Issue 9, July-December 2006
p. 103-110

# Development of Cassava Grating Machine: A Dual-Operational Mode

Mohammed B. NDALIMAN

*Mechanical Engineering Department, Federal University of Technology, Minna*
mbndaliman@yahoo.com

**Abstract**

Design of a Cassava grating machine which has two modes of operation was made. It can be powered either electrically or manually. It takes care of power failure problems, and can be used in rural settlements where electricity supply is not in existence. Cassava is fed with the Machine through the hopper made of metal sheet to the granting drum, which rotates at a constant speed. This process grates the cassava into cassava pulp. The chute constructed of metal sheet accepts the pulp and send it out because of its inclination which operated manually, the efficiency of the machine was found to be 92.4%, which the efficiency of the electrically powered machine was found to be 91.9%.

**Key Words**

Grating Efficiency, Hopper, Delivery Chute, Cassava Pulp

## Introduction

Cassava is a major source of carbohydrates in human diet, being processed into Garri, fatal and typical as a constituent for human food. Recently other areas of uses of cassava are being implored. It is also being used as starch. The crop tolerance makes it more popular and now replacing yam in some part of Nigeria. The sweet varieties could be boiled for human consumption.

The tubers of cassava cannot be stored longer after harvest before decaying, and so processing follows immediately after harvesting. Cassava processing leading t size reduction includes peeling, grating dehydrating, milling and sieving. A typical cassava processing plant should therefore consist of units produced to achieve all the stages or steps mentioned above. The aim of this paper is therefore to present the result of efforts made in producing a device that is used in granting. The transformation of cassava tubers into pulp form is called grating.

Traditional tools used in Garri processing includes: Millstone, grinding stone, pestle and mortar. In these methods have low productivities and low hygienic solution to these problems that led to the designing and construction of machines that can grate the cassava of high quality in a short period of time and reduce human drudgery. Some of the machines include: roller crushing mill, hammer mill, bar mill, grater etc, all having one problem or the other.

Oyesola (1981) reported that, the traditional method of grating involves placing of the local grater, which is made of perforated metal sheet on the table where it is convenient for effective use and brushes sheet metal. The cassava turns into pulp and drop into container that is being used to collect the grated pulp cassava.

Adejumo (1995) in his design used a wooden grater in which the cassava forced into a hopper is rubbed against the grater which is being electrically power. Enhanced quantity of cassava can be grated using this method. However the durability of grater is low because of its wooden nature.

Ndaliman (2006) described a pedal operated cassava grinder which is powered by human efforts applied to pedal. The grinder pulverizes the cassava tubers into paste which can pass through a wine sieve. The effective performance of the design was at 60%.

The current design consists basically of 3 units: the hopper unit, the grating drum and the delivery channel. All these components are mounted on an angle iron frame. The machine assembly is powered mechanically or manually incase of electricity failure. It can be use in rural settlements where electricity supply might not in existence. Apart from faster rating rate, it required less him involvement. The grating drum is made of metallic pipe that carries a perforated plate which served as the grater. This overcomes the problem faced in the wooden grating drum.

## Design Analysis and Calculations

### *Design Considerations*

The general consideration in designing this dual – operational grating machine is producing a machine that can be easily assembled or disassembled, a machine in which the hopper allows materials to pass through effectively with minimum wastage; the grating drum is made of metal so as to increase its durability; the chute is sloppy to allow grating pulp to slide downward and get discharge by gravity.

### *Hopper Design*

A hopper with rectangular cross section was considered.

The Volume of which was obtained as follow:

$$V = L \cdot B \cdot H \ (m^3) \quad (1)$$

where V = Volume of the hopper, L = Hopper's length, B = Hopper's breath, and H = Hopper's height.

The mass of Hopper is given as:

$$M = \rho \cdot V \ (kg) \quad (2)$$

where $\rho$ = density of material.

### *Grating Drum Design*

The grating drum is cylindrical in shape. The volume of the cylinder is given by:

$$V_c = \pi \cdot r^2 \cdot l \ (m^3) \quad (3)$$

where $V_c$ = volume of cylinder, R = radius of cylinder, and L = length of drum.

The force acting on the cylinder drum is given as:

$$F = V \cdot \rho \cdot g \quad (4)$$

where g = acceleration due to gravity.

### *Shaft Design*

The shaft considered for satisfactory performance is to be rigid enough while transmitting load under various operating conditions. To achieve this, a solid circular shaft was considered for analysis of combined torsional and bending stresses.

For solid shaft having little or no axial load, the diameter is given by:

$$d^3 = 16/\pi S_s\,((K_b M_b)^2 + (K_t M_t)^2)^{1/2} \quad (5)$$

where $M_t$ = torsional moment, $M_b$ = bending moment, $K_b$ = combined shock and fatigue applied to bending moment (1.5), $K_t$ = combine shock & fatigue applied to torsional moment (1.0), and $S_s$ = allowable stress.

For a shaft transmitting power (kW) at a rotational speed (rpm) the transmitting torque is given as:

$$M_t = \text{Power/Speed} \quad (6)$$

### *Speed Ratio*

The speed ratio of the larger pulley on the machine shaft to the smaller pulley on the electric motor is givens as:

$$N_1\, D_1 = N_2\, D_2 \quad (7)$$

where $N_1$ = speed of electric motor, $N_2$ = speed of machine driving shaft, $D_1$ = diameter of motor pulley, and $D_2$ = diameter of machine drived pulley.

The Results of Design calculations are summarized in Table 1.

