Development of an Improved Garri Sifting Machine.

O.R. Adetunji, Ph.D.[1*]; O.U. Dairo, Ph.D.[2]; T. Aina, B.Engr.[1]; and A.S. Osunlana, B.Engr.[1]

[1]Mechanical Engineering Department, Federal University of Agriculture, Abeokuta, PMB 2240, Abeokuta, Nigeria.
[2]Agricultural Engineering Department, Federal University of Agriculture, Abeokuta PMB 2240, Abeokuta, Nigeria.

E-mail: adetunjiolayide@gmail.com*
Telephone: 2348033467246

ABSTRACT

Cassava is a multipurpose crop for man and livestock. Cassava starch is an ingredient in the manufacture of dyes, drugs, chemicals, carpets and in the coagulation of rubber latex. The way forward is the design of appropriate mechanical device and system for sieving dried cassava flakes (Garri). This project seeks to design and fabricate an improved garri sifting machine. There is need for the development of commercial scale garri sifting machine where the roasted garri can be properly monitored. Some design considerations used in this project include efficiency, portability, and safety of operations. Adequate care of chemicals present in cassava juice was considered in selecting materials for fabrication of the machine. The machine was damped to reduce noise pollution during its operation. The machine runs on a single phase 1 HP. electric motor at a speed of 1400 RPM. The result obtained from performance evaluation test showed a sieving efficiency of 92.5% as compared with machine efficiency of 99.14%. This is an indication of the proper working of the garri sifting machine as compared to ones produced earlier with less than 50 % efficiency.

(Keywords: design, fabricate, improved, garri, sifting, machine)

INTRODUCTION

Cassava is a major source of carbohydrate in most developing nations of the world. It can be used as binder in the textile industries as well as in many pharmaceutical and agro allied industries. Cassava (*Manihotesculenta crantz*) is a short-lived perennial tropical shrub growing from about 1.0-3.5 m tall. Believed to be first domesticated in South America, its cultivation has spread throughout the humid tropics and subtropics (Nweke et al., 2002).

Total production of cassava in Africa has increased from 35 – 80 million tons between 1965 and 1995 (Ajibola, 1995). Africa now produces cassava than the rest of the world combined with biggest increase from 22% to 35% (of African total production) in Nigeria and 4% to 8% in Ghana (FAO, 2002). In Ghana, it is eaten boiled. It could be pounded to be eaten with soup in addition to some of the processed forms in Nigeria. Co-incidentally the Government of the two respective countries has started 'presidential initiatives' to increase cassava production for local consumption and export promotions. In 2004, a policy was initiated to produce bread with cassava: wheat flour ratio of 1:9 in Nigerian bakery industry. Apart from human food, cassava is also used for animal feed and alcohol production (Odighoh, 1983).

Traditional tools used in garri processing include mill stone, grinding stone, and pestle and mortar. In this method we have low productivities and low hygienic solution to these problems that led to the designing and construction of machines that can grate, mill, press and cassava of high quality in a short period of time and reduce human drudgery. Some of the machines include Cassava harvesters, grater, Cassava pressing machine mill, grater, sifter and fryers (Hahn et al., 1986).

There is an ever-increasing global demand for cassava chips and pellets particularly from China and Brazil. Cassava can therefore be referred to as a multipurpose crop for man and livestock. Cassava starch is an ingredient in the manufacture of dyes, drugs, chemicals, carpets and in coagulation of rubber latex (Hahn et al., 1986).

Since 1990, Nigeria has surpassed Brazil as the world's leading producer of cassava with an estimated annual production of 26 million tonnes from an estimated area of 1.7 million hectares of land (IITA, 2004). Other major producers of cassava are Zaire, Thailand, Indonesia, China, India, Malaysia, Malawi, Togo and Tanzania.

Cassava processing thus deserves serious attention in order to meet the local and international demand for cassava products. The unit operations involved in cassava processing include peeling, grating, boiling/parboiling, drying, milling, pressing, sieving, extrusion and frying. Several processes have been mechanized successfully, however, cassava peeling remains a serious global challenge to design engineers involved in cassava processing. The way forward is the design of appropriate mechanical device and system for sieving dried cassava flakes (Adetunji and Quadri, 2011).

