Design and Production of a Powered Cassava Grating Machine

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Abstract:- This work focused on the design and production of a powered cassava grating machine using locally sourced material which makes it affordable to both the middle and the low class populace. The major consideration was to produce a cassava grating machine that can be coupled or decoupled easily, the hopper was designed to accommodate a specific volume of peeled cassava conveniently without wastage, the grating unit was made of stainless metal so as to promote safe grating operation, and the delivery chute was made sloppy for easy discharge. The machine is powered either electrically using an electric motor or mechanically using a gasoline engine. The powered cassava grating machine is durable, light-weighted and easily operated and will greatly reduce importation of similar machines. The machine is portable and can be used commercially to produce cassava pulp and also solves the problem of fatigue resulting from the manual grating of cassava. Testing of the powered cassava grating machine shows that the performance was excellent.

Keywords:- *Powered, Cassava, Grating machine, Durable, Light-weighted, Easily operated, Performance.*

I. INTRODUCTION

This work focused on the design and production of a powered cassava grating machine using locally sourced material which makes it affordable to both the middle and the low class populace. The major consideration was to produce a cassava grating machine that can be coupled or decoupled easily, the hopper was designed to accommodate a specific volume of peeled cassava conveniently without wastage, the grating unit was made of stainless metal so as to promote safe grating operation, and the delivery chute was made sloppy for easy discharge. The machine is powered either electrically using an electric motor or mechanically using a gasoline engine. The powered cassava grating machine is durable, light-weighted and easily operated and will greatly reduce importation of similar machines. The machine is portable and can be used commercially to produce cassava pulp and also solves the problem of fatigue resulting from the manual grating of cassava. Testing of the powered cassava grating machine shows that the performance was excellent.

II. JUSTIFICATION

The need to increase food supply has been recognized by many developing countries including Nigeria as a means to attain food sustainability and self-sufficiency as a country. Thus considerable research especially in the area of starchy tubers used as food such as potatoes, yam, and cassava are being carried out. These have led to the increase of those products. Cassava is a good source of carbohydrate in terms of nutritional value, cassava starch when processed is suitable for livestock feeds. It also generate rural-employment through its wide spread cultivation, increase farmers income and could be exported. Most existing grater consist of heavy perforated rotating circular grating drum attached to a shaft and driven by a prime mover. Most farmers prefer to preserve their cassava in the soil, delay harvesting in order to prolong its storage period due to lack of proper processing equipment. Therefore, to boost the preservation of the tuber in large quantities and retain their qualities, the need to design and produce a machine that will enhance this operation cannot be over emphasized. The designed machine would be produced, tested and used in solving cassava grating problems of small-scale farmers domestically as well as commercially.

III. AIM AND OBJECTIVES

The aim of this study is to design and produce a powered cassava grating machine with the following objectives:

To use the locally available materials and appropriate technology to produce an improved affordable machine which can serve as an import substitute

- To ease the problem of grating both domestically and commercially.
- To eliminate vibration of the grating drum during operation, thereby ensuring proper grating performance of cassava roots.
- To produce a machine with simple design, that can easily be operated.
- To reduce cost of cassava processing and save time.
- To ensure the consumption of healthy and safe cassava products.

IV. REVIEW OF RELATED WORK

In present day Nigeria, the cassava products are largely consumed locally with little or no exportation due to the fact that the products do not meet up with the required standards for foods to be exported. Therefore, there is the need to encourage small scale producers of cassava product to promote products quality and good hygienic values [1]. Several works have been carried out on cassava grating machines, Ndaliman [4] designed and developed a cassava grating machine which has two modes of operation. The machine 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. Aideloje et al. [2] designed and fabricated a mechanically powered mobile cassava grating machine using locally

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sourced material and tested to determine its output capacity. The machine is economically affordable and can be used for both household and industrial purposes. Yusuf, Akpenpuun and Iyanda [6] designed and fabricated a simple pedal operated cassava grater for rural dwellers using locally sourced material. Bello, Lamidi and Oshinlaja [3] designed and fabricated a home-scale cassava grating machine taking into consideration machine efficiency, safety factors, and portability. Okoli and Okonkwo [5] designed and fabricated an improved double barrel cassava grating machine for better and faster cassava processing.

