Development of a Motorized Akpu Milling Machine Design to Improve Poverty Eradication in Nigeria

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Abstract – This research work was carried out in order to develop a motorized Akpu Milling Machine in the quest to improve poverty eradication in Nigeria through technological innovation. Considering the various traditional method of grinding Akpu (Cassava). This machine was fabricated and has the ability to grind tubers of Akpu (Cassava) squeezing/ extracting the moisture content out before frying on the fire, or oven. This research work aimed at eliminating the problem of traditional method of milling Akpu. The capacity of the Akpu milling machine developed is 158kg/hr. The machine runs on a single phase three horse power electric motor at a speed of 1450 rpm. Due to the inherent problems of contamination the machine may be adopted for large scale industrial applications.

Key Words: Akpu, Eliminating, Grinding, Milling Machine, Single Phase, Speed

1. INTRODUCTION

Akpu popularly known as cassava originated from Latin America and was later introduced to Asia in the 17th century and to Africa in about 1558. In Nigeria, cassava is mostly grown on small farms, usually intercropped with Vegetables, plantation crops, yam, sweet potatoes, melon, maize etc. Cassava is propagated by 20 -30 cm long cutting of the wood stem, spacing between plants is usually 1.5 meters. Intercropping with bean, maize, and other annual crops is practiced in young cassava plantations. There are two common varieties of cassava, namely, the bitter and sweet varieties. The cyanide content differs as well as suitability for different growing and consumption conditions. Usually, higher cyanide is correlated to high yields. Nigeria is one of the world largest producer of Cassava tuber in the world, producing about 34 million tonnes of the world's 174.0 tonnes. Over the past 25years significant market opportunities for cassava have opened up in the animal feed industry, initially in the EEC (European Economic Community) countries but more recently for the rapidly expanding animal feed industries of tropical developing countries. Cassava roots compete with other carbohydrate sources, especially maize and sorghum, on the basis of price, nutritional value, quality and availability. Cassava has several advantages compared with other carbohydrate sources, especially other root crops. It has a high productivity under marginal climatic conditions, which result in a low cost raw material. Root dry matter content is higher than other root crops at 35-40%, giving optimum rates of 25:1 or better. Over 85% consists of highly digestible starch. Cassava starch has excellent agglutinant properties which make it especially suitable for shrimps and fish feeds, replacing expensive artificial agglutinants. The potential disadvantages of cassava roots are their bulk and rapid perish ability, their low protein content and presence of cyanide in all root tissues. Through simple processing the disadvantages of bulk and perish ability can be overcome: A stable product is reached when moisture content falls below 14%, natural drying is widely used to achieve this objective. Drying also permits the elimination of most of the cyanide from root tissues. The dried cassava product thus has only one disadvantage with respect to other carbohydrate feed sources: low protein content. This can be overcome through price competitiveness. For export markets, where transportation over thousands of kilometers is necessary, further processing to produce high density pellets is carried out to minimize transport costs.

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Local Varieties

In the traditional bush-fallow system, some cassava plants are always left to grow with the fallow which is long enough to enable the cassava to flower and set seed. The natural out crossing habit of cassava leads to the production of numerous new hybrid combinations from self-sown seed from which farmers select and propagate desirable types. By this process, pools of new local varieties are continuously created which are adapted to the different agro-ecological zones of the country. As these selections are made on account of their excellent cooking qualities, low Hen (Hydro-cyanide) content and high yields, they are used as parents in breeding programmes mainly to improve pest and disease resistance.

The undermentioned are the local varieties:

i. Akpu ii. Dan wari iii. Oko Iyaw iv. Panya
v. Akintola vi. Akon vii. Etunbe

B. Evolution of Traditional Graters

- The traditional method of grating cassava was by pounding it in a mortar with a pestle.
- Another Innovation is by grating it with a tin can with holes punched in the bottom since the cassava root is spongy and this leads to lots of hand injuries.
- This traditional technology improved by mounting the grating surface on a wooden table at a convenient height so the rubbing action is horizontal rather than in a downward slant when the grating surface is supported against the operators.

In Nigeria many of the cylindrical power milling machines developed to be used in villages are based on the existing design which has some unique design features intended to improve milling efficiency and output without necessarily increasing power requirement. There are however, many

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variations in design, power transmission, capacity and type of construction.

The cassava milling machine presented a great innovation in cassava processing since grating is central to traditional processing of cassava in Nigeria. Since then, several equipment manufacturers including Engineering firms, research institute, university departments, small-scale artisanal shops, blacksmiths and mechanics have developed and produced various types of cassava processing equipment. Over the past three decades there has been a gradual but steady increase in the adoption of cassava processing equipment in the cassava processing industry. The adoption of mechanized cassava processing appears to have escalated in recent years through assistance provided by non-governmental organization to the rural area.

