Futo Journal Series (FUTOJNLS)
e-ISSN : 2476-8456 p-ISSN : 2467-8325
Volume-3, Issue-1, pp- 273 - 279
www.futojnls.org

Research Paper July 2017

Modification of a Self-Loading Cassava Tuber Peeling Machine.

Chilakpu, K.O

Agricultural Engineering Department,
Federal University of Technology, Owerri, Nigeria.
Corresponding author email: kchilakpu@yahoo.com

Abstract

This work is aimed at modifying and improving the performance of the rotating drum cassava tuber peeling machine. The physical parameters of the fresh cassava tubers, such as shape and size were taken into consideration in the course of modifying and fabricating the machine. The need to load unsorted sizes of cassava tubers and run the machine smoothly was also taken into consideration. The existing machine was tested to identify areas for modification. The absence of a self-loading hopper was found to be the reason for starting the machine on load. Thus, a self-loading hopper was incorporated to the machine. Post modification test-run results show that the modified machine has a capacity of peeling 700 to 1000 kg/h at an average speed of 1500rpm. It recorded an average flesh loss of 8%, at a peeling efficiency of 97%. This is against the machine efficiency of 70.45% and flesh loss of 5.09% at a throughput capacity of 8.5kg as reported by Oluwole and Adio in their 2013 research publication on cassava tuber peeling machine.

Keywords: self-loading, modification, peeling machine, cassava tuber.

1.0 Introduction

Cassava (*Manihot esculenta*) prepared in various forms are staple food and source of income for about 600 million people in Africa, Asia and Latin America (IFAD,2008). It is also an essential raw material for some industries. A cross section of cassava tuber shows that it consists of central core called the pitch this is surrounded by the starchy flesh that forms the bulk of the tuber and constitutes the main storage zone. It is white or cream in color and is surrounded by a thin cambium layer Adetan, Adekoya & Aluko (2003). This cambium layer is covered by a brown colour outer layer known as the peel.

The major function of any cassava tuber peeling machine is to remove the outermost layer with little or no damages to the starch storage and cambium part of the tuber. Designs of most cassava peeling machines involve the arrangement of peeling tools in rows, opposite positions or around a hollow tube to effect peeling of the tubers. These peeling tools could be in the inform of knife like edges in motion or rough surfaces (abrasives) such as- sand paper materials or rough concrete work cast around rotating cylindrical containers to achieve peeling. The action could be by scraping the peels or by friction as a result of tuber to tuber contact and tuber to rough wall surface contact.

Efforts have being made in the past towards developing suitable and acceptable cassava tuber peeling machine to handle various sizes and shapes of cassava tubers. The National Centre for Agricultural Mechanization (NCAM), Federal University of Technology Akure, and some other institutions and individuals in and outside the country have made serious attempt at proffering a solution to this global problem (Odigboh, 1983)). There is still the need to improve on the designs to effectively remove the tuber peels with minimal damage to the starch storage layers.

The design of interest in this work is the rotating drum batch type. This design tends to combine both the tool edge scrapping and abrasive technique in achieving peeling of cassava tubers. It can peel unsorted shapes and sizes of cassava tubers as a result of the combined peeling systems. This machine can be adopted for the peeling of other agricultural root crops like yams tuber and potatoes.