Mechanization in all its form ensures ease and speed of production. To ensure that cassava is processed with ease (reduce stress during processing) and improve the hygienic condition of processing within short period of time (Ajao and Adegun, 2011).

From the previous design, it was discovered that the speed of the reciprocating shaft of the sifter was too high, which led to spilling of the garri instead of sieving it (Adetunji and Osunlana, 2011) [9].

The basic function of the sifter is to separate grain sizes and gangue:

This project therefore aimed at achieving the following objectives:

1 To properly classify Garri grain sizes by regular movement of the sift.

2 To carry out detail performance evaluation to determine the efficiency of the machine.

MATERIALSAND METHODS

Some of the materials used in the construction of a garri sieving machine are listed below:

Table 1: Materials Used for the Fabrication.

S/N	NAME	MATERIALS USED
1	Hopper	Mild Steel
2	Pulley	Mild Steel
3	Electric motor	1 kw single phase electric motor
4	Bolts & Nuts	Mild Steel
5	Belts	Rubber/Leather
6	Bearings	Ball bearings
7	Wire mesh	Stainless Steel

Shafts Design

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is transmitted by some tangential force and the resultant torque (or twisting moment) set up within the shafts permits the power to be transmitted to various machine or its elements linked up to the shaft.

In order to transfer the power from the shaft, the various members such as pulleys, bearings, etc. are mounted on it. These members along with the force exerted upon them causes the shaft to bend.

Therefore, we may say the shaft in this case is exposed to bending moment and torsional forces since it is utilized for torque transmission and bending moment.

The power delivered by a shaft is given by:

$$P = F \times V \quad \textbf{(1)}$$

Where P = Power (Nms^{-1})**,**F= Force of sifting (N) and V=velocity (m/s) (Shingley, 1986).

Determination of the Bending Moment at Each Point of Loading

This involves the preparation of the bending moment diagram or the two perpendicular planes: vertical and horizontal.

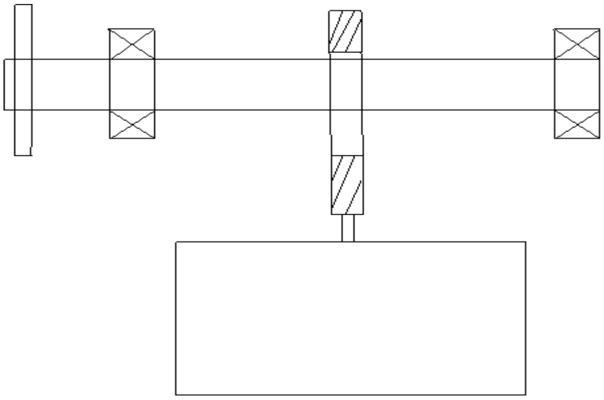

Figure 1: Schematic Diagram of Shaft and Bearing.

- D_t=density of steel plate is 7930kg/m^2
- V_t=l×b×h=500×500×120=0.03m^2
- W_t=0.03×7930×9.81 =2334N
- M_p = Mass of the pulley in kg
  = Mass of the two small bearings + Mass of two big bearings + Mass of Perforated Mesh.
- and Mass=Density of Material × Volume of the material =ρV
- g=Acceleration due to gravity
- M_p = (4kg+10kg+237.9kg)=251.9kg
- Weight of Pulley
  W_t=M_p× g
  =251.9×9.81=2471.14N

Horizontal Weight on the Pulley, $W_p = \frac{Torque}{Radius\ of\ the\ Pulley, Rp}$ **(2)**

Torque = $\frac{Power\ Rating}{Ang\ Acceleration, \omega\ in \frac{rad}{s}}$

Angular Acceleration, $\omega\ in\ rad/s = 2\pi N/60$

Using the W'$_p$ horizontal force, I then obtained the horizontal reactions at the bearings by taking the moment about the two bearing points independently.

