MODIFICATION OF CASSAVA CHIPPING MACHINE

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A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BARCHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING OF THE FEDERAL UNIVERSITY OF TECHNOLOGY MINNA,

NIGER STATE, NIGERIA

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DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communication, published and unpublished work were duly referenced in the text.

....   20/08/2010 ....

Uuzebor Abraham   **Date**

CERTIFICATION

This project entitled "Modification of Cassava Chipping Machine" by Uuzebor Abraham, meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG.) of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

In most profound gratitude, I dedicate this project to Almighty God, the beneficent, the Merciful for guiding me and showing me with his mercy through the course of my study.

This project is also dedicated to my beloved parents, wife, daughter and my mother in-law for their immense investment in my education, without you this dream would not have been achieved.

ACKNOWLEDGEMENT

I acknowledge the Almighty God in whom the success attained in this work is by his infinite grace indeed I acknowledge the marker for the success of the project.

My sincere appreciation goes to my supervisor Dr A. A. Balami, Head of Department, a man in whom I have come to realize words are silver but silent is gold. Thanks for your tolerance on my shortcomings. Words will not be enough to appreciate all the members of staff of the Department Engr. Sadiq Mohammed, Mrs. H.I Mustapha, Mr. P. Adeoye and other members of the staff, thank you all for your guidance and advice. I wish to acknowledge the technologist Mr. Kehinde Bello, Mallam Isyaka, thanks for your assistance.

My sincere gratitude goes to my beloved parent Uuzebor Benson and Mrs Caroline Adolphus for their both moral and financial support through out my study period.I appreciate your concern and contribution in my life.

ABSTRACT

An existing manually operated cassava chipping machine was modified by introduction of pulley, hopper, trough and electric motor base. The performance of the machine was carried out using three different pulleys of 60mm, 145mm, and 250mm that give three different speeds of 1450rpm, 600rpm, and 348rpm.

The Ø60mm diameter pulley at a speed of 1450rpm could process 200kg of chips (1.15mm diameter) per hour while the pulley with Ø250mm diameter at a speed of 348 rpm could process 95kg of chips (1.25mm diameter) per hour. That means the machine running at the highest speed has an efficiency of 70% while running at the lowest speed has an efficiency of 60%.

The machine was produced at a cost of #44,764:00 which I think can be afforded by the processors.

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CHAPTER ONE

1.0. INTRODUCTION

1.1. Background of the Study

Cassava is one of the most important root crops grown in West Africa, Cassava makes up to half of the nutritional requirements in many Nigerian household and it is one of the most important root crops grown in West African. It is known for its names like: tapioca manioc mandioca yuca and saga around the world and in Nigeria it is known by various names such as "ege" by Yorubas, "akpu" by Ibo's, madiaka by "Urhobo's", "Iwa', Anga's, "Okponkor" by Ijaws, "Igari" by "Ikas". The exact origin of Cassava is not known but apparently it was taken from some where in south America most likely Brazil (Eze, 2008). it was taken to Africa by Portuguese as early as 1558 and spread to Africa in the seventeeth (17) century (Eze, 2008). The plant has spread to varioys parts, it is an important food crop grown through out the humid and semi tropics. Cassava is a major source of low cost carbohydrates for population in the himud tropics. Nigerian cassava production is by far the largest in the world; a third more than production in Brazil and almost double the production in Indonesia and Thailand (Abdulmalik , 2004).

The few methods currently available for processing roots and tubers limit these crops from reaching their full potential as a sources of both food and income. Development and introduction of new processing technologies offers the potential to improve access to markets for cassava producers thereby increasing their incomes. Chip production is relatively simple. It calls for no major investments and provides an effective means for producers to boost the value of their crop. Yam chips are stabilized products with a moisture content of around 12% and can be kept for up to a year when stored under insect proof conditions. The cassava chip produced by the chipping machine dry quickly, are of high quality, reduce labour input involve in processing, easy to transport to the market, contain less cyanide and have improved palatability. The crop has about 69% moisture content and transportation from the rural area to Urban area for marketing is usually difficult. The processed product are easier to store, than the raw cassava, they need less storage space and can be stored for a longer period of time (Busari, 2005).

1.2. Importance

Cassava is a staple food in the Nigerian diet eaten for its nutritional and stomach filling value as well as its affordable price by low income families. Cassava is a high energy root crop consumed in the tropics and many regions of the developing world. Cassava is of great important in the nutrition of over 800 million people in the tropical world (Eze, 2008), more than 100 million people in the world obtain 500kcal per day from cassava. In central Africa, cassava is estimated to provide 100cal per day to 30 million people (Kenneth , 1999) It is also a raw material in the production of animal feed, starch, alcohol.

1.3. Statement of The Problem

The cassava produced by the manually operated cassava chipping machine is time consuming, labour intensive and the chips produced per time is little. To reduce this problem, there is need for the modification of the existing manual chipping machine.

1.4. Objectives of the Project

The objective of the project is to improve on the existing hand cranking cassava chipping machine by the introduction of electric motor.

1.5. Justification for the Study

The modification of this cassava chipping machine offers to produce an electric motorized machine and a new product chips within a shortest possible time and thereby increasing the chip produce and also increase in the producers income. This method which was found efficient in time of hastening the drying rate is cutting the tuber into chips, increased labour productivity and improved product quality. Chips produced are potential source of both food and income.