The modified machine consists of two 900 mm diameter metal sheets with the edges trimmed with 50 mm metal bars to form stronger metal rings. The rings are fixed 1200 mm apart on a perforated 50 mm diameter metal pipe at their centres. The pipe which is sealed on one end delivers continuous splashes of water through series of 10mm diameter perforations for self-washing of peeled cassava tubers. The steel pipe also serves as the shaft on which two 50mm inner diameter pillow bearings are mounted on both ends. The bearings are in turn fixed to two triangular shaped frames for stability during operation. Fifty pieces of Iroko woods were cut into regular triangular cross sections of 60mm width and 1200mm long. These un-smoothened woods were fixed across and round the metal rings with the help of bolt and nut arrangement to form a wooden drum. An opening is created on the body of the wooden drum with the help of metal lock and hinge arrangement which isolated four wooden members to form the material discharge lid. In the previous designs, this opening served as both material inlet and discharge points. This explained why the machine has to start only after cassava tubers are loaded. The hopper is now created to feed the machine through an opening made by the side of one of the main frame rings. At the sealed end of the steel water pipe, an 80mm diameter sprocket is fixed to facilitate drive connection with a 5HP (1480rpm) electric motor coupled to a 10:1 gear. Chain drive arrangement is used to minimize slip during operation. Water for washing is introduced through the open end of the perforated pipe while a wooden tray is place below the wooden drum for collection of peels during operation. The same tray after discarding the peels is used to collect washed cassava tubers after the process.

Cassava and it's by product accounts for about 60% of root crop consumption in Africa (Jeon and Halos, 1992). The major challenge faced in the processing of cassava into various forms of food such as garri, cakes, flour and chips is the huge time wasted in peeling the tubers. The development of a machine that can effectively peel and wash cassava tubers is a big relieve to our famers.

Fresh cassava tuber is bulky with about 70% moisture content. The rotten of the tuber sets in 1-7 days after harvesting, depending on storage conditions (Wenham, 1995). Hence, cassava must be processed further to increase the shelf life and facilitate transportation and marketing of the products (Nweke, 1994). Some of the major challenges facing mechanization of cassava processing are in the area of designing machine that can effectively peel different sizes and shapes of cassava tubers. However, this work took care of these materials property problems. The main challenge facing in this work is that of calibrating the hopper shutter to flip open exactly at the point of admitting the tubers into the rotating peeling chamber and close afterwards to stop the tubers from falling out.

2.0 Materials and Methods

2.1 Materials

The major materials used for the machine design include: galvanized sheets, perforated galvanized pipes, mild steel for frames and split triangular section wooden members. Galvanized materials were used to minimize corrosion of the metal parts and contamination of the food item. Wood on its own is an edible material and the rough surfaces are required to peel the tubers effectively.

2.2 Method and Design Considerations

The earlier model of drum peeling and washing machines were designed to start on load. They consist of sets of square section wooden members of 800 mm long fixed edge wise to the rotating drum. The wooden members were arranged on a circular frame which forms the edge of the drum with about 25 mm spacing between each member. The machine had a common material inlet and outlet opening created with a wooden lid. Some factors were observed to play key roles in the peeling process these include– The roughness of the wooden member in contact with the tubers, the height of fall of the tubers during tumbling, the spacing and number of wooden members use and the supply of water for wetting and washing during the peeling process. The smooth starting of the machine was highly impeded by the fact that it was meant to be loaded before starting. This resulted in longer process duration and loss of man's hour.

2.3 Modifications

Some modifications were carried out on the existing drum peeler to enhance the peeling efficiency. These include the addition of more rough edges by introducing un-smoothened seasoned Iroko woods which are hard woods and more resistant to wear and tear under wet conditions. Peeling is achieved mostly by frictional forces created by tuber- tuber or tuber – wood contact. The wooden members are 60 x 60 x 1200 mm logs split edge wise to give equilateral triangular sessions. A drum diameter of 900mm was selected to accommodate about 80 kg of fresh cassava tubers and still have rooms for free movement (tumbling) of the tubers while in operation. A reducer gear (1:10) was used to step down the 1450 rpm speed of the electric motor to the recommended drum speed of 150 rpm (Ni, 2012). The low drum speed is necessary to set the tubers tumbling to facilitate the required tuber to tuber or tuber to wood contact to achieve peeling by abrasion. Increasing the drum size allows for more height of throw during tumbling thereby creating more impact force required to peel tubers with thicker outer cover. The triangular split wooden members were fixed to the circular edge of the drum with about 250 mm spacing between each member, so as to enhance the discharge of tuber peels and waste washing water from the peeling drum. The spacing distance was selected after taking into consideration the average sizes of tubers considered. This tuber size analysis which was found to be 340 mm is necessary to avoid smaller size cassava tuber falling out through the waste material outlet. In addition to the peeled tuber outlet created on the wooden members, a hopper with shuttering mechanism was incorporated by the side of the drum. The shutter which is made of galvanized material flip open on its own by the weight of the shutter (lid) to admit tubers into the peeling chamber and falls back to close as the drum rotates beyond the point of material entry to prevent the falling off of tubers from the chamber while in motion. The shatter which serves also as the metering device for the machine is hinged on two metal bushings and is calibrated with the rotating speed of the drum to open and close at given positions while in operation. The calibration was achieved through series of trial test runs and adjustment of the shatter mechanisms (trial and error method).