The total areas under cassava cultivation in Nigeria, is about .3.60 million hectares. All states including the Federal Capital Territory (FCT), cultivate appreciable quantities of cassava. However, Akwa Ibom, Edo and Delta States including Cross River are major producers. Most of the cassava produced in Nigeria are processed and consumed in various forms locally with little Botanical Name Manihot esculenta. Local Names in Nigeria include;

Hausa: Rogo, Igbo: Akpu, Yoruba: Ege

C. Problem Statement

From the survey, it was discovered that most of the graters incorporated inside the cassava milling machine are usually corroding (reducing service life) due to the acidic nature of the cassava fluid and materials used for the fabrication .To ensure all Cassava products is free from any taste, odour, or infected by iron content of parts (food poisoning) which may affect the quality of their contents, hence need to modify the design and use appropriate materials for fabrication. The product

tuber spoils after 2-3days of harvesting, hence need for processing into safer stable products.

In view of the above mentioned problems and the overall importance of the cassava products the following objectives are required to address the shortcomings of the grater.

D. Objectives

1. To design a prototype cassava milling machine
2. To fabricate a prototype cassava milling machine
3. Ensuring proper grinding performance thereby eliminating vibrating sieving since the cassava products can be re-grinded to finer particles after pressing and frying etcetera (ensuring no waste).
4. To save time and cost of processing cassava products by the average Family.
5. To promote healthy consumption of cassava products.
6. To test-run and confirm working of the cassava milling.

E. Scope of Research

The scope of the research is to design and construct a viable motorized Akpu (cassava) milling machine which would be useful for home-use, retailers and small sale farmers.

- To carry out a review on cassava and cassava milling machines in existence.
- To obtain some data or information that will be required and that are suitable in the design and construction of cassava milling machine.
- To select suitable materials based on result of the analysis for the construction of the machine
- To prepare a neat and detailed working drawing for the construction process.
- To discuss the results of the performance test.
- To present the necessary information on the machine efficiency.

II. ECONOMIC IMPORTANCE OF AKPU MILLING MACHINE

Cassava was introduced to Africa by the Portuguese more than 300 years ago close to the mouth of the Congo River by Portuguese explorers and traders from Brazil, and today is the primary carbohydrate source in sub-Sahara Africa. The plant grows as a bush or little tree. From there it was diffused by Africans, to many parts of sub-Saharan Africa over a period of two to three hundred years. In the course of its spreading across the continent, cassava has replaced traditional staples such as millet and yam, and has been successfully incorporated into many farming systems. It was initially adopted as a famine reserve crop as it provided a more reliable source of food during drought, locust attacks and the hungry season, the period before seasonal food crops are ready for harvesting. Cassava is a staple crop in many tropical countries and is harvested for its tubers, which are grated and pounded into a spread or flour. It is a member of the Euphorbiaceous, which includes those red flowered poinsettias we get at Christmas and those little spurge weeds found in southern USA gardens. Its tubers are toxic and must be processed to eat, but they provide a lot of calories in the form of carbohydrates. That's not of much interest to those in the North, who avoid calories, but it is the lifeline against famine in the South. At present, approximately half of the world production of cassava is in Africa where it is cultivated in around 40 countries, stretching through a wide belt from Madagascar in the southeast to Senegal and Cape Verde in the northwest. Approximately 75 percent of Africa's cassava output is harvested in Nigeria, the Democratic Republic of Congo, Ghana, Tanzania and Mozambique. Cassava is grown by millions of poor African farmers, many of them women, often on marginal land. For these people, the crop is vital for both food security and income generation. Cassava is vegetative propagated through stem cuttings and produces well on poor soils. The tubers may be kept in the soil for extended time periods. This secures rural farmers a carbohydrate source in years with adverse growth conditions where other crops fail and famine would otherwise prevail. These features and high crop yield contribute to the importance of cassava in Africa, South East Asia, and South America (Nweke et al, 2002). Also cassava can be grown on poor soil with no investment in irrigation, fertilizers or pesticides. Currently, the African crop is threatened by African cassava mosaic virus, which can reduce yields by 75 percent. Over the past decade, the virus has caused famines in several local regions of central Africa. The disease is prevalent because the African cassava varieties, having been introduced, have no natural defense against the virus. All cassava contains varying amounts of cyanide, a toxin that protects the plant from insects. Indigenous people have learned to avoid poisoning themselves by spitting into batches of the ground tubers; the saliva introduces bacteria and fungi, which activate an 8 enzyme that breaks down the cyanide. Villagers accomplish the same thing by depositing freshly dug cassava tubers into a community pond; microorganisms in the water degrade the cyanide. It is speculated that starvation indirectly led to these culinary rituals; starving people may have found that, having once spit out the bitter cassava tubers, then trying them again, the bitter taste was lessened.

