MODIFICATION AND TESTING OF A CASSAVA FLASH DRYER FEEDER UNIT

Balami, A. A.
Federal University of Technology
NIGERIA
aabalami783@yahoo.com

Adgidzi D.
Federal University of Technology
NIGERIA
p.adgidzi@yahoo.com

Kwaya, E. I.
Raw Material Research and Development Council
NIGERIA
ekwaya@yahoo.com

ABSTRACT

A flash dryer feeder Unit was modified and tested under industrial conditions on a Flash Drying Plant at Godilogo Farms Ltd, Obudu in Cross River State of Nigeria. The earlier feeder unit was designed based on flow properties of sugar beets to handle 820 kg/hr of grated and dewatered wet cassava cake/mash feed but the throughput obtained was 702 Kg/hr due to a rathole formed in a section of the unit. This gave rise to erratic flow with frequent blockages in the flash tube which consequently disrupts the attainment of the designed capacity. As a result of this setback, the modified feeder was designed based on flow properties of grated and dewatered cassava cake using Jenike – Schulze Ring Shear Tester at Jenike and Johanson Inc, Facility Boston, USA. The results obtained indicate that the feed rate of cassava wet cake/mash at moisture content of 42 % can be varied from 115 kg/hr – 1120 kg/hr, without noticeable flow blockage or the formation of a rathole in the feeder. The production capacity of the flash drying plant using the modified feeder unit is higher than the one obtained with the earlier feeding unit by 64 %. Also, the quality of the cassava flour produced using the modified feeder unit falls within the acceptable Nigerian standards for this product.

Key words: Cassava cake, rathole, feeder unit, feed rate

INTRODUCTION

Nigeria's Presidential Initiative on Cassava of 2002 which directed the inclusion of 10% High Quality Cassava Flour (HQCF) in Bakery Flour policy set in motion the process of achieving an annual income of US$5 billion from the processing and exports of cassava and cassava products such as starch, ethanol, chips, flour and others. Since the inception of the initiative, Nigeria's export of cassava products has been actively pursued, with organic gari(or farina, as the roasted granule as known in Latin America) being exported to Europe and the United States (CgiarNews , 2007; Kwaya, 2008). Implementation of this policy requires that appropriate and efficient processing techniques be put in place. Therefore, the role of dryers comes to play

CONTEXT AND LITERATURE REVIEW

Dryers are used to convert cassava mash to flours. Among the different dryers, flash dryers have the shortest residence time and can be used for the production of High Quality Cassava Flour (HQCF). Flash dryers can be the most economical choice for drying solids that have been dewatered or have inherently low moisture content (Barr-Rosin, 2010). They have several advantages over more complex gas suspension dryers such as fluid bed or rotary types. They are relatively simple and take up less space and usually require lower capital investment. Because of the extremely short residence time, these devices are well-suited for processing heat-sensitive products like cassava or easily oxidized materials (Ove*et al.,* 2001). Since 2004, dryers have been fabricated and installed in Nigeria. However, all these flash dryers are inefficient in terms of energy consumption and/or product quality (Kuye, *et al*., 2010). Among all the units' components of flash dryer plant (Feeder, Heat Exchanger, Flash Tube (Drying Column) and the Cyclone Separator units), it is worthy to note that the feed unit (used to control the rate of material discharge from a bin (hopper, silo, and bunker) outlet) is the most critical component required for the efficient operation of the plant and also guarantees finished product specifications and quality.

Therefore in pursuant to the Federal Government's mandatory inclusion of 10% HQCF in Bakery Flour policy this, research work "Modification and testing of cassava flash dryer unit" was embarked upon.

METHODS

Design Parameters

The design parameters (cohesive strength, wall friction, shear strength, bulk density, compressibility, flow ability and particle size) were determined according to standard procedures (Schulze, 2008; ASAE Standards, 2003; ASTM standard D 6128, 2000; Jenike and Johanson Inc, 2010; Carson and Marinelli, 1992; Sanni, *et al*; 2005; Ajao and Adegun, 2009; Kuye, *et al.*, 2010; GEA-Barr-Rosin, 2006) using cassava wet cake (TME-419 variety) grated with a Brazilian made grater. The wet cake was tested to determine its properties for continuous flow at 30°C and 90 % relative humidity at 34 – 45 % moisture content. The experiment was carried out in the Jenike and Johanson Inc, Facility Boston, United States of America.

Test procedure

18 months old Cassava samples were harvested, hand peeled and grated in the Brazilian made grater with the root pusher after which it was dewatered in the dual chamber hydraulic press with a load of 68.65 kN. The resulting flakes were again grated and sifted to obtain uniform particle size for the test. A batch sample size of 100 kg at moisture content of 42% was used to run the test in the feeder at different rotational speeds (rpm) fig.1. Several trials were carried out to enable the operator get used to the feed rates before the reading of time interval versus rpm were obtained for the calibration and performance test. The samples were analysed in the Laboratory within 48 hours of harvesting the fresh tubers.