V. MATERIALS AND METHOD

A. Machine Description

Cassava tubers, after peeling are required to be grated before processing into other products. Powered cassava grater is a farm processing equipment which will serve as an improvement over the traditional way of cassava grating by eliminating drudgery and time wastage, and improving output capacity. The cassava grater comprises a grating drum, hopper and drum housing, a prime mover and the body frame. The processing of cassava should follow immediately after harvest since its roots starts to decay thereafter. The main consideration is to produce a cassava grating machine that can be coupled or decoupled easily, the hopper accommodates a specific volume peeled cassava conveniently without wastage, the grating unit is made of stainless metal so as to promote safe grating operation, and delivery chute is made sloppy for easy discharge.

B. Principle of Operation

The rotation of the grating drum is initiated by a prime mover. The prime mover is started and it rotates the grating drum through the help of a belt and pulley attached to its ends. Peeled cassava tuber is held against the rotating grating drum by opening the top cover pouring the cassava inside the drum's housing. Sometimes, the peeled cassava can be held against the rotating grating drum to effect grating. The grated cassava falls inside a trough placed at the outlet. It requires two persons to operate the machine effectively and conveniently. One feeding the machine and the other offloading the grated materials and monitoring the prime mover. The operation of the machine is simple. When operated mechanically, the machine is attached to a prime mover by a v-belt connected to the shaft pulley. Cassava is fed through the chute into the basin or trough. Fig. 1. shows the schematic diagram of an electrically powered cassava grater.

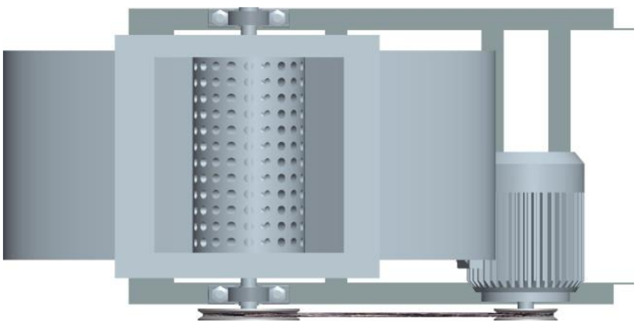

Fig. 1: Schematic diagram of an electrically powered cassava grater

C. Component Parts

- Prime mover: this is the major component that brings about rotation. The prime mover is a 3.5hp gasoline powered engine connected to the grating drum by the use of a belt and pulley.
- The grating drum: this is cylindrical in shape which carries a perforated stainless plate wound around it. This serves as the grater.
- The feed hopper (inlet): here, the peeled cassava is poured into it and covered. It is a circular (oval) shaped cross-section.
- The outlet: this is where the grated material falls for bagging and conveyance.

D. Design Analysis and Calculations

- *Volume of the grating drum material*

For perforated stainless steel sheet

$V_{psm} = 2\pi r L_1 t_1$

r= 0.0875m

$L_1 = 0.57$m

$t_1 = 0.0005$m

$$V_{psm} = 2\pi \times 0.0875 \times 0.57 \times 0.0005 = 1.57 \times 10^{-4} m^3$$

For the two circular plates material

$V_{cpm} = \pi r^2 t_2$

$t_2 = 0.003$m

$$V_{cpm} = \pi \times 0.0875^2 \times 0.003 = 7.22 \times 10^{-5} m^3$$

For rolled steel sheet

$V_{rsm} = 2\pi r L_2 t_3$

$L_2 = 0.56$m

$t_3 = 0.001$m

$$V_{rsm} = 2\pi \times 0.0875 \times 0.56 \times 0.001 = 3.08 \times 10^{-4} m^3$$