The diversity of the plant is remarkable. "There must be thousands of different varieties. In Brazil, every little village has its own varieties. There are bitter ones, sweet ones, even ones used as baby food.

"(Schaal et al, 1999) Burgeoning interest in the crop in recent times results from the realization of the potential of cassava as a food security and emergence crop which could generate employment for the rural poor and foreign exchange for the country. Since 19901 the Government, through the Ministry of Food and Agriculture, has demonstrated its determination and commitment to promote cassava for the alleviation of poverty particularly in rural households and communities. The main reasons for expansion of cassava are population growth, famines or seasonal hunger and market availability. In Nigeria, cassava is moving from a starvation-prevention crop to a cash crop for local urban consumption. The next stage is to develop novel uses for the crop, such as livestock feed and industrial uses and to identify new markets. The top cassava producers are, in order, Nigeria, Brazill Thailand and Indonesia (the next six countries are all in Africa).

A. Handling and Processing

Handling and processing conditions often result in a very poor quality of the products. In addition to the high labour intensity and drudgery, the conditions during processing are generally unsanitary and unwholesome. During processing by women in rural areas, losses of some mineral and vitamin value do occur (FDA, 1994). This can be avoided with better-designed equipment (Kolawole et at. 2007). Agricultural improvements via technology and marketing can make a big difference in less developed countries.

B. Processing

Processing of cassava into various shelf-stable and semi-stable products is a widespread activity carried out by traditional cassava processors and small-scale commercial processing units. The traditional methods for processing cassava involve combinations of different unit processes including peeling, grating, dehydration, and dewatering, sifting, fermentation, milling and roasting. During processing, the cassava tuber is transformed from a highly perishable root crop into a convenient, easily marketable, shelf-stable product which meets consumer demand for a staple food. Processing may improve the palatability of the product and also reduce the level of cyanogenic glycosides in the tuber thereby detoxifying the product. Products fermented by some species of lactic acid bacteria such as agbelima and Garr; may attain anti-microbial properties. Several problems are encountered during traditional processing which have created an urgent need for mechanization and upgrading of processing. Operations are often uneconomical because the product is not properly costed; for instance, there is heavy reliance on family labour which is not perceived as cost. Operations are carried out on a very small-scale and the areas of manufacture may be unorganized and scattered. The processing procedures are labour intensive and time consuming and mostly carried out manually, dust and foreign matter contaminations, losses due to rodents' birds and other domestic animals. Operations are not adequately mechanized because processors cannot afford equipment and do not have access to capital. Processing is often carried out under unhygienic conditions and some unsanitary practices such as improper effluent disposal during the dewatering of cassava mash have adverse effect on the environment. Some operations such as the roasting of gari on open fires present a risk to the health of the processors. Products may be of inconsistent Organoleptic and microbiological quality because no formal quality system is applied during processing to assure the quality of the product. There is rudimentary packaging of products. But cassava is the "food of choice" even with an abundance of other options in urban settings. However, there is a lot of work needed in processing the tuber. To be edible, it must be peeled, washed, soaked, wet sieved, grated and bagged: no less than 14 steps. This work is done by hand by women of a village. Improvements in processing would greatly aid production. The operations involved in cassava processing depend on the end product desired. In general, the processing stages in cassava include:
i. Peeling ii. Washing iii. Grating iv. Chipping v. Dying vi.Dewatering/fermentation vii. Pulverization and sieving/ sifting and viii. Frying/drying

When cassava products are used as a primary staple food, careful processing to remove these toxic constitutes is required to avoid chronic intoxication (Onabolu et al 2002). Incomplete processing may result in high cyanide exposure and give rise to severe diseases like tropical ataxic neuropathy and konzo, especially in population with poor nutritional status. Unfortunately, careful processing generally results to loss of proteins, vitamins, and minerals, i.e. in products with low nutritional value. In spite of the availability of efficient processing procedures, cyanide exposure from cassava diets prevails (Oluwale et aI 2000).

