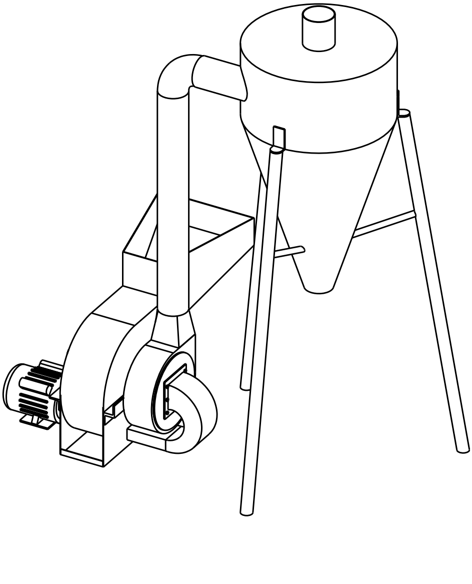
CAVA2

CASSAVA: ADDING VALUE FOR AFRICA PHASE II

How to evaluate the performance of HAMMERMILLS

Aditya Parmar & Marcelo Precoppe



Booklet 6

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Preface

This booklet is the sixth of a 6-part series of booklets on performance evaluation of cassava processing equipment. These technical booklets are developed keeping in mind their target audience of local equipment manufacturers in developing countries, particularly Sub-Sharan Africa. The purpose is to determine the various performance parameters with simplistic techniques requiring no sophisticated instruments.

The online version of these booklets is available at: www.cassavatech.com.

At cassavatech.com we help cassava processors to learn how to choose suitable equipment and what performance parameters to ask for. These booklets series are a complement to that information provided, where equipment manufacturer can demonstrate to their potential customers the performance of the machine regarding the listed performance parameters.

A list of all the booklets in this series is provided below.

Booklet Number	Name
1	How to evaluate the performance of CASSAVA PEELING MACHINES
2	How to evaluate the performance of CASSAVA GRATERS
3	How to evaluate the performance of CASSAVA PRESSES
4	How to evaluate the performance of CASSAVA PNEUMATIC DRYERS
5	How to evaluate the performance of CYCLONE
6	**How to evaluate the performance of HAMMERMILLS**

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CAVA II

Cassava: Adding Value for Africa (CAVA II) is a project led by the Federal University of Agriculture Abeokuta, Nigeria, working closely with the Natural Resources Institute. CAVA II aims to improve the livelihoods of smallholder farmers and processors in Nigeria, Ghana, Tanzania, Uganda, and Malawi.

CAVA II works across the value-added cassava chain, it interacts directly with farmers to improve the profitability of cassava sales, both through increasing overall market demand and through boosting farmer yields.

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HAMMERMILLS

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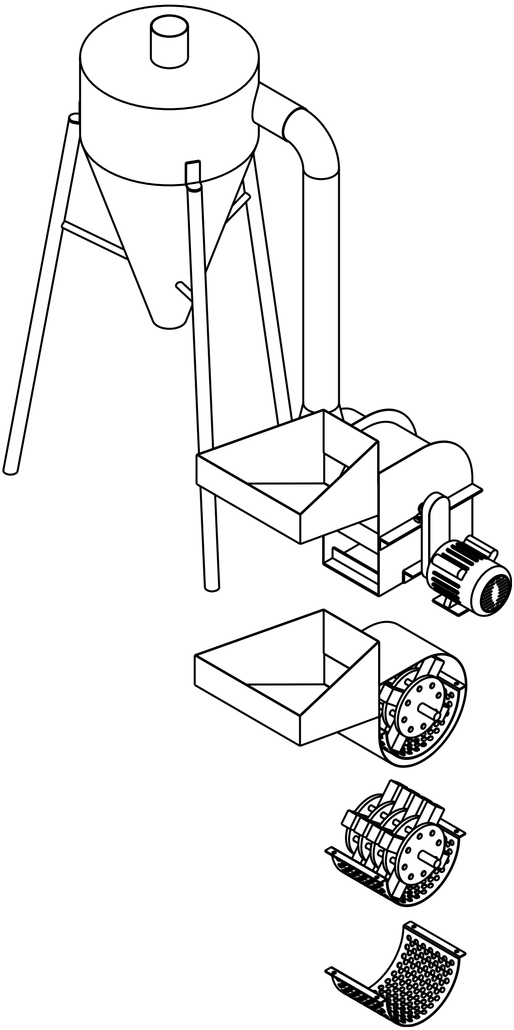
Milling in the food industry