- *Weight of the grating drum material*

$M_{gdm} = \left(V_{psm}\rho_1 + V_{cpm}\rho_2 + V_{rsm}\rho_2\right)$

$\rho_1 = 7930$ Kg/m^3

$\rho_2 = 7850$ Kg/m^3

$$M_{gdm} = (1.57 \times 10^{-4} \times 7930 + 7.22 \times 10^{-5} \times 7850 + 3.08 \times 10^{-4} \times 7850) = 4.23kg$$

$$W_{gdm} = M_{gdm} \times g = 4.23 \times 9.81 = 41.50N$$

- *Force required to grate cassava*

$$F = M_{gdm} r \left(\frac{2\pi N}{60}\right)^2$$

N is the desired speed of the grating drum

$$F = 4.23 \times 0.0875 \times \left(\frac{2\pi \times 300}{60}\right)^2 = 365.30N$$

- *Torque at the grater drum surface*

$$T = F \times r = 365.30 \times 0.0875 = 31.96Nm$$

- *Power required to grate cassava*

$$P = T \times \left(\frac{2\pi N}{60}\right) = 31.96 \times \left(\frac{2\pi \times 300}{60}\right) = 1004.05W = 1.35hp$$

Factor of safety = 2.0

$$P = 1.35 \times 2 = 2.70hp$$

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- *Torque transmitted from the electric motor*

$$T_m = \frac{60 \times P_m}{2\pi \times N_m} = \frac{60 \times 2238}{2\pi \times 1440} = 13.30Nm$$

- *Torsional moment*

$$M_t = \frac{9550\ \times KW}{N} = \frac{9550 \times 1.004}{300} = 31.96\text{Nm}$$

Tension on the belt

$M_t = (T_1 - T_2) \times r_1$

$r_1 = 0.0925$m

$r_2 = 0.040$m

$(T_1 - T_2) = 345.51$N

$2.3 \times log\left(\frac{T_1}{T_2}\right) = \mu\theta$

$\mu = 0.3$(constant for v-belt drive)

$\left(\frac{T_1}{T_2}\right) = log^{-1}(0.39) = 2.45$

$T_1 = 583.79N$

$T_2 = 238.28N$

$T = T_1 + T_2 = 822.07N$

- *Weight of the pulley*

$W_P = M_P \times g = 1.5 \times 9.81 = 14.72N$

- *Shaft design analysis*

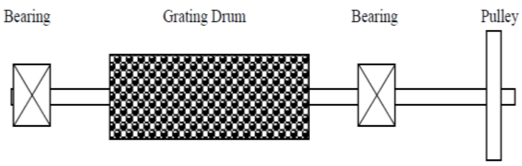

Fig. 2: Shaft loading

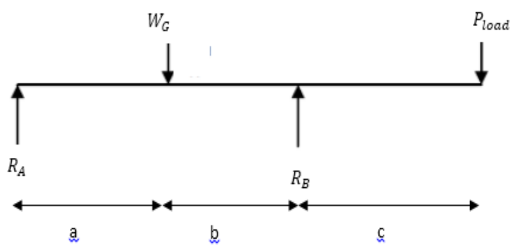

Fig. 3: Reactions

$W_G = W_{gdm} + W_{cassava} = 41.5 + 196.2 = 237.7N$

$P_{load} = W_P + T = 14.72 + 822.07 = 836.79N$

- *Moment consideration for vertical loading*

Upward forces = downward forces

$R_A + R_B = W_G + P_{load} = 237.70 + 591.70 = 829.40N$

Taking moment about R_A

$W_G(a) - R_B(a+b) + P_{load}(a+b+c) = 0$

$R_A = -29.08N$

$R_B = 858.48N$

- *Bending moment about A*

$M_A = 0$

- *Bending moment about B*

$M_B = R_A \times a = -29.08 \times 0.20 = -5{,}82Nm$

- *Bending moment about C*

$$M_C = R_A \times (a+b) - W_G(b) = -29.08 \times 0.40 - 237.7 \times 0.20 = -59.17Nm$$

- *Bending moment about D*

$$M_D = R_A \times (a+b+c) - W_G(b+c) + R_B(c) = -29.08 \times 0.50 - 237.7 \times 0.30 + 858.48 \times 0.1 = 0Nm$$