Some theoretical formulas used in the course of the design include: (Hall, Holowenko, Laughlin, Hills & Benneth (1982).

Peeling chamber design

$$V = \pi r^2 \mathrm{L}\ (\mathrm{m}^3) \quad (1)$$

Where; V= Volume of Cylinder (m^3), R = Radius of Cylinder, L = Length of Cylinder.

Hopper Design;

$$V_h = LBH\ (m^3) \quad (2)$$

Where; V_h= Volume of Hopper (m^3), L = Length of Hopper, B = Breath of Hopper.
H = Height of Hopper.

Through put Capacity (TPC);

$$\mathrm{TPC} = \frac{Mass(kg)}{Time\ (hour)} = \frac{80}{5mins} = \frac{80}{0.083hr} = 963.86\ kg/hr \quad (3)$$

The designed peeling chamber and hopper are as shown in Figure 1 and Figure 2 and Plate 1 which represent the orthographic view, isometric drawing and picture of the modified machine respectively.

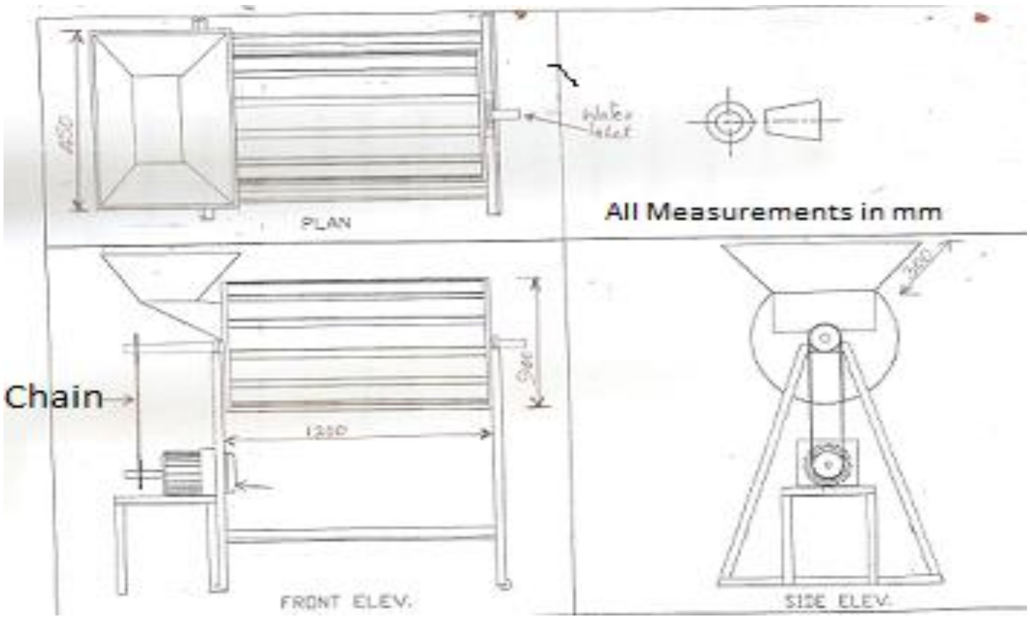

Fig. 1: Orthographic View of Modified Cassava Peeling Machine

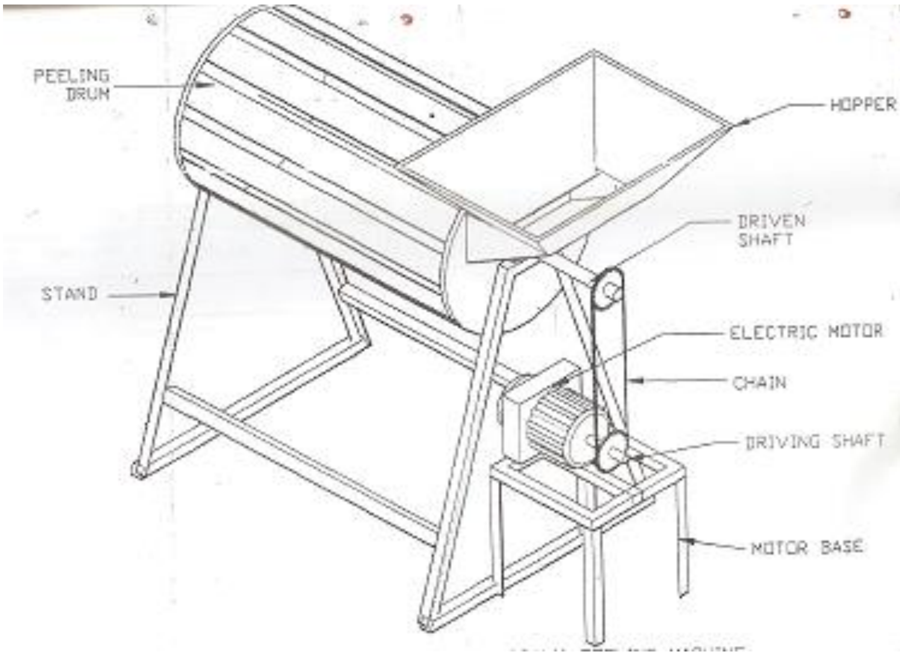

Fig. 2: Isometric View of Modified Cassava Peeling Machine

Plate 1: Photo of Modified Cassava Peeling Machine During Test-run.

4.0 Performance Tests and Results

The modified machine was started on no-load-condition and pre measured quantity of fresh cassava tuber was introduced via the hopper, and the washing water inlet was opened. A stop watch was used to monitor the peeling duration. The timer was stopped at the point when no appreciable