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MODIFICATION OF NCAM MOTORIZED CASSAVA GRATING MACHINE

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ABSTRACT

The need to redesign the NCAM motorized cassava grater became imperative upon discovery that the existing motorized NCAM developed grating machine splashes grated mash on the operator, not portable, as it was too heavy to be transported from a location to the other using motorcycle. The hopper was therefore redesigned and further scaled down for ease of transportation with motorcycle on the farm. The design gave birth to an affordable and portable cassava grating machine. The performance evaluation revealed that using a 9HP petrol engine at a speed 78.40 rpm to run the cassava grater gives an output capacity of 2.0 tons/day at 84% efficiency. This is in addition to its portability and elimination of splashing of grated cassava mash on the operator.

KEYWORDS: Cassava, Grating machine, Hopper, Modification, Performance Evaluation, Efficiency.

INTRODUCTION

Considering the significant roles that cassava root played domestically and industrially hence the need to modify NCAM cassava grating machine looking at the challenge attached to the existing cassava grating machine, it is not affordable by low income earner and local processors, not portable that can be move from one point to another by motorbike which is the most common means of transportation by low income earners because of it size and not weightless, there is also issue of opening and closing of hopper during grating operation which is stressful to the operator at the same time splashing of cassava pulp which distract the operator and littered the environment and reduce the quantity of the pulp as the splashing continue during operation.

Modification of NCAM grating machine became necessary to make it portable, affordable looking at the economic realities and emphasis during agricultural stakeholders and West Africa Agricultural Productivity Programme (WAAPP) meetings, there is need to scale down and modify our existing innovative and adaptive technologies to meet the need of low income earners and local processors, also to reduce drudgery and improve the quality of agricultural production to ensure food security for the nation.

NCAM cassava grating machine has been modified with the following areas portability, affordability, eradication of splashing of cassava pulp, eradicating the stress of opening and closing of hopper cover by the operator during grating, littering of environment due to splashed cassava pulp is eradicated.

Cassava (Manihot esculenta Crantz) is a very important crop in Nigeria deriving from the extensive use of the various products and by-products as staples to most Nigerians. The consumption of cassava cuts across all parts of the country. Its adaptability to climatic and soil conditions even in marginal soil has endeared cassava to most people that have to do continuous cultivation on limited available land. Cassava is a shrubby, tropical, perennial plant that is not well known in the temperate zone. For most people, cassava is most commonly associated with tapioca. The plant grows tall, sometimes reaching 15 feet, with leaves varying in shape and size. The edible parts are tuberous root and leaves. The tuber (root) is somewhat dark brown in colour and grows up to 2 feet long. Cassava (manihot esculenta), has its origin as South America, presumably eastern Brazil. It thrives better in poor soils than any other major food plants.

Nigeria has been world-leading producer of cassava with an estimated annual production of 2.6 million tons from an estimated area of 1% million hectares of land (IITA, 1990) and (Agbetoye, 2005). The major problem of cassava is that it is extremely perishable and the harvested tuber must be processed to curb post-harvest losses (Davies, 1991). According to Food and Agricultural Organization (FAO, 2007), the estimated industrial cassava use was approximately 16 percent of cassava root production and was utilized as an industrial raw material in 2001 in Nigeria. Around the world, cassava is a vital staple for about 500 million people. Cassava's starchy roots produce more food energy than any other crop.

MATERIALS AND METHODS

Description of the machine

The modification of NCAM cassava grating machine was carried out, followed by the fabrication of the cassava grater in the Fabrication Workshop of the National Centre for Agricultural Mechanization, Ilorin. The following materials were used to fabricate the machine. Stainless steel sheet, Angle iron, galvanize sheet, bolt and nut, pillow bearings, hinges. Evaluation of the grater was carried out considering the grating capacity, quality of mash and efficiency.