Milling is a process of size reduction, an operation where the average size of solid food is reduced by the application of forces. Milling is usually done to improve a product's edible quality or to make it more suitable for further processing. Milling can be achieved by crushing, cutting, shearing or impacting. **Crushing** is when the forces applied are much larger than the strength of the material, and the food material splits in all directions. **Cutting** involves knives passing through the material. **Shearing** is a combination of crushing and cutting. **Impacting** is when the material is subjected to a sudden blow of forces exceeding the material strength.

Cassava milling

During cassava processing, dried cassava grits are milled into flour with a **hammermill**. Hammermills reduces size by impact, it has hammers attached to a rotor that turns inside a case. The cassava grits are fed into the case from the hopper. The product is delivered by forced air generated by a centrifugal fan. Once inside the case, the grits are broken down by the hammers. The hammers keep grinding the grits until its size is small enough to pass through a screen located at the bottom of the case. Particle size can be adjusted by changing the opening size of this screen, a screen with larger openings results in larger particles. A cyclone at the end separates the material from the conveying air.



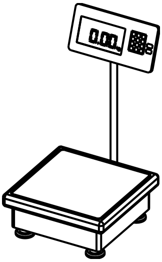
Performance assessment

Performance of a hammermill can be assessed based on its **throughput** and **energy consumption**.

Throughput

Throughput is the amount of milled material obtained per unit of time. Throughput is expressed in kilogram per hour (kg/h) To measure **throughput** it is necessary to have:

- Dried cassava grits
- Weighing scale
- Stopwatch or a regular watch



Step 1. Separate enough dried cassava grits to run the hammermill for at least 30 minutes.

Step 2. Start the stopwatch when milling begins.

Step 3. Stop the stopwatch when all the cassava grits have been milled. Record the time taken.

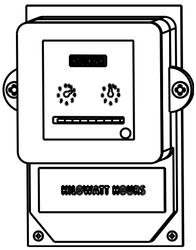
Step 4. Measure the **weight of the milled material** using the weighing scale.

Step 5. Now divide the weight of the milled material by the recorded time (in hours). This is **throughput**.

Specific energy consumption

Specific energy consumption is the amount of energy needed to mill a certain quantity of material. For machines running on electric motors it is expressed in kilowatt-hour per kilogram (kWh/kg), for those running on internal combustion engines it is expressed in litres of fuel per kilogram (L/kg). To measure **specific energy consumption of a hammermill running on electric motor** it is necessary to have:

- Dried cassava grits
- Weighing scale
- Electricity meter



The **electricity meter** (also called kilowatt-hour meter or energy meter) is a device that measures the amount of electric energy consumed.

Step 1. Separate enough dried cassava grits to run the hammermill for at least 30 minutes.

Step 2. Switch-off all electric appliances and keep them off until the end of the measurements.

Step 3. Note down the **initial reading** in kWh from the electricity meter.

Step 4. Mill the cassava grits with the hammermill.

Step 5. Note down the new **final reading** from the electricity meter.

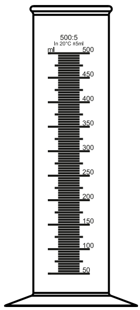
Step 6. Measure the **weight of milled material** using the weighing scale.

Step 7. Subtract from the final electricity reading (Step 5) the initial reading (Step 3). This is the amount of **electric energy consumed**.

Step 8. Now divide the electric energy consumed by the weight of milled material (Step 6). This is the **specific energy consumption**.

To measure **specific energy consumption of a hammermill running on internal combustion engine** it is necessary to have:

- Dried cassava grits
- Weighing scale
- Graduated cylinder



A **graduated cylinder**, also known as measuring cylinder, is a piece of equipment used to measure the volume of liquids.

Step 1. Select enough dried cassava grits to run the hammermill for at least 30 minutes.

Step 2. Fill the fuel tank of the equipment to its maximum level.

Step 3. Mill the cassava grits.

Step 4. Measure the **weight of milled material** using the weighing scale.