1.6. The Scope of the Project

The scope of the study is the modification of manual cassava chipping machine which is limited to the following

1. The use of electric motor as the source of power
2. The use of pulleys and v-belt as the means of power transfer
3. The feed chute wheel to be made of aluminum cast
4. The cutting blade to be made of galvanized iron
5. The frame is to be made of angel iron

CHAPTER TWO

2.0. LITERATURE REVIEW

The growing urban population in African represents a vast potential market for local food crops provided that stable processing transport and marketing networks can be established between rural urban areas.

There are many different utilization patterns that are influenced by and in turn influenced both production and processing patterns. At present some information is available on cassava exports, but little data exist on the quantity of different products used within the countries. This is particularly true for the amount used directly as human food and one of the cassava's major advantages over the other carbohydrates/starch producing crops is that the roots can be put to many uses. But the methods and equipment used in the production of chips vary in the different countries of the region.

The enormous potential for using cassava as a feed for all types of livestock has recently been recognized, a large amount of research has been devoted to defining the optimum level of dry cassava in animal diets and to modifying the plant's chemical and physical properties that restricts its use by (Smith, 2002) was carried out and defined the eoptimum level of dry cassava in animal diet and to modifying the plant's chemical and physical properties that restricts its uses.

2.1 Existing Cassava Chipping Machines

Some designs for chipping machine are already available from Southeast Asia, especially Indonesia, Malaysia and Thailand.

Generally, the chipping element is a circular plate carrying set of blades with corrugated cutting edges. Sometimes the chipping wheels are mounted on wooden frames.

Chips produced from the machines are usually irregular. The demands for chipping machine in Nigeria indicate that there is support for local production of the machine. Hence the focus on the development works at Obafemi Awolowo University, Ile Ife, Nigeria (Eze, 2008).

(Busari, 2005) has studied the growing habit and responses of cassava tuber in creep and stress relaxation and has proposes model to represent those "behaviour" he measured such properties as stress relaxation modulus and creep compliance.

(Abdulmalik, 2004) has also conducted extensive work on the mechanical and rheological properties of cassava. He has studied such properties as modules of deformation, shear strength, hysteresis losses, degree of elasticity and failure energy as affected by moisture content.

2. Types of Cassava Chipping Machine in Use

Two main types of chipping machine are in use in Nigeria. There are manual and power operated. There are two kinds of the latter:- cylindrical and disk. Within the power operated group, variations in design, power source, transmission and materials of construction occur, especially between cylindrical types.

2.2.1 Power-Operated Chipping Machines

A. Chipping Machine Driven By Water Power

These are larger type which is used where running water is available. The rotation of the water wheel is transmitted by means of a fly wheel and driving belts to a pulley on the shaft of the chipping drum, 20-30centimers in diameter, is either attached to a primitive wooden construction or filled to a chipping table. The operator seated on the ground or on a bench before the tables, presses the root against the drum. The chipping mash is forced through a narrow slit between the drum and the shelf, before it is carried to the sieves.

The chipping devices mentioned above are made of perforated tin-plate though widely used on account of their cheapness, but are relatively inefficient and the rasping on account of rapid water.

B. **Engine-driven chipping machines**

These have more carefully constructed gears. The machine contains rotor of hard wood or drawn steel tube, with a diameter of about 50 centimeters having a number of grooves mailed longitudinally to take the chipping blade or saws. The numbers of saw teeth on this blade varies between 19 and 26 per inch according to need. They are placed at distances of 6 to 7 millimeter and the rotor.

In the smaller versions, the rotor is filled into a housing in such a way that the chipping surface form part of the bind wall of the receptacle for the roots facing the chipping surface of this kind hopper a block or board inserted which movable by a lower and turns on an axis near the upper part of the compartment.

2.2.2 **The Manual Chipping Machines**

A. **Chipping By Hand**

In different parts of the world rasping by hand is still effective in very small holdings, bamboo malting being used for this purpose.

B. **Rotating Chipping Machine –Driven By Man Power**

A simple but effective chipping machine perforating a sheet of galvanized iron with a nail and the clasping it around a wheel with sharp rim of the nail openings turned outward. The wheel may be drive by hand. But it is also often driven by root like a bicycle. The worker processes the roots from above into the chipping surface, or else the chipping surface through an opening attached to one side of a rotating disk equipped with a crank transmission. The pulp is collected in baskets or wooden containers to be carried to the sieves.

C. **Local made chipping machine made of iron roofing sheets**

This is normally produced from iron roofing sheets which are normally punched by nails to produce a sharp coarse surface on the back side of the sheet. The chipping is therefore achieved by compressing and reciprocating the peeled cassava roots on the sharp coarse surface of the iron sheet.

2.3 Cultivation of Cassava

2.3.1 Soil Requirement and Planting of Cassava

Cassava, even though can be grown in different climate thrives well in drained loamy soil with light or medium rainfall which is characteristics of significant part of the middle belt and southern part of Nigeria. In drought areas it losses its leaves to conserve moisture, producing new leaves when the rain resumes.

The selection of healthy disease free and pest free propagules is essential. The stem cutting arte planted as soon as danger of first, has past. The cutting's are planted by hand in moist prepared burying the lower half. When soils are too shallow to plant the stakes are put in upright or stunted position the cutting are load flat and covered with 2-3cm soil observing the polarity of cutting successful establishment of the cutting. The top of the cutting must be placed up. Typical plant spacing is 1m by 1m cutting produce root within a few days and new shoot soon appear at old leaf petiole axes ion the stem.

