underline{10407.8}}$$

Kcal/kg

$$NCV = GCV - \left[\frac{H}{100} \times 9 \times 587\right]$$

$$\cdots 28 = (725.2625 + 345H) - \left(\frac{H}{\cancel{100}} \times 52.83\right)$$

$$= 725.2625 + 345H - 52.83H$$

$$\cdots H = 8925.28 - 725.2625$$

$$H = \frac{8200.0175}{292.17} = \underline{28.0659}\ \%$$

Combustion Numericals

6.12 Numericals on Combustion

(A) Calculation of Amount of Air (Weight Basis)

Problem 1

A coal sample contains C = 65%, H = 13%, O = 6%, S = 4%, N = 2%. Calculate the minimum amount of air needed for complete combustion of 1 kg of coal.

(M.U. May 2008)

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[redacted]

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	65	65 / 100 = 0.65
H	13	13 / 100 = 0.13
O	6	6 / 100 = 0.06
N	2	Does not contribute
S	4	4 / 100 = 0.04

$$\text{Amount of air required} = \frac{100}{23}\,[\,2.67\,C + 8\,H + S - O\,]\ \text{kg}$$

$$= \frac{100}{23}\,[\,2.67 \times 0.65 + 8 \times 0.13 + 0.04 - 0.06\,]\ \text{kg}$$

$$= \frac{100}{23}\,[\,1.7355 + 1.04 - 0.02\,]\ \text{kg}$$

$$= \frac{100}{23}\,[\,2.7555\,]\ \text{kg}$$

$$= 11.98\ \text{kg}$$

Ans. : Weight of air needed for combustion of 1 kg of fuel = 11.98 kg.

Problem 2

A coal sample was found to contain the following constituents : C = 81%, O = 8%, S = 1%, H = 5%, N = 1%, ash = 4%. Calculate the minimum amount of air required for complete combustion of 2 kg of coal. **(M.U. May 2010)**

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	81	81 / 100 = 0.81
O	8	8 / 100 = 0.08
S	1	1 / 100 = 0.01
H	5	5 / 100 = 0.05
N	1	Does not contribute

$$\text{Amount of air required} = \frac{100}{23}[2.67\,C + 8H + S - O]\ \text{kg}$$
$$= \frac{100}{23}[2.67 \times 0.81 + 8 \times 0.05 + 0.01 - 0.08]\ \text{kg}$$
$$= \frac{100}{23}[2.163 + 0.4 + 0.01 - 0.08]\ \text{kg}$$
$$= \frac{100}{23}[2.493]\ \text{kg}$$
$$= 10.839\ \text{kg}$$

$\therefore$ Amount of air required for 2 kg of coal

$$= 2 \times 10.839$$
$$= 21.68\ \text{kg}$$

Ans. : Amount of air needed for 2 kg of coal = 21.68 kg

Problem 3

Calculate weight of air needed for complete combustion of 1 kg of coal containing C = 72%, H = 10%, O = 9%, N = 3% and remaining being ash. **(M.U. Dec. 2011)**

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	72	72 / 100 = 0.72
H	10	10 / 100 = 0.01
O	9	9 / 100 = 0.09

$$\text{Amount of air required} = \frac{100}{23}[2.67\,C + 8\,H + S - O]\ \text{kg}$$
$$= \frac{100}{23}[2.67 \times 0.72 + 8 \times 0.1 - 0.09]\ \text{kg}$$
$$= \frac{100}{23}[1.9224 + 0.8 - 0.09]\ \text{kg}$$
$$= \frac{100}{23}[2.6324]\ \text{kg}$$
$$= 11.45\ \text{kg}$$

Ans. : Weight of air required for combustion of 1 kg of coal = 11.45 kg.

Problem 4

A coal sample was found to contain the following constituents :

$C = 81\%$, $H = 6\%$, $S = 1\%$, $N = 2\%$, Ash = 4% and rest is oxygen.

Calculate the minimum weight of air required at STP for complete combustion of 1 kg of the coal sample.

(M.U. Dec. 2019)

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	81	81 / 100 = 0.81
H	6	6 / 100 = 0.06
S	1	1 / 100 = 0.01
N	2	Does not contribute
O	6	6 / 100 = 0.06
Ash	4	Does not contribute

$$\text{Amount of air required} = \frac{100}{23}[2.67\,C + 8\,H + S - O]\text{ kg}$$

$$= \frac{100}{23}[2.67 \times 0.81 + 8 \times 0.06 + 0.01 - 0.06]\text{ kg}$$

$$= \frac{100}{23}[2.1627 + 0.48 - 0.05]\text{ kg}$$

$$= \frac{100}{23}[2.5927]\text{ kg}$$

$$= 11.273\text{ kg}$$

Ans. : Weight of air required for combustion of 1 kg of coal = 11.273 kg.