ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 5, Issue 10 , October 2018

Design and Construction of a Manually Operated CASSAVA Gratting Machine for the Post Harvest Unit of the Department of Agricultural Engineering of BOLGATANGA Polytechnic

Joseph. Apodi, Paul AkidiweAsagadunga,Sherry KwablaAmedorme

Bolgatanga Polytechnic, P. O Box 767, Bolgatanga, Upper East Region, Ghana
Bolgatanga Polytechnic, P. O Box 767, Bolgatanga, Upper East Region, Ghana
Department of Mechanical and Automotive Technology, University of Education, Winneba –Kumasi

ABTRACT: Cassava is a major root crop cultivated and consumed mostly in the southern part of Ghana and some parts in the north. Apart from its contribution to the Ghanaian economy, the crop has been described as the solution to the country's food crisis, the crop however, faces a serious storage problem, especially in its fresh state due the sufficient amount of moisture content it contains. Dried cassava grates commonly referred to as "gari" in Ghana is the best way to store this crop as it contains a lot of moisture when harvested freshly. To reduce the drudgery in processing freshly harvested cassava tubers into gari and to enhance its storability and market value, a manually operated cassava grating machine which operates on a frame has been designed and constructed for the post-harvest unit of the Department of Agricultural Engineering of the Bolgatanga Polytechnic to process freshly harvested cassava tubers to be grated and dried for the purpose of storage. The cassava grating machine consists of metal frame, cutting edge or blade, bearings and its housing, a rotating handle and a hoper. It operate by peeling cassava tubers and then cutting them into smaller pieces and then washed and weighed using weighing balance scale. The peeled cassava is then poured into the grating machine's hopper, and then fed into the grating chamber, the hand presser is used to press the cassava against the blade to prevent scattering of the cassava whiles at the same time the other hand rotates the handle to grate the cassava. The peeled fresh cassava tubers is grated into smaller sizes of about 3 to 4 cm, similar to the size of fine aggregate (sand). The pulp is then collected with a basin through the deliverer, it is then squeeze for the water in it to escape, the grated cassava is then dried for future use. The grates dry faster, easily packaged and it takes less space.
A mass of 84kg of cassava was poured into the hopper and it was able to grate 78.5kg of the cassava within 15 minutes of operation with only5.5% wastage, representing 93.5% efficiency.
The test results of the design showed that the design was well constructed and works satisfactorily and with only 5.5 % of wastage and as such will satisfy the processing needs of the people in the department and the community as a whole.

KEYWORDS: Cassava; Grating Machine; Working drawing; Torque; Shear stress; Shear strain

I. INTRODUCTION

Cassava is among the world's most important staple food crops and provides major sources of energy to over 300 million people. Cassava is now cultivated in all tropical regions of the world including Ghana. It has a potential tuber yield of seventy tones per hector or having the highest output per unit area among all staple food [1] [2].
Cassava has the ability to resist pest infestation especially (locust), it is drought tolerant, can be used for the production of starch and alcoholic beverages and also as a source of food in the tropics. The tubers of cassava cannot be stored for long after they are harvested, and therefore need to be processed in order to prevent them from going bad after harvesting. Cassava processing normally lead to size reduction and it involves; peeling, grating, dehydrating, milling and sieving, therefore a typical cassava grating machine should consist of a units that can be used to achieve all these stages or steps [3].
Most Ghanaian farmers and business people, who engage in cassava production and trading normally lack simple machines that can be used to processing fresh cassava into dried cassava chips popularly called "gari" in Ghana, the

ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 5, Issue 10 , October 2018

gain in output through the use of simple and an improved machines is normally high and therefore, there is the need to ensure that the production and the processing of cassava is achieved through the use of simple and better machinery.
One of the problems faced by cassava farmers in Ghana is the processing and preserving facilities which are not available to them and therefore the traditional method of processing cassava which has low productivity and is unhygienic and drudgery is what they depend on, this has made many people to look for ways of designing a machine that can grate cassava at high quality rate and in a shorter possible time and also reduce human drudgery. [4] [5].