2.3.2 Harvesting of cassava

In lighter soils, the roots can be lifted by pulling, while in heavier soils lifting is done with a hoe. Since the roots keep in the soil they can be harvested over a long period, which is normal practice in subsistence agriculture.

2.4 Cassava utilization

Cassava is a high potential crop as it is applicable in many produces such as food, confectionery, glues, plywood, textile, monosodium glutamate, paper, biogradable product, drugs, sweeteners. Cassava chips are used in animal feed and alcohol production. Nutritionally cassava contains potassium, iron, calcium, vitamin A, folic acid, sodium, vitamin C, vitamin B6 and protein (Busari, 2005)It is a staple food in many parts of Western and Central Africa and is found in the tropics. Compared to other staple crops it gives relatively high yields and is an excellent source of carbohydrate. Cassava is being used for the following.

2.4.1 Food

Cassava is mostly as food mostly in form of garri, fufu, caasavita, abacha, and lafu. In Northern Nigeria the sweet cassava is eaten raw as snack, cassava flour is mostly used in bakery product, cassava starch is delicacy eaten in Delta State, Nigeria. Modified cassava starch or starch derivatives have been applied for thickening, binding texturing and stabilizing a range of food products such as canned food salad dressing sauce and infant food.

2.4.2 Textile

Cassava starch is used in three stages of textile processing to size the yam is stiffen and protect it during weaving to improve color consistency during printing to make the fabric durable and shinning at finishing.

2.4.3 Pharmaceutical

Native and modified cassava starches are used as binders, fillers and disintegrating agents for tablets production.

2.4.4 Plywood

Glue made from cassava starch is a key material in plywood manufacturing. The quality of plywood is dependent on the glue that is used.

2.4.5 Paper

Modified cassava starch is used in the wet stage of paper making to flocculate the pulp improving the run rate and reducing the pulp loss. Native and modified cassava starches are used in the coding and sizing of paper, improving the strength binding to the paper and controlling ink consumption to improve print quality.

2.4.6 Confectionery

Modifies cassava starch derivatives are used in confectionery for different purpose such as thickening and glazing.

2.4.7 Ethanol

Cassava chips are an alternative source of materials for producing liquor as well as medical and industrial alcohol.

2.4.8 Livestock Feed

Cassava roots can be processed into chips and pullets which can be used in compounding animal feed for Cattle, Sheep, Goats, poultry and Farmed fish. The cassava leaves and peels are also a good source of feed for living.

2.5 Principle of Processing Techniques

Approximately two-third of the cassava used in Africa for food is eaten after specialized traditional processing usually at the farm or village level. The processing methods comprise combinations of some of the following activities; Peeling, boiling, steaming, slicing/chipping, grating, soaking, or fermenting, pounding, frying, roasting, pressing, sieving, drying and milling.

2.5.1 Peeling

This involves the removal of the inedible outer layers of the cassava and is traditionally done with a knife.

2.5.2 Washing

Washing involves soaking the peeled or unpeeled tubers in a pool of water and washed with hand with aid of splotch pad.

Washing is thus an effective methods of reducing wastage, improving the economics of processing and protecting the consumers.

2.5.3 Drying

Drying is the elimination of excess water from the materials in order to bring the total moisture content to a level considered to be safe for long-time storage. The excess water in cassava or other agricultural produce responsible for intensive microbial activity leading to the formation of molds and general deterioration of the product.

2.5.4 Grating

The action of grating into fine shred or pulp is a step common in the processing of many cassava food products and facilitate subsequent steps in process e.g. dewatering, drying or pulping. The process after the texture of the raw material.

2.5.5 Frying or Roasting

Frying roasting is the most difficult part in garri processing and is normally done on earthen ware oven the fuel efficiency of which is very low. Apart from its low fuel efficiency, it compounds its negative effect by heating the immediate surrounding which includes the women fryer. Roasting is widely practiced throughout Africa where traditional techniques include burying the whole root in hot ashes or holding it on top of fire.

2.5.6 Starch extraction

Industrially, starch is extracted by a combination of a wet milling, sieving and either centrifuging or setting. Starch can also be extracted by simple methods. The juice draining from cassavas during watering may be collected and left to stand allowing the starch to settle. After decanting the liquid layer, the remaining starch may be rinsed and further processed into four by pounding grinding and drying.

2.5.7 Chipping

Traditionally, chipping is done with hand knives which cut the tubers into small unequal pieces. Improved methods, both manual and powered chipping machines, however shred the tubers into uniform sizes that dry an ferment quickly and uniformly.

2.5.8 Milling/Grinding/Pounding

This is done traditionally in Nigeria using wooden mortars and pestles. However, milling technologies using powdered plate mill or occasionally hammer mills have spread rapidly throughout Nigeria, resulting in every village having one or a few millers who perform custom service at fixed charges. After preliminary processing, including slicing or shredding and drying, the cassava roots can be grind to a flour which are being used in many traditional dishes such as fufu, lafun etc. also pounding changes the texture of the previously prepared cassava to a more palatable paste like consistency.

2.5.9 Sieving

Sieving is done with the purpose of removing the excess fibrous material and to separate undesirable particles from mixed materials as used in starch extraction and Gari separation is achieved using sieves made out of metal or local plant material or finely woven cloth material in case of starch extraction.

