DESIGN AND FABRICATION OF A CASSAVA MULTI-PROCESSING MACHINE

BY

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FEBUARY, 2010.

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN AGRICULTURAL & BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

FEBUARY , 2010.

DECLARATION

I hereby declare that this project work is 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 Information derived from published and unpublished work was duly referenced in the text.

Evabeta Ese Timeyin

11/02/2010

Date

CERTIFICATION

This project entitled "Design and Fabrication of a Cassava Multi- Processing Machine" by Evabeta Ese Timeyin , 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 the scientific knowledge and the literary presentation.

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External Examiner — Date

DEDICATION

This work is dedicated to God Almighty , my light in the dark, my hope, my source, my every thing .

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ABSTRACT

A cassava multi- processing machine was designed, fabricated and tested. The machine was designed to chip, grate and slice cassava tuber using different operation plates, same power unit and the same frame for the various processing operations. The plates are changed according to use. The evaluation test carried out gave the following result; Chipping operation(capacity rating of 110kg/hr, efficiency of 55%). Grating operation (capacity rating of 120kg/hr, efficiency of 80%), Slicing operation (capacity rating of 40kg/hr, efficiency of 35%). The different results are due to moisture content of cassava tuber to plate contact etc. Using the machine three operation can be accomplished with ease as chipping, grating and slicing can be done on the same frame thereby saving cost

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CHAPTER ONE

1.0 Introduction

1.1 Background of study

Cassava (*Manihot esculenta Crantz*) is a perennial shrub belonging to the family Euphorbiaceous, subfamily of crotonoideae and subclass of Angiosperm (dicotyledonous) (Fageria et al. 1990). Cassava is commonly known as tapioca, manioc, mandioca, yuca, and sagu all over the world and here in Africa more than half dozen vernacular names prevail (FAO 1985). The exact origin of cassava is not known but apparently it as first cultivated somewhere in South America, It was taken to Africa by Portuguese as early as 1558 and spread to Asia in the seventeenth century (Cock, 1985). From its place of origin, the plant has spread to various parts of the world and it is today cultivated in all tropical regions of the world. It is an important food crop grown throughout the humid and semi-tropics. It has also displaced vain to some extent of southern area of Nigeria due to ease of cultivation, considerable resistance to drought it ability to give acceptable yields on low-fertility soils (Larsen, 1984).

Cassava cultivars are described as sweet or bitter according to their degree of toxicity, which is due to the presence of cyanide content in the fiber . Fortunately, most of the cyanide can be removed by post harvest treatments and cooking (Bradbury and Holloway 1988). Numerous cassava cultivars exist in each locality where the crop is grown. The cultivars have been distinguished on the basis of morphology, tuber shape, and earliness of maturity, yield and time content of cyanogenic of the roots. The glycoside content of one cultivars may be high under some conditions amid low under others (Obigbesan , 1991). Cassava varieties grown in various parts of the world include CH50, and 53101 and TMS 30575; Kebabu, San Trung-Tam in Vietnam, IAC-7-127 in Brazil ,Cambi and Pembero Blanco in Argentina Ankra in Ghana; and Colombia Ilanera in Colombia (I.I.T.A, 1990)

1.1 IMPORTANCE

Cassava production in Africa has increased by 12.5% between 1988 and 1990 with Nigeria becoming the largest cassava producer in the world (Bokanga , 1991) . Almost all of the African cassava production is destined for human consumption .Cassava is a very popular high-energy root crop consumed in the tropics and many regions of the developing world. Apart from cassava's importance as a staple hand in many tropical developing Countries, it is a raw material for the production of animal feed. Starch, alcohol, e.t.c. cassava is consumed, as food, mostly in the form of gari, fufu, lafun and cassava. The maximum production of cassava is in African followed by Asia and South Africa. The average world yield is about 5.7 tons of fresh root ha^{-1}, which far below the potential yield of 50 tons ha 1 produced under experimental condition, (Howeler, 1955).

Cassava is of great important in the nutrition of over 800 million people in the tropical world (F.A.Q, 1991). More than 100 million people obtain 500 kcal per day from cassava. In central Africa, cassava is estimated to provide over 1000 kcal per day to 30 million people (Cock, 1984).Current trends indicate that the consumption of cassava is increasing, and that the growing of cassava is expanding to semi-arid areas where cassava was not cultivated 20 years ago. (FAO, 1991)

Table 1.1: Cassava production in the world and in major producing countries (in million tons)

REGIONS	1988	1989	1990	% Increase
World	146.2	157.7	158.1	8.1
Africa	64.6	71.7	72.7	12.5
Nigeria	20.0	25.5	26.0	30.0
Zaire	16.2	16.4	17.0	4.9
Asia	54.6	52.4	52.6	2.0
Thailand	22.3	24.3	22.8	2.2
Indonesia	15.5	17.1	15.9	2.6
Latin America	29.1	31.5	32.8	12.7
Brazil	21.7	23.6	24.6	13.4

Source FAO, food outlook, May, 1991.

The most important food product in Nigeria is gari. This is made by grating the peeled roots, fermenting the mash obtained for 3 or 4 days in sacks. A weight in from of stones or logs is usually placed on the mash to apply pressure on it. (Vansconcelos *et al* ,1990). After fermentation the material is sieved to removed coarse fibers and later in a flat iron pan with continuous stirring or even drying . The heat needed for frying is supplied by burning firewood . The finishing product is coarse granular flour which may be reconstituted with hot or cold water into a dough or gruel (Westby 1991).

Cassava flour may be prepared by sun-drying slices of tuber, and milling the resulting chips. Other cassava foods are prepared from wet-extracting starch. Whole or peeled tuber are soaked either in streams or in static water for several days until it is soft, after which the peel (cortex) and fiber are removed by hand picking and the starch washed out and allowed to settle. The starch is used in other for food products (Onwucme, 1 978).

1.3 Statement of Problem

A vital step in processing, cassava is the reduction of peeled fresh roots into smaller size by slicing, grating and chipping. The traditional method of cassava processing are very tedious and body injures are sustasined . Also high labour inputs and high processing loss are incurred (Aravie and Ohwovoriole).There are existing designs of chipping machine, grating machines and slicing machines but this design is considered to reduce investment cost combining three unit operation to one frame and using the same power unit. The design is simple and can be easily accessible; it would reduce cost of buying various unit machines. It is. The demand for the machine that will reduce cost , space and reduce health hazards especially to women who are major cassava processor's and it is an improvement of existing chipping, grating and slicing machines.

1.4 Objective of Study

The general objectives of this study is to develop a cassava processing machines which is capable of slicing, grating and chipping, using the same frame, power unit but diff operation plates, plates are fixed according to use and when not in use are cleaned and kept in a safe place.

Specific objectives of the study include:

- To improve existing cassava processing machines, to incorporate different operation unit to work on the same frame using the same power unit
- To design and fabricate a cassava multi-processing machine.
- To carry out evaluation of the designed machine.

1.5 Justification of Study

The research work when undertaken would help improve efficiency and cost. The use of cassava cannot be overemphasized and in production chipping slicing and grating are intermediate steps in cassava processing. Slicing and chipping reduce the volume to weight of cassava making it easier to dry and to ferment and reduction of volume to weight makes exportation readily cheaper, Grating breaks down the cyanide level in cassava tuber for this reason a challenge is posed to have a cheap and efficient machine that will carry out this various processes at a minimal cost.

1.6 Scope of Study

This research study is the area of specific processing unit operation (grating, chipping and slicing). It is necessary to overcome the difficulties in processing various machines to do various unit operations which will reduce cost and spaces. The project reports the design and fabrication of a cassava multiprocessing, machines using locally sourced materials.

CHAPTER TWO

2.0 Literature Review

2.1 Principle of processing

The importance of cassava as a staple food cannot be overemphasized because it possesses properties such as tolerance to drought, poor soils and even neglect. The cassava plant has long been studied because of its much application. In industry, cassava is used in the manufacture of paper adhesive, drug cosmetics and explosives. The starch from cassava tuber is widely used in laundry and textile industries.

The enormous potential for using cassava as food for all types of livestock has been recently recognized and a large amount of research has been devoted to defining the optimum level of dried cassava in animal diets and to modify the plant's chemical and physical properties that restricts its use . Smith, 2002 carried out and defined the optimum level of dried cassava in animal diet and to modify the plants chemical and physical properties that restrict it's uses.

Grating, chipping and slicing operations are major fundamental processing operations and they are based on size reduction. Basically, size reduction means reducing the size of agricultural material to a form (Henderson and Perry, 1974). Grating, chipping and slicing are achieved by cutting. In order for cutting to take place, a system of process must act upon the material e.g. (cassava flesh). Cutting creates new surface, reduces the surface area thereby reducing drying and fermentation time. Considering gari processing as a major economic activity and a viable additional source of food and also other cassava produce like starch , cassava flour etc and other cassava food as additional source of food and income, the grating, slicing and chipping important operations that can not be ignored.

2.1.1 The need for chipping / slicing

A method found for hastening drying rate is cutting the tuber into chips, chipping / slicing. It reduces dry and fermenting time. The operation virtually eliminate drudgery and odour in the cassava.

2.1.2 The need for grating

The action of grating into fine shreds or pulps is a step common in the processing of many cassava food products and facilitates subsequent steps in processing cassava tuber i.e. dewatering, drying etc.

2.2 Past works on cassava processing

Some designs exist of chipping machine, grating machine and slicing machine. The design of this machine was considered in order to reduce investments cost while providing opportunity to expand utilization of cassava. An extensive work has been carried out on designs of chipping, grating and slicing machines . Ajibola et. al, reported the design and constructed of a cassava chipping which consist of a shaft a circular plate and a frame.

Y.W. Jeon 1998 reported the design and construction of a cassava grater which consist of a shaft, frame and it is manual powered. Y.W. Jeon 1992 reported the design of a grating machine and chipping and grating machine using different shaft. The grating machine uses a hopper while the chipping machine uses a feed plate but its power consumption is high. IITA post harvest team designed a slicing machine which consists of a shaft and a circular plate on which the slicer is operated. It is powered by electricity and uses a feed plate. Jekayinfa et. al, Adejuyigbe and Bolaji reported that for mechanization of agriculture in Nigeria to succeed it must be based on indigenous design, development and manufactured most of the required machines and equipment to ensure their suitability for the crops, as well as for the farmer's technical and financial capabilities. Some notable contribution to the mechanization of cassava processes includes Ohwovoriole et. al, Igbeka et. al , Araive and Ohworiole, Ukatu and Jekayinfa et. al.

