Method 2.3 – Bagasse: calorific value

1. Rationale

This method is applicable to bagasse and determines the calorific value of the sample.

2. Principle

The higher or gross calorific value (HCV) and the lower or net calorific value (LCV) of bagasse are calculated. When calculating the LCV it is assumed that the water formed by combustion and the water of constitution of the bagasse remains in vapour form and that it is not practical to reduce the temperature of the combustion products to below the dew point to condense the moisture present and recover its latent heat. The latent heat of the vapour is therefore not available for heating purposes and must be subtracted from the HCV.

3. Apparatus

3.1 **Light duty balance** readable to 0.01 g

3.2 **Moisture oven** operating at 105°C

3.3 **Weighing scoop**

3.4 **Moisture tray**

3.5 **Brush**

3.6 **Furnace** operating at 650°C

3.7 **Crucible**: Vitreosil, 400 cm^3, 62 mm deep

3.8 **Lid** to fit crucible: Vitreosil

3.9 **Desiccator** with self-indicating silica gel

3.10 **Refractometer** operating at 20.0 ± 0.1°C

3.11 **Stemless funnel**: 100 mm ϕ

3.12 **Watch glass**: 100 mm ϕ

3.13 **Beakers**: 3 × 250 cm^3

3.14 **Bottles**: 250 and 500 cm^3

3.15 **Filter paper**: Whatman No. 6, Postslip medium white or equivalent, 150 mm ϕ

4. Reagents

4.1 Celite 577

Celite is an inert powder and should not be inhaled. Use a dust mask.

5. Procedure

5.1 Moisture

Clean the moisture tray with a brush and weigh accurately to 0.1 g. Add 300 g of the bagasse sample to the tray and weigh again accurately to 0.1 g. Transfer the tray to the oven and dry for 1 hour at 105°C. Cool in a desiccator for 1 hour and weigh accurately to 0.1 g.

5.2 Ash

Heat the crucible and lid for approximately 30 minutes in the oven at 105°C. Remove the crucible and lid from the oven and allow to cool in a desiccator for about 1 hour before weighing accurately to 0.01 g. Add approximately 50 g of sample to the crucible. Weigh the dish, lid and contents accurately to 0.01 g. Place the lid on the crucible, transfer to the furnace at 650°C and incinerate for 10 minutes. Remove the lid and incinerate for another 35 minutes. Replace the lid and transfer the crucible to a heat resistant surface to cool for 2 minutes. Transfer the crucible to a desiccator to cool for 90 minutes and weigh accurately to 0.01 g.

5.3 Brix

Weigh 350 g bagasse accurately to 0.1 g into a weighing scoop and transfer to a cold digester. Weigh 2 541 g water accurately to 0.1 g, add to the bowl and digest for 20 minutes. Pour the contents of the bowl onto a decanter screen and use the first 300 cm^3 to rinse the 500 cm^3 bottle. Collect the next 400 cm^3 in the bottle and allow to cool to room temperature.

Add 2 g Celite 577 to 100 cm^3 of the extract in a 250 cm^3 bottle, replace the lid and shake vigorously. Transfer the total contents of the bottle to a fluted filter paper in a funnel which rests directly on a 250 cm^3 beaker. Do not overrun the rim of the filter paper. Do not allow the filtrate to touch the bottom of the funnel or filter paper. Do not replenish the solution in the filter funnel. Seal the funnel with a watch glass to minimise evaporation. Discard the first 10 cm^3 of filtrate and collect about 25 cm^3 of the filtrate in another clean beaker.

Zero the refractometer using distilled water. If the reading is not 0.00°Bx at 20.0 ± 0.1°C, record this value as the water blank.

Pour the filtrate into the refractometer cell compartment using three portions to ensure complete displacement of the previous solution. Record the reading once it stabilizes at 20.0 ± 0.1°C.

6. Calculations

6.1 Moisture

$$\text{Moisture } (\%) = \frac{(M_2 - M_3)}{(M_2 - M_1)} \times 100$$

where M_1 ≡ mass of dish (g)
M_2 ≡ mass of dish and sample before drying (g)
M_3 ≡ mass of dish and sample after drying (g)

Report as percentage to two decimal places

6.2 Ash

$$\text{Ash } (\%) = \frac{(M_3 - M_1)}{(M_2 - M_1)} \times 100$$

where M_1 ≡ mass of crucible and lid (g)
M_2 ≡ mass of crucible, lid and sample before incineration (g)
M_3 ≡ mass of crucible, lid and sample after incineration (g)

Report as percentage to two decimal places

6.3 Brix

Correct the refractometer readings for the water blank.

$$\text{Fibre in bagasse } (\%) = \frac{100 \times S - S \times M - (S + W) \times B}{S \times (1 - 0.0125 \times B)} \qquad \text{(Equation 1)}$$

where S ≡ mass of bagasse sample (g)
M ≡ moisture of bagasse (%)
W ≡ mass of water (g)
B ≡ Brix in extract (%)

Report as percentage to two decimal places

$$\text{Brix of bagasse } (\%) = \frac{B}{100}\left[100 \times \frac{(S + W)}{S} - 1.25 \times F\right] \qquad \text{(Equation 2)}$$

where B ≡ Brix in extract (%)
S ≡ mass of bagasse sample (g)
W ≡ mass of water (g)
F ≡ fibre in bagasse (%)

Report as percentage to two decimal places

6.4 Calorific values

HCV (kJ/kg) = 19 605 - 196.05 × moisture - 196.05 × ash - 31.14 × Brix

where HCV ≡ high or gross calorific value
moisture ≡ percentage moisture in bagasse
ash ≡ percentage ash in bagasse
Brix ≡ percentage Brix in bagasse

* LCV (kJ/kg) = 18 260 - 207.01 × moisture - 182.60 × ash - 31.14 × Brix

***** *Latent heat of steam at 25℃ is 2 441 kJ/kg*

where LCV ≡ low or net calorific value
moisture ≡ percentage moisture in bagasse
ash ≡ percentage ash in bagasse
Brix ≡ percentage Brix in bagasse

Report in kJ/kg to the nearest unit

7. Example

7.1 Moisture

Mass of moisture tray = 500.25 g
Mass of tray with sample = 802.73 g
Mass of tray after drying = 651.39 g

$$\text{Moisture} = \frac{(802.73 - 651.39)}{(802.73 - 500.25)} \times 100$$

$$= 50.03\%$$

7.2 Ash

Mass of crucible empty = 320.65 g
Mass of crucible with sample = 370.73 g
Mass of crucible after drying = 322.02 g

$$\text{Ash} = \frac{(322.02 - 320.65)}{(370.73 - 320.65)} \times 100$$

$$= 2.74\%$$

7.3 Brix

Mass of bagasse sample = 350.4 g
Mass of water added = 2 541.0 g

Refractometer water blank = 0.01°Bx
Refractometer reading at 20.0°C = 0.40°Bx
Brix of the extract at 20.0°C = 0.39°Bx

Fibre in bagasse = 94.51% (Equation 1)

Brix in bagasse = 2.76% (Equation 2)

7.4 Calorific values

High or gross calorific value = 9 174 kJ/kg
Low or net calorific value = 7 317 kJ/kg

8. References

SASTA (1985). *Laboratory Manual for South African Sugar Factories*. 3rd Edition: 229 - 230, 231 - 232, 241.

Wienese A (2001). Boilers, boiler fuel and boiler efficiency. *Proc S Afr Sug Technol Ass,* **75**: 275 - 281.