2.6 Fermentation

Fermentation is an important step in the processing of cassava. Fermentation result in a reduction in the level of toxic components. In fermentation cassava, two methods are commonly practiced which may be conveniently considered as the dry and wet methods.

The dry method is used in the production of gari and is essentially fermentation in the presence of air. The grated cassava passes through two stages of fermentation. During the first stage starch is broken down and acid is produced subsequently, break in the cyanide containing toxic component occurs through the action of naturally occurring enzymes in the root releasing hydrogen cyanide.

The simply wet method of fermentation sometimes referred to as retting takes place in the absence of air. Cassava roots either peeled or unpeeled, are soaked in water for several days until they soften. The material is then broken up, sieved and finally squeezed to remove water. Although culturally acceptable in many areas, cassava processed in this way has a some what unpleasant odour.

2.6.1 Dewatering

Dewatering as the name implies, involves the removal of internal liquid from the cassava by pressing. It is an important method reducing toxicity. Traditionally heavy weights are place on the prepared pulp and the expelled liquid is allowed to drain away. Improved method use presser such as screw press or hydraulic press.

2.6.2 Boiling and Steaming

Cassava is often cooked by boiling or steaming either for direct consumption or as one step in a processing system. This does not preserve the crop which is usually eaten soon afterwards, unless it is further processed. Boiling and steaming are also important in cassava processing to partially detoxify the material.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Design consideration

The following factors were considered while constructing the electric power operated Chipping machine.

1. Availability of material: one tends to go for a material that is readily available in the market.
2. Type of material to used: this depends on the peculiarity of the machine such as shape, size, strength, vibration, conductivity, expansion and other parameters to be considered.
3. Duration of materials: the tendency of the material to over-come all the forces acting on the machine with failure with time.

Cost of materials: the material used should be cheap / affordable and will serve the purpose of the design.

3.2 Modification procedure

1. Incorporation of two pulleys for easy transfer of speed from electric the electric motor to the machine.
2. A chipping trough cover the machine plate to prevent the chips from wasting.
3. A hopper for feeding the cassava to the chute chipping.
4. A motorize bass for the electric motor.
5. The brazing

3.3 Design features and material selection from the design view point, the basic features of chipping machine consist of:

1) The frame
2) The chipping wheel
3) The shaft
4) The hopper
5) The electric motor base.

3.3.1 The frame

The frame of the modified cassava chipping machine are made of mild steel (angle iron 1.5 x1.5) cut into various required size required or according to the dimension and joined first tacking it and later welding it.

The dimension of the frame is 500 x 400 x 500mm

3.3.2 The chipping wheel

Chipping wheel is one of the major components of the machine. It is about 380 mm diameter. The wheel was divided into eight equidistant parts. It is made or cast from Aluminum and machine on the lathe to give proper finishing. The function of the chipping wheel is to support the chipper plate and to excrete chips of chipping mechanism.

3.3.3 The Hopper

The hopper assembly is a rectangular box (tray like) with dimensions of 150 x 410 x 500mm. it is made from mild steel plate, rein forced with angle iron, and it is attached permanently to the mainframe. It is designed mainly to hold some peeled cassava tubers while the operator for feed tubers singly through the feeding chute.

3.3.4 Shaft

The shaft was made of mild steel rod of 20 mm diameter and 600mm long(the existing manual type as a diameter of 20mm and 400mm long). It is this shaft that carries the two bearings, the wheel, and the pulley.

3.3.5 The Electric Motor Base

This is a base that is made of mild steel (angle iron 1.5x1.5) cut into various sizes required or according to t he dimension and joined by first tacking it and later welding.

3.4 Design Calculation

Frame

A. Usually rectangular solid with dimensions = 400 x 500mm (Khurmi, 2006)

Length of the rectangular horizontal frame = 0.5m

Breadth= 0.4m

Cross sectional area of the rectangular horizontal frame =

Length x breadth = $(0.5 \times 0.4)\ m^2$ = $0.20m^2$

Volume of horizontal frame = thickness x cross-sectional area

$= (0.025 \times 0.20)\ m^3 = 5 \times 10^{-3}\ m^3$

Mass of horizontal frame = volume x density of material (steel)

$= 5 \times 10^{-3}\ (m^3) \times 7830\ kg/m^3 = 39.15kg$

Weight of horizontal frame = mass x acceleration due to gravity

$= 39.15(kg) \times 9.81\ (m/s^2) = 384.06\ N$

3.4.1 Design of chipping wheel

The diameter of flat pulley ranges from 40-5400mm (Khurmi, 2006). This design adopted a pulley (wheel) diameter of 380mm the thicknesses of the wheel was determined from the relationship.

(Khurmi, 2006).

$$T = \frac{D}{200} + 6mm$$

$Where\ D = diameter\ of\ the\ wheel = 380mm$

$T = thickness\ of\ the\ wheel$

$$T = \frac{380}{200} + 6mm = 7.9mm$$

Considering the aluminum is used in the cast or fabrication for its anti rust and hygienic condition, a wheel thickness of 24mm was adapted, due to purpose the wheel will serve or the nature work.

3.4.2 Design of plate

The centre of the plate is drilled to diameter of 20mm and punches of holes round the plate to accommodate the cutting edges.

(Khurmi, 2006).

