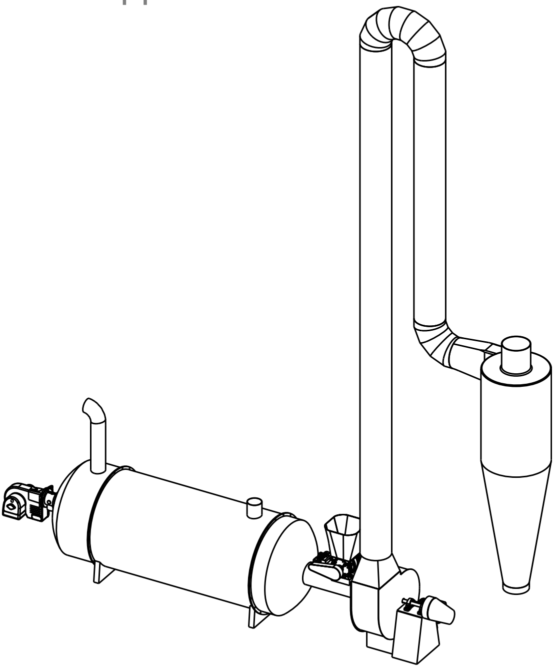
How to evaluate the performance of
CASSAVA DRYERS

Aditya Parmar & Marcelo Precoppe



Booklet 4

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Preface

This booklet is the fourth 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 DRYERS**
5	How to evaluate the performance of CYCLONES
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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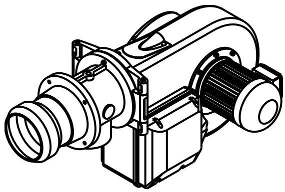
Pneumatic dryers in the food industry

Pneumatic dryers, also known as a flash dryers, are commonly used to dry granular material in the food industry. In this kind of dryer, the wet product is transported by the hot airstream, losing moisture as it moves. At the end of the drying duct, a cyclone separates the dried product from the drying air. The material stays inside the dryer only a few seconds and this allows heat sensitive materials to be dried at relatively high temperatures, without being damaged.

Pneumatic dryers for cassava processing

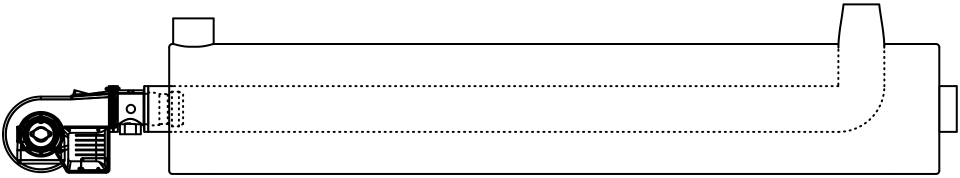
A pneumatic dryer is the most suitable type of drying equipment for cassava. The main components of a pneumatic dryer are burner, heat exchanger, feeder, fan, drying duct and cyclone.

Burners are devices that burn fuel to produce heat. The heat generated by the combustion is used to warm air via a heat exchanger. For cassava processing diesel is the most common fuel type used.

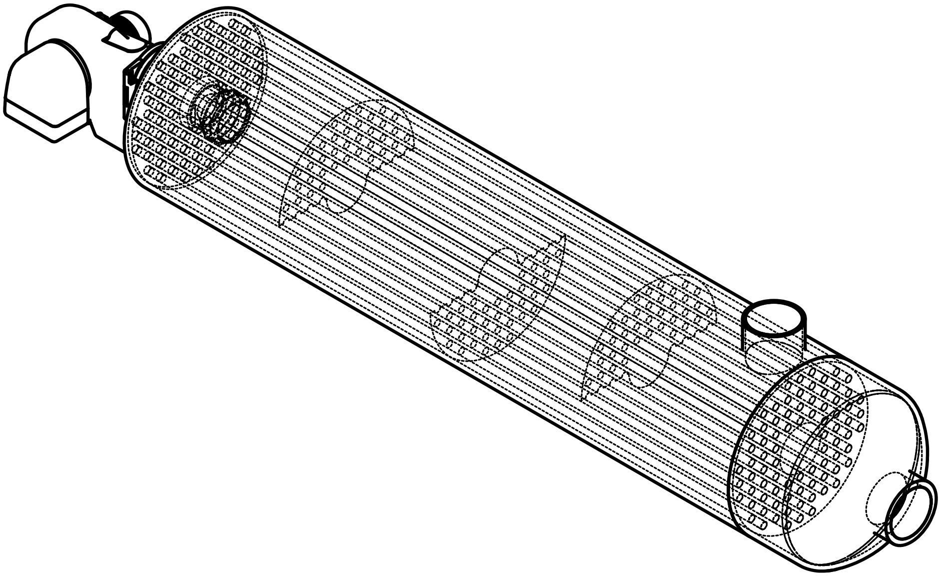


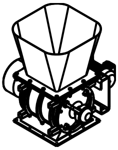
Heat exchangers are devices that transfer heat from the combustion gases to the drying air. The fluids are separated by solid walls that prevent mixing. For cassava processing, the most common types of heat exchangers are the double-pipe heat exchanger and the shell-and-tube heat exchanger.