Testing Of the Old Feeder Unit

The feed rate of the old feeder

The variation of the feed rate with the speed of the variable geared motor attached to the feeding mechanism was measured. The feed rate was calculated by weighing the amount of cake fed to the dryer during a given time. The flash dryer was designed for a feed rate of 820 kg/hr and a screw speed of 72 rpm.

Testing Of the Modified Feeder Unit

The feed rate

Also the variation of feed rate with the speed of the variable mechanical geared motor attached to the feeding mechanism was measured. 100 kg of feed material was used in batches at different screw speed to determine the feed rate and to observe the formation of rathole, arching or bridging in the feeder. The feeder was tested at shaft speeds of 15 to 100 rpm. A mechanical variable speed geared AC motor was used, while a digital photo tachometer was used to calibrate the rotary speed range.

The tested material was sieved to eliminate particle sizes greater than 6 mm. The time interval for each batch was taken and later converted to feed rate in Kilogram per hour (kg/hr). A maximum feed rate of 1120 kg/hr was achieved, though the material could not attain the final moisture content of 5 - 7 % as expected in the dryer at this feed rate. Figure 1 shows the pictorial view of the modified feeder unit.

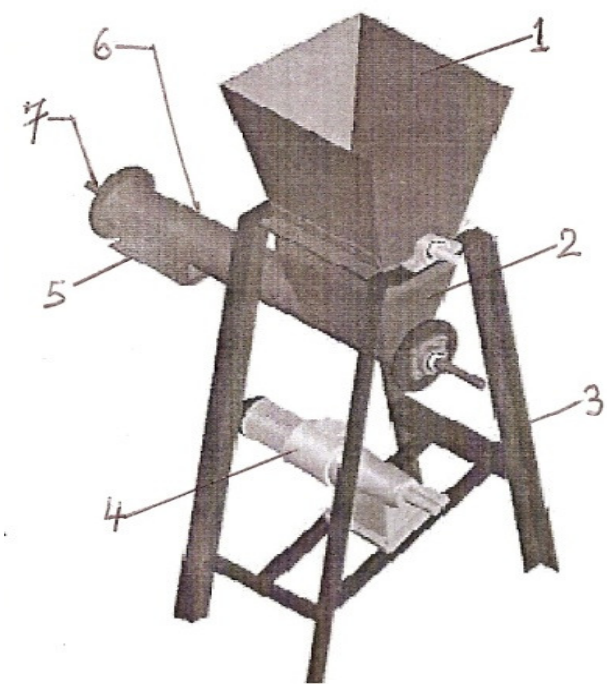

Figure 1. Pictorial view of the feeder unit

1 – Hopper, 2 – Pulveriser, 3 – Frame, 4 – Motor, 5 – Lower feeder discharge chute, 6 – Screw Conveyor, 7 – Screw shaft

FINDINGS AND DISCUSSION

However, Figure 2 indicates that the maximum feed rate observed on load was 702 kg/hr at a screw speed of 72 rpm. Equation (1) shows the relation between flow rate and speed using regression analysis.

$$FR = -0.003s^3 + 0.3279s^2 + 0.1311s + 113.81 \qquad (R^2 = 0.9907) \qquad (1)$$

Where FR is flow rate (kg/hr) and s speed (rpm)

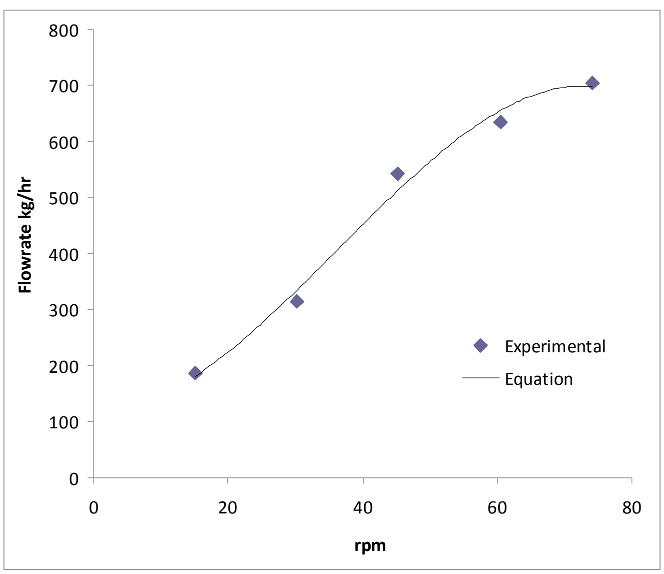

Figure 2.Wet mash feeding rate relation with speed

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Though the feeder was designed for 820 kg/hr, the feeder was only able to deliver 702 kg/hr without noticeable flow problems, while at a higher speed a noticeable and a stable rathole is formed leading to erratic flow, which eventually blocks the flash tube as shown in plates 1 and 2.