$Area\ of\ Plate\ (Ap) = \frac{\pi D^2}{4}$

Where $D = 360$

$$Ap = \frac{\pi \times 360^2}{4} = 101.80\text{mm}^2$$

$Area\ of\ hole\ on\ the\ plate\ (Ah) = \frac{\pi d^2}{4}$

$Where\ d = 20$

$$Ah = \frac{\pi \times 28^2}{4} \quad = 314.2mm^2$$

$$Area\ of punches = \frac{\pi d^2}{4} \times n$$

$Where\ d = 5mm, n = 128m$

$$= \frac{\pi \times 5^2 \times 128}{4} \quad = \quad 251.6mm^2$$

$Area\ of\ plate\ machined = 314{,}2 + 2513.6 = 2827.8$

Area of plate left = 10800 – 282.7 = 989.72mm²

$Volume\ of\ plate\ (V) = Are\ of\ plate\ left \times thickness$

$= 98972.2 \times 0.6 \quad = 593.83mm^2$

$Weight\ of plate = v \times \rho \times g$

$Where\ \rho = density\ of\ iron\ (7850kg/m^3)$

$g = acceleration\ due\ to\ gravity$

$5.958 \times 10^{-5} \times 7850 \times 9.81 = 4.57N$

3.4.3 Design of the Hub

The diameter of the hub (dh) in terms of the diameter of the shaft diameter may be fixed by the following relation.

$dh = 1.5D + 25mm$ (Khurmi, 2006).

$Where\ 0 = diameter\ of\ shaft\ (20)$

$dh = 1.5 \times 20 + 25 = 55mm$

The length of the hub (Lb) is found from the relation

$L = \frac{2D}{\pi}$

$= \frac{2 \times 20}{\pi} = 12.73mm$

3.4.4 Weight of the wheel

The wheel comprises of the rim , Hub and Arms

Area of the Hub = area of the major diameter – area of Minor diameter

Area of hub $= \pi\ (r_2^2 - r_1^2)$ (Khurmi, 2006).

$d_1 = Major\ diameter = 55$

$r_1 = Major\ radius = \frac{d_1}{2} = \frac{55}{2} = 27.5mm$

$d_2 = Minor\ diameter = 10mm$

$r_2 = Minor\ radius = d_2 = 20 = 10mm$

$A = \pi(27.5^2 mm - 10^2 mm) = 206.16mm^2$

$V = A \times d_1$

Volume of hub $= 2061.67 \times 55 = 11393.18mm^3$

Area of the rim = area of the major diameter – area of the minor diameter

$A = \ = \pi\ (r_2^2 - r_1^2)$

d_1 = *the major diameter* = $380mm$, $r_1 = 190mm$

d_2 = *the minor diameter* = $368mm$, $r_2 = 184mm$

$A\ =\ 3.14^2\ (190^2 - 184^2)$

$=\ 7049.73mm^2$

Volume of the rim= area × thickness

$= 7049.73\ \times\ 23\ =\ 162143.88mm^2$

Area of the rim = total area of the arm – removal area.

$Total\ area\ =\ (162.5)^2 = 82957.68mm^2$

Removal area (area of a sector × 8)

$$Area\ of\ a\ sector\ =\ \frac{\theta}{360}\ \times\ r_2$$

$\theta\ = 22.5\ \times r\ = 105mm$

$$A\ =\ \frac{22.5}{360} \times\ \pi\ \times\ 105^2 \quad = 216.47mm^2$$

8 sectors $= 216.47 \times 8 = 1731.76mm^2$

Area of arm $= 829.57 - 173.76 = 656.39mm^2$

$Volume\ of\ arm = area\ of\ am \times thickness$

$T = 8mm$

$= 656.39 \times 8 = 5251.12mm^3$

$Volume\ of\ wheel = volume\ (Rim + Hub + Arm)$

$= 5251.12 + 113.39 + 162.14 = 8006.53mm^3$

$Weight\ of\ the\ wheel = volume\ of\ the\ wheel\ x\ density\ of\ the\ wheel.$

$= 8.00 \times 10 - 4 \times 2700 = 2.161kg = 2.2\ kg$

3.4.5 Determination of tension in the belt

The belt is a V-grooved which is inclined at 30^0 to the horizontal.

The following formula can be used to determine the tight and slack side tension.

The belt is inclined at an angle of 30^0 to the horizontal.

$T = (t_1 - t_2)$ R (Khurmi, 2006).

$$\frac{t_1}{t_2} = e^{\mu} \text{cosec}\beta$$

Where :

T= torque

R = radius of the driven pulley

t_1 = tight side tension of the belt

t_2 = slack side tension of the belt

μ = coefficient of friction (0.3)

$\theta = angle\ of\ wrap\ or\ contact$

2β = Groove angle of the pulley (36^0)

$$\emptyset = \frac{(180 - 2\propto)\pi}{180}$$

$$\text{Since} \propto = \frac{r_1 - r_2}{X}$$

Where :

r_1 Radius of the driven pulley, 50mm

r_2= Radius of the driven, 25 mm

X = Distance between pulleys, 50mm

Imputing data

$$\text{Sine} \propto = \frac{50-25}{500}$$

Substituting 0.05 for $\propto$

$$\emptyset = \frac{(180-2\times7.47)\pi}{180}$$

$\emptyset$ = angle of wrap or contact = 3.14rad

$$\frac{t_1}{t_2} = 16.38$$

t_1 = 16.38t_2

Substitute 16.38t_2 for t_1

23047 = (16.38t_2 - t_1) 50

$$t_2 = \frac{460.94}{16.38} = 28.14N$$

t_1 = 16.38 X 28.14 = 460.94 N

3.4.6 Power transmitted

Power transmitted is the product of torque of the system angular speed of the pulley and sprocket shaft.