The modified NCAM motorized cassava grating machine consists of a trapezoidal shaped hopper made up of 2mm thick stainless steel sheet materials, the grating drum is made up of a cylindrical perforated galvanized sheet and the frame made from 50mmx50mm angle iron. It is powered by a nine horse power (9HP) petrol engine at a speed of 78.40 rpm; cassava is fed into the machine through the hopper down to the grating drum, which rotates at a constant speed. The machine consists of the followings:

Hopper: The machine hopper has the length of 455mm and the height is 350 mm, it was made from 2mm stainless sheet materials and it is attached to grating unit. The hopper accommodates cassava roots during grating.

Grating Drum: It is made from 2mm galvanized sheet perforated in cylindrical shape which is the grating mechanism, the grating drum has a shaft that passed through it and supported by pillow bearings at the two ends it moves in circular motion driven by power from 9HP petrol engine transmitted through the belt.

Frame: The frame of the modified grater is 560mm height and 405mm width, it supports all components of the machine and makes it rigid during grating operation the frame is made from 50mmx50mm angle iron.

Shaft: The shaft has the diameter of 20mm and it support the grating drum held by two pillow bearing at the two ends the shaft transmits torque and motion generated by 9HP petrol engine to drive the grating drum been directly attached to it, the shaft is made up of mild steel.

Working principle of the Machine

The modified NCAM cassava grating machine is operated and powered by a 9HP petrol engine. Cassava is fed into the machine through the hopper down to the grating drum, which rotates at a constant speed in circular motion. As the grating drum rotates, the perforated grating drum robs the tubers continuously to grate it. It falls and goes through the chute and collected by bowl or sack.

Design Considerations

In the design of the modified NCAM cassava grating machine several factors were considered to achieve reliability and efficiency. These include:

1. Affordability, workability, availability and strength of materials used for fabrication;
2. Physical properties of materials to be handle;
3. Effective grating and minimal loss of useful grated mash; and
4. The quality of food to be handle, hence material that will not contaminate it.

Design Calculations

a. Hopper Design

A hopper with trapezoidal cross section was considered.

The Volume of which was obtained as follow:

$$V = \frac{1}{3}AH \qquad (1)$$

Where: A is the Area of base and H is the perpendicular height

The mass of Hopper is given as:

$$M = \rho V (kg) \qquad (2)$$

Where,

ρ is the density of material.

b. Grating Drum Design

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

$$V = \pi r^2 h (m^3) \qquad (3)$$

Where,

V is the volume of cylinder,

R is the radius of cylinder, and

h is the height of drum.

The force acting on the cylinder drum is given as:

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

Where, g is the acceleration due to gravity.

Shaft Design

Shaft is a common and important machine element. It is a rotating member, in general, has a circular cross-section and is used to transmit power. The shaft may be hollow or solid. The shaft is supported on bearings and it rotates a set of gears or pulleys for the purpose of power transmission. The shaft is generally acted upon by bending moment, torsion and axial force. Design of shaft primarily involves in determining stresses at critical point in the shaft that is arises due to aforementioned loads. Strength and rigidity were considered in the design of the shaft.

Bending Stress

$$\sigma_b = \frac{32 M_b}{\pi d^3 \left(1 - k^4\right)} AH \quad (6)$$

(Ghupta & Khurmi, 2004)

Where,

M_b is the Bending moment (Nm), d is the outer diameter Shaft (m), and

k is the ratio of inner to outer diameter of shaft (k= 0 for solid shaft).

c. Axial Stress

$$\sigma_a = \frac{4aF}{\pi d^2 \left(1 - k^2\right)} AH \quad (7)$$

(Ghupta & Khurmi, 2004)

Where,

F is the axial force (tensile or compressive); and

a is the Column-action factor (= 1.0 for tensile load)

d. Stress Due to Torsion

$$\tau_{xy} = \frac{16\tau}{\pi d^3 \left(1 - k^4\right)} \quad (8)$$

(Ghupta & Khurmi, 2004)

