MODIFICATION OF CASSAVA CHIPPING MACHINE

BY

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MAT. No. 2004/18430EA

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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 Information derived from personal communication, published and unpublished work were duly referenced in the text.

.... 30-08-010

Yakubu Danladi **Date**

CERTIFICATION

This project entitled "Modification of Cassava Chipping Machine" by Yakubu Danladi, 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

I dedicate this project to Almighty Allah, the sustainer of the world.

This project is also dedicated to my beloved parent Alh Abubakar Danladi and Hajiya Maryam Abubakar for their immense investment in my education, without you this dream would not have been achieved.

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

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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 single largest source of calories produced throughout tropical Africa. West and central African each account for about one–third of Cassava production in Africa; Zaire and Nigeria are the containment's leading producers (Osiru, et al 1990). About three to fourth of the cassava in west African is growth in the forest and most savanna zone. Data on production of root crops in Africa are especially suspect, but production of cassava has undoubtedly increases in West African and Central Africa, although perhaps not as fast as population. Almost no export/import trade in cassava products is recorded, but some trade does take place across land borders (Osiru, et al 1990).

Cassava is more productive under soil conditions than are most other crops, and for this reasons it often is planted last in the cropping sequence just before the land reverts to fallow. Production of Cassava roots requires relatively little labour compared with that of rice or yams; moreover, the timing of these labour inputs is very flexible since the roots can be left in the ground for period of several months or even a few years in some cases before harvesting. The ability of cassava to withstand drought once the plant is established has also encouraged its uses as a famine reserve crops in drier parts of Africa. Tolerance of poor soils and low flexible labour requirements help explain why cassava production has historically increased in areas where the best land and most of the available labour are devoted to cast crops (for example, cocoa) or labour intensive food crops (yam). As population pressure leads to increase used of marginal lands, the area planted to cassava is likely to expand.

The land required for processing the roots into gari, one of the most widely consumed cassava product in West Africa, is very high and equals the total labour input for production of the roots themselves. This processing is usually done at the household or village level, almost exclusively by women and children,. The end product is suited for low income urban consumers because of its low cost per calories (Slightly lower than that of maize) and because it requires almost no further processing. The low protein content of gari is augmented by soups and meant with it is usually eaten.

A method that was found efficient in hastening the dry rate and improving the quality of products is chipping the tuber into smaller piece called "chips" (Smith, 2002).

Chip production is relatively simple; it calls for no major investments and provides an effective means for production to boost the value of their crop. Yam chips are stabilized products with a moisture content of around 12% and can 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, reduced labour input involved 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 stored than the raw cassava, they needless storage space and can store for a longer period of time (Smith, 2002).

Cassava chips are used in production of pellets for export in many countries. So there is need for a cheap and efficient cassava chipping machine. All the material used has been considered to be non-toxic to human consumption (Smith, 2002).

1.2 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.

1.3 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.

1.4 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.

1.5 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 is to be made of aluminum cast
4. The cutting blade is 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 optimum 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 Chippings Machine

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.

2.2 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. Cassava as a Crop (*Manihot Esculenta*)

Cassava is the major stable food in the tropics. It is the largest starch producer per unit area, but owing to lack of other nutritive components a cassava diet is rather one – sided. An advantage with this crop is that harvesting can be spread over many months by leaving the roots in the soil.

There are sweet and bitter varieties according to the cyanogenic glycoside content which causes toxicity owing to the conversion into HCN. Content of HCN. may vary from 10 to 490mg/kg of roots. It is also influence by the location where is panted (Elsevier 1989).

2.4. Cassava Food Processing

Cassava, also known as Tapioca or Manioc is one of the most important cheap sources of carbohydrate in developing tropical countries it is high important in Nigeria and Africa accounting for approximately half of their staples.

Its efficient production of food energy, year – round availability and tolerance of extreme environmental stresses make it eminently suitable for present farming and food system in Africa, cassava is playing a major role in efforts to alleviate the African food crises over half of the total cassava production is in Africa and it has been estimated that 37% of the energy in the diet in tropical comes from cassava.

Chemically cassava is composed of water (60_ 70%) and starch with minor amount of protein, fiber, mineral, vitamin and toxic component linamarin – a cyanide containing glycoside. The presence of this toxic tractor demands special processing producers to make the product safe for human consumption.

The toxic glycosides of cassava are reduced to safer level during processing. Toxicity is initially considerably reduced during peeling. Grating breaks down the internal cells and so releasing the enzyme which breaks down the cyanogenic glycoside complex and release hydrogen cyanides.