Double-pipe heat exchangers are the simplest type and consist of two concentric pipes. They have limited heat transfer surface and consequently have lower efficiency.

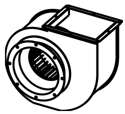


Shell-and-tube heat exchangers consist of a bundle of parallel tubes enclosed in a shell. This configuration allows a wide heat transfer surface and consequently have higher efficiency.

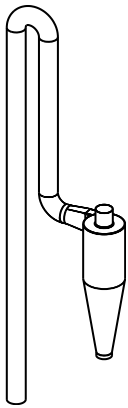




Feeders are devices that introduce materials into the dryer at a controlled and specified rate. For pneumatic dryers, it is important that the feeder promotes good dispersal of the material into the airstream.



Fans are used to produce the air. The fan can be installed at the beginning of the drying duct (positive-pressure conveying) or after the cyclone (negative-pressure conveying).



Drying duct is where the cassava grits are dried. It is important that the drying duct is long enough to provide the time needed to achieve the desired moisture content. Also, it is important the drying duct is thermally insulated to minimise heat losses.

Cyclones are devices that separate the dried cassava grits from the airstream. The dried grits leave the cyclone at the bottom and the air exits at the top. The expelled air may still contain small-sized particles and a second cyclone can help to separate them further.

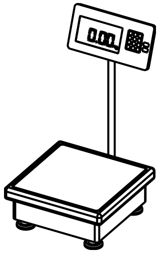
Performance assessment

Performance of pneumatic dryers can be assessed by determining its **evaporation rate** and its **specific energy consumption**.

Evaporation rate

Evaporation rate is the amount of water evaporated per unit of time. Evaporation rate is expressed in kilograms per hour (kg/h). To measure the **evaporation rate**, it is necessary to have:

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



The **wet cassava grits** should be from pressed and pulverized material. Its moisture content should be around 40% and it should be in a free-flowing form, without lumps.

Step 1. Separate enough wet cassava grits to run the dryer for at least 2 hours.

Step 2. Divide the separated material into 2 parts and measure the weight of one part. This is the **weight of the wet cassava grits**.

Step 3. Start the pneumatic dryer and operate it, as usual, feeding it with the other part of the wet cassava grits.

Step 4. When a steady-state condition has been achieved stop feeding the dryer and remove any dried grits present in the system.

Step 5. Start the stopwatch and start feeding the dryer with the separated wet cassava grits, the one of known weight.

Step 6. Stop the stopwatch when all the wet cassava grits have been dried. Record the time taken.

Step 7. Measure the **weight of the obtained dried cassava grits** using the weighing scale.

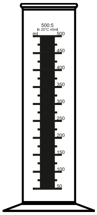
Step 8. Now subtract the weight of the obtained dried cassava grits from the weight of the wet cassava grit (Step 2). This is the **amount of water evaporated**.

Step 9. Divide the amount of water evaporated by the recorded time. This is the **evaporation rate**.

Specific energy consumption

Specific energy consumption is the amount of fuel needed per unit mass of water evaporated. It is normally expressed in litres of fuel per kilogram of water (L/kg). To measure **specific energy consumption** it is necessary to have:

- Wet 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. Separate enough wet cassava grits to run the dryer for at least 2 hours.

Step 2. Divide the separated material into 2 parts and measure the weight of one of them. This is the **weight of the wet cassava grits**.

Step 3. Start the pneumatic dryer and operate it, as usual, feeding it with the other part of the wet cassava grits.

Step 4. When a steady-state condition has been achieved stop feeding the dryer, remove all dried grits from the system and fill its fuel tank to the maximum level.

Step 5. Start feeding the dryer with the separated wet cassava grits, the one of known weight.

Step 6. Stop the dryer when all the wet cassava grits have been dried.

Step 7. Measure the **weight of the obtained dried cassava grits** using the weighing scale.

Step 8. 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 9. Subtract the weight of the obtained dried cassava grits from the weight of the wet cassava grits. This is the **amount of water evaporated**.

Step 10. Divide the amount of fuel consumed (Step 8) by the amount of water evaporated. This is the **specific energy consumption**.