From these results of the calculations, the shear force and the bending moment diagrams required were obtained.

Considering the horizontal, vertical forces, and the bending reactions, the maximum bending moment can be easily obtained from the resultant bending moment:

$$Resultant\ Bending\ Moment = \sqrt{(Horizontal\ Forces)^2 + (Vertical\ Forces)^2}$$ **(3)**

Then, it equivalent twist moment from the torque.

Equivalent Twist Moment,

$$T_e \sqrt{(Maximum\ Bending\ Moment)^2 + (Torque)^2}$$ **(4)**

The Diameter of the shaft can be determined by:

Equivalent Twist Moment, $T_e = \frac{\pi}{16 \times \tau \times D_S^3}$ **(5)**

$\tau =$ $Permissible\ Shear\ Stress\ on\ the\ Shaft\ Material$

$D_s = Diameter\ of\ Shaft$

Design of Hopper

The volume of the hopper was calculated as :

V = L x B x H **(6)**

Where:
L = Length (mm)
B = Breadth (mm)
H = Height (mm)

Pulley Design

The ratio between the velocities of the electric motor pulley/driven pulley and the driven pulley may be expressed mathematically as discussed below. Let"

$D_e = Diameter\ of\ the\ driver\ pulley$
$D_d = Diameter\ of\ the\ driven\ pulley$

$N_e = Speed\ of\ the\ driver\ in\ r.p.m$
$N_d = Speed\ of\ the\ driven\ in\ r.p.m$

Length of the belt that passes over the driver, in one minute $= \pi D_e N_e$ **(7)**

Similarly, length of the belt that passes over the follower, in one follower, in one minute $= \pi D_d N_d$ **(8)**

Since the length of belt that passes over the driver in one minute is equal to the length of belt that passes over the follower in one minute, therefore (Balogun, 2006) [11].

$$D_e N_e = D_d N_d \quad \textbf{(9)}$$

Therefore, $N_d = \frac{D_e N_e}{D_d}$ **(10)**

Belt Design

In order to compute the length of the belt required, we use the formula below:

$$L = \frac{\pi(D_d + N_e)}{2} + 2x - \frac{(D_d - D_e)}{4x} \quad \textbf{(11)}$$

Where,

$D_e = Diameter\ of\ the\ driver\ pulley$
$D_d = Diameter\ of\ the\ driven\ pulley$
X = Center diameter
L = Length of Belt Required

Where, [12]
$X = \frac{D_d + D_d}{2} + D_1$ (Alabi, 2009)

Power Design

The power p, in kw required to operate the machine was estimated using:

$$P = Ww^3r^2 \quad \textbf{(13)}$$

(ASME, 1995)

$$P = \left(\frac{2\pi N^3}{60}\right)r^3 \quad \textbf{(14)}$$

(Nwakaire et al., 2011)

Where,

W = mass of the pulley, kg
w = angular velocity,
R = radius of the pulley
N = number of revolution per minute
P = Power

Pulley Belt Contact Angle

The pulley belt contact angle θ was evaluated using the expression (ASME, 1995).

$$\theta = 180 + \frac{D_d - D_e}{2} \quad (15)$$

RESULTS

Design of Garri Sifter

Computer Aided Design (CAD) was used to create two and three-dimensional drawings through AUTOCAD software, such as those for automobile and airplane parts, floor plans, maps and machine assembly. While it may be faster for an engineer to produce an initial hand drawing, it is more efficient to change and adjust drawings by computer.