2.3 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 sleeping, fermenting, pounding, frying, roasting, pressing, sieving, drying and milling.

i. Peeling

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

ii. Washing

Washing involves soaking the peeled or unpeeled tubers in water and washed with hand scotch pad. Cleaning should take place at the earlier opportunity in a food process both to prevent damage to subsequent processing equipment and to prevent time and money from being spent on processing contaminants which are then discarded. Washing is thus an effective method of reducing wastage, improving the economics of processing and protecting the consumer

iii. Drying

Drying is the elimination of excess water from the material in order to bring the total moisture content to a level considered to the safe for long-term storage. The excess water in cassava or other agricultural produce is responsible for intensive microbial activity leading to the formation of molds and general deterioration of the product. Drying is mostly done in the open air under sunlight on the roofs of building, roadsides, concrete patches, spread on mats or directly on tamped soil. Lafun, for example, is dried very often on rocky surfaces which accumulate tremendous heat energy during day time and release it during the night, providing a natural heat exchanger. The above traditional method of drying however has problems. The quality of the product is low due to contamination by dust, particles of plant and other foreign matters, sometimes stones and fragments of glass.

Drying becomes very difficult during the rainy season. It is during this time that the price of Lafun and other dried cassava products goes up as lack of sunny hours for drying reduces the quantity of product marketed. Drying during the rainy season is a very cumbersome procedure as the drying product has to he taken in and out, or left in the rain causing harmful deterioration and Loss of quality due to information of fungi.

v. Grating

The action of grating into fine shreds or pulps is a step common in the processing of many cassava food products and facilitates subsequent steps in process e.g. dewatering, drying or pulping. The process alters the texture of raw material. Grating methods range from simply rasping the roots on the trunks spine of palms through simple hand raspers to mechanized graters.

v. Frying or roasting

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

In gari processing, proper roasting is important to ensure a good quality product. Both flying and roasting enhance the flavour of the cassava and most importantly reduce its moisture content. When packed properly, fried products can have a shelf-life of several months.

vi. Milling/Grinding/Pounding

This is done traditionally in Nigeria using wooden mortars and pestles. However, milling technologies using powered plate mill or occasionally hammer mills have spread rapid 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 grinded to flourb which are being used in many traditional dishes such as'fufu" "lafu" etc . Also pounding changes the texture of the previously prepared cassava to a more palatable, paste like meal.

vii. Sieving

Sieving is done with the purpose of removing the undesirable particles from mixed materials as used in starch extraction is achieved using sieves made out of metal or local plant material or local plant material or fine woven cloth material in case of starch extraction.

viii. Fermentation

Fermentation is an important step in the processing of cassava. Fermentation result in a reduction in the level of toxic components. In fermenting 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, breakdown in the cyanide containing toxic component occurs through the action of naturally occurring enzymes in the coot releasing hydrogen cyanide. The condition at the end of this first stage allows the growth of a range of microorganism that produce compounds which give gari its characteristics flavor. Much of the cyanide is lost during fermentation, the remainder being largely driven oft during the final roasting step. The simple wet method of fermentation, sometimes 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 somewhat unpleasant odour.

ix. Dewatering

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

x. 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.

xi. **Starch extraction**

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

xii. Chipping

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

The toxic glycosides are reduced to a safer level during processing. Toxicity is initially considerably reduced during peeling, grating breaks down the internal cell and so releasing the enzymes which break down cynagonic glycosides complex and release hydrogen. During subsequent fermentation stage almost a total breakdown of glycoside occurs and finally , frying, roasting and boiling drives off the remaining hydrogen

2.4 Cassava Utilization

Cassava is a high potential crop as it is applicable in many products 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 (IITA .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 a 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 yarn to stiffen and protect it during weaving to improve color consistency during printing to make the fabric durable and shinning at finishing

2.4.3 Monosodium glutamate

Cassava starch is a common source for making monosodium glutamate in Asia. It is used to enhance flavor in food. Examples of this seasoning in Nigeria are 'Vedan' 'Ajinomoto' soup flavoring source.

2.4.4.Pharmaceutical

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

2.6.5 Glue

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

2.4.6 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.

2.4.7 Ethanol

Cassava chips are an alternative source of materials for producing liquor as well as medical and industrial alcohol (IITA 2005)

2.4.8 Livestock Feed

Cassava roots can be processed into chips and pellets 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..4.9 Confectionery

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

2.4.10 Glue

Cassava starch is a very important raw material in making glue. Cassava starch – based dextrates excellent based adhesives and are used in many application including pre gummed papers tapes labels stamps and envelope.

2.4 Major constraint in Cassava Production

Cassava is a highly perishable crop and this presents a very serious problem in processing and storage. Cassava is a highly perishable tuber begins to deteriorate in 40-48 hours after harvest if no preservative measure is taken. According to Kwate (1986) the deterioration of cassava is not so much due to pest attack but microbial infestation and physiological factors such as loss of moisture, This is encouraged by the mode of storage i.e. storage area of land cassava in the ground beyond maturity has a number of disadvantage . This practice locks up large area of land , quality and quantity reduces since rodent and nematode damage increase with time and intermittent harvesting of the crop may be consuming particularly when farms are situated at long distances from home. From the established fact it can be deduced that processing of fresh cassava root into staple non-perishable and early transportable products offer an alternative to storage of cassava fresh. Cassava chips help to reduce the volume to weight ratio which helps to lower shipping or transportation cost (Akintunde and Tunde Akintunde 2001) also chipping is a potential process improvement to minimize losses, increase labor productivity and improve taste of cassava food.

CHAPTER THREE

3.0 Method and Materials

3.1 Machine Description and Design considerations

The machine is designed to do three major cassava processing opreations ie chipping grating and slicing using diffrent opreation plates on the same frame. From past works; Jeon Y. W and Halos Kim (1992) ,Bolaji B. O. (2005),Ademola Adebayo (2007) the machine was designed to adopt ; grating speed of 720rpm, chipping speed of 300rpm, slicing speed of 400rpm.

The machine has four major part components and they are

1 Hopper/ Feeding chute

2 The operation unit

3 The power unit

4 The machine frame

3.1.1 Hopper / Feed chute

It consist of

a Feed tray

b Feeding chute

3.5.1.1 Feed tray

it is made of galvanized steel, it is attached permanently on the frame. It is designed to hold some peeled root while operator feeds tuber singly through the chute

3.1.1.2 Feed Chute

Feed chute is in shape or a funnel or a frustum cut in a slanting form to give certain angle or inclination to chipper plate this chute is bolted to the frame and it is made of galvanized steel.

Design of Feeding Chute

Feeding chute in the cassava multi processing machine is a component on which material to be chipped is first fed against the operating plate

The aim of the design is to achieve the following objective:

- comfort in feeding
- regulate rate or feeding
- volume

Comfort for the Operator

The feeding chute could he design in a way that the operator will he very comfortable during operation, and to avoid stretching while feeding material into the machine, which cause fatigue.

Ease of Feeding

Obviously the essential of the whole machine design is 10 reduce drudgery in chipping, the feeding chute should he designed in such a way to feed the machine easily with the use of minimum human energy

Volume

This is the capacity of feed chute: it should be designed by considering the physical parameters of the materials be processed so as to achieve all optimum feed rate.

Advantage of Feeding Chute

(1) Ease of feeding the cassava since feeding chute is inclined to the operating

plate

(2) The volume is average size of cassava

(3) Comfortable while feeding

(4) Greater processing is achieved as a result

3.1.2 The operating unit

The operation unit is attached to the discharge chute. This allows the processed pulp to to slide and drop under gravity to the collecting box provided . The unit is fastened to the shaft . it consist of the grating plate, chipping plate and slicing plate.

3.1.3 The power unit

The power unit consists of the electric motor, belt and pulley. The electric motor is the prime mover of the machine. The pulley of the electric motor is 50.8mm in diameter. The machine is designed to use an open belt system for power transmission from the electric motor to the operation unit via the pulley to shaft. The belt specification is V set. The electric motor and shaft pulley serve as means through which the belts transmit power from the electric motor to the shaft. An electric motor of 2Hp and rpm of 1440rpm is the required motor for the machine.

3.1.4 The machine frame

It houses all other component and it is made of mild steel (angle bar 2.5x2.5) cut into various size required according to dimension and framed by first tacking and later welding . The frame dimension of the frame is 600 x 500 x 600

3.2 Design Considerations

The following factors are considerd in the design

1 Safety

2. Capacity

3. Multiple plates to conform to the objectives/ funcction

4. Power driven

3.3 Mode of Operation

The machine is designed to accommodate multiple process operations i.e. grating, chipping and slicing. The plates are changed depending on the opreation to be performed. A 3 step pulley is used for the various speed, three diffreent belts are used for the three diffrent pulleys depending on the speed used per time. The chipping operation is expected to be carried out at a speed of 300rpm (Jeon, 1991). The grating and slicing speed are expected to be carried at 720rpmn (Alenkhe, 2009) and 400rpm (Adebayo ,2005) respectively.

The machine is simple to operate and so requires only one operator. As the shaft rotates it turns the rotor plate (slicing plate, chipping wheel and grating wheel) anticlockwise. The operator feeds in tuber manually through the feeding chute. The rotation of the rotor plate performs an impact action on the tuber's. The plate mounted on the rotating shaft cuts the tubers by shearingto the dsired sizes. The processed cassava is discharged via the chute.