- *Moment consideration for horizontal loading*

Upward forces = downward forces

$R_A + R_B = P_{load} = 591.70N$

Taking moment about R_A

$P_{load}(a+b+c) - R_B(a+b) = 0$

$R_A = -147.93N$

$R_B = 739.63N$

- *Bending moment about A*

$M_A = 0$

- *Bending moment about C*

$M_C = R_A \times (a+b) = -147.93 \times 0.40 = -59.17Nm$

- *Bending moment about D*

$$M_D = R_A \times (a+b+c) + R_B(c) = -147.93 \times 0.50 + 739.63 \times 0.1 = 0Nm$$

- *Maximum bending moment*

$$M_b = \sqrt{M_V^2 + M_H^2} = 83.67Nm$$

- *Diameter of the shaft*

$$D^3 = \frac{16}{\pi S_s}\sqrt{(k_b M_b)^2 + (k_t M_t)^2}$$

k_b = Combined shock and fatigue applied to bending moment (1.5)

k_t = Combined shock and fatigue applied to torsional moment (1.0)

S_s = Allowable stress (40MN/m^2 for mild steel)

$$D^3 = \frac{16}{\pi \times 40 \times 10^6}\sqrt{(1.5 \times 83.67)^2 + (1.0 \times 31.96)^2}$$

$D = 25.45mm$

A standard shaft size of 30mm was used

VI. PRODUCTION OF COMPONENT PARTS

A. Hopper

The hopper which serves as the channel through which the cassava is fed for grating, was produced using stainless steel sheet. The plain sheet was placed on a steel table for marking out by means of a scriber to its required dimensions and thereafter cut to shape before it was folded and welded.

Fig. 4: Hopper

B. Grating Drum

The grating drum which performs the grating of cassava that is fed into the hopper, is housed within the hopper. It consist of a solid shaft, passing through two circular plates, folded galvanized steel sheet and perforated stainless steel sheet. The two circular plates were placed at both ends of the folded steel sheet and welded to the shaft.

Fig. 5: Grating Drum

C. Support Bearings

The bearings were used to support the grating unit and also to aid in the transmission of speed via the pulley from the electric motor to the grating unit. They enhance the smooth running of the grating machine.

Fig. 6: Support Bearing

D. Pulley

These are part of the transmission system of the grating machine. They can be used to increase or decrease speed transmission from the electric motor to the shaft or vice-vassal.

Fig. 7: Pulley

E. Shaft

The shaft was used to transmit power to the grating drum. It is a solid shaft machined from mild steel. In order to maintain satisfactory performance, the shaft was stiffened, supported on rigid bearings and properly balanced. It was equally designed to withstand bending, tensile, compressive and torsion loads all acting at the same time.

F. Maintenance of the Cassava Grating Machine

Fig. 8.shows the assembled cassava grater. Maintenance activities should be carried out so as to prolong the life span of the machine and to obtain optimum performance. The important maintenance activities to be carried out regularly on the machine for effective and maximum performance include:

- Lubrication of the moving parts before operation
- If any machine component is worn out, it should be replaced
- The belt driving the pulleys should be checked before use for proper tightening
- When carrying out any maintenance or repairs on the machine, all bolts and nuts must be properly tightened
- The machine should undergo daily routine maintenance so as to improve its life span and durability.

Fig. 8: Assembled cassava grater

VII. CONCLUSION

This work focused on the design and production of a powered cassava grating machine using locally sourced material which makes it affordable to both the middle and the low class populace. The cassava grating machine can be coupled or decoupled easily, the hopper of the machine was designed to accommodate a specific volume of peeled cassava conveniently without wastage, the grating unit was made of stainless metal so as to promote safe grating operation, and the delivery chute was made sloppy for easy discharge. The machine is powered either electrically using a 3hp electric motor or mechanically using a 6.5hp gasoline engine. The powered cassava grating machine is durable, light-weighted, easily operated and will greatly reduce importation of similar machine types. The machine is portable and can be used commercially to produce cassava pulp and also, it solves the problem of fatigue resulting from the manual grating of cassava. Test indicated that the machine performed excellently well.

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