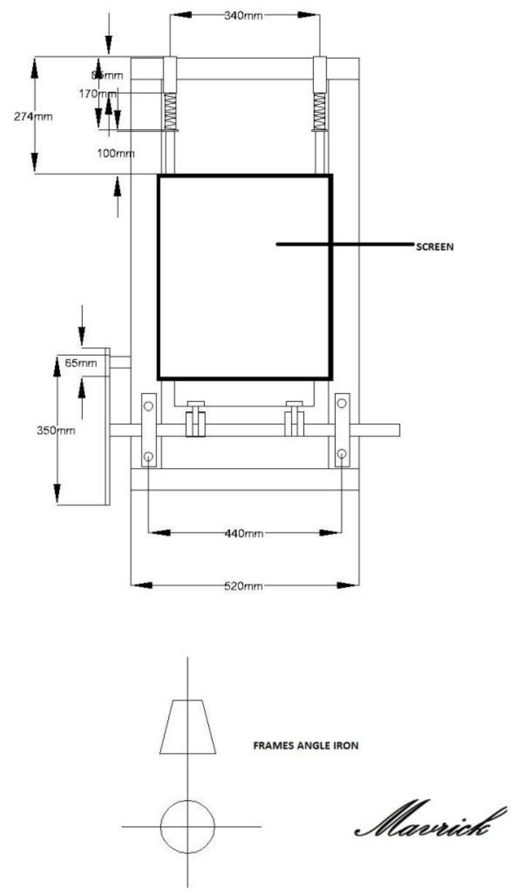

Figure 2: Plan View of Garri Sifting Machine.

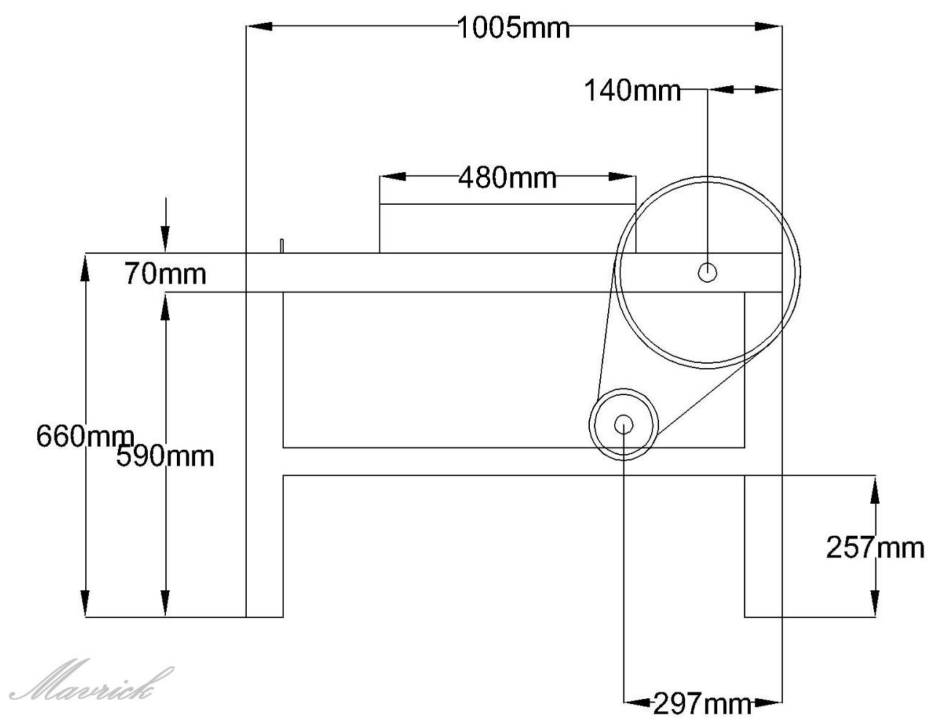

Figure 3: Front Elevation of the Machine.