3.4 Design Calculation

3.4.1 Power Requirement

$$P = \frac{2\pi N_2 t}{60} \quad \text{(Hall et al, 1980)} \qquad 3.0$$

P= Power required

N_2 = speed of rotating shaft

t = torque

$$t = F\,r \quad \text{(Hall et. al, 1980)} \qquad 3.1$$

F = Force required to chip

r = radius of shaft

Diameter of shaft= 0.025m

radius of shaft = 0.0125m

Force required to chip/grate/slice cassava is equal to reaction offered by the cassava tuber (R_t) which is equal to the sum of shearing force (Fs) and frictional force Fr) (between the chipping plate and tuber (Bolaji 2008).

$$R_t = Fr + F_s \qquad 3.2$$

Where R_t = Reaction offered by the cassava tuber

F_s = shearing force

Fr = frictional force

$Fr = F_s + \mu$ (Odigboh ,1996) 3.3

Where μ for average coefficient of friction (Odigboh, 1996)

$\mu = 0.364$ (Ejovo *et al*, 1988)

$R_t = F_s + F_s + \mu$ 3.4

$R_t = F_s (1+\mu)$

F_s= for peeled tuber = 140 (Ejovo *et al*, 1988)

$Rt = Fs (1+ \mu)$

$Rt = Fs (1+0 .364)$

$Rt = 140 (1+0 .364)$

$Rt = F = 190.96$

$t= Fr$ 3.5

$t= 190.96 \times 0.125$

$t =23.670$ N

$t = 0.023$ kN

Power requirement for chipping operation

N_2 for chipping operation = 300rpm

$$P = \frac{2\pi \times 300 \times 0.023}{60}$$

P= 0.72kw

Power requirements for grating operation

$R_t = F = 190.96$

r = radius

$t = Fr$

$= 190.96 \times 0.125m$

$t = 26.67 = 0.223KN/m$

$P = \frac{2\pi N_2 t}{60}$ (Hall *et al*, 1990)

N_2 for grating operation= 720rpm

$P = \frac{2 \times \pi \times 720 \times 0.023}{60}$

$P = 1.73kw = 1.3hp$

Power requirement for slicing operation

$R_t = F = 190.96$

$r = 0.125$

$t = Fr$

$t = 96 \times 0.125$

$t = 23.87Nm$

$t = .023kNm$

$t = .023kNm$

N_2 for slicing operation= 400rpm

$$P = \frac{2\pi N_2 t}{60} \quad \text{(Hall etal, 1980)}$$

$$= \frac{2 \times \pi \times 400 \times 0.023}{60}$$

$0.62kw \cong 0.46hp$

Considering the varying power requirement and the starting torque a 2hp motor will be used to power the machine.

3.4.2 Dimension of Hub

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

$$dh = 1.5d + 25mm$$

The diameter of the hub should not be greater than 2d

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

$$dh = 55mm$$

The length of hub (L)

The length of the hub (L) was found from the relationship

$$L = \frac{\pi}{2} \times d$$

where d = diameter of the shaft

$$L = \frac{3.142}{2} \times 25$$

$$= 39.269mm$$

3.4.3 Dimension of Arm of Wheel

The number of arms may be taken as 4 for pulley diameter from 200mm to 600mm (Khurmi & Gupta, 2004).

For this design, the wheel is provided with eight arms, which are elliptical in shape. The cross section of the arm is obtained by considering the arms as cantilever i.e. fixed at the hub end and carrying a concentrated load at the rim-end. The length of the cantilever is taken equal to the radius of the pulley. It is further assumed that at any given time, the power is transmitted from the hub to the rim or vice versa through only half the total number of arms.

Tangential load per arm (wt)

$$Wt = \frac{2T}{R \times n}$$

Where;

T – Torque transmitted = 4.79Nm

R – Radius of pulley = .125m

N – Number of arms = 8

$$Wt = \frac{2 \times 4.79}{8 \times 0.125}$$

Wt = 9.8N

For 8 sector = 2165 x 8 = 17325 mm

Area of the arm = (82991.10 – 17325) mm^2

$= 65666.10 mm^2$

Volume of arm = area of arm x thickness

$T = 6mm$

65666.10×6

$393996.6 mm^3$

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

$= 109807.5 + 162209.14 + 393996.6$

$= 666013.24 mm^3$

Weight of the wheel = volume of the wheel x density of wheel

$= 6.66 \times 10\text{-}4 \times 2700$

$= 2.0 kg$

3.4.4 Determination of Number of Punches of Chipping Plate

CASSAVA TUBER (IITA, 1992)

The average diameter of cassava tuber is 50mm

The average length of cassava tuber is 300mm

Therefore;

Area of the tuber = πr^2

$= 3.142 \times 25^2$

$= 1963.75mm^2$

Volume of cassava tuber = Area x length

$= 1963.75 \times 300$

= 589,125mm

Therefore each punch on the chipping plate is 10mm, which produce strips (chips) of 10mm, the length of the chips depends on the position of the tuber at the time of cutting. But usually the average length of chips 60.5mm

Area of strips (chips) = πr^2

$= 3.142 \times (5)^2$

$= 78.55mm^2$

Volume of chips = area x length

$= 78.55 \times 60$

$= 4713.00mm^3$

Number of punches on the chipping plate $= \frac{\text{volume of cassava tuber}}{\text{volume of cassava chips}}$

$= \frac{589123}{4713.00}$

$= 125$ *punches or holes*

Therefore 125 punches were considered which means at a complete rotation of chipping mechanism almost one cassava tuber is chipped.

3.4.5 Dimension of Plate

The area of chipping is shown below. The area is given as The plate thickness is 0.6mm and is of 360mm in diameter.

Required area = Total area – removed area

Total area $= \pi r^2$

$= 3.142 \times (180)^2$

$= 101800.8mm^2$

The center diameter

Area $= 3.142 \times (29)^2$

$= 2642.422mm^2$

The punches (128 punches)

Area $= \pi r^2$

Area $= 3.142 \times (5)^2$

Area $= 78.55mm^2$

Total area of punches = 78.55mm2 x 128 = 10054.4mm2

Therefore:

Required area = Total area – center remove – total punches

= 1018008 – 2642.422 – 10054.4

= 89103.978mm

The volume of plate = Area x thickness

V = 89103.978 x 0.6

V = 53462.38mm3

V = 5.346 x 10-5m3

Mass of plate = Volume x Density

= 5.34 x 10-5 x 7900

= 0.42kg

3.4.6 Design Calculation of Feeding Chute

The volume of the frustum = volume of the major cone – volume of the minor cone

The volume of External Frustum

The volume of a cone, $V = 1/3\, \pi r^2 h$

Volume of the major cone = $1/3\, \pi r^2 h$

Where hi = (200 + x)

To find the value of x

$$\frac{200 + x}{75} = \frac{x}{60}$$

60 (200+x) = 75x

Mass of plate = 2.39kg

Weight of plate = weight of hub + weight of plate

Weight of plate = 2.39 x 9.81

Weight of plate = 23.4459N

Weight of hub = 1.769N

s(23.4459 + 1.769)N

Weight of slicing plate = 25.21N

3.4.9 Weight of Wheel

Weight of wheel comprises of Rim, Hub and Arms

Area of hub = Area of major diameter ---area of minor diameter

$$A = T_1\left(r_1^2 - r_2^2\right)$$

$$D_1 = major\ diameter\ r_1 = \frac{55}{2} = 27.5mm$$

$$D_2 = monor\ diameter\ r_2 = \frac{D_2}{2^2} = \frac{22}{2} = 11.2mm$$

$$= \frac{22}{7}\left(27.52^2 - 11.2\right)$$

$$A = 1996.5mm^2$$

$$volume\ of\ hub = 1996.5 \times 55 = 109807.5mm^3$$

Area of volume

Area of rim = area of major diameter -- area of minor diameter

Weight of the wheel = volume of wheel x density of wheel

$$= 6.66 \times 10^{-4} \times 2720$$
$$Mass\ of\ wheel = 2.kg$$
$$weight\ of\ wheel = 2 \times 9.81 pg 19.62$$
$$Weight\ of\ plate = mass\ of\ plate \times 9.81$$
$$= 0.42 \times 9.81$$
$$= 4.12N$$

3.4.10 Design of Shaft

Shaft design considering the slicing plate acting as load on the shaft

Power 2hp = 1.4 kw

Speed of rotation electric motor N_1 = 1440rpm

Pitch diameter for motor pulley D_1 = 50.8mm (ITA)

Speed of shaft N_2 = 300rmp

Pitch diameter of shaft pulley D_2 = ?

Note: $V = N_1D_1 = N_2D_2$ (Khurmi and Gupta 2005)

$N_1D_1 = N_2D_2$

$$D_2 = \frac{N_1D_1}{N_2} = \frac{1440 \times 50.8}{400}$$
$$D_2 = 183mm$$

$$W_m = \frac{2\pi N_1}{60}$$
$$W_m = \frac{2 \times 3.143 \times 1440}{60}$$
$$W_m = 150.816 rad/\sec$$

Torque transmitted by electric motor

$$T_t = \frac{P}{W_m}$$
$$T_t = 9.41Nm$$

Torque supplied Tt = (T_1 -- T_2)r

T_1 = tension in the tightening side of the belt

T_2 = tension in the slackened side of the belt

r_1 = radius of the motor pulley = 25.4mm

Radius in meters = 0.025mm

9.41 = (T_1 – T_2) 0.025

$$T_1 - T_2 = \frac{9.41}{0.025}$$

T_1 – T_2 = 198.92N (1)

For a V belt $\frac{T_1}{T_2} = 3$ (2)

T_1 = $3T_2$ (3)

Substituting (3) into (1)

$3T_2$ – T_1 = $2T_2$

$2T_2$ = 198.92

T_2 = 99.462N

Substituting T_2 into equation (2)

$T_1 = 3 \times 99.462$ N

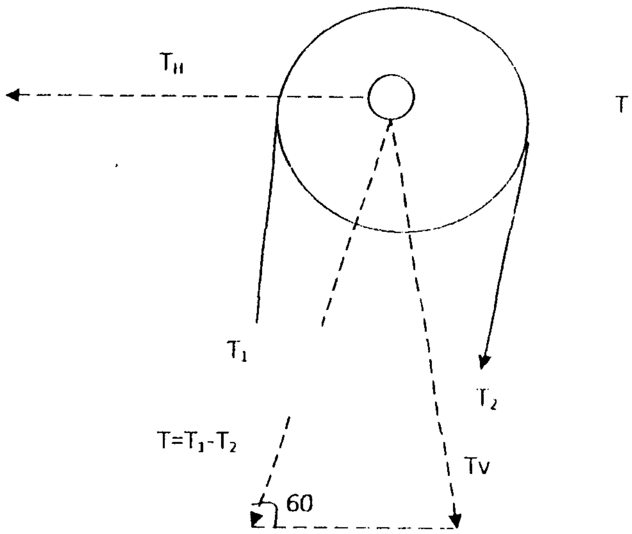


Fig 3.1

$T = T_1 + T_2 = 298.38N + 99.46N$

Total T = 397.84N

$\sin 60 = \frac{Tv}{t} \quad \Rightarrow \quad Tv = T \sin 60^o$

$$T_v = 398.24 \times \sin 60$$
$$T_v = 344.33N$$

$$T_H = T \cos 60$$
$$T_H = 397.84 \times \cos 60$$
$$T_H = 198.92N$$

$\therefore$ Total vertical force on pulley

Fv= Tv + weight of pulley

Mass of pulley $= 3kg$

Weight of pulley $3 \times 9.81 = 9.81N$

$Fv = 397.84N + 29.43N = 427.65N$

Analysis to obtain the maximum bending moment on slicing plate

Considering the vertical loading on the slicing plate

The weight of slicing plate = 25.51N.