There is also a wide variation in the designed maximum particle size of 1.5 mm to the observed 8 - 10 mm particle sizes, which also contributed to the flow problems and reduced capacity. The flow was observed to totally stagnate above the screw, because the smallest clearance of the rectangular inlet cross-section (width of the slot), which for single screw feeders is equal to the screw diameter plus twice the clearance between screw and tubular housing was not observed.

As observed by (Vetter, 1991), the following flow problems were observed.

- Poor flowing of materials causing bridging or blocking above the feeder or at the inlet
- Cohesive materials (Cassava wet cake) sticking to the feeder components which may also be due to moisture laden gas, steam or high humidity atmospheric conditions (in this high pressure drying air from the flash tube)
- Blockages in the feeder itself
- Product not flowing away from the feeder as shown in plates 3 and 4. (Blockages in the rotary airlock caused by degraded feed materials)


Plate 1: Initial Stage of Rat hole formation   Plate 2: Later Stage of Rat hole Formation


Plate 3: Rotary airlock blocked decayed Plate 4: Rotary airlock with blocked feed with material

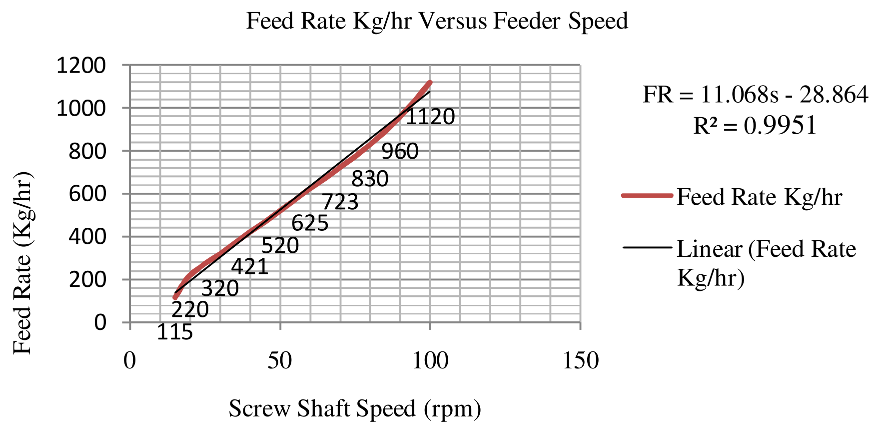

Figure 3.Feed rate Versus Feeder Speed

The coefficient of determination arising from equation (2) is $R^2 = 0.9951$

$$FR = 11.068s - 28.864 \quad (2)$$

Where FR is flow rate (kg/hr) and s speed (rpm)

From the coefficient of determination ($R^2 = 0.9951$) which is close to unity, it implies that the equation is almost a perfect fit for the experimental data.

The noticeable improvement of this feeder unit, is as a result of changes in the design based on the materials flow properties and the use of 3 mm thick 304 #2B Finish Stainless Steel Sheet: This surface is a cold rolled mill finish that cannot be achieved by polishing.

The proper use of the discharge outlet slot, which is a critical dimension based on the cassava wet characteristics as compared to the previous feeder unit that was designed based on the flow properties of Sugar Beet is also responsible for the improvement in the design.

Results from fig. 3 shows that the modified feeder can be operated between 115 – 1120 kg/hr depending on the desired production output. However, at the higher output the drying efficiency was affected because the flash drying plant as a whole was not designed to handle that capacity. Therefore, to increase the plant's throughput, several parameters would have to be look at simultaneously.

CONCLUSIONS

A feeder unit for a cassava flash dryer plant was successfully modified and fabricated. With the new fabricated feeder unit, the flash plant dryer can now attain a throughput of 1120 kg/hr as against 702 kg/hr using the previous feeder unit. Hence, the overall production cost of the flash dryer plant will reduce, as the increase in feed capacity at constant energy greatly affects production cost. Also, the downtimes associated with blockages in the flash tube have been eliminated through proper design of the feeder.

Therefore, the proliferation of this technology will help to meet the national demand for HQCF and at the same time responding to ending hunger and extreme poverty.

The following recommendations are hereby suggested:

- Bulk handling plants and equipment should be designed based on flow properties and material's characteristics.
- Every operational step including the method of feed and the interface at the inlet and outlet must be correctly designed.
- The incorporation of real time moisture content measurement and feedback system in this feeder unit is also suggested to ensure that there is no variability in the final finished product.

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