peels are dropping from the peeling chamber. Series of test runs were carried out on the machine, it was noted that adequate peeling was achieved at an average of 5minutes at a selected drum speed of 150 rpm.The results obtained are as shown on table 1.

Table 1: Results of Modified machine Test- run

Drum rotation speed (rpm)	Peeling Duration (mins)	Fresh Tuber W_1 (kg)	Peeled Tuber W_2 (kg)	Weight of Peels W_3 (kg)	Weight of unpeeled tubers W_4 (kg)
1500	5	50	48.87	0.28	0.85
1500	4	45	43.40	0.42	1.18
1500	5	48	46.14	0.59	1.27
1500	3	40	38.23	0.59	1.18
1500	8	50	48.93	0.51	0.56
Total		233	225.57	2.39	5.04
AVG.1500	5	46.60	45.11	0.48	1.01

where
W_1 = weight of fresh unpeeled tubers
W_2 = weight of tubers after machine peeling
W_3 = weight of peels.
W_4 = weight of unpeeled tubers.
AVG. = Average Value

$$\%\text{ Peeled} = \frac{W_2}{W_1} \times 100 \tag{4}$$

$$\%Peeled = \frac{45.11}{46.60} \times 100 = 96.80 \sim 97\% \tag{5}$$

$$\%unpeeled = \frac{1.01}{46.60} \times 100 = 2.17\% \tag{6}$$

The modified machine has a capacity of peeling 700 - 1000 kg/h as against 20-35kg/h peeling by hand (World Journal of Agricultural Sciences, 2008). It recorded an average flesh loss of about 8% (manually sorted) with an average peeling efficiency of 97% and percentage unpeeled of 2.17%, as against 25% peeling lost by hand at about 60% peeling efficiency.