C. Industrial Uses Cassava Leaves And Livestock Feeds

Cassava leaves are edible and a more convenient food product than fresh roots. Cassava leaves are storable in dry form and since they have lower water content, they are less expensive to dry than the roots. If leaf harvesting is 15 properly scheduled, it does not have an adverse effect on cassava root yield (Dahniya, 1983 and lutaladio and Ezumah, undated). Cassava leaves have a nutritive value similar to other dark green leaves and are an extremely valuable source of vitamins A (carotene) and C, iron, calcium and protein (Latham, 1979). The consumption of cassava leaves helps many Africans compensate for the lack of protein and some vitamins and minerals in the roots. Cassava leaves are prepared by leaching them in hot water, pounding them into pulp with a pestle and mortar before boiling in water along with groundnuts, fish and oil. This process eliminates cyanogens from the leaves, making them safe for human consumption. Because of the high-energy contents and low prices of cassava, livestock industries have since been using cassava chips in compounding animal feed production both locally and internationally. The compound livestock feeds are developed for pigs, cattles and sheeps, goats and poultry.

- UTA Ibadan had succeeded in extracting oil from cassava seeds. The oil is yet to be developed to edible level, but it had been confirmed that it could be used for making soap and for some pharmaceutical products.

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VITANOI is also obtainable from it. That is, it is medicinal.

- Used as monosodium glutamate, an important flavouring agent in cooking.
  Cassava flour is increasingly being used in partial substitution for wheat flour.
- Cassava can also be also used for alcohol, syrups etc. Alcohol is in demand in both the food and beverage industry and in the pharmaceutical industry. However, only 5% was processed into syrup for soft drinks and less than 1% was used for refined flour or adhesives, so much of the value added production potential is neglected.

D. Role of Akpu(Cassava) Products

Cassava performs five main roles:

- famine reserve Crop
- rural food staple,
- cash crop for urban consumption,
- industrial raw material, and
- foreign exchange earner, also that Nigeria is the most advanced of the African countries poised to diversify the use of cassava as a primary industrial raw material in addition to its the role as livestock feed.

Two factors were identified for Nigeria situation: the rapid adoption of improved cassava varieties and the development of small-scale processing technologies. Despite this development, the demand for cassava is mainly for food; and opportunities for commercial development remain largely undeveloped. Cassava production exhibits high levels of variability and cyclical gluts, due mainly to the inability of markets to absorb supplies. As a result, price of storage roots decline sharply and production levels are reduced in succeeding years before picking up again. Such factors were identified by IITA as cause of price instability over the years, which significantly increase the income risk to producers. Insufficient processing options and equipment for the processing and storage leading to inadequate marketing channels, and a lack of linkages between producers and the end-users are major factors preventing greater profitability for producers and processors. There is a potential to generate from one crop multiple economic benefits through improved post harvest handling and processing. Major constraints are technical, resources, socio-economic and organizational.

III. DESIGN OF AKPU(CASSAVA) MILLING MACHINE

A. Parts Design and Material Selection

In the design of Akpu milling machine many things were considered when analyzing the system.

Manufacturing processes includes the processes involved in using various construction methods in producing the extracting machine. In manufacturing, the principal common characteristic is that something physical is being produced or created i.e. output consists of goods or machine, which differ physically.

Manufacturing therefore requires some physical transformation or a change in utility of resources. The parts are different components that when assembled make up the unit in such processes care precision should be the top most priority when carrying out the construction. As far as the selection of material for the construction of machine component and parts is a vital aspect of design.

Various manufacturing processes were carried out during the fabrication, production and assembling of the components parts of this machine in order to be producing the required or particular goods.

The processes involves in producing the machine are as follows:

1. **DRILLING MACHINE:** this can be hand drilling or pillar drilling machine. This machinery was used for most drilling job. The work is stationary while the spindle carrying the drill chuck and bit moves the work must be held with a vice during drilling.
2. **MILLING MACHINE:** this machine was used for cutting of the keyway on the grater shaft.
3. **LATHE:** this was used for an extensive array of precision works also such as boring, turning. Facing of the assembly part.
4. **HAND GRINDING/CUTTING DISC MACHINE:** This is hand held and it comes in two sizes. The disc comes in the size 9", 7" or 4" diameters. The 7" disc was used for cutting and grinding.
5. **WELDING MACHINE:** it is used in conjunction with electrode and tong for joining two or more metals together. It was used with mild steel electrode when welding the mild steel. Welding can either be tacking (which can be easily broken) during setting, stitching, (which can be used to hold thin metals or running. The mild steel electrode of gauge twelve (2.5mm diameter) was used. Welding glasses (dark) was used when working.
6. **BENDING MACHINE:** it is used for bending sheet metals up to 5mm thick at different desired angles. It was used for bending the 3mm grater sheets at 1300.
7. **TABLE SHEAR:** It is big and heavy. It was used for cutting plate less than the 3mm and 4mm sheet, and it gives a straight cut edge unlike the hand cutting disc.
8. **PEDESTAL GRINDING MACHINE:** It is used for sharpening the tools, work piece drill bits.