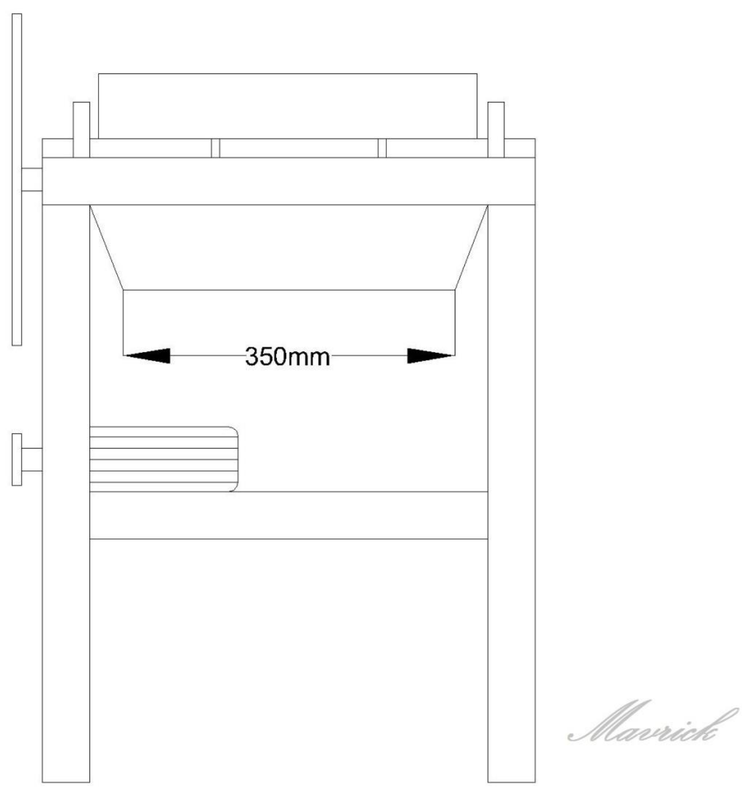

Figure 4: End Elevation of Garri Sifting Machine.

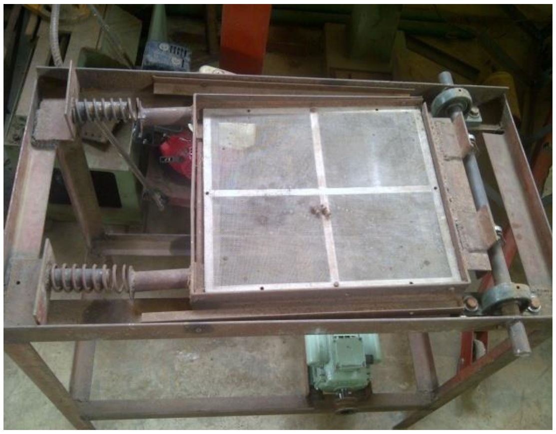

Figure 5: Garri Sifter Construction.

The design, construction and fabrication of the garri sifter were not so complex but have some intricate parts to complete its working mechanism. Engineers use CAD to create two and three-dimensional drawings of machines, parts, and components.

- The stage of idea conception is advanced to sketches
- Determining the working mechanism and identifying the working parts
- The accurate drawing is produced with dimensions
- Identifying the individual parts of the machine

Performance Evaluation

Garri of mass 6098.3g was used to evaluate the performance of the machine.

Figure 6: Garri Grains.

Figure 7: Gangue.

The following results were obtained:

$$W_t = Weight\ of\ total\ garri = 6098.3g$$

$$W_g = Weight\ of\ gangue = 487g$$

$Time\ Taken: 119\ s$ =1.98 min

$$Efficieny = \frac{W_t - W_g}{W_t} \times 100\% \quad \textbf{(16)}$$

W_a = 6046 g

$$Efficiency = \frac{6098.3 - 487.0}{6098.3} \times 100\%$$

$$Efficiency = 92.01\%$$

The throughput capacity (T_p) is given as $T_P=W_T/t_T$ in kg/hr.

Where $W_T$is total weight of material handled (i.e. sieved) and t is total time taken.

The effective throughput capacity is the ratio of actual weight of material handled without spillage to effective time of operation [14].

$$T_{pe}=W_a/t_e \quad \textbf{(17)}$$

The efficiency in %, η is the percentage of the ratio of the total weight of garri actually handled (output). W_a (kg) to the total weight of garri handled (input), W_t (kg).

$$\eta = W_a/W_t \quad \textbf{(18)}$$

T_p=184.5 kg/hr,

T_{pe}=183 kg/hr and

η =99.14 %.