Angular speed is given as

Amount of force transmitted by electric motor is given as $(T_1 - T_2)$ Hence this relationship can be re-written as $= \frac{\pi DN}{60}$

$$P = \frac{(T_2 - T_1)\pi DN}{60}$$

(Khurmi, 2006).

Where

P = power on the shaft

N = speed of the shaft

D = diameter of pulley

T_1 = Tension on the tight side of the belt

T_2 = Tension on the slack side of the belt

T_1 = constant (3.142 or 22/7)

To calculate power require to drive the chipping machine from the available data.

D = 0.06m

N = 1450rpm.

$(T_1 - T_2) = (460.94 - 28.14) = 432.8$

$$P = \frac{(T_2 - T_1)\pi DN}{60}$$

$$P = \frac{432.8 \times 0.06 \times 450}{60} = 1971.79W$$

$$P = \frac{1.971}{0.745}$$

P = 2.646 = 3HP.

3.4.7 Speed

The s peed generated by the driving pulley where varied by using 3 different pulley diameters of pulley.

Pulley 1:- the speed of the driven pulley is determined by the relationship

$N_1 D_1 = N_2 D_2$ (Khurmi, 2006).

Where N_1 = Speed of the driving pulley, 1450rpm

N_2 = speed of the driven pulley, rpm

D_1 = Diameter of the driving pulley, 60mm

D_2 = Diameter of the driving pulley, 144mm

Imputing data:

Pulley 2:- The speed of the driven pulley is determined by the relationship

$N_1 D_1 = N_2 D_2$, where D_2 = 60 mm

Imputing dat a:

$$\frac{1450}{N_2} = \frac{60}{60}$$

$$N_2 = \frac{1450 \times 60}{60} = 1450rpm$$

Ratio 1:7

Pulley 3. The speed of the driven pulley is determined by the relationship:

$N_1 D_1 = N_2 D_2$,

Where,

N_1 = speed of the driving pulley, 1450

N_2 = speed of the first driven pulley, rpm.

D_1 = Diameter of the driving pulley, 60mm

D_2, = diameter of the driving pulley, 250mm

Inputting data:

$$N_2 = \frac{1450 \times 60}{250} = 348rpm$$

3.4.8 Design of hopper

The capacity of the hopper is given by (Khurmi, 2006).

$$V_{hop} = \frac{h}{3}(A_1 + A_2 + \sqrt{(A_1 \times A_2)})$$

Where $A_1 = L_1 + B_1$

$$A_2 = L_2 + B_2$$

The weight of the hopper is given as

$$W_{hop} = \rho g V_{hop}$$

Where ρ = density of mild steel

The hopper volume is given by equation 1

$$V_{hop} = \frac{1}{3}(A_1 + A_2 + \sqrt{(A_1 \times A_2)})$$

$$A_1 = L_1 * B_1$$

$$A_2 = L_2 * B_2$$

L_1= length of top of hoper = 0.150m

L_2= length of base of hoper = 0.410m

h = height of hopper = 0.350m

B_1= breath of top of hoper = 0.500m

B_2= breath of base of hoper = 0.150m

$$A_1 = (0.150 \times 0.500) = 0.075m^2$$

$$A_2 = (0.410 \times 0.150) = 0.0615m^2$$

Therefore,

$$V_{hop} = \frac{1}{3}(0.075 + 0.0615 + \sqrt{(0.075 \times 0.0615)})$$

$$= 1559\text{m}^3$$

The weight of the hopper is determined from equation 4

$$W_{hop} = \rho g V_{hop}$$

Where ρ = 7850 kg/m^3 for mild steel

g = 9.18 m/s

W_{hop} = 7850 × 9.81 × 1559 = 120056.25N

3.4.9 Shaft design

Power of the electric motor 2.25kw

Speed of the electric motor 1450rpm

Diameter of the Driving Pulley 60mm

Determination of bending moment : All dimensions in mm.

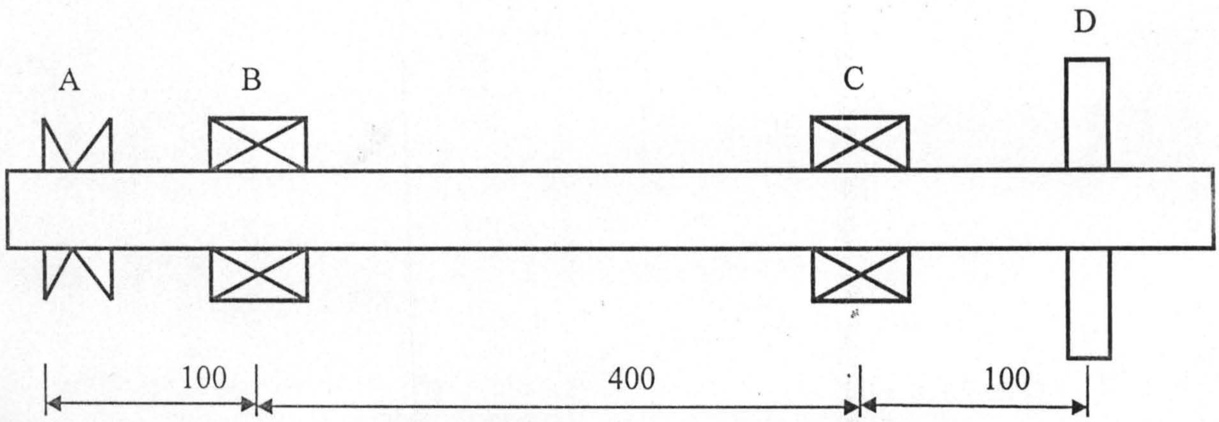
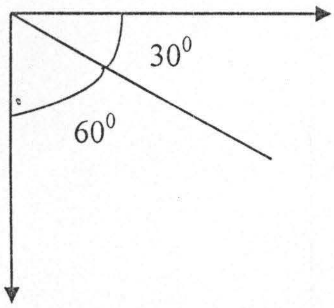