B. Theoretical Design and Methodology

The material for the fabrication of the enhanced prototype of cassava milling machine are; the electric motor, mild steel plates and sheets, mild steel angle bars, hexagonal rod mild steel cylindrical tube.

A study was carried out, hardness and resistant ability of cassava tuber was investigated, the study involved the use of laboratory penetrometer and a data lodger. Hand-drilling machine was fitted with a 500mm diameter blade. These devices were powered manually and by application of electricity. Forces were applied by allowing direct cutting of the tubers using rotating sharp blade. The penetrometer was used to test the strength of fresh tuber. The result obtained indicated that cassava tuber hardness increases with the reduction of moisture content. The penetration force of 60 Newton at 70% moisture content wet basis was recorded.

IV. DESIGN ANALYSIS OF THE TRANSMISSION DRIVES

In the design of the milling machine, the drives used were the belt drive and pulley transmission system

A. Determination of Rotor Diameter

Mass of rotor = 10Kg

Force to crush fresh cassava = 60N

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Recall that;

$$F = Ma = \frac{Mv}{t} = \frac{m\pi cND}{60} \quad (1)$$

Where D = DR; the dimension of the rotor

$$DR = \frac{Fx60}{m\pi N_R} = \frac{105\ x60}{10\ x3.142\ x1977}$$

$DR = 0.101 \approx 0.1m = 100mm$

The diameter of the wooden rotor is 100mm

B. Diameter of Motor Pulley

Rotation speed N of rotor = N_R = 1977

Diameter of rotor = 100mm

Available rotational speed = 1450rpm of motor Nm

$$DmNm = D_RN_R \quad (2)$$

$$\frac{D_RN_R}{Nm} = \frac{0.1\ X1977}{1450}$$

$Dm = 0.135m \approx 135mm$

C. Value of Electric Motor

$$P = \frac{FWD}{2} \quad \frac{F\pi NmDm}{60} \quad (3)$$

Where F = force to crush fresh cassava

Nm = rotational speed of motor

Dm= diameter of motor

Adding $^3/_4$ of the force to crush the cassava and also move the wooden shaft so that it overcomes the strength of the cassava to be milled; i.e F = 105N

$$P = \frac{105\ x3.142\ x1455\ x0.273}{60}$$

$= 21841w \approx 2.93hp$

$\approx 3hp$

Hence, an electric motor of 3 horse power, 1450rpm, frequency of 50hz is needed for the fabrication of this machine.

D. Value of Belt Based on the Power

A transmitted (2.2KW) and according to the Indian standards (Is: 2494-1974), belt type B was selected from the table 3.1 below.

Table I Dimensions of Standard V-Belt

Type of belt	Power range in kw	Minimum pitch diameter of pulley D(mm)	Top width b(mm)	Thickness t(mm)
A	0.7 - 3.7	75	13	8
*B	2-15	125	17	11
C	7.5 -75	200	22	14
D	20-150	355	32	19
E	30-350	500	38	23

E. Calculation of Belt Length, L

Khurmi and Gupta (2006) developed equation for belt length as shown in
equation below;

$$L = \frac{\pi}{2}(D_1 + D_2) + 2X + \frac{(D_1\text{-}D_2)^2}{4X} \quad (4)$$

Where L = length of belt (mm)

D_1 = wooden shaft diameter, (mm)

D_2 = electric motor diameter (mm)

x = center distance between pullies

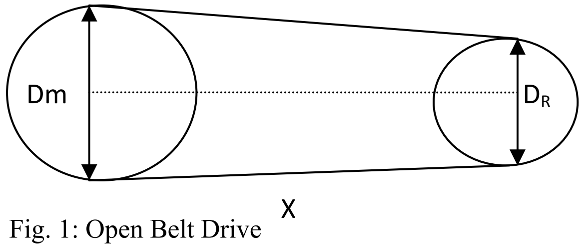

Fig. 1: Open Belt Drive

Apply equation 4 when,

$D_1 = 0.1$, $D_2 = 135$ and $X = 0.6654$

$$L = \frac{\pi}{2}(0.1 + 135) + 2(0.6654) + \frac{(0.273 + 0.2)^2}{4\ x\ 0.6654}$$

$L = 0.36919 + 1.3308 + 0.08829$

$L= 1.78828m \approx 1800mm$

A belt of A50 (12.5 x 1800)mm was selected.