The Working Mechanism of the Garri Sifting Machine

The machine is basically powered by an electric motor of using belt and pulley system for transmission, which turns the worked camshaft. The motion is further transmitted to the tray thus providing the forward throw while the spring returns the load on the backward throw

DISCUSSION

The result obtained from the performance evaluation test showed a sieving efficiency of 92.5% as compared with machine efficiency of 99.14%.This is an indication of the proper working of the garri sifting machine as compared to ones produced earlier with less than 50% efficiency.

The machine is basically powered by an electric motor of using belt and pulley system for transmission, which turns the worked camshaft. The motion is further transmitted to the tray thus providing the forward throw while the spring returns the load on the backward throw. The right electric motor was selected and appropriate coupling designed which aided the performance of the sifter.

CONCLUSION

The commercial based garri sifting machine was designed, fabricated and tested. It was found to be effective and efficient.

This machine can be used for commercial purposes and it is affordable like the cassava milling machine with high scale production.

With the construction materials selection and quality of fabrication work, the machine is durable and expected to last long. The machine is available for about $300 and it has salvage value when it is no longer operable.

REFERENCES

1. Nweke, F.I., D.S.C. Spencer, and J.K. Lynam. 2002. T*he Cassava Transformation. Africa's Best Kept Secret*. Michigan State University Press: East Lansing, MI.

2. Ajibola O.O. 1995. "Food Processing Technology Profiles for Women in Nigeria". A Survey Report Prepared for Technoserve.

3. Food and Agriculture Organization. 2002. FAOSTAT, Statistical Data Base of the Food and Agricultural Organization (FAO) of the United Nations. Rome, Italy.

4. Odighoh, E.U. 1983. "Cassava Production, Processing and Utilization". In: Chan Jr. H.T. (ed.). *Handbook of Tropical Foods*. Marcel Dekker: New York, NY. 145-200.

5. Hahn, S.K., N.M. Mahungu, J.A. Otoo, M.A.M. Msabaha, N.B. Lutaladio, and M.T. Dahniya. 1986. "Cassava and the African Food Crisis, Tropical Root Crops". International Institute of Tropical Agriculture (IITA): Ibadan, Nigeria. 24-26.

6. IITA. 2004. "IITA Annual Report". http://www.cassavabiz.org/postharvest/cpc_1.htm

7. Adetunji, O.R and A.H. Quadri. 2011. "Design and Fabrication of an Improved Cassava Grater". *Pacific Journal of Science and Technology*. 12(2): 20-129.

8. Ajao, K.R. and I.K. Adegun. 2011. "Performance Evaluation of a Locally Fabricated Mini Cassava Flash Dryer". *Journal of Science Publication*. 1(3): 54-60.

9. Adetunji, O.R. and A.S. Osunlana. 2011. "Design and Fabrication of Garri Shifting Machine". An unpublished B.Eng. Thesis Submitted to the Department of Mechanical Engineering.

10. Shingley, J.E. 1986. *Mechanical Engineering Design*. S.I Metric (ed.) McGraw-Hill: New York, NY.

11. Balogun, A.L. 2006. "Design, Fabrication and Performance Evaluation of a Multi-Crop Slicing Machine". An Unpublished M.Eng Thesis Submitted to the Department of Agricultural Engineering at the Federal University Technology: Akure, Nigeria.

12. Alabi, O.O. 2009. "Design, Fabrication and Performance Evaluation of a Cassava Lump Breaking and Sieving Machine". An unpublished HND project. Department of Agricultural and Water Resources, Kwara State Polytechnic: Ilorin, Nigeria.

13. ASME. 1995. *Design of Transmission Shafting*. American Society of Mechanical Engineers: New York, NY.

14. Nwakaire, J.N., C.J. Ugwuishiwu, and C.J. Ohagwu. 2011. "Design, Construction and Performance Analysis of a Maize Thresher for Rural Dweller". *Nigerian Journal of Technology*. 30(2).

SUGGESTED CITATION

Adetunji, O.R., O.U. Dairo, T. Aina, and A.S. Osunlana. 2013. "Development of an Improved Garri Sifting Machine". *Pacific Journal of Science and Technology*. 14(2):54-61.

Pacific Journal of Science and Technology