Fig 3.1 A Free Body diagram of vertical load.

But the belt is inclined at 60 to the vertical as shown in figure 3.1



Therefore, effective tension t_1 becomes:

But vertical component $t_1 Sin$ $=339.19N$

Therefore $horizontal\ component = t_1 Cos60$
$= 230.47N$

and similarly for t_2

if vertical componen $=24.37N$

Therefore horizontal component = 14.07N

The tension acting on the load is shown in figure 3.2

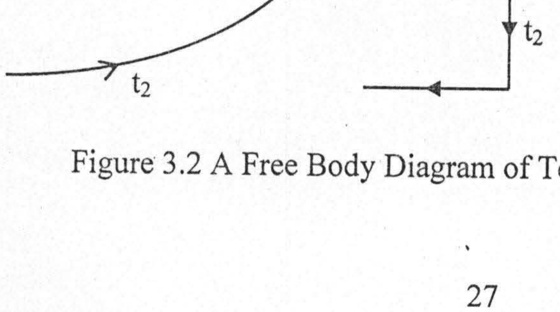


Figure 3.2 A Free Body Diagram of Tension Acting on the Load

Resolution of forces:

$Vertical\ component = 339.185 + 24.37 \quad = 363.56N$

$Horizontal\ component = 230.47 - 14.07$

$= 216.4N$

Effective forces on the shaft = 363.56N

$(horizontal\ component\ is\ used\ in\ deflection)$

Therefore total force at A

= 363.65 + *weight of pulley* (20N) = 383.55N

$At\ D, total\ force$

$= Weight\ of\ plate + Weight\ of\ wheel$

$+ Weight\ of\ Cassava\ (5N)(assumed)$

$= 4.57 + 7.66 + 5 = 17.23N$

The reaction of the load on the vertical components is shown in figure 3.3

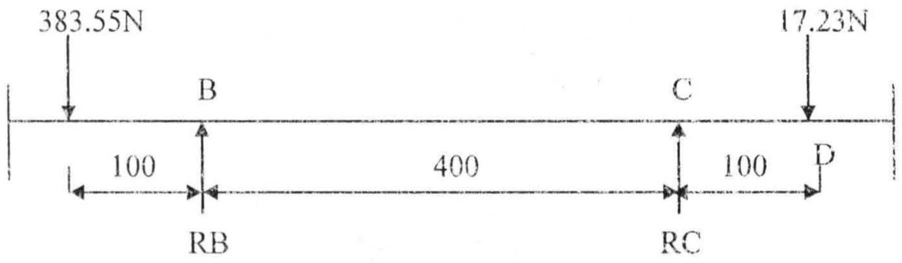


Figure 3.3 Reaction and Load Diagram of the Vertical Component

Resolving Forces:

$R_B + R_C = 383.55 + 17.23$

$R_B = 400.76 - R_C$

Taking moment at B

$$\sum MB + \vec{B} = 0$$

$R_C = -74.375N$

$R_B = 460.75 + 74.3375 = 475.125N$

Bending moment at A and D = 0

$Bending\ moment\ at\ B = 100 \times 475.125Nmm$

$$Bending\ moment\ at\ C = +400.75 \times 800$$
$$=2002.75Nmm$$

Determination of Axial Forces (Fa)

$$Fa = \frac{Total\ force\ of\ the\ Shaft}{Area\ of\ the\ Shaft} = \frac{400.76}{\pi d^2} = \frac{127.55}{D^2} N/_{mm^2}$$

Determination of Shaft Diameter

The ASME code for shaft with combines torsional, bending moment and axial load, apply the maximum shear stress equation modified by introducing the shock and fatigue factors as follows;

$$\frac{Ss}{n_s} = \frac{16}{\pi D^3}\sqrt{\left(\left(k_b M_b + \frac{Fad}{8}\right)^2 + (M_t K_t)^2\right)}$$ (Khurmi, 2006)

Where $M_t = \frac{127.55}{D^3} N/_{mm^2}$

$M_b = 2002.75\ N/_{mm^2}$

$Fa = \frac{127.55}{D^2} N/_{mm^2}$

Ss= *Maximum allowable shear stress to be* 550*Mpa but is reduced to* 430*MPa*

$for\ allowance\ for\ key\ way\ for\ pulley\ and\ wheel\ plate$

$K_t = 1.0; K_b = 1.5$

$n_s = Safety\ factor\ 1.8$

But for solid shaft axial loading is negligible

Therefore, Eqn. (3.6.5.1), is reduced to

$$\frac{Ss}{n_s} = \frac{16}{\pi D^3}\sqrt{((k_b M_b)^2 + (M_t K_t)^2)}$$

$$\frac{420}{1.8} = \frac{16}{\pi D^3}\sqrt{((1.5 \times 200275)^2 + (117362.10)^2)}$$

$$16 \times 1.8 \frac{(0.616511344 + 0.1377388364)^{1/2}}{3.142 \times 720}$$

$$D^3 = 16 \times 1.8 \frac{(0.7542501804)^{1/2}}{3.142 \times 720}$$

$$D = 20mm$$

3.5 Machine Description and operation procedure

The cassava chipping machine is a machine operated by electric motor. The power from the electric motor is transmitted through the V-grooved belt to the shaft with the aid of the pulleys. The shaft is attached to the pulley by means of a key (bolt), which hold the both in place and they rotates as one body. The shaft is held place by two bearing for proper rotation.