F. Design for Shaft

$$T = \frac{\pi}{16} x\ \delta\ x\ d^3 \quad (5)$$

$$T = (T_1 - T_2)R \quad (6)$$

G. Determination of T_1 and T_2

$$T_1\text{-}Tm - Tc \quad (7)$$

$$Tm = \delta_a \quad (8)$$

Where T = torque on the iron shaft

δ = allowable shear stress

d = diameter of the shaft

T_1 = tension on tight of the belt

T_2 = tension on slack of the belt

Tm = centrifugal tension

Tm = maximum tension on belt

H. Determination of Belt Cross Sectional Area

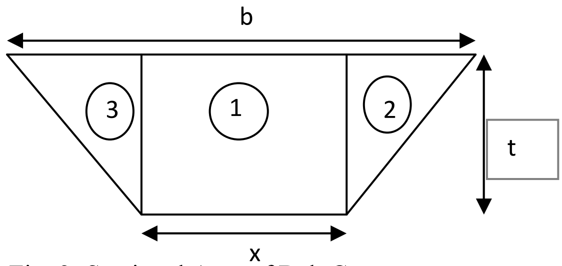

Fig. 2: Sectional Area of Belt Cross

From table 3.1

width b = 17

t = 11

x = 13.4

$$\tan 79 = \frac{11}{t_1}$$

$$t^1 = \frac{11}{\tan 79} = \frac{11}{5.1445} = 1.8$$

Area of belt = area of triangle 1 + area of square 2 + area of triangle 3 (9)

$= (^1/_2 x\ 1.8\ x\ 11)\ 2 + 13.4\ x\ 11$

$= 19.8 + 147.4 = 167.2mm^2$

The area of the belt = $167.2mm^2$

Maximum available, $\delta = 2.8mpa = 2.8N/mm^2$

Apply equation 8

$Tm = 2.8\ x\ 167.2 = 468.16N$

Also, centrifugal tension Tc,

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$Tc = mv^2$ (10)

m = mass of belt per unit length

$m = \varepsilon a$ (11)

Table. II: Density of Belt Material

Materials of belt	Mass density in Kg/m^3
Leather	1000
Canvass	1220
Rubber	1110
Balata	1170
Single woven	1250

From table 3.2, density of belte = 1140

$$m = \frac{1140 \times 167.2}{1000000} = 0.1906Kg$$

Also, linear speed of belt

$$V = \frac{\pi DN}{60} \quad (12)$$

D = Dm = 273

N = Nm = 1450rpm

$$V = \frac{3.142 \times 0.273 \times 1450}{60} = 20.73m/s$$

$Tc = mv^2$ $0.1906 \times (20.73)^2 = 81.9N$

Apply equation 7

T_1- Tm – Tc = 468.16 - 81.9 = 386.26N

V-belt drive, the tension is given by;

$$\frac{T_1 - T_c}{T_2 - T_c} = \varepsilon^{\o\mu\text{cosec}\frac{x}{2}} \quad (13)$$

μ = coefficient of friction between belt and pulley

ø = angle of wrap measures in (ratian)

X=groove angle = 60 (Gupta, 2006)

From the table below, coefficient of friction between rubber and pulley (dry cast iron) = 0.3

Table. III: coefficient of friction of materials

Belt material	Cast iron steel			Mod	Leader face
	Dry	Wet	Greasy		
Leather oak tamed	0.25	0.2	0.15	0.30	0.38
Leader chrome tamed	0.035	0.32	0.22	0.40	0.48
Canvass stitched	0.25	0.15	0.12	0.23	0.27
Rubber	0.30	0.18		0.32	0.40
Balata	0.32	0.2		0.35	0.40

By considering the small pulley, the angle of wrap 0 was calculated using

$$Ø = \left(180 - 2\,\text{Sin}^{-1}\frac{D_1 - D_2}{2x}\right)\frac{\pi}{180}\ \text{rad} \quad (14)$$

$$= \left(180 - 2\sin^{-1}\frac{0.135 - 0.1}{2 \times 0.6654\ 180}\right)\frac{3.142}{180}$$

$$= \left(180 - 2\sin^{-1}\frac{0.035}{1.3305}\right)\frac{3.142}{180}$$

$$= (180 - 2 \times 1.50)\frac{3.142}{180}$$

$$= (180 - 3.014)\frac{3.142}{180} = 3.089\ \text{rad}$$

From equation 13

$$\frac{386.26 - 81.9}{T_{2} - 81.9} = e^{0.3X3.09\text{cosec}\frac{60}{2}}$$

$$\frac{386.26 - 81.9}{T_{2-81.9}} = e^{0.20}$$

$$\frac{304.36}{T_{2-81.9}} = \frac{1.2177}{1}$$

$1.21744T_2 - 99.7 = 304.36$

$$T_2 = \frac{304.36 + 99.7}{1.21744}$$

$T_2 = 332.28$

I. Value of PowerTransmitted by the Belt

$Pb = (T_1 - T_2)V$ (15)