5.0 Conclusions/Recommendations

A self-loading cassava peeling machine was modified and performance test conducted on the machine. Some key machine design parameters as presented by Chilakpu and Asoegwu (2010) were carried forward while parameters directly affecting modified parts are as presented on equations 1 to 3. The mathematical approach used in arriving at the performance percentages are as presented on equation 4 - 6. Depending on cassava tuber species (thick or thin peel), the throughput capacity of the modified machine range between 700- 1000kg/hour with an efficiency of about 97% at an average flesh loss of 8% and 2.17% of unpeeled tubers. These results are great improvement when compared with the work reported by Oluwole and Adio in their 2013 research publication which presented machine efficiency of 70.45% and flesh loss of 5.09% at a throughput capacity of 8.5kg operating at a speed of 364rpm, (Oluwole and Adio, 2013). A similar work on pedal drum cassava peeler presented a throughput capacity of 60-100kg/hr at an efficiency of 95%, (http://anniledesign.com/MASTER-s-DEGREE-PROJECT, 2012).

The unmodified machine had a throughput capacity of 300-500 kg/hr with an efficiency of 89.7% and flesh loss of 8.6% when tested at a speed of 1500 rpm. There is every indication that the introduction of a self - loading hopper coupled with the modifications carried out on the peeling drum contributed significantly towards the enhanced performance of the machine.

To further enhance the peeler performance, it is recommended that improved varieties of cassava tubers with uniform thickness and fewer or no curvatures be developed to ensure minimal loss of tuber flesh.

References

Adetan D.A, Adekoya, L.O & Aluko, O.B (2003). Characterisation of some properties of cassavaroot tubers, *Journal of Food Engineering*, 59, 349-353.

Chilakpu K.O & Asoegwu S.N. (2010), Design and fabrication of drum cassava peeling machine. Exhibited at Raw Materials Research and Development Council Expo 2010, Abuja.

Hall, A.S., Holowenko, A. R., Laughlin, H. G., Hills, P.C. & Benneth, M. D. (1982).*Theory and problems of machine design:* Schaum's Outline Series. New York: McGraw- Hill Book Company. http://anniledesign.com/MASTER-S-DEGREE-PROJECT, (2012)

IFAD. (2008), Improving marketing strategy in Western and Central Africa. Factsheet. [Online], Aug. 10, 2008, www.ruralpovertyportal.org.

Jeon, Y.W. & Halos, L.S. (1992). Innovations for improved roots and tuber food processing, An Unpublished Training Manual: Design, Operation and Maintenance of IITA-developed Postharvest Technologies,

Ni L. (2012). Pedal powered cassava peeling machine. *World Journal of Agricultural Sciences*. July 2012.

Nweke, F.I. (1994). *Processing potentials for cassava production growth in Africa, COSCA working paper No. 11. Collaborative Study of Cassava in Africa*, Ibadan, Nigeria: IITA.

Odigboh, E.U. (1983) Cassava production, processing and utilization, In: H.T. Chan (ed.). *Handbook of tropical foods.* New York: Marcel Dekker, 145-200.

Oluwole, O.O & Adio, M.A (2013), Design and construction of a batch cassava peeling machine. *Journal of Mechanical Engineering and Automation,* 3(1), 16-21.

Wenham, J.E (1995) *Postharvest deterioration of cassava:* A biotechnology perspective. FAO Plant Production and Protection Paper 130, Rome: FAO.