The machine is simple to operate and so requires only one operator. Before it is operated, all the parts must be properly set and fixed or bolted together. The chipping unit is driven in the normal cycling mode. The rotary motion is transmitted to the chipping unit shaft via the chain and sprockets mechanism. As the shaft rotates, it turns the rotor plate anticlockwise and the peeled root is fed against the chipping plate. The operator feeds in tubers manually through the feeding chute. The rotation of the rotor plate performs an impact action on the tubers, and the blade mounted on the rotor plate cuts the tubers by impact-shear force to the designed sizes. The chips then press through the opening in the rotor plate and are discharged via the chute.

3.6 The chipping capacity of the machine in kilogram per hour and the chipping efficiency can be calculated thus:

$C_C = \frac{A_C}{T}$ Where,

C_C = chipping capacity (kg/hr)

A_C = Amount chipped

T = time taken 0.042hr

$$C_C = \frac{4.2}{0.042} = 200kg/hr$$

3.6.1 Chipping efficiency

$\eta_c = \frac{C_C}{C_1} \times 100\%$ Where,

η_c = chipping efficiency

C_C = Chipped cassava 4.2kg

C_I = Cassava introduced to machine 6kg

$$\eta_c = \frac{4.2}{6} \times 100 = 70\%$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

The machine was tested and the following results were obtained as shown in table 4.1 below.

Table 4.1 Results of the test

Pulley (mm)	Revolution per minute(rpm)	Chipping capacity (kg/hr)
60	1450	200
145	600	153
250	348	95

4.2 Discussion of results

The testing of the machine was carried out by varying the speed of the machine using three different pulleys of different diameters having a speed ratio of 1:1 for the first pulley, 1:2 for the second pulley and 1:4 for the third pulley.

From table 4.1, it can be observed that using a pulley of Ø60mm at a speed of 1450rpm a chipping capacity of 200kg/hr it attended while using a pulley of Ø250mm with a speed of 348rpm a chipping capacity of 95kg/hr is attended.

That means at a higher speed more amount of chips could be produced with thickness of 1.15mm while at lower speed small amount of chips could be produced with 1.25mm thickness.

4.3 Material Costing

The cost of producing a motorized cassava chipping machine mainly depends upon the local cost its new material and its labor cost. Table 4.2 give the cost of producing the machine

Table 4.2: Showing Material Specification and Cost

S/No	Material	Quantity	Cost (=N=)	Amount(=N=)
1	Square Pipe	1lenght	1000	1000
1	Angle Iron	2 length	1500	3000
2	Galvanized Steel sheet	1sheet	6500	6500
3	Chipping disc	1	3500	3500
4	Shaft	1	1000	1000
5	Bearing	2	1000	2000
6	Rivets	20	10	200
7	Bolts and Nuts	12 pc	20	240
8	Bearing housing	2	500	1000
9	Paint	2 liter	1000	2000
10	Thinner	1 liter	250	250
11	Sprocket	2	500	1000
12	Chain	1	550	550
13	Hub	1	1000	1000
14	Seat	1	500	500
15	Handle	1	400	400
	Total			**23,940**

4.3.1 Labour cost

The project labor cost is determined as 60% of the total material cost

$$Total\ Labour\ Cost = ₦14{,}364{:}00$$

4.3.2 Overhead Cost

This includes the costs that cannot be visibly accounted for (unseen expenditure) e.g. transportation, consumable materials, miscellaneous costs.

The overhead cost is 45% of labor cost

$$Total\ Overhead\ Cost = ₦6{,}460{:}00$$

4.3.3 Total cost

$$The\ total\ cost\ of\ the\ project = Material\ cost + Labor\ cost + Overhead\ cost$$

=₦44,764:00

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The existing cassava chipping machine has been modified and tested. The machine showed that it is a good substitute for the manually type chipping machine of chipping cassava tuber because it reduces time wastage, drudgery and it is efficient.

The chipping plate was able to produce a chipping efficiency of 70% at a speed of 1450rpm. However with little and proper adjustment between the chipping plate and feed chute machine efficiency will be improved.

Each components of the machine is made from materials readily available in the market and only the chipping plate may have to be replaced after long use or when the quality of chips produced is declining.

5.2 Recommendations

The cassava-chipping machine is recommended to be used properly and according to the provided operational procedure.

In addition because of our daily advancement in technology all over the world, I advise that the machine should be improved upon.

It is also recommended that improvement should be done in the following areas!

1. The punches on the plate should be sharp and tilt at an angle of 30^0 to the direction of cut.
2. A hollow cylindrical pipe should be used at the feeding chute to align the cassava in position for chipping and also for the safety of the operator.

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