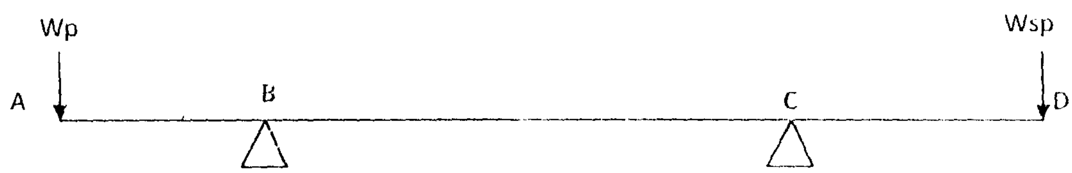
Maximum cassava that can be sliced per unit time= 1.4kg = 13.8N

Total weight W_{sp} = weight of slicing plate + max number of cassava the slicing plate can slice per unit time.

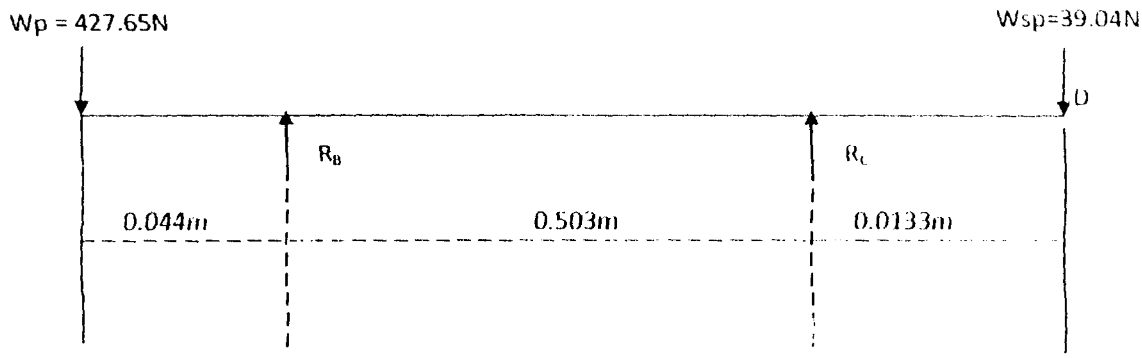
Total weight acting on shaft vertically per unit time =

$W_{sp} = 25.21N + 13.83N = 39.04N$

Total length of shaft = 680mm



Converting length into mm



$\Sigma f = 0$

$\Sigma f \downarrow 407.65N + 39.04N = 446.69$
$\Sigma f \uparrow = R_A + R_b$

Total force acting on Shaft

427.63+39.04N = R_A+R_B

Taking moment about point C

$(39.04 \times 0.110) + (R_B \times 0.400) - (407.23N \times 0.411) = 0$

$$R_B = \frac{(407.63 \times 0.411) - (39.04 \times 0.110)}{0.400}$$

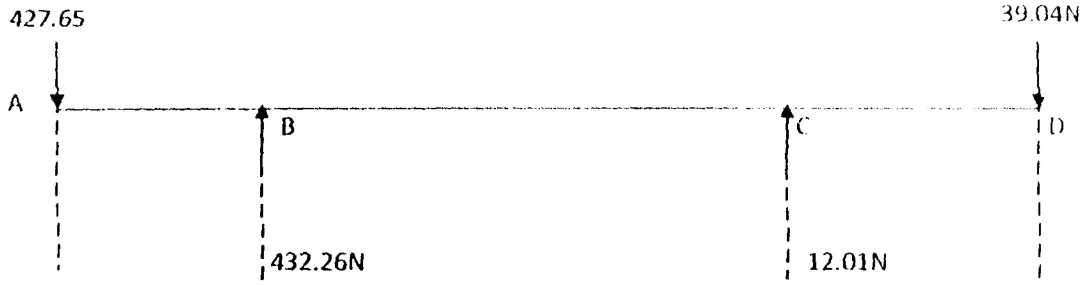
$$R_B = \frac{222.477}{0.503}$$
$R_B = 432.965N$

Substituting R_B into equation 4 we have:

$R_c = 407.65 + 39.04 - 432.26N$

$R_c = 14.74N$

Hence the new representation of the vertices loading is given as:



Considering moment about points A, B, C, D

M_A= -427.65X0 = 0Nm

M_B= -427.65 x 0.044 = -17.936N

M_C = (-407.65 x 0.547) + (432.96 x 0.503) =-222.98N + 217.77N

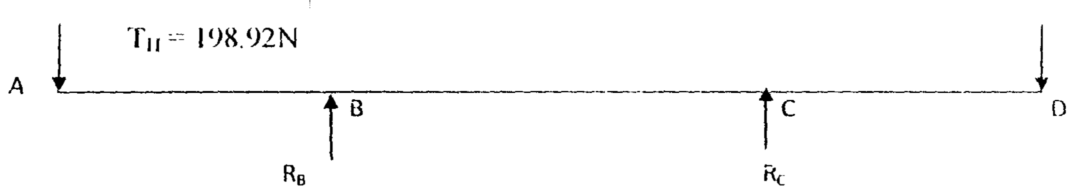
M_C = -5.320Nm

M_D = (-427.65 x 0.680) + (432.96 x 0.636) + (14.74 x 0.133)

M_D = -277.20 + 298.36 + 1.96

M_D = -0.123 $\approx$ 0

Considering the horizontal loading



$\Sigma f = 0$

$R_B + R_C - 197.92 = 0$

$R_B + R_C = 198.92$

$R_B + R_C = 198.92$ (5)

Also taking moment about point C

$$(R_B \times 0.503) - (198.92 \times 0.547) = 0$$

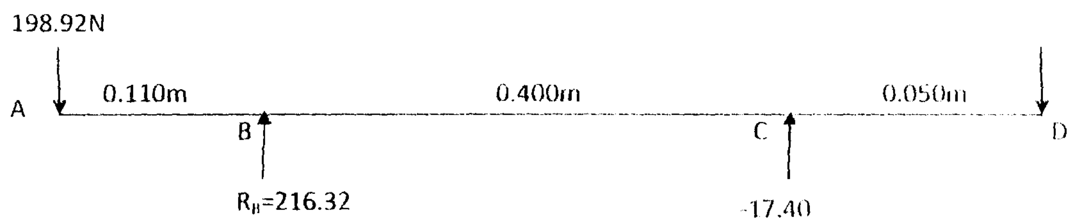
$$R_B = \frac{198.92 \times 0.547}{0.503}$$

$$R_B = 216.320$$

Substituting R_B into equation (5)

$$216.32 + R_c = 198.92N$$
$$R_c = 198.92 - 216.32$$
$$R_c = -17.40N$$

Hence the representation of the horizontal loading

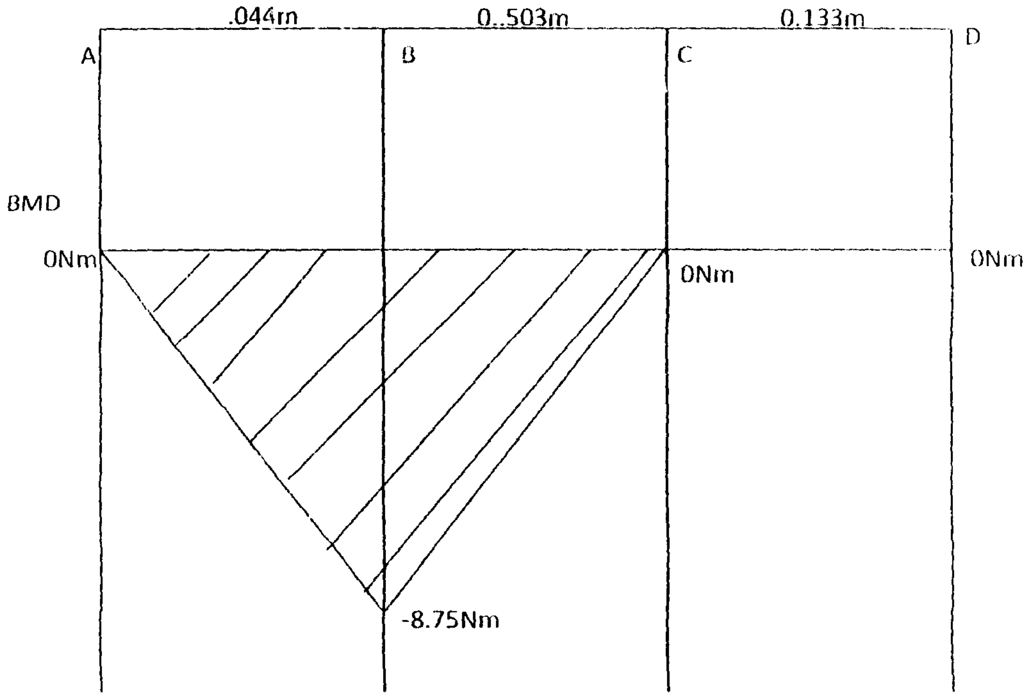


Obtaining moments at points A, B, C and D

M_A = - 198.92N x 0 = 0Nm

M_B = -198.92N x 0.44 = -8.752

M_C = (-198.92N x 0.547) – (216.32 x 0.503) = -0.00028 ≈ 0



To calculate the maximum bending moment, we calculate the B.M at point B on C considering both vertical and horizontal loading.