= (386.26 - 332.28) 20.73

(53.98) 20.73 = 1119.00

Power per belt (Pb) = 1119.00w

J. Number of Belt Used

The number of belts required to transmit 3hp power from electric motor was calculated using

$$N = \frac{\text{Motor Power}}{\text{Power}} \quad (16)$$

$$N = \frac{2238}{1119} = 2$$

Number of belts to be used = 2

From equation 6

$\tau = (T_1 - T_2)R$

= (386.26 - 332.28)R = 10.8

Also, from equation 5

$$d = \sqrt[3]{\frac{T \times 16}{\pi\tau}}$$

$$\sqrt[3]{\frac{10.8x16}{3.142x42x10^6}}$$

= 0.0109 ≈ 11mm ≈ 15 or 20mm

The diameter of the iron shaft inside the wooden shaft =25mm

V. RESULT AND DISCUSSION

Engineers use CAD to create two- and three-dimensional drawings, such as those for automobile and airplane parts, floor plans, and maps and machine assembly.

While it may be faster for an engineer to create an initial drawing by hand, it is much more efficient to change and adjust drawings by computer.

In the design stage, drafting and computer graphics techniques are combined to produce models of different graters. I manipulate these models on video display screens until they incorporate the best balance of features, including ease of production and cost. Using a computer to perform the six-step 'art-to-part'

- The first two steps in this process are the use of sketching software to capture the initial design ideas and to produce accurate technical views.
- The third step is rendering an accurate image of what the part will look like.
- Use of analytical software to ensure that the part is strong enough.
- Step five is the production of a prototype, or model.

- In the final step the CAM software controls the machine that produces the part.

During the design of the machine, the drafting software I used was AUTOCAD 2010 version. This was used to draw the orthogonal views, Isometric views and exploded drawings of the model cassava grater before the commencement of the development/construction of the machine.

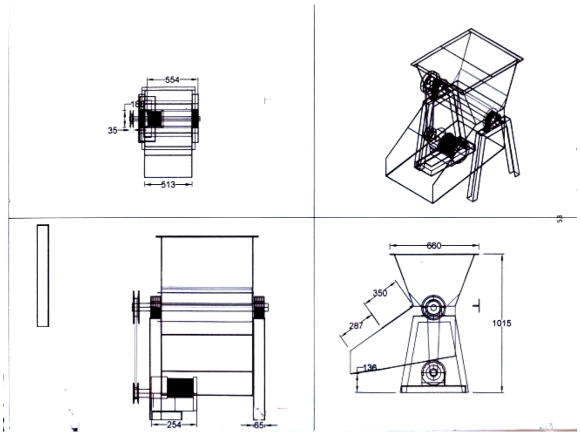

Fig. 3: The Technical view of Akpu (Cassava) Milling Machine

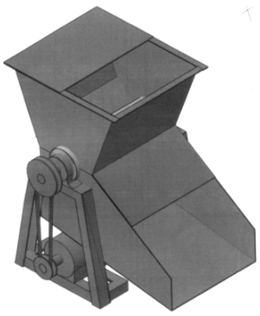

Fig. 4: The Designed Akpu (Cassava) Milling Machine in Solid Drawing

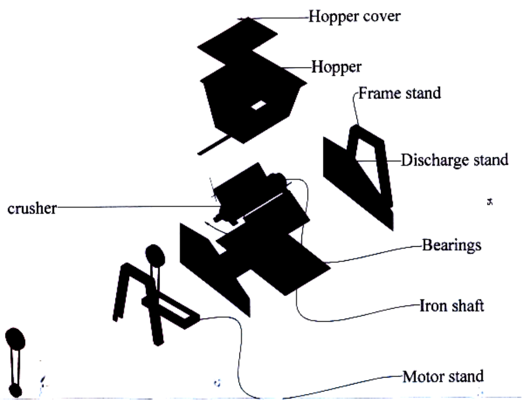

Fig. 5: Parts Description of Exploded view of Akpu (Cassava) Milling Machine

A. Performance Evaluation

There are several methods of testing for the efficiency of machines but with respect to this small-scale cassava grater, the following method for efficiency of the cassava grater was examined as follows:

i. Employing existing wooden grating drum grater that is prevalent for grating taking the weight of the cassava being grated and the time taken to grate this size. 50g was considered for this method
ii. Tests were also carried out on constructed machine using 50kg of cassava for five different batches. The time taken for each batch was accurately checked and recorded.