II. METHODOLOGY

The paper started with a survey which was carried to find out how cassava producers process their cassava after harvesting, and the observation was that most of the farmers still rely on the traditional method of processing their cassava which was time consuming and cumbersome. Per the research it was found that the farmers faced a lot of challenges with the above mentioned method which includes; contamination and food odor. A design procedure was prepared and updated in the course of the design and construction of the manually operated cassava grating machine for the post-harvest unit of the Department of Agricultural Engineering of Bolgatanga Polytechnic in the Upper East Region of Ghana until the correct method was achieved.
The design was then divided into the following components and then produced individually;

A. Hopper

This is a container in square shape mounted on the upper part of the machine; it is this container that the peeled cassava is poured into before grating. After cutting the into the required dimension for the hopper using the gellaton shear, two plates for the front and back side of dimensions (15m^{x}17m^{x}12m) and sideways (15m^{x}17m^{x}6m) it was tagged together then welded completely and the sharp edges were grinded to get a smooth surface of the edges.

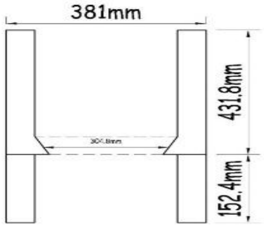


Fig 1: Hopper

B. Cylindrical Chip Deliverer

This is where the grater is mounted, a **2** mm mild steel plate was used to form the cylinder with the dimension 6m x 12m. It was folded and welded, a lathe machine was used to bore holes through the cylinder where the shaft passes and was welded against the shaft. The shaft serves as a connecting rod from the handle to the grater and these parts are mounted on the frame together with the hopper.

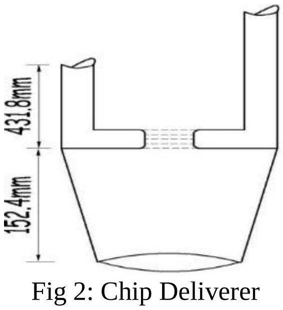


Fig 2: Chip Deliverer

C. Blade

This is the part that does the grating, a galvanized sheet was used to form the blade and it was cut with a table shears, the blade was formed by punching a nail through the galvanized sheet and was rolled over the cylinder and then riveted.

ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 5, Issue 10 , October 2018

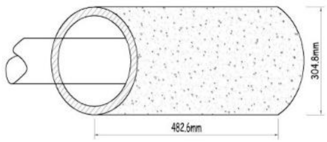


Fig3: Grater Blade

D. Stands

This is where all the parts of the machine are mounted and assembled together firmly in place. It was form with angle iron of dimension $2.5m^{x}40m^{x}$ 40m and was cut with a cutting disc. The top frame was welded together with the stand and the sharp edges were grinded. Also the holes on both sides of the frame were drilled with a drilling machine which enables the bearing case to sit on the frame and it was tighten with M13 bolts and nuts.

Fig4: Stand

E. Hand presser

A wood was used to form the hand presser with the required dimension which has a flat base. This is what is used to force the cassava into the grater.

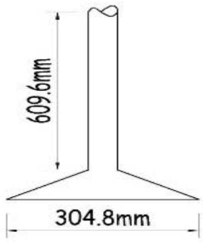


Fig5: Hand Presser

F. Handle

This is what is used to turn the shaft to rotate the cutter for the machine to operate.

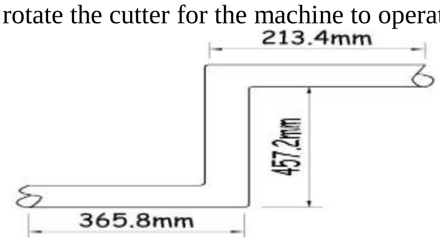


Fig6: Handle

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 10 , October 2018

III. DESIGN CALCULATION AND PARAMETERS

A. Shear Stress and Strain

A shear stress, often denoted by τ is the component of stress. Shear stress arises from the force vector component parallel to the cross section of the material. Shear stress arises from shear forces, which are pairs of equal and opposing forces acting on opposite sides of an object.[6] [7]

The formula to calculate average shear stress is force per unit area.

$\tau = F/A$ ………………………….. (1)

Where:

τ = the shear stress;

F = the force applied;

A = the cross-sectional area of material with area parallel to the applied force vector.

Also;

Shear strain, denoted γ, is calculated from the equation :

$\gamma = \tau / G$ ……………… (2)

From (2)

$\tau = \gamma G$ ………………………………(3)

Equating (1) and (3)

$F/A = \gamma G$

Therefore

$F = \gamma A G$ …………….. …(4)

Where;

F = Applied force on the handle

G = The shear modulus of the cassava

A = Area of shear

γ = The shearing strain

Also from the equation

$\sigma = \frac{F}{A}$ …………………………… .(5)

$\varepsilon = \frac{\Delta L}{L}$ ………..(6)

$E = \frac{\sigma}{\varepsilon} = \frac{FL}{A\,\Delta L}$ ………………………(7)

Where;

E = Young modulus of elasticity of the material

σ = Stress

ε = Strain

F= force

A = Area

L= length of material

Δ L = change in length

Also, from (3) $G = \frac{\tau}{\gamma}$ ……………..(8)

Equating (7) and (8)

$\frac{FL}{A\,\Delta L} = \frac{\tau}{\gamma}$

Therefore

$\tau = \frac{FL\gamma}{A\,\Delta L}$ ……………… (9)

τ = the amount of shearing stress required to grate the cassava.

B. Torque (T)

Torque is a measure of how much a force acting on an object causes that object to rotate. The object rotates about an axis, which is called the pivot point. The distance from the pivot point to the point where the force acts is called the moment arm, and is denoted by 'R' The turning moment or torque on the element will be equal to shearing force (F) x Radius (R).[8] [9].

It is very essential to know the amount of torque on the handle where the blade is mounted. To determine this, you need to understand that during the grating process of the cassava, there is some amount of resistance force offered by the cassava when turning the handle and for that matter the blade which is fixed to the shaft. This resistant force offered by the cassava is opposite in direction to the force applied on the shaft of the garter through the handle by the operator.

Therefore;

Toque (T) = F x R …………… (10)

From (4)

$F = \gamma A G$

$T = \gamma A G \times R$

But $A = \pi R^2$

Therefore;

$T = \gamma \pi R^2 G \times R$

$= \gamma \pi R^3 G$ ………… (11)

Also from (1)

$\tau = \frac{F}{A}$

$F = \tau A$

But $A = \pi R^2$

$F = \tau \pi R^2$

Torque (T) = F x R

$= \tau \pi R^2 \times R$

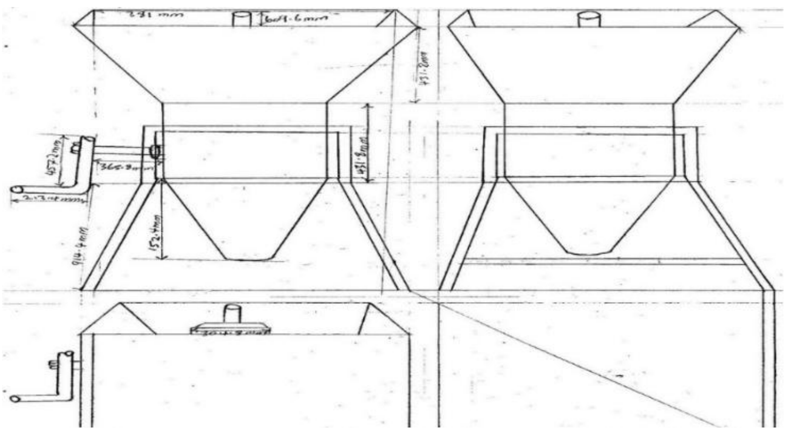
$= \tau \pi R^3$ ………………………….(12)

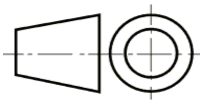
IV. CONSTRUCTION

In constructing the cassava grating machine, the individual components were assembled together by means of welding, bolting and riveting, a working drawing was prepared in first angle projection and then used in the construction.

A. Working Drawing

This is a scale drawing which serves as a guide for the construction or manufacture of a machine. [10]





First Angle Projection

Figure7: Working Drawing of Cassava Grater in first angle projection

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 10 , October 2018

B. Cross-Sctional View of the Cassava Grater

A cross-sectional view portrays a cut-away portion of the object and is another way to show hidden components in a device or a sliced view of a part or component in a drawing showing its internal make up. [11].

The cross-sectional view of the cassava grater is shown in figure 8below and it shows how the inside of the cassava grater looks like after a cut has been made through it.