At point B $$M_B = \sqrt{(-17.98)^2 + (-8.757)^2}$$

$$M_B = \sqrt{321.700 + 76.68}$$
$$M_B = 19.959$$

At point C $$M_C = \sqrt{(-5.32)^2 + (0)^2}$$

$$M_C = \sqrt{28.30}$$
$$M_C = 5.32$$

Hence maximum bending load M_B(max) M_B = 19.89Nm

Therefore, using the ASME code equation for a solid shaft

$$d^3 = \frac{16}{\pi S_s}\sqrt{(kb\ \ Mb)^2 + (kt\ Mt)^2}$$

Ss = Allowable stress for steel with key way = 42 x 10^6

K_b =1.5

K_t = 1.0

M_b = 19.57Nm

T_t = 9.41Nm

$$d^3 = \frac{16}{3.142 \times 56 \times 10^6}\sqrt{(1.5 \times 19.59)^2 + (1.0 \times 4.97)^2}$$

$$d^3 = \frac{16}{3.142 \times 56 \times 10^6}\sqrt{(29.34)^2 + (9.41)^2}$$

$$d^3 = \frac{16}{3.142 \times 56 \times 10^6}\sqrt{860.835^2 + 24.7}$$

$$d^3 = \frac{16}{3.142 \times 56 \times 10^6} \times 42.75$$

$$1.21 \times 10^{-7} \times 42.75$$

$$d^3 = 5.61 \times 10^{-6}$$

$$d^3 = 0.0173m$$

$$d = 17.3mm$$

Shaft design considering the grating plate acting on the shaft

Power rating of motor 2hp = 1.4kw

Speed of rotation of collective motor N_1 = 1440rpm

Pitch diameter of motor pulley D_1 = 50.8mm

Speed of rotation of shaft of grating wheel N_2 = 720rpm

Pitch diameter of shaft pulley D_2 =?

Note: $V = N_1D_1 = N_2D_2$ (Khurmi and Gupta)

$$N_1D_1 = N_2D_2$$
$$D_2 = \frac{N_1D_1}{N_2}$$
$$D_2 = \frac{1440 \times 50.8}{740}$$
$$D_2 = 98.85 \approx 99MM$$

$$W_m = \frac{2\pi D_1}{60}$$

$$W_m = \frac{2 \times 3.142 \times 1440}{60}$$
$$W_m = 150.816 rad/\sec$$

Torque transmitted by electric motor

$$T_t = \frac{P}{W_m}$$

$$T_t = \frac{1400}{450.816}$$
$$T_t = 9.41Nm$$

The following values have previously been calculated

$T_1 = 298.38$

$T_2 = 99.46N$

$T_{II} = 198.29N$

Mass of pulley = 3kg

Mass of pulley = 9.81N

Analysis to obtain maximum bending load moment on the grating wheel

Considering the vertical loading on the grating plate

Mass of wheel is taken as 2kg

Weight of wheel = 19.62N

Weight of grating plate = ?

Grating plate is assumed to have a diameter of 360m

r = 180mm

Area of plate = πr^2

$\pi \times 180^2 = 101787.602mm^2$

Volume = Area x thickness

Thickness is assumed to be 0.5mm

Volume = $101787.602 \times 0.5mm^3$

Volume = $50893.80mm^3$

Mass = volume x density

Mass = 5.089×10^{-5}

Density of steel = 7850 (Roger 1990)

Mass = $5.089 \times 10^{-5} \times 7850$

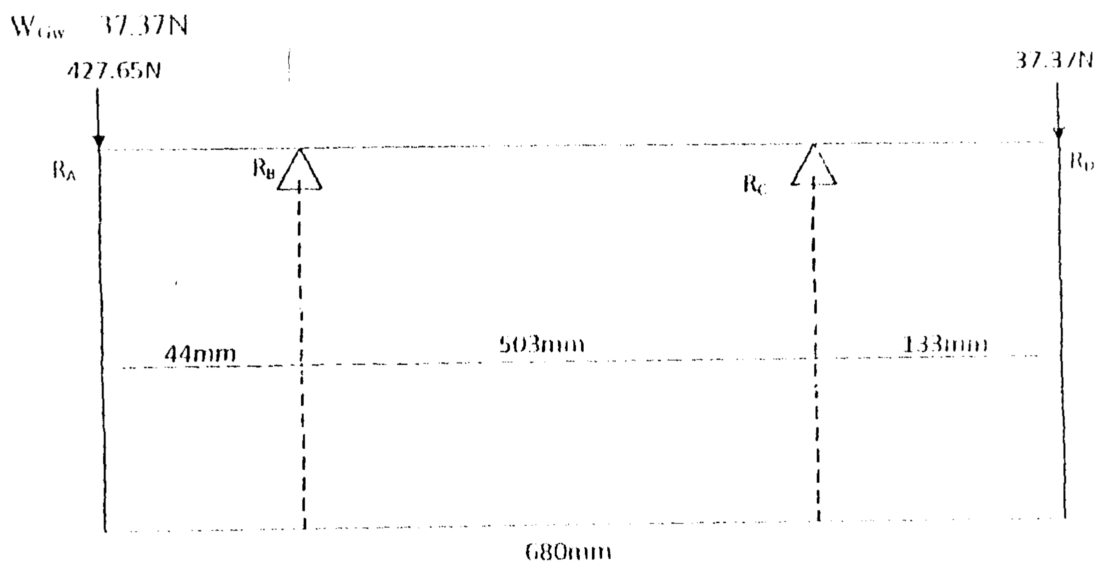
Weight of grating plate = 0.4×9.81

Weight of grating plate = 3.924N

Total weight on wheel = weight of wheel + weight of plate+ weight of cassava that can be grated per unit time.

Total weight on wheel = 19.62N + 3.92N + 13.832

Total weight acting on grating wheel = 37.37N



Obtaining moment about point A,B,C and D

$M_A = 427.65 \times 0 = 0Nm$

$M_B = 427.65 \times 0.044 = -17.936N$

$M_B = (-427.65 \times 0.54N7) - (N32.96 \times 0.503) =$

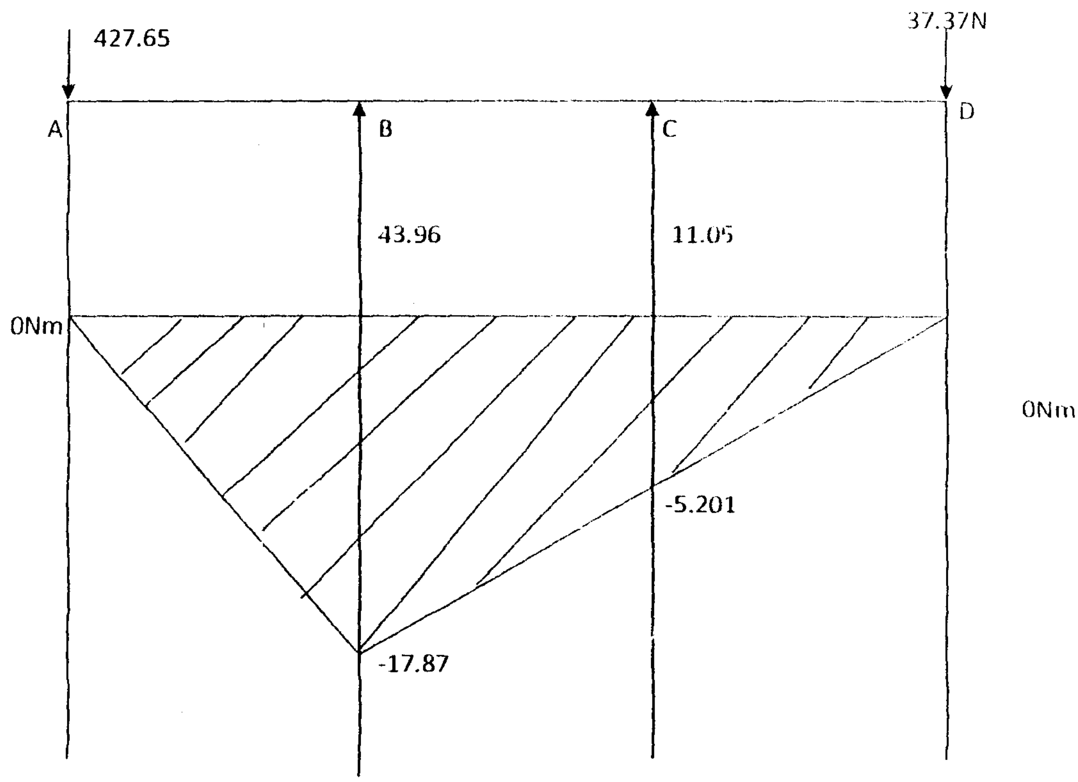
$M_C = 22.98 - 217.778$

$M_C = 5.201Nm$

$M_D = (-427.65 \times .0.680) + (432.96 \times 0.636) + (11.05 \times 0.133)$

$= 277.20 + 275.36 + 1.467$

$= -0333Nm \approx = 0$



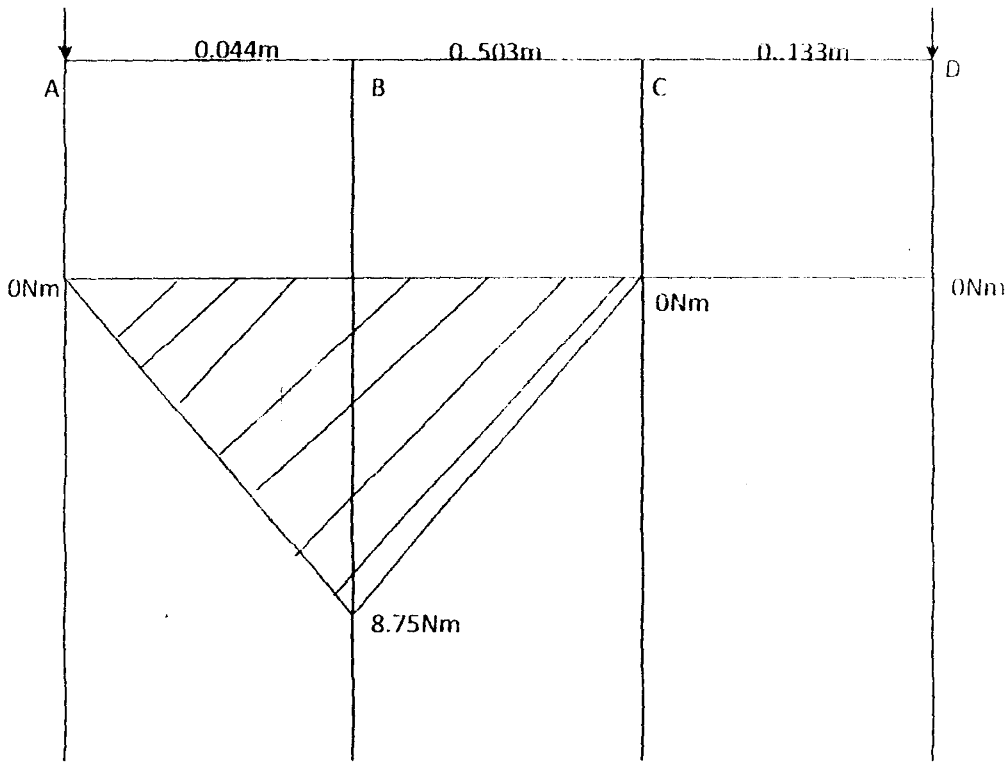
Horizontal loading previously calculated as:

$M_A = 198.92N \times 0 = 0Nm$

$M_B = -198.92N \times 0.44 = -8.752$

$M_C = (-198.92n \times 0.547) - (216.32 \times 0.503)$

$= 0.02028$



To calculate the maximum bending load at point B and C

At point B

$$M_B = \sqrt{(-17.877)^2 + (-18.757)^2}$$
$$M_B = 19.959$$

At point C

$$M_C = \sqrt{(-5.201)^2 + (0)^2}$$
$$M_C = 5.32$$

Hence maximum bending load M_B (max)

$M_B = 19.59$Nm

Using the ASME code equation for a solid shaft

$$d^3 = \frac{16}{SS}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$

Ss allowable stress for steel = 56×10^6

$K_b = 1.5$

$K_t = 1.0$

$M_b = 19.59$Nm

$M_t = 9.88$Nm

$$d^3 = \frac{16}{3.142 \times 56 \times 10^{-6}} \sqrt{(1.5 \times 19.59)^2 + (1.0 \times 9.41)^2}$$

$$d^3 = \frac{16}{3.142 \times 56 \times 10^{-6}} \sqrt{(860.830) + (81.16)}$$

$$d^3 = \frac{16}{3.142 \times 56 \times 10^{-6}} \times 42.75$$

$$d^3 = \sqrt[3]{5.60 \times 10^{-6}}$$

$$d = 0.0178m$$

$$d = 17.8mm$$

Shaft design considering the chipping plate acting on the shaft

Power 1hp = 1.4kw

Speed of rotation of electric motor N_1 = 1440rpm

Pitch diameter for motor pulley D_1 = 50.8mm

Speed of shaft N_2 = 300rpm

Pitch diameter of shaft pulley D_2 = ?

Note: $V = N_1 D_1 = N_2 D_2$

$$N_1 D_1 = N_2 D_2$$

$$D_2 = \frac{N_1 D_1}{N_2}$$

$$D_2 = \frac{1440 \times 50.8}{3000}$$

$$D_2 = 249 \approx 250mm$$

Angular speed of rotation of electric motor

$$W_m = \frac{2\pi D_1}{60}$$

$$W_m = \frac{2 \times 3.142 \times 1440}{60}$$

$$W_m = 150.81 rad/\sec$$

Torque transmitted by electric motor

$$T_t = \frac{P}{W_m}$$

The following values have previously been calculated

$T_1 = 298.38$

$T_2 = 99.46N$

$T_H = 198.92N$

$T_V = 407.65N$

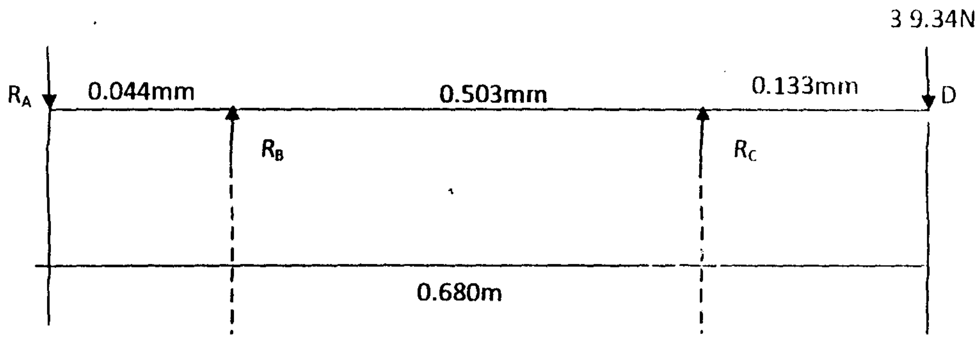
Analysis to obtain the maximum bending load

The weight of chipping wheel = 25.15N (previously calculated).

Average weight of cassava that can be chipped per unit time

= 13.83N (previously calculated)

Total weight acting on the shaft vertically on the chipping end = 25.15 + 13.83 = 39.34N



$\Sigma f = 0$

$407.65 + 39.34 = R_B + R_C$ (4)

Taking moment about point c

$(39.34 \times 0.133) + (R_B \times 0.503) - (407.65 \times 0.547)$

$$R_B = \frac{(407.65 \times 0.547) - (39.34 \times 0.133)}{0.503}$$

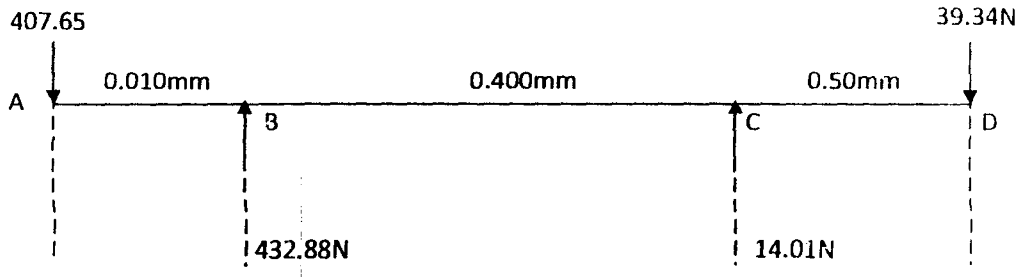
$$R_B = \frac{222.98 - 5.24}{0.503}$$
$$R_B = \frac{217.739}{0.503}$$
$$R_B = 432.88N$$

Substituting R_C into equation

$$\Sigma f = 407.65 + 39.34 = 432.88 - R_C$$

$$R_C = 407.65 + 39.34 - 432.88$$
$$R_C = 14.10N$$

Hence new representation of vertical loading is:



Obtaining moments about points A,B,C and D.

$M_A = -427.65 \times 0 = 0Nm$

$M_B = -407.65 \times 0.44 = -17.93Nm$

$M_C = (-407.65 \times 0.547) + (432.88 \times 0.503)$

$M_C = -222.98 + 217.738$

$M_C = -5.24$

$M_D = (-407.65 \times 0.680) + (432.88 \times 0.636) + (4.05 \times 0.133)$

$M_D = -227.20 + 275.31 + 1.86$

$M_D = -0.02 \approx 0Nm$

Considering the horizontal loading

$T_H = 198.92\ N$

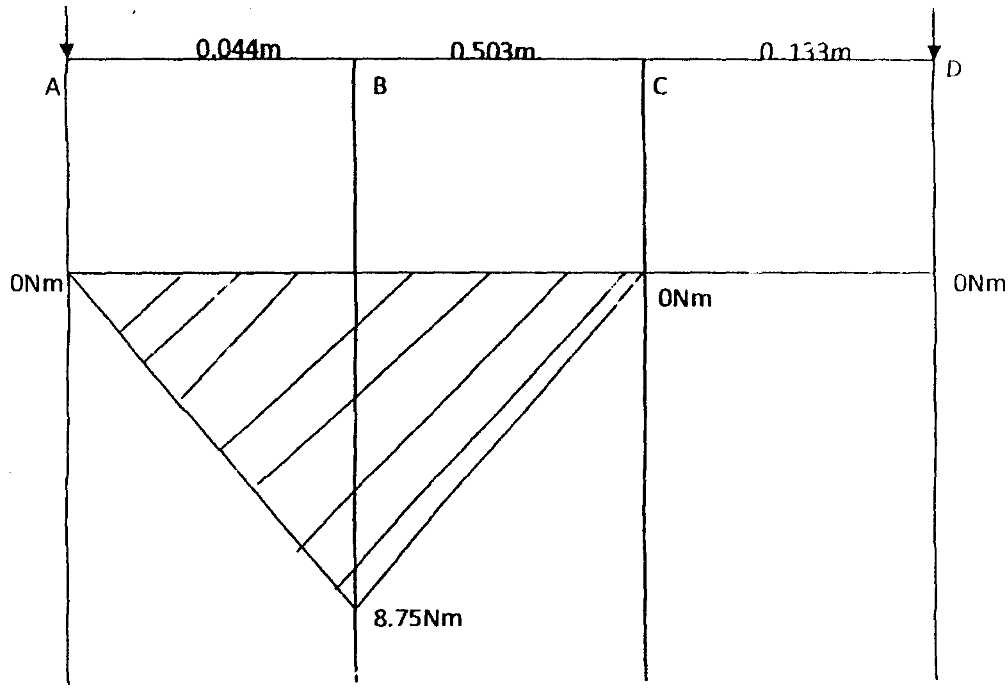
Horizontal loading previously calculated as:

$M_A = 198.92N \times 0 = 0Nm$

$M_B = -198.92N \times 0.44 = -8.752$

$M_C = (-198.92n \times 0.547) - (216.32 \times 0.503)$

= 0.02028



To calculate maximum bending load

At point B

$$M_B = \sqrt{(17.93)^2 + (-8.75)^2}$$
$$M_B = \sqrt{398.0}$$
$$M_B = 19.95$$

At point C

$$M_C = \sqrt{(-5.201)^2 - (0)^2}$$
$$M_B = 5.32$$

Hence maximum bending load M_B(max)

$M_{B\,max} = 19.95$

Using ASME code for solid shaft

$$d^3 = \frac{16}{\pi Ss}\sqrt{(M_b K_b)^2 - (K_t M_t)^2}$$

Ss allowable stress for steel = 56 x 10^{-6}

$K_b = 1.5$

$K_t = 1.0$

$M_b = 19.59Nm$

$M_t = K_t = 9.41$

$$d^3 = \frac{16}{3.142 \times 56 \times 10^{-6}}\sqrt{(1.5 \times 19.59)^2 + (1.0 \times 4.92)^2}$$
$$d^3 = \frac{16}{3.142 \times 56 \times 10^{-6}}\sqrt{(29.32)^2 + (9.41)^2}$$
$$d^3 = \frac{16}{3.142 \times 56 \times 10^{-6}}\sqrt{(860.830 + 81.16)}$$
$$d^3 = \frac{16 \times 42.75}{3.142 \times 56 \times 10^{-6}}$$

$$1.21 \times 10^{-7} \times 29,75$$
$$d^3 = 5.65 \times 10^{-6}$$
$$d^3 = \sqrt[3]{(5,65 \times 10^{-6})}$$
$$d = 0.174m$$
$$d = 17.4mm$$

With safety function of 1.5 and using a standard shaft size. A shaft size diameter of 25mm was considered for use.