Where,

T is the Torque on the shaft,

τ_{xy} is the shear stress due to torsion

e. Combined Bending and Axial Stress

Bending and axial stresses are normal stresses; hence the net normal stress is given by:

$$\sigma_x = \left[\frac{32M}{\pi d^3 \left(1-k^4\right)} \pm \frac{4aF}{\pi d^2 \left(1-k^2\right)} \right] \tag{9}$$

(Ghupta & Khurmi, 2004)

f. Maximum Shear Stress

The shaft was designed using maximum shear stress theory which states that a machine member fails when the maximum shear stress at a point exceeds the maximum allowable shear stress for the shaft material. Therefore,

$$\tau_{\max} = \tau_{allowable} = \sqrt{\left(\frac{a_x}{2}\right)^2 + \tau^2 xy}$$

Substituting for σ_x and τ_{xy} the above equation becomes,

$$\tau_{allowable} = \frac{16}{\pi d^3 \left(1-k^4\right)} \sqrt{\{M + \frac{aFd(1+k^2)}{8}\} + T^2} \tag{10}$$

(Ghupta & Khurmi, 2004)

Therefore, the shaft diameter can be calculated in terms of external loads and material properties. However, the above equation is further standardised for steel shafting in terms of allowable design stress and load factors in ASME design code for shaft.

The shafts are normally acted upon by gradual and sudden loads. Hence, the equation is modified in ASME code by suitable load factors,

$$\tau_{allowable} = \frac{16}{\pi d^3 \left(1-k^4\right)} \sqrt{\{MC_{bm} + \frac{\alpha Fd(1+k^2)}{8}\} + \left(C_t T\right)^2} \tag{11}$$

(Ghupta & Khurmi, 2004)

g. Shaft Diameter

The shaft diameter is calculated using

$$d^3 = \frac{16}{\pi S_s}\sqrt{(K_b M_b)^2 + (K_t M_t)^2} \tag{12}$$

(Ghupta & Khurmi, 2004)

Where,

d is the diameter Shaft (m), S_S is the allowable shear stress (Nm^{-2}),

K_b is the Combined shock and fatigue factor applied to bending moment,

K_t is the Combined shocking and fatigue factor applied torsional moment,

M_b is the bending moment (Nm), and

M_t is the transitional moment (Nm).

h. Power Requirement of the Machines

$$P = T\omega \tag{13}$$

(Ghupta & Khurmi, 2004)

Where T is the Torque and ω is the Angular velocity

i. Pulley and Belt Design

The pulley and belt length were determined using the following equations:

$$N_1 D_1 = N_2 D_2 \tag{14}$$

(Ghupta & Khurmi, 2004)

$$L = 2C + 1.57(D_2 + D_1) + \frac{D_2 - D_1}{4C} \tag{15}$$

(Ghupta & Khurmi, 2004)

Where,

N_1 is the speed of the driven pulley, rpm;

N_2 is the speed of driving pulley, rpm;

D_1 is the diameter of driven pulley, mm;

D_2 is the diameter of driving pulley, mm;

L is the length of belt, mm; and

C is the distance between driving and driven pulley, mm.

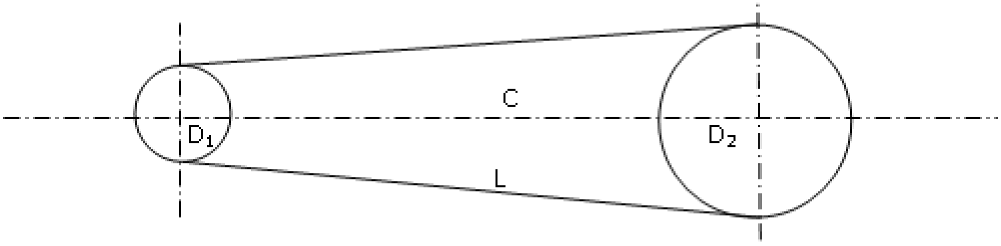

Figure 1: Pulley and Belt Arrangement.

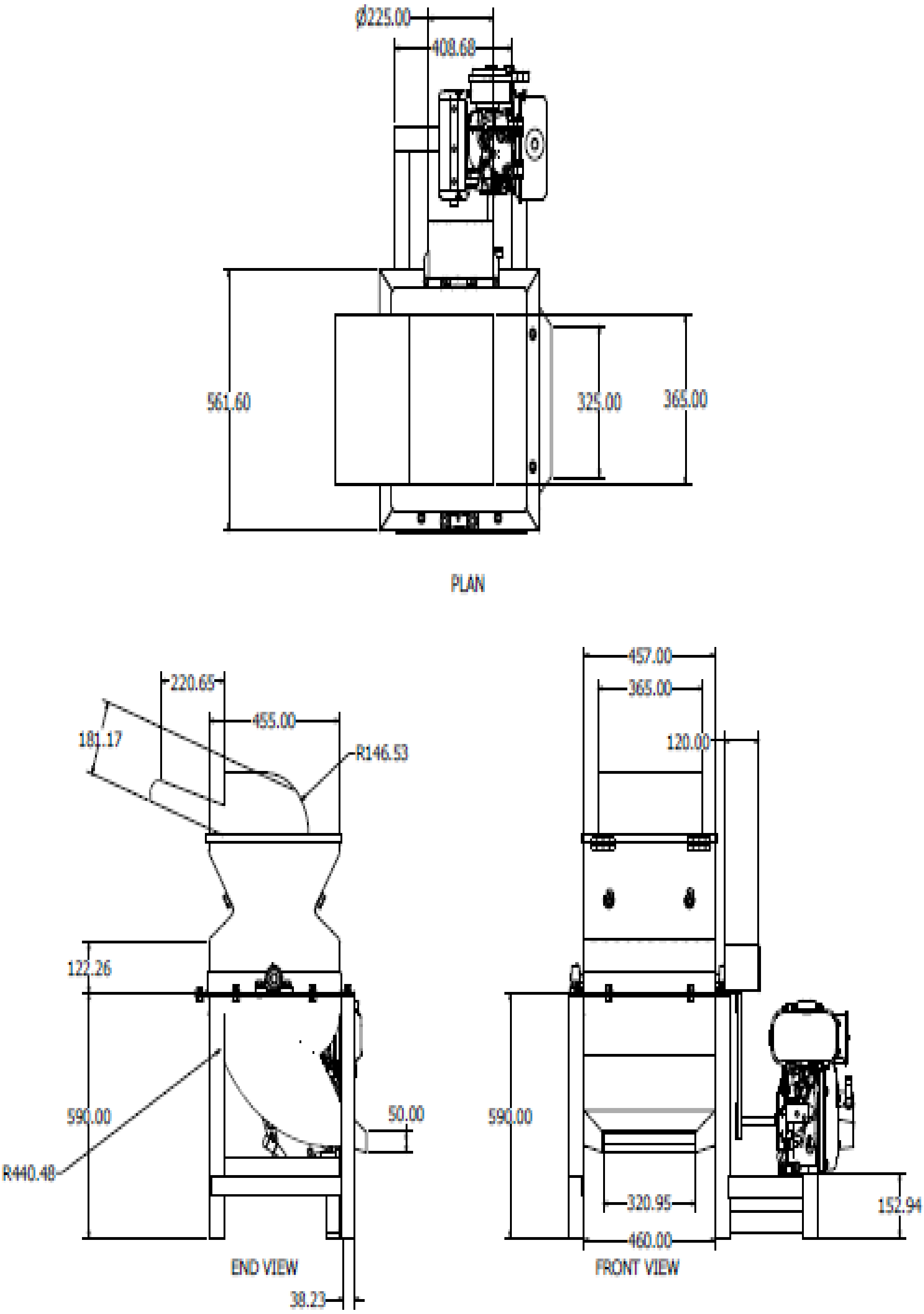

Figure 2: Orthographic view of the machine.