*Table 1. Results of Design Calculations and Specifications*

| Parameter | Values |
|---|---|
| Volume of Hopper | 0.071232 m |
| Mass of the Hopper | 555.61 kg |
| Shaft of diameter | Ǿ 23.00 mm |
| Selected Shaft diameter | Ǿ 25.00 mm |
| Speed of electric motor | 1500 rpm |
| Speed of Machine driven shaft | 1150 rpm |

## Construction & Performance Evaluation

### *Main features*

The main features of the machine are: the frame and stand; the hopper, grating unit, delivery chute; the shaft and bearings, and the power transmission unit. The assembled machine is shown in Figure 1.

*Figure 1. A Dual - Operational Cassava Grating Machine*

Table 2 gives the bill of materials used in production of one unit of the machine. The total cost of production of one unit is estimated to be about N 23,000.00 including both manufacturing and overhead cost.

*Table 2. Bill of Materials*

| No. | Material | Specification | Quantity | Unit price (=n=) | Amount (=n=) |
|---|---|---|---|---|---|
| 1. | Metal sheet | Mild steel gauge 14 | I full sheet | 3500 | 3500 |
| 2. | Round plates | Mild steel 170mm dia | ¼ length | 1,000 | 1,000 |
| 3. | Angle Iron | Mild steel 50 x 50 | 2 full length | 1,100 | 2,000 |
| 4. | Shaft | Mild steel 25mm dia | 870nn long | 1,000 | 1,000 |
| 5. | Round pipe | 170mm dia | 480m long | 1,000 | 1,000 |
| 6. | Bearing | 6305 | 2 | 500 | 1,000 |
| 7. | Housing | 39mm | 2 | 500 | 1,000 |
| 8. | Pulley | 750mm dia | 1 | 1,500 | 1,500 |
| 9. | Bolts and nuts | M10 | 1½ dozen | 500 | 750 |
| 10 | Electrode | Gauge 12 | ½ | 600 | 500 |
| 11 | Wood | 1½ | 1 | 500 | 500 |
| | TOTAL COST | | | | 14,350 |

### *Operating principle*

The machine is design in such a way as to make its operation simple. When mechanically operated, the machine is coupled to an electric motor by a V- belt pulley on the shaft. And when manually operated, the grating drum is set in revolution through the turning of the steering. Cassava is fed through the hopper and an additional plank is used to press the cassava on grater. The pulps are collected through the chute to the basin or directly on a cemented floor.

### Performance test

Series of tests were conducted using the machine. Cassava tubers were obtained from a farm and peeled manually, thoroughly washed and weighed using weighing balance scale. The machine was operated for some minutes to allow speed to stabilize. Peeled cassava was introduced into it through the hopper. A piece of wood was used to press the cassava against the drum to prevent scattering of the cassava caused by machine vibration. The pulp was collected into a sac and taking to a press for dewatering. The dewatered pulp was weighed and recorded using the weighing balance scale. The pulp was then sieved. The weight of sieved and unsieved materials was recorded.

The grating efficiency is given as:

$$\eta_g = W_r / W_f \cdot 100 \quad (8)$$

where $\eta_g$ = Grating efficiency, $\underline{W_r}$ = Total weight recovered, and $W_f$ = Total weight fed in.

This was obtained for each of the manually operated and electrically powered operations.

## Discussions

The fabricated grating machine can be operated both manually as well as by electric power. It is therefore versatile and simple. The total cost of production of a unit is estimated to be about =N=23,000.00 including both manufacturing and overhead costs. This is affordable for an average entrepreneur.

The performance tests conducted indicated that high values of grating efficiencies are attainable when powered electrically and manually operated.

Both tests were conducted with 2.0kg of cassava. When manually operated, the grating efficiency was found to be 92.4%. That of electrically operated machine gave the efficiency of 91.95%. These levels of performances are satisfactory. They are even higher than that of pedal operated type (Ndaliman, 2006).

## Conclusions and Recommendations

The constructed grating machine has been found to be effective and efficient. It can be powered both electrically and manually. Therefore, it can be used by both rural as well as urban dwellers. It is also affordable since the cost of production is low.

Efforts should be made to adopt and popularize this design, especially for the benefits of rural people who make up a greater percentage of the nation's population. It is also hoped that when mass-produced, the unit cost would even be lower than it is now.

## Acknowledgement

The Author expresses his gratitude to Mr. R. A. Adamu for fabricating and assisting in testing the machine.

## References

[1] Adejumo S. O., *Construction and Evaluation of an Engine Operated Bur*, 1994.

[2] Mill Project Report Submitted to the Department of Agricultural Engineering, Federal College of Agriculture, Ibadan, pp.1-5.

[3] Hicks T. G., Standard Handbook of Engineering Calculations, $3^{rd}$ editions, 1995.

[4] Ndaliman M. B., *Design and Construction of a Pedal Operated Cassava Grinder*, Unpublished Manuscript, 2006.

[5] Oyesola G. O., *Technology Processing Cassava and Utilization*, Advisory Leaflet No. 3 Cassava and Garri Storage, NCAM, Kwara State, Nigeria, 1981.

## Nomenclatures and Symbols

B = Hopper's breath
$D_1$ = Diameter of motor pulley
$D_2$ = Diameter of machine drived pulley
H = Hopper's height
$K_b$ = Combined shock and fatigue applied to bending moment (1.5)
$K_t$ = Combine shock & fatigue applied to torsional moment (1.0)
L = Hopper's length.
L = Length of drum
M = Mass of the hopper
$M_b$ = Bending moment
$M_t$ = Torsional moment
$N_1$ = Speed of electric motor
$N_2$ = Speed of machine driving shaft
R = Radius of cylinder
$S_s$ = Allowable stress
V = Volume of the hopper
$V_c$ = Volume of cylinder
$W_f$ = Total weight fed in
$W_r$ = Total weight recovered
$\eta_g$ = Grating efficiency
$\rho$ = Density of material