Each tuber of cassava was weighed and the weight of the whole batch of cassava obtained. The following measuring parameters were obtained and compared with the results of tests on the constructed machine.

Table IV: Indicating the Number of Loading and Time for each Loading in Order to Evaluate Performance of Existing Machine

NUMBER OF LOADING	MASS OF CASSAVA KG	TIME TAKEN TO GRATE LOADING
FIRST LOADING	1.95	
	1.55	
	1.98	
	2.02	
	1.75	
	1.75	
	1.58	
	1.90	
	1.42	
	1.88	
	1.78	
TOTAL	19.56	2min 58secs

Table V: Indicating the Number of Loading and Time for each Loading in Order to Evaluate Performance of Existing Machine

NUMBER OF LOADING	MASS OF CASSAVA (KG)	TIME TAKEN TO GRATE LOADING
SECOND LOADING	1.75	
	1.75	
	1.58	
	1.55	
	2.10	
	1.77	
	1.42	
	1.88	
	1.55	
TOTAL	18.77	2m in 58secs

Table VI: Indicating the Number of Loading and Time for each Loading in Order to Evaluate Performance of Existing Machine

NUMBER OF LOADING	MASS OF CASSAVA (Kg)	TIME TAKEN TO GRATE LOADING
THIRD LOADING	2.10	
	2.00	
	1.75	
	1.88	
	1.78	
	1.95	
	1.99	
	2.00	
	1.20	
Total	16.65	2min 31secs

B. Rate of Cassava Grating

This is the quotient of the weight (tones) of cassava extracted per hour.
For existing machine,

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$$\eta r = \frac{\textit{weight of cassava grated (kg)}}{\textit{time taken (Hrs)}} \qquad (17)$$

$$\frac{(19.56 + 16.65 + 18.77)3600(kg)}{(168 + 151 + 178)\ (Hrs)}$$

$$= 390.4 kg/hr$$

Table VII: Indicating the Number of Loading and Time for each Loading in Order to Evaluate Performance of Fabricated Machine

NUMBER OF LOADING	MASS OF CASSAVA	TIME TAKEN
1	4.2	1m in 34sec
2	5.5	2min 3sec
3	3.5	1min 26sec
4	3.5	1min 26sec
5	3.2	1min 11sec
6	4.1	1min 36sec
7	5.1	1min 54sec
8	4.9	1min 50sec
9	3.9	1min 27sec
10	4.3	1min 36sec
11	4.4	1min 38sec
12	5.0	1min 52sec
Total	51.6	1169sec

Therefore for test machine,

$$\eta r = \frac{\text{weight of grated cassava (kg)}}{\text{time taken (Hrs)}}$$

$$\frac{[51.6]3600\ (kg)}{[1169]\ (Hrs)}$$

$$= 158.9 kg/hr$$

C. Constraints to Further Development of Akpu (Cassava) Production

The major problems faced for the production and development of cassava are

- Lack of planting material (or effective distribution system), especially of improved varieties;
- High transport costs. Inadequate transport systems and inappropriate handling at ports.
- limited utilization in non-traditional products (feed, composite flours, starch and starch derivatives);
- low uptake of new/improved products from research;
- low profitability of gari processing
- Poor packaging of products.
- Another problem is that cassava produces a large amount of cyanogenic glycosides, which our digestive enzymes break down to toxic cyanide. The plants produce this to defend against herbivores. This is why the cassava tubers must be so heavily processed, otherwise, ingestion leads to konzo (paralysis of the legs). Genetically engineered cassava has been created with greatly lowered cyanogenic glycosides.

VI. CONCLUSION AND RECOMMENDATION

The home use/small scale cassava milling machine was designed, fabricated and tested. It was found to be effective and efficient and could grate about 158.9kg/hr.

This machine can be used at home-scale for domestic applications and it is affordable since the cost of production is low which will reduce during large scale production.

Based on the construction materials selection and quality of the research, the machine is durable and expected to last for long time.

Also, I recommend that the machine should be produced on large scale for small- scaled use (commercialization)

The efficiency, design mechanism (in terms of grating unit), and speed at which the machine operates can be improved upon in the future.

The above can be done hand in hand with weight reduction while maintaining balance and reducing machine vibration.

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