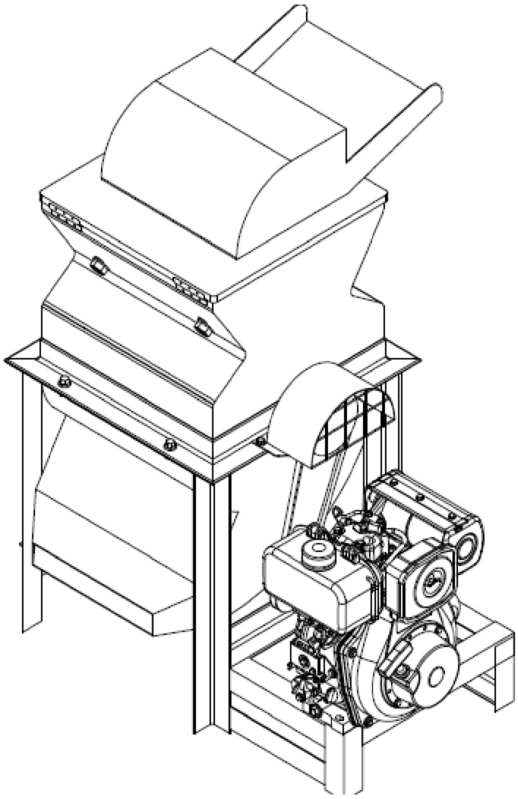

Figure 3: Isomeric view of the machine.

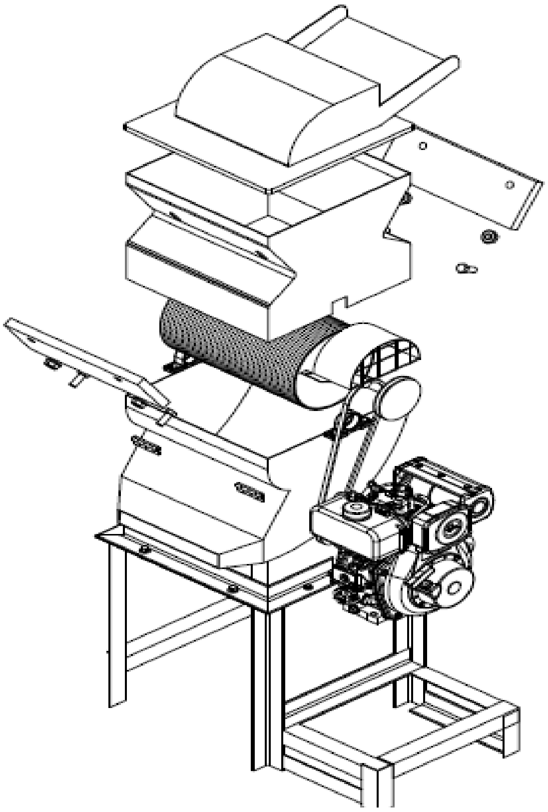

Figure 4: Exploded view of the machine.

Figure 5: Modified NCAM Cassava Grater on Motorbike.

Performance Evaluation

Fresh harvested cassava root was peeled using knives and were washed for hygiene, after that the peeled cassava root were measured in 3 batches of 30kg using weighing scale. The machine was started and the speed was regulated to 132.65 rpm using tachometer. The peeled cassava root were fed into the grating machine through the hopper allowing the root fall directly on the grating drum of the machine. As the grating begins, the speed of the machine was again regulated to be 78.40 rpm. After grating the machine was stopped, the weight of the well grated mash, total grated mash, grating time, good quality mash, and bad quality mash were measured to ascertain the machine's efficiency, capacity and the quality of mash the machine produced.

Figure 6: Peeling of cassava roots.

Figure 7: Peeled cassava root as samples for performance evaluation.

Figure 8: Weighed cassava root.