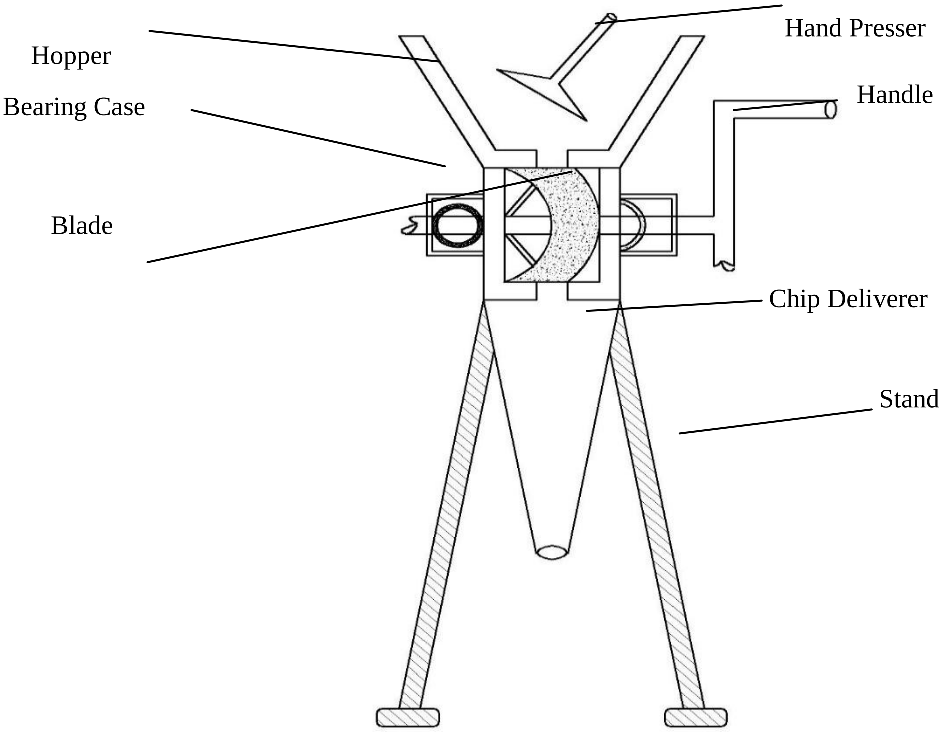


Figure 8: Cross Sectional View of the Cassava Grater

V. DISCUSSION OF TEST RESULTS

The cassava tubers were peeled thoroughly washed and weighed using weighing balance scale. The peeled cassava was poured into the improved manually operated cassava grating machine's hopper, the hand presser was used to press the cassava against the blade to prevent scattering of the cassava caused by the machine vibration. The pulp was collected with a basin through the deliverer. A mass of 84 kg of cassava was poured into the hopper and it was able to grate 78.5kg of the cassava within 15 minutes of operation. Comparing the output of the manually operated cassava grater to traditional method of grating cassava, it shows clearly that the manually operated grater is faster and very efficient, with less stress in operating it.

Fig9: The constructed manually operated cassava grater

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 10 , October 2018

Table1: Test results of the manually operated grater machine as compared with Traditional Method.

Mode of processing	Tuber Input (kg)	Time (m)	Output (kg)	Losses (kg)	Efficiency (%)
Grating Machine	84.0	15.0	78.5	5.5	93.5
Traditional Method	84.0	15.0	40.0	44.0	47.6

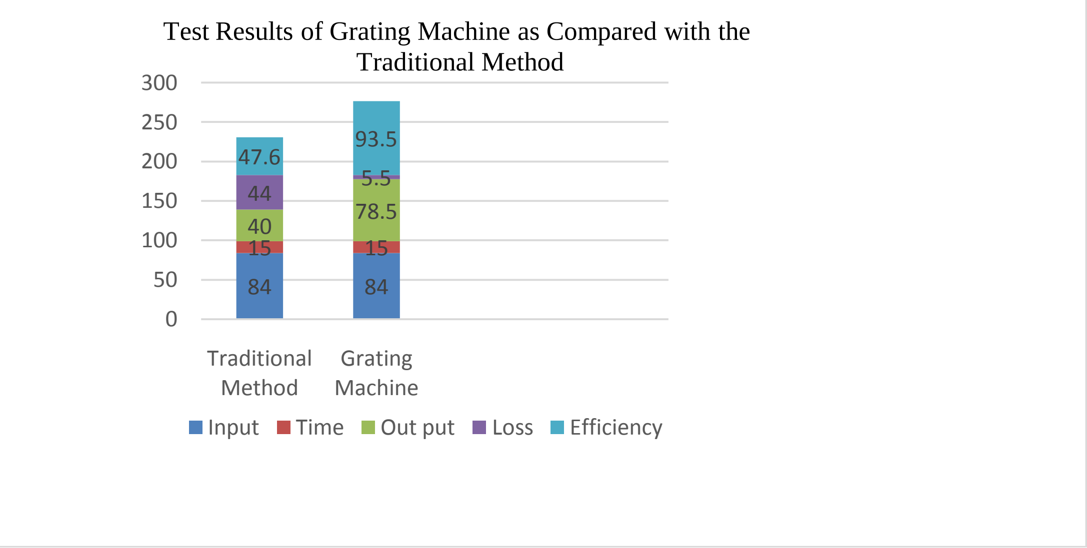


Fig10 : Comparing Grating Machine with the Traditional Method

From the above diagram, it can be seen that the efficiency of the manually operated cassava grating machine is higher (93.5%) as compared with the traditional method which has efficiency of 47.6%. This high grating efficiency is as a result of the construction which included provision of a hopper box with a base supported with wood which is used to adjust the clearance. The adjustment helps for different grating sizes of the cassava of which the traditional one do not have.