Traditionally, cassava roots are processed by various methods into many different products and used in diverse ways, according to local custom and preference, to provide carbohydrates in the diet. The processes involved in cassava production and processing are labour intensive, time- consuming and are normally performed by women and children. The various unit operation involved include peeling, washing, grating, drying, boiling/steaming, frying, pounding, dewatering and others. Sun drying, soaking, fermenting and other activities are old proven remedies used to reduce cyanide level.

Cassava can be eaten raw or boiled depending on variety or it can be processed into different products such as Garri (West Africa), Fufu (Nigeria, Ghana, and Zaire), Chikwange (Central Africa), Lafun (Nigeria). Starch etc. almost every house hold in rural Nigeria is involved in one or another form of cassava processing to satisfy the house hold demand or sell outside.

Cassava and other root crops in general are a cheap, available and essential energy source for many poor people who face problems of food availability. Although they contain little protein or fat, some, particularly potato and yam, are a source of vital vitamins (A&C)

The main advantages of cassava as a crop and a food are;

- It is cheaper source of energy.
- Can be cultivated easily and provide more dietary energy per hectare at a lower cost to the farmer principally because of reduced labour inputs.
- It can be stored for up to 2 years in the soil until required.
- Cassava processing provides employment and income for rural women.
- Crude cassava starch, an important industrial material, can be produced by women's co-operatives.

2.5. Objectives of Cassava Processing

Cassava processing activities are under taken because of the following reasons:

1. Reduce post harvest losses of fresh tubers as cassava is extremely perishable and must be either consumed or processed within 245 – 48 hours of harvest
2. Elimination or reduction of cyanide content. Processing is a key element in reducing the concentration of hydrogen cyanide in cassava tubers and leaves. Reduction in concentration of the toxic element to a safe level is necessary for both human and animal consumption. Consumption of inadequately processed cassava has chronic effect on health and nutritionally well – being and it can lead to death.

2.5.1. Peeling

Roots and tubers are peeled to remove the inedible outer layers. Peeling is traditionally carried out by hand, although mechanical peelers are available. Lye peeling is an effective way of peeling roots and tubers.

The food is placed in a hot solution (at or near boiling point) of sodium hydroxide for a specific time which varies, according to the type of vegetable. The loosened skin is removed by jets of water. Care needed as hot is Iye is very dangerous and corrosive to some metal equipment. Iye peeling is often combined with blanching in one operation.

Mechanical peelers operate by rubbing the roots against a rotating abrasive surface. They are best suited to raw materials of a regular shape. Irregular shaped materials have high peeling losses or require hand peeling to finish them off.

The use of mechanical peelers is dependent on the throughout required and the cost of the machine versus the wages for peeling by hand.

2.5.2. **Slicing**

The peeled roots are sliced roots are sliced or chipped before drying. The exposes more surface area to the air and speeds up the drying process. Slicing root crops period to cooking is also important as it allows more rapid and even cooking.

Traditionally roots are sliced by hand. A range of mechanized chipping and slicing machines are available.

2.5.3 **Drying**

Root crops have high moisture content. Reducing the amount of water by drying is a simple way of extending the storage life of the root and tubers.

There are two stages in drying processes:

1. Removing surface water
2. Removing internal moisture form within the material.

The relative humidity of air decreases rapidly as its temperature is raised at the same time its water absorbing capacity increases. The rate of drying during the first stage is dependent on the ability of the air passing over the material to absorb and remove moisture. Airflow rate is more important than temperature. However, in areas of high humidity the air may need heating to lower its humidity to level that allows it to absorb significant amount of water. In general, air with a relative humidity of 75% or more is not effective at drying, except at the earliest stages when the root is very wet. The surface area of food exposed to the air is very important. Slicing or chipping the rood crop will increase the surface area and hereby reduce the drying time.

The rate of drying in the second stage is dependent on the rate at which moisture can pass through the issue to the surface where it evaporates into the passing air.

The passage of water from the inside to the outside is a slow process so drying rates is lower than in the first stage of dying. The drying rate is dependent on the moisture content and on temperature rather than in air flow.

A range of driers are available, ranging from solar driers through kiln driers and forced driers. The selection of driers depends on the cost of the drier and the value of the product being dried. Traditionally, high-tech driers are not used for root crops. This is because root crops and their produce are fairly low value foods and the use of a drier would not be economically viable.

Grating the root into fine shreds is a common step in the processing of many root crop products. It helps to facilitate later in the process, for example de-watering, drying, fermentation or pulping.

Grating alters the texture of the raw material. It is an essential step during cassava processing as it allows for fermentation of the material and the breakdown of cyanide containing compounds.

Grating is time consuming and hard work. A range of simple hand held and mechanical graters are available. Many graters are based on a rooting horizontal disc or held horizontally in a frame or downwards.

2.5.4. Boiling and Steaming

Root crops are often cooked by boiling or steaming, either for direct consumption or as a step in a processing system.

Boiling and steaming does not preserve the crop. It needs further processing for preservation.

Boiling and steaming are important in cassava processing to detoxify the material.

2.5.5. **Fermentation**

Fermentation is most important step during the processing of cassava and high-alkaloid varieties of potato. It results in a decrease in the level of toxic compound.

In cassava processing, there are two methods of fermentation-wet and dry methods.

The dry method is used in the production of gari and is carried out in the presence of air. The grated cassava passes through a two – stage fermentation during the first phase, starch is broken down and acids are produced. Enzymes contained in the root start to break down the cyanide compounds and release hydrogen gas.

At the end of the first stage the condition are just right for the growth of a range of micro –organism that ferment the gari to give it the characteristic flavour.

Most of the cyanide is lost during the fermentation, but any remaining is driven off during the subsequent roasting step.

The wet method of fermentation is sometimes referred to as retting. It take place in absence of air. Cassava roots 9either pealed or entire) are soaked under water for several days until they have softened. The material is then broken up, sieved and the water squeezed out.

The wet fermentation of cassava makes a product with an unpleasant odour. It also produces lot water that can be difficult to dispose off.

2.5.6. Pounding

Pounding changes the texture of the previously prepared root crop into a more paste – like consistency. The root is first peeled and softens by boiling or soaking.

Traditionally material is ground using a large pestle and mortar.

Pounding of fufu from yams and cassava to make a gelatinous sticky product can take up to one hour using a mortar and pestle. Pounding machine is available. But hand pounding is often preferred as it gives the product a superior taste.

2.5.7. **De –Watering**

De – watering or pressing is a process that can remove up to 50% of the water present form the root crop.

The process is most common in cassava processing where it is an important method of reducing toxicity. Traditionally heavy weights are placed on the prepare crop to pres out the liquid, which drains away. There are several press designs available, ranging from the simple easily constructed parallel press to the more sophisticated screw pres or hydraulic press.

Screw presses can be made from a circular press cage that holds the pulp or a square press frame into which sacks of pulp are placed. A heavy weigh is lowed and raised by a screw thread to press the pulp.

Some presses are made using hydraulic car jacks to apply pressure to the material that is being pressed. Care is need to prevent leakage to poisonous hydraulic fluid from the jack.

2.5.8. **Sieving**

After roots have been sliced and dried, most can be ground into flour. Cassava is the most commonly processed in this way, where it is used prepare fufu.

Traditionally, dried pieces of roots are ground in mortars and pestles. For large scale use, a range of manual or powered plate and disc mills are available.

Lumps often occur in gari if it is not heated evenly during roasting. The lumps can be broken down into finer particles by passing the roasted cassava through a hammer mill or plate mill.

After grinding the flour is sieved to remove large particles, which are returned to mill for further grinding. Sieving can be mechanized by using a vibrating or rotating.sieve.

Roasting is an important stage during the production of gari from cassava. The heat applied burned off the cyanide gas. It also partially gelatinizes the starch.

Gari is traditionally heated in shallow cast iron pans over a fire while being pressed and stirred against the hot surface to prevent burning roasting can be mechanized by making a cylindrical drum roaster.

2.5.9 Starch Extraction

Starch can be extracted from any root crop. However, the two most common are potato and cassava. Industrially, starch is extracted by a combination of wet milling, sieving and settling.

Starch can also be extracted more simply, by collecting the liquid that drains off during pressing and allowing in starch to settle out.

2.5.10. **Chipping**

Traditionally, chipping is done with hand knives which cut the tuber into small unequal pieces, improved methods, both manual and powered chipping machines.

However, stretch the tubers into uniform sizes that dry and ferment quickly and uniformly.

2.6. **Cyanide in Cassava**

Most varieties of cassava contain compounds (glycosides that contain cyanide. They must be processed to removed the cyanide before consumption, a few 'sweet' varieties contain no or very low levels of compound and are sometimes eaten raw or with minimal processing.

Peeling the root reduces the level of toxicity since many of the glycosides are contained within the peel and outer layers of the root. After peeling, the toots are grated which breaks down the internal cells and release an enzyme that breaks down the cyanide glycoside complex. This the acidic conditions of fermentation further break down glycosides. When this is complete, the cyanide gas is evaporated by heating the cassava, either by frying, roasting or boiling.

The detoxified product can be dried and ground into a flour or used to make gari and other products.

2.7. **Uses of Cassava**

Cassava is grown for its enlarge starch filled roots, which contains nearly the maximum theoretical concentration of starch on a dry weight among good crops fresh rots like potato. They can be peeled and boiled, baked or fried. It is not recommended to eat because of potentially toxic concentration of cyanogenic glucosides that are reduced to innocuous level through cooking, in additional settings of the America, roots are grated and sap is extracted through squeezing or processing.

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 ρ = 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).

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

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

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

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

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

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).

$d_1 = Major\ diameter = 55$

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

$d_2 = Minor\ diameter = 10mm$

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

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

$V = A \times d_1$

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)

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

$$\text{Since } \alpha = \frac{r_1 - r_2}{x}$$

Where :

r_1 Radius of the driven pulley, 50mm

r_2= Radius of the driven, 25 mm

X = Distance between pulleys, 50mm

Imputing data

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

Substituting 0.05 for α

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

$\emptyset$ = 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,

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

$$= 1559m^3$$

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.

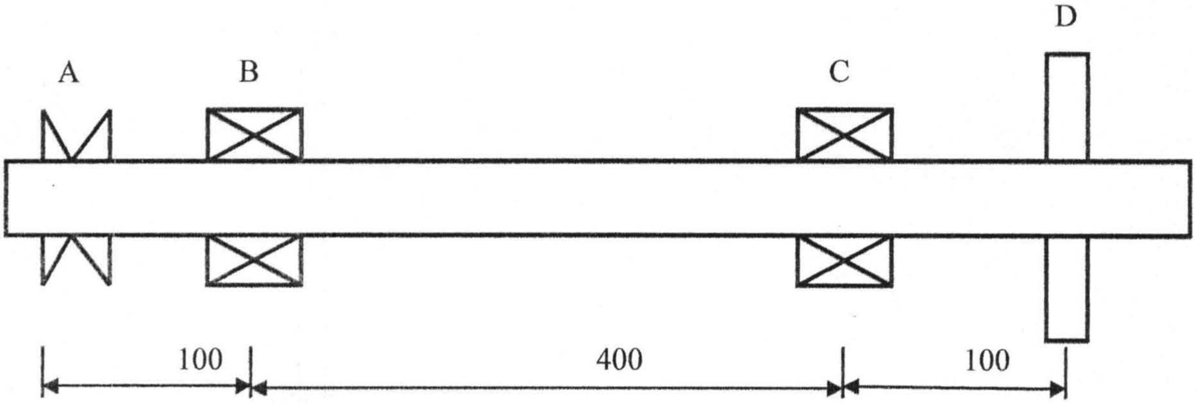
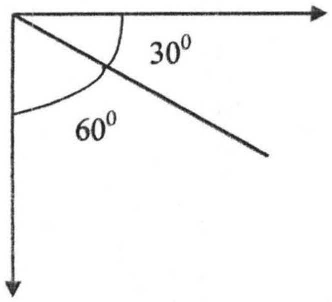


Fig 3.1 A Free Body diagram of vertical load.

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* = *= 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

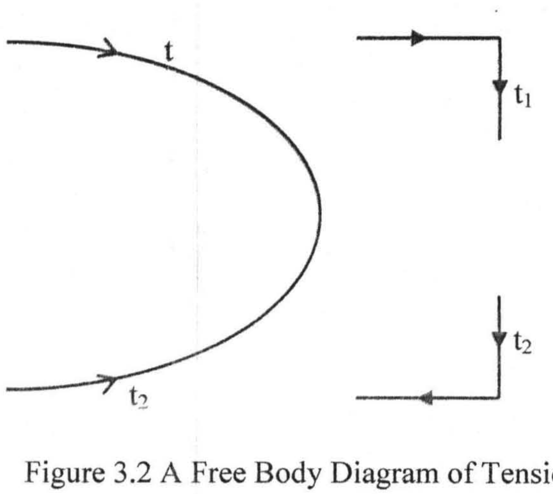


Figure 3.2 A Free Body Diagram of Tension Acting on the Load

Resolution of forces:

$Vertical\ component = 339.185 + 24.37$ = 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

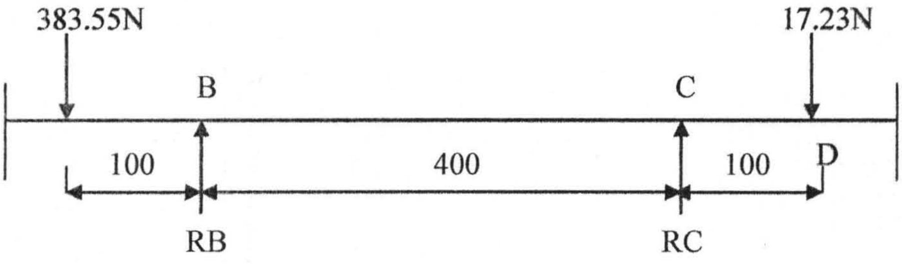


Figure 3.3 Reaction and Load Diagram of the Vertical Component

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)

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

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 $M_t = \frac{127.55}{D^2} N/\text{mm}^2$

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

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

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

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

$K_t = 1.0; K_b = 1.5$

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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