Calculation of parameters

$$\text{Grating Efficiency} = \frac{W_{wg}}{W_1} \times 100\%$$

$$\text{Machine Grating Capacity} = \frac{W_{tg}}{T_1} kg/hr$$

$$\text{Grating Mechanical Loss} = \frac{W_1 - W_{tg}}{W_1} \times 100\%$$

$$\text{Quality Performance Efficiency} = \frac{G}{G+B} \times 100\%$$

Where,

W_{wg} is the mass of well grated cassava (kg)

W_{tg} is the mass of total grated cassava (kg)

W_i is the initial mass of cassava tuber (kg)

T_g is the grating time (s)

G is the good quality (kg)

B is the bad quality (kg)

Performance indices

S/N	W_i (Kg)	W_{wg} (Kg)	W_{tg} (Kg)	T (S)	G (Kg)	B(Kg)
1	30.0	24.1	26.6	390	27.6	2.4
2	30.0	24.3	25.4	286	27.5	2.5
3	30.0	27.4	28.2	343	27.9	2.1

Speed of the grater before loading: 132.65 rpm

Speed of the grater after loading: 78.40 rpm

Figure 9: Pictorial view of the machine.

Machine Specification

Efficiency	84%
Capacity	2.0 tons/day
Mode	9Hp petrol engine
Feature	The machine produced fine marsh (pulp) suitable for the production of high quality cassava flour, gari and starch. Portable machine that is easy to operate and maintain.

RESULT AND DISCUSSION

The mass of peeled cassava root fed into the machine was 30kg. It was observed that almost all peeled cassava root fed into the machine were grated except for few that hung on the wood placed in the hopper. This was attributed to the efficiency of the grater and the freshness of the cassava root; it is believed that cassava root has more moisture content in raining season which enhances the grating quality of the grater. The machine produced cassava mash finer than the mash produced by the existing grater as the coarser mash might still contain level of cyanide as not all the cells have been broken down mechanically (IITA), this could be due to the diameter of the perforated grating drum and the clearance between the plank and the grating drum. The grating efficiency of the modified grater is 84%, grating capacity is 2.0 tons/day, the mechanical loss is 10.9% and quality performance efficiency is 92.23%. The modified grater is fuel economy as 90kg of cassava root was grated in 1022 sec using half litre (½ litres) of petrol at the speed of 78.40 rpm, the grater is efficient, affordable and portable that can be move from one point to another with motorbike.

CONCLUSION

This work aimed at modifying NCAM cassava grater with a view to remove drudgery associated with opening and closing of the hopper, improving portability and affordability while the efficiency is not affected. The grater was modified and the performance evaluation was carried out, the modified grater is effective in the production of good and fine mash. The grating efficiency of the grater is 84% and the capacity is 2.0 tons/day, it is observed that this grater would solve the problem of grating cassava by low income earner and local processors because it is efficient, affordable and portable at the same time the grater can be use where there is erratic power supply or none at all, since it does not require the use of electricity. However it is recommended that care should be taking in ensuring good maintenance of the grater.

REFERENCES

1. Abudu et al, Development and performance evaluation of automated cassava grating machine, Applied Science Repor, 2017.
2. Agbetoye. O., Oyedele A. Development and testing ofa Dual grain sifter. Proceeding of the Nigerian Institution of Agricultural Engineers, NIAE/ 2005/192, 2005; 192-193.
3. Akanbi O.P. Performance and sensitivity Evaluation of a Developed cassava grating machine, 2014.
4. Davies R.M. A survey of cassava processing machinery in oyo state of Nigeria, project Report, Agricultural Engineering Department, University of Ibadan, Nigeria, 1991.
5. FAO, (Food and Agricultural Organization) of United Nations (2004). Annual Statistic Rome, Italy, 2007.
6. IITA (International Institute for Tropical Agriculture) Cassava in Tropical Africa, a reference manual, 1990; 83-100
7. Okonkwo et al, Performance evaluation and optimization of single barrel cassava grating machine on selected fresh and stored cassava species, IOSR Journal of mechanical and civil engineering. (IOSR-JMCE), 2016.
8. Oriaku et al, Design and performance evaluation of a double action cassava grating machine, journal of emerging trends in engineering and applied science (JETEAS), 2015.