It can also be seen from the table that the grating machine performed at a faster rate with minimal loses as compared with the traditional one thereby reducing time consumption and drudgery which normally is associated with the traditional method.

VI. CONCLUSION

A cassava grating machine has been designed and constructed for the post-harvest unit of the Department of Agricultural Engineering of the Bolgatanga Polytechnic in the Bolgatanga Municipality of Upper East Region of Ghana to help solve the problems associated with cassava farmers in term of cassava processing and storage in the region. The machine was found to be effective and efficient and could grate up to about 84 kg of cassava tubers in 15 minutes. This machine can be used at home for domestic applications and it is also affordable since most of the materials used are relatively cheap and can be obtained in the local the market. The test results of the design showed that the design was well constructed and works satisfactorily as when it was compared with the traditional method of processing cassava, it was found that the machine has efficiency of 93.5% with only 5.5 % of wastage and as such will satisfy the processing needs of the people in the department and the community as a whole.

Based on the construction and the materials used as well as the quality of fabrication work, the machine is durable and expected to last for a longer period. Also, the machine is manually operated and therefore can be used in areas without electricity as the saving in energy as well as the production of carbon gases such as carbon monoxide (CO) and carbon dioxide (CO_2) when compared with other methods of grating such as electricity, and gas or generator show that the design is environmentally friendly and cost-effective and therefore its use should be encouraged.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 10 , October 2018

VII.RECOMMENDATION

Based on the experience and problems encountered throughout the design and construction stage of the cassava grating machine, it is recommended that in order to improve the operational performance and durability of the machine, the following should be considered;

- Effort 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.
- Any improvement or alteration on this machine should include movable wheel for easy transportation.
- It is also recommended that the machine be produced on large to help rural farmers
- The efficiency, design mechanism and speed at which the machine operates can be improved upon by introducing durable and lighter materials to reduce weight while maintaining balance and reducing machine vibration.

REFERENCES

[1]. Cock J.H (1985) cassava. New potential for a Neglected crops.
[2]. Adjekum, A. (2006). *Cassava Processing and Marketing: Experiences from Ghana.* Accra.
[3]. Jumah A, Anaglo J and Atendem P. (2006). Demand for cassava food products in Ghana. *Cassava SME Project report*.
[4]. Processing, C. (2017, April 10). *Cassava processing plant*. Retrieved from Cassava processing plant: http://www.cassava machine.cn/cassava production equipment
[5]. Processing, C. P. (2018, March 21). *agric in ghana .com*. Retrieved from agric in ghana .com: http:// www.agricinghana.com/ cassava production processing.
[6]. R.C, H. (2004). Mechanics of materials. In H. R.C, *Mechanics of materials* (p. 32). New Jersey USA: Peason Education.
[7]. Ronald Huston and Harold Josephs. (2009). Practical Stress Ananlysis in Engineering Design. In R. H. Josephs, *Practical Stress Ananlysis in Engineering Design* (p. 634). CRC Press.
[8]. Torque. (2018, September 24). *Physics.uoguelph.ca/tutorials/torque/Q.turque.intro.* Retrieved from Physics.uoguelph.ca/tutorials/torque/Q.turque.intro.: http//www.Physics.uoguelph.ca/tutorials/torque/Q.turque.intro.
[9]. In Answer. (2012, July 22). *In.Answer*. Retrieved March 17, 2013, from In.Answer.yahoo.com/ how to calculate torque : http: // www.in.answer.yahoo.com
[10]. Working Drawing. (2018, September 24). *collins english dictionary.com*. Retrieved from collins english dictionary.com: http//www.collins english dictionary.com
[11]. sectional, C. (2018, October 10). *me.umn.edu/courses/handouts/drawing/section*. Retrieved from me.umn.edu/courses/handouts/drawing/section: http//www.me.umn.edu/courses/handouts/drawing/section