Step 5. Using the graduated cylinder, measure the amount of fuel needed to bring the level back to its maximum. This is the **amount of fuel consumed**.

Step 6. Divide the amount of fuel consumed by the measured weight of milled material (Step 4). This is the **specific energy consumption**.

Specific energy cost

To compare the energy consumption of a hammermill running on electric motor with one running on internal combustion engine it is necessary to convert it to **specific energy cost.** To calculate simply multiply the specific energy consumption by the cost of electricity or fuel. For example, if the specific energy consumption is 0.02 kWh/kg and the price of 1 kWh is $0.50, the specific energy cost will be: 0.02 kWh/kg × 0.50 $/kWh = 0.01 $/kg.

Worked examples

Throughput

To measure the throughput of a hammermill, a certain amount of dried cassava grits was separate and milled. It took **30 minutes** to mill them. The weight of the obtained milled material was **50 kg**. What is the throughput of this hammermill?

$$\text{Throughput} = \frac{\text{Weight of the milled material}}{\text{Time needed to mill it}}$$

$$\text{Throughput} = \frac{50\ \text{kg}}{30\ \text{min}} = \frac{50\ \text{kg}}{0.5\ \text{hour}} = 100\ \text{kg/hour}$$

*The throughput of this hammermill is **100 kg/hour**.*

Specific energy consumption

To determine the specific energy consumption of a hammermill running on an electric motor, a certain amount of dried cassava grits was separated. All electric appliances and equipment were switched-off and a reading of **12540.0 kWh** was made from the energy meter. All other electric equipment remained switched-off. The hammermill was switched-on, and the grits were milled. After that, a new reading of **12546.0 kWh** was made from the energy meter. The weight of the obtained milled material was **50 kg**. What is the specific energy consumption of this hammermill?

$$\text{Specific energy consumption} = \frac{\text{Final electricity reading - Initial electricity reading}}{\text{Weight of the milled material}}$$

$$\text{Specific energy consumption} = \frac{12540.0\ \text{kWh} - 12546.0\ \text{kWh}}{50\ \text{kg}} = \frac{6\ \text{kWh}}{50\ \text{kg}} = 0.12\ \text{kWh/kg}$$

*Specific energy consumption this hammermill is **0.12 kWh/kg**.*

To determine the specific energy consumption of a hammermill running on an internal combustion engine, a certain amount of dried cassava grits was separated, and the fuel tank of the equipment was filled to its maximum level. The hammermill was switched-on, and the grits milled. The weight of the obtained milled material was **100 kg**. Using a graduated cylinder, the fuel tank of the grater was refuelled. To bring it back to its maximum level **5 litres** of diesel were needed. What is the specific energy consumption of this hammermill?

$$\text{Specific energy consumption} = \frac{\text{Amount of fuel consumed}}{\text{Weight of the milled material}}$$

$$\text{Specific energy consumption} = \frac{5 \text{ litres}}{100 \text{ kg}} = 0.05 \text{ L/kg}$$

*Specific energy consumption of this hammermill is **0.05 L/kg**.*

Specific energy cost

Calculate the specific energy cost of a hammermill running on electric motor that has a specific energy consumption of **0.12 kWh/kg**. Also, calculate the specific energy cost of a hammermill running on internal combustion engine with specific energy consumption of **0.05 L/kg**. Consider the cost of electricity **$0.50 per kWh** and the cost of fuel is **$2.00 per litre**.

$$\text{Specific energy cost} = \text{Specific energy consumption} \times \text{Fuel cost}$$

$$\text{Specific energy cost} = \frac{0.12 \text{ kWh}}{1 \text{ kg}} \times \frac{\$0.50}{1 \text{ kWh}} = 0.06 \text{ \$/kg}$$

$$\text{Specific energy cost} = \frac{0.05 \text{ L}}{1 \text{ kg}} \times \frac{\$2.00}{1 \text{ L}} = 0.10 \text{ \$/kg}$$

*The specific energy cost of the hammermill running on electric motor is **0.06 $/kg** and the specific energy cost of the hammermill running on internal combustion engine is **0.10 $/kg**.*

Hammermills is the most common type of equipment to reduce the size of dried cassava grits. In this booklet, performance indices for hammermills are described and a step-by-step guide to calculating them is presented, along with practical examples.

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