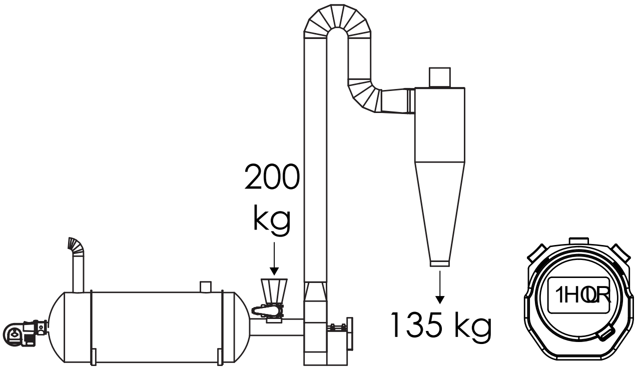
Specific cost

To compare the energy consumption of pneumatic dryers using different fuel types it is necessary to convert it to **specific energy cost**. To calculate, simply multiply the specific energy consumption by the cost of fuel. For example, if the specific energy consumption is 0.5 L/kg and the price of fuel is $2.00 per litre, the specific energy cost will be:
0.5 L/kg × 2.00 $/L= 1.00 $/kg.

Worked examples

Evaporation rate

To measure the evaporation rate of a pneumatic dryer used to process cassava, enough wet cassava grits to run the equipment for at least 2 hours were separated. The wet cassava grits had been earlier mechanically dewatered with a press and pulverized with a grater. The material was free-flowing and without lumps. The prepared material was divided into two parts of similar size. One part was weighed, it was **200 kg**. The dryer was switched-on and fed with the other part of wet grits. When a steady-state condition was achieved no further product was fed into the dryer, and any dried grits were cleaned from the system. After that, the drying process resumed, using the wet grits of known weight. It took **1 hour** to dry it, and **135 kg** of dried grits were obtained. What is the evaporation rate of this dryer?



$$\text{Evaporation rate} = \frac{\text{Weight of the wet cassava grits - Weight of the dried casssava grits}}{\text{Time needed to dry it}}$$

$$\text{Evaporation rate} = \frac{200\text{ kg} - 135\text{ kg}}{1\text{ hour}} = \frac{65\text{ kg}}{1\text{ hour}} = 65\text{ kg/h}$$

*The evaporation rate of the dryer is **65 kg/h**.*

Specific energy consumption

To measure the specific energy consumption of a pneumatic dryer used to process cassava, enough wet cassava grits to run the equipment for at least 2 hours were mechanically dewatered with a press and pulverized with a grater. The wet cassava grits were then separated into two parts. One part was weighed, it was **200 kg**. The dryer was switched-on and fed with the other part of wet grits. When a steady-state condition was achieved no product was further fed into the dryer, any dried grits in the system removed, and its fuel tank was filled to the maximum level. The drying process resumed, using the wet grits of known weight. The obtained dried grits weighed **135 kg**. Using a graduated cylinder, the fuel tank of the dryer was refuelled. To return it to its maximum level **26 litres** of diesel were needed. What is the specific energy consumption of this dryer?

$$\text{Specific energy consumption} = \frac{\text{Amount of fuel consumed}}{\text{Weight of wet cassava grits - Weight of dried cassava grits}}$$

$$\text{Specific energy consumption} = \frac{26 \text{ litres}}{200 \text{ kg} - 135 \text{ kg}} = 0.4 \text{ L/kg}$$

*The specific energy consumption is **0.4 L/kg**.*

Specific cost

Calculate the specific energy cost of a pneumatic dryer fuelled by diesel and with a specific energy consumption of **0.4 L/kg**. Also, calculate the specific energy cost of another dryer fuelled by kerosene and with specific energy consumption of **0.5 L/kg**. Consider the cost diesel **$2.00 per litre** and the cost of kerosene **$1.80 per litre.**

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

$$\text{Specific energy cost} = \frac{0.4 \text{ L}}{1 \text{ kg}} \times \frac{\$2.00}{1 \text{ L}} = 0.80 \text{ \$/kg}$$

$$\text{Specific energy cost} = \frac{0.5 \text{ L}}{1 \text{ kg}} \times \frac{\$1.80}{1 \text{ L}} = 0.90 \text{ \$/kg}$$

*The specific energy cost of the dryer fuelled by diesel is **0.80 $/kg** and the specific energy cost of the dryer fuelled by kerosene is **0.90 $/kg**.*

Pneumatic dryer, also known as flash dryer, is the most suitable types of drying equipment for cassava processing. In this booklet, performance indices for evaluating the performance of pneumatic dryers are described, and a step-by-step guide to calculating them is presented, along with practical examples.

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