3.4.8 Ball Bearing Selection

The approximate rating (or service life of ball or roller bearing is based on the fundamental equation (Khurmi and Gupta, 2004).

$$C = w(1/10^6)^{1/k}$$

where: L = Rating life

C = Basic dynamic load ratiSg

C = basic dynamic load rating

W = Equivalent dynamic load

K = 3, for ball bearings

The relationship between the life in revolution (L) and the life is working hours (LH) is given by;

L = 60N .L .H revolutions

The dynamic equivalent radial load under combined constant radial load (WR) and constant axial or thrust load (W A) is given by

$W = x \cdot v \cdot w_R + y \cdot w$

Where v = a rotation factor

1; for all types of bearing when the inner race is rotating.

The values of radial load factor (x) and axial load factor (y) for the dynamically bearing may be taken from the table.

The value of x and y for single row hearing are I and o. but in this type of loading, thrust load are not applied, hence NA = 0 (Kurmi and Gupta, 2004)

But ∴ = p/2π ×60 /60 x 0.0125

=1018.59N

but w - x. v. w. =y.w

= I x lx 1018.59 + Ox O

= 1018.59N

For the machine working 8 hours per day and not always fully utilized. The life of bearing in hours is given as 12,000 - 20,000

Therefore

L= 43200000 revolution

C= 1018.59(43.2 × 10)

= 3,574.1 N.

In order to select a most suitable ball bearing, the basic dynamic radial load is multiplied by the service factor (ks) to set the deign basic dynamic radial load capacity The service factor for the ball bearing of moderate shock load is 2.0 (Khurmi and Gupta, 2005)

Therefore c x ks

3,574 x I x 2.0

= 7148.IN

7.148kN

From the catalogue of a manufacturer, bearing number 205 was selected.

The dimensions for hearing Number 205 were the following

Bearing Number 205, Bore diameter =25mm, outside diameter = 52mm, width = 15

3.5 Material selection and Basic machine components

3.5.1 Material Selection

Materials selected for the component parts of the Cassava multi- processing machine were based on the following considerations.

1 Can it be done?-this question refers to cast-ability, machine-ability, and surface finish performance or surface enhancement such as coating, plating painting anodizing. Etc

2 will it work?-here we compare the primary criteria such as: hardness, strength, yield. elastic behavior etc. (Ashby 1972)

3 Will it last?-when material is subjected to operation conditions how durable? Considering corrosion, heat resistance, wear resistance, shock, creep and stress concentration.

4 Can it be done within a specified limit?-the main constraint of most engineering components or structures are cost and weight. Bearing in mind that design against failure is a multi faceted process in which we need to examine each facet separately for its influence on successful avoidance of failure in our design.

3.5.1.1 Factors to be considered in material selection

A good knowledge of the engineering properties of a material and the functional requireSments of the proposed machine would provide a guide on appropriate choice of materials to be used.

Some engineering properties of materials are discussed below

1. **Strength of Materials**

The strength of materials is relevant to resist the stresses and strains induced when the structure is in service.

2. **Durability**

Materials are considered durable if they retain their strength and other properties over a considerable period of time. This characteristic varies with the material and service conditions. For example, a material may be durable for some purposes and not for others.

3. **Resistance to Corrosion**

The degree to which a material resists chemical combination with other materials with which it comes in contact is a measure of its resistance to corrosion.

4. **Hardness**

The hardness of a material is a measure of its resistance to indentation and this can be measured experimentally.

5. **Toughness**

Toughness is the capacity of a material to resist fracture under impact loading.

6. **Workability**

This is the characteristic of a material which measures the ease with which it can be worked or shaped. Workability is dependent on the characteristics of the material, the working tools and the construction method applied.

7. **Ease of Cleaning**

This quality is important in materials for surfacing walls, floors, ceilings and counter tops. It is usually associated with high density of surface material and hardness.

8. **Appearance**

Appearance embraces colour and texture. These elements are to large subjective qualities.

Other factors to be considered are cost of maintenance, cost of materials and the cost of alternative materials that can be used.

3.5.2Basic machine component

3.5.2.1 Chipping plate

It is a plain GI sheet cut into a circular plate 360mm, and pressed to form alternate 4mm deep concentric grooves , Two rows of alternate punches 1cm apart are made on each groove along the eight equidisant radial lines . The plate is fixed on an alluminium wheel .

3.5.2.2 Grating plate

The grating plate is made from stainless steel of high tensile sheet of about (20 GI sheet). The grating plate is cut in a circular shape of 360mm diameter .it consist of neatly perforated plates which is a modification of locally used rasp for grating cassava . The grating plate is mounted in such a way that the rough surface is mounted on the wheel is outwards

3.5.2.3 Wheel

W heel is one of the major components of the machine. It is about 380mm diameter. The wheel was divided into eight equidistant parts; it is made or cast from Aluminum and machining on the Lathe machine to give proper finishing. The function of chipping wheel is to support the plate (grating and chipping)

3.5.2.4 Shaft

The shaft was made of mild steel rod of 25mm diameter and 680mm in length, it carries the two bearings, the wheel, handle and, operator plates i.e. chipping plate and slicing plates.

3.5.2.5 Slicing plate

The slicing plate is made of mild steel. The blades are removable and can be sharpened. It slices the cassava into 2mm to 4mm thickness.

3.5.2.6 Bolt and nuts

They serve as materials for holding or fixing two components together to make them act like one. The bolt and nuts are used to hold the bearing housing to the main frame. The dimensions of the bolt are according to use.

3.5.2.7 Bearing

The bearing provides the rotational motion of the inner cylinder without the bearing; it will not be possible for the inner cylinder to rotate inside the outer cylinder. It is of bearing no 205. Bore diameter 25mm outside diameter 52mm width 15mm. It holds the shaft and it is fixed on the shaft using bolts and nut.

CHAPTER FOUR

4.0 Result and Discussion

4.1 Result

The performance and evaluation test was carried out when the construction of the machine was completed. Each of the operation plates (grating plates, slicing plates, chipping plates) were tested one after the other in other to evaluate operation capacity and efficiency of the plate . For each test, peeled cassava of 1.5kg was fed into the feed chute and was timed to be processed within 60secs, The test for each plate was carried out three times and the average capacity was calculated in kg/hr. After each test the following result was obtained.

1 Weight of cassava processed

2 Weight of unprocessed cassava

3 Spillage of processed tuber

4 Capacity of the operation in kg/hr was noted

5 The efficiency of machine was calculated

The results obtained are as shown below

Table 4.1 Result of Machine Performance

Capacity (Kg/hr)	Operation plates	Weight of cassava processed (kg)	Spillage(kg)	Weight of unprocessed cassava(kg)	Efficiency
120	Grating plate	1.2	0.25	0.15	80
110	Chipping plate	1.1	0.10	0.20	55
40	Slicing plate	0.4	0.10	1	35

4.2 Discussion of Result

From the test result it was observed that the plates gave different capacity and efficiency result and the following were observed.

1 Plates to tuber contact

2 Moisture content of cassava tuber

3 Cutting efficiency of plate

4 Spillage of cassava pulp

5 Vibrating effect of machine

6 The size of tuber fed

7 The strength of the cutting blade of cassava slicer

4.3 Cost evaluation

This is the cost of material included in the processing per unit multiplied by number of unit produced. The table is shown below.

Table 4.2 Bill of Materials

S/No.	Materials	Quantity	Unit price	Amount (=₦=)
1	Angle iron	2 length	1500	3000
2	Mild steel sheet	1 sheet	3500	3500
3	Step pulley	1	1000	1000
4	Shaft	1	100	1000
5	Bearing	2	200	400
6	Bolts and nuts	24pcs	240	480
7	Cutting blade	2	200	400
8	Chipping plate	1	9000	9000
9	Grater plate	1	1500	1500
10	Paint	200ml	250	250
11	Thinner	1 liter	250	250
12	Electrode	30 pieces	10	300
14	Mild steel plate	1	1500	1500
	Total			22,830

Total Material Cost = **₦22,830**

Labor Cost

The project labor cost is calculated by taking 25% of the total material cost (Tyler et al., 1991).

Labor cost $\frac{25}{100} \times 25830$

$= 64457.5$

Overhead Cost

It comprises of the costs that cannot be visibly accounted for (unseen expenditure) such as transportation, consumable materials, miscellaneous costs.

The overhead cost is 10% of total material cost (Tyler et al., 1991)

Overhead cost $\frac{10}{100} \times 25830$

=₦ 2583

Total Cost

The cost of the project is given by = Material cost + Labor cost + Overhead cost.

(25830 + 2583 + 6457.5) = ₦33,319

Total cost of the project is given as ₦33,319

Note: The cost of electric motor is not added to the total cost of the project. The electric motor used for the test evaluation of the machine was borrowed from the Department of Agric and Bioresources Engineering, Federal University of Technology, Minna.

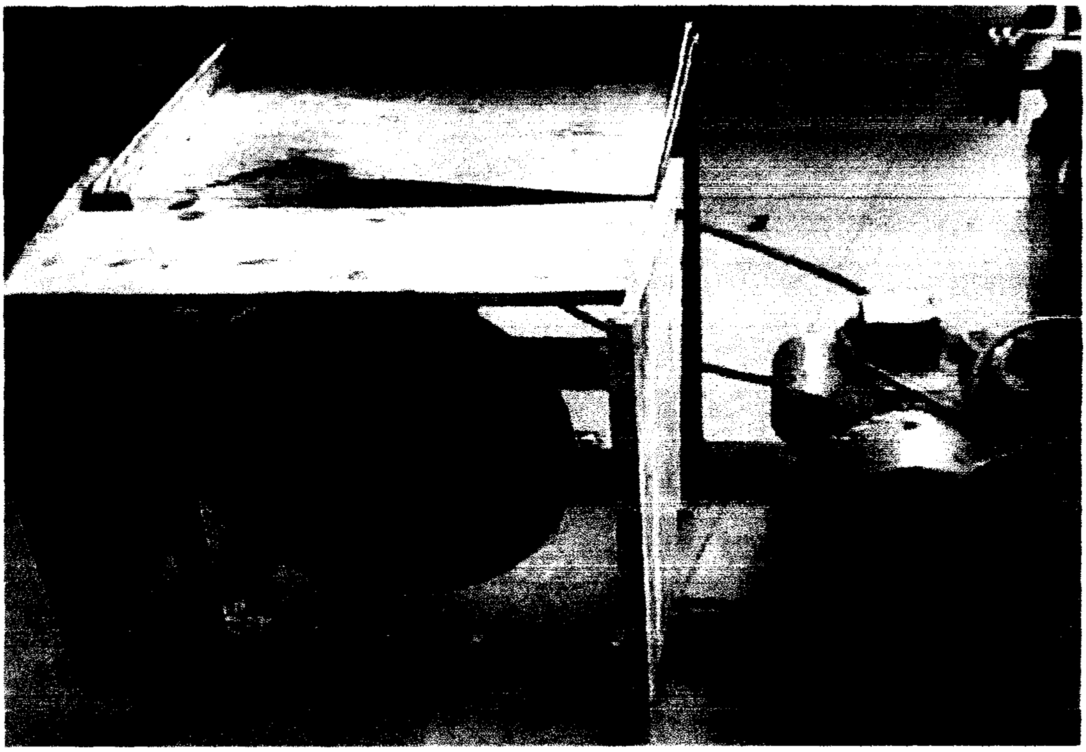


Plate 4.1 showing The Cassava Multi- Processing machine

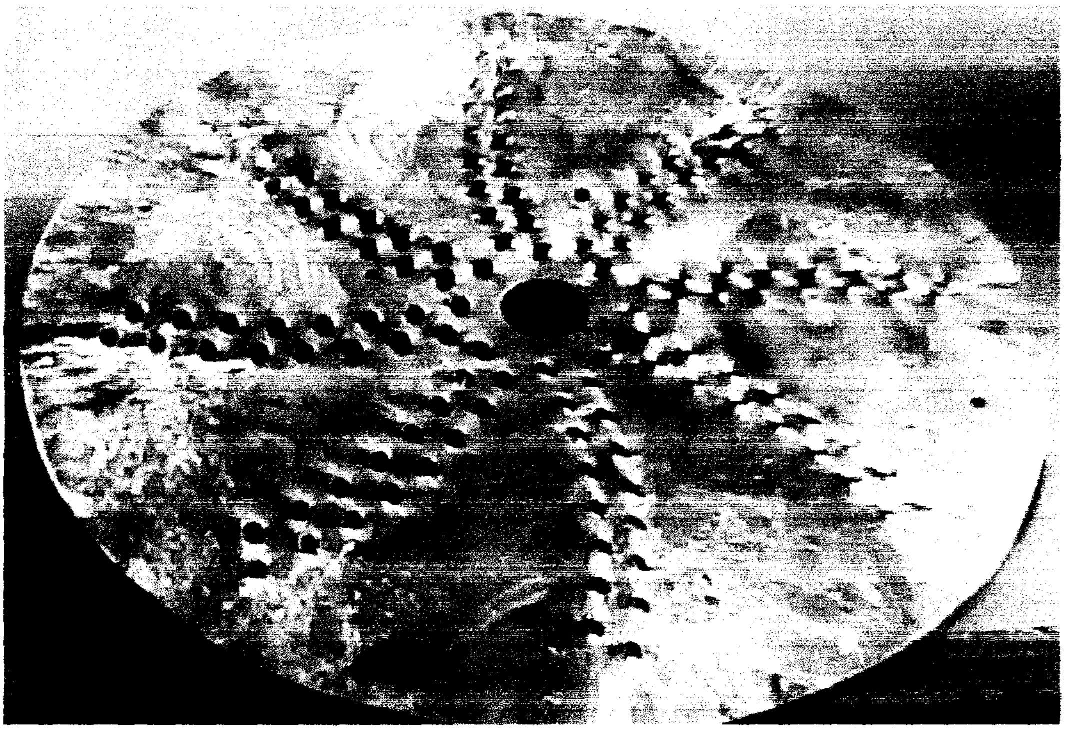


Plate 4.2 showing Cassava Chipping Plate

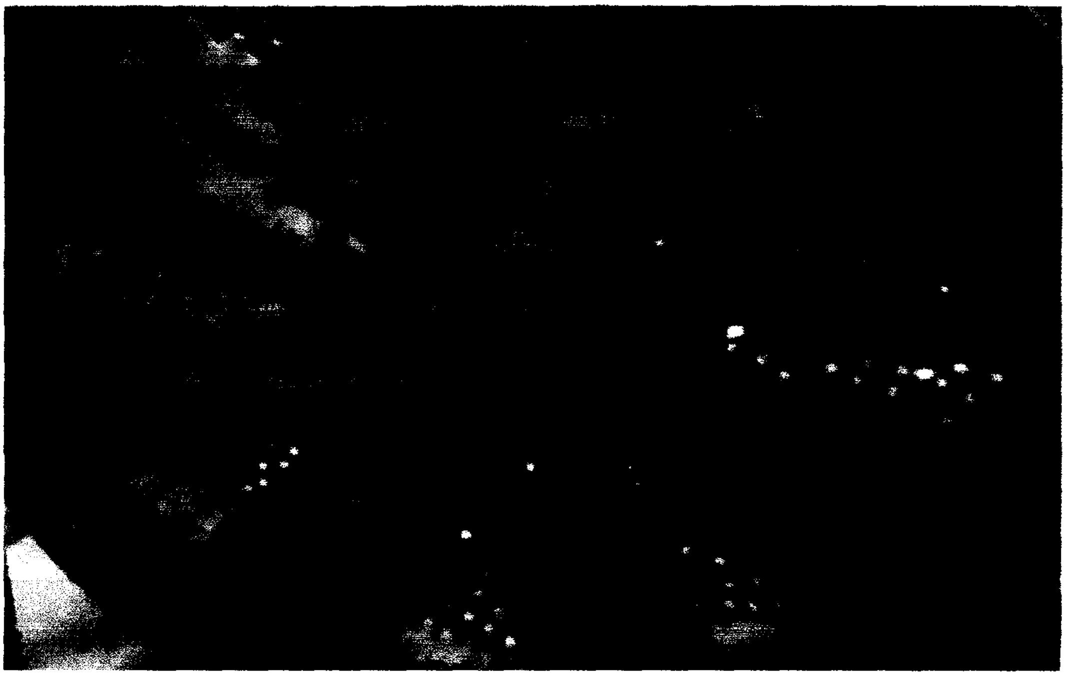


PLATE 4.3 showing Grating plate on the wheel

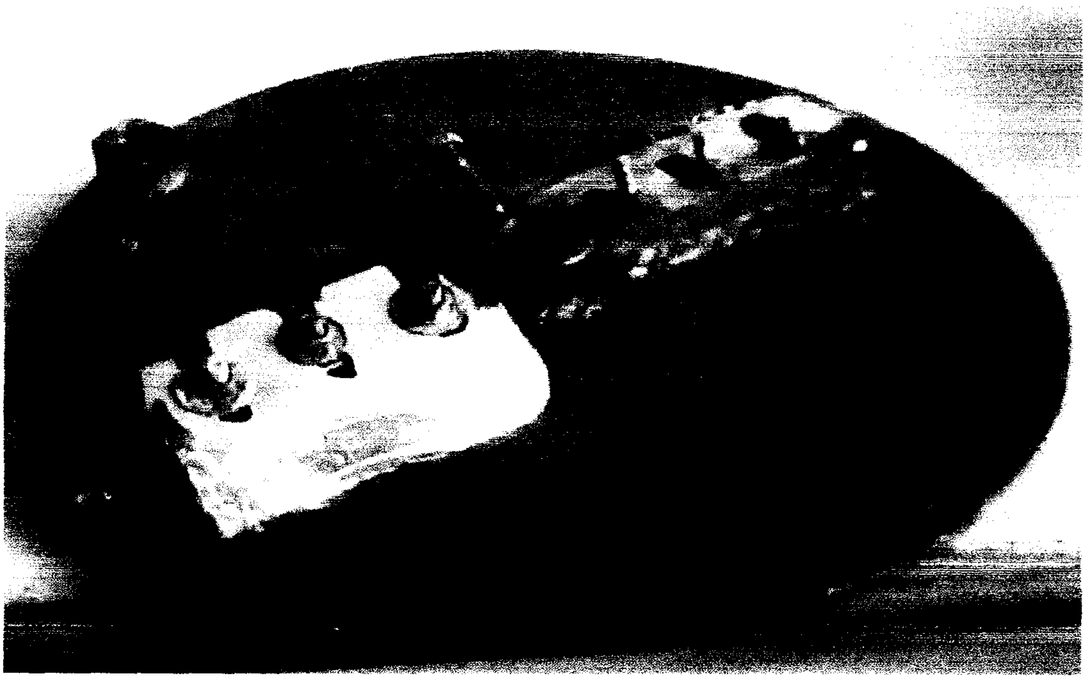


PLATE 4.4 showing Slicing plate

PLATE 4.5 Chipped Cassava sample

PLATE 4.6 Grated Cassava sample

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

A cassava multiprocessing machine using different operation plates on the same frame and the same power unit was designed, fabricated and tested. The result gotten from the test is as follows: chipping plate (capacity 110kg/hr/efficiency 65%), slicing plate (capacity 40kg/hr/efficiency 30%), grating plate (capacity 120kg/hr/efficiency 70%)

5.2 RECOMMENDATION

Based on the result, the following recommendations were made for future designs;

1 Some parts of the machine that came in contact with the tuber are made of aluminium, mild steel, galvanised steel. Future research should be made for this parts to be replaced with stainless steel

2 The efficiency can be improved upon by proper adjustments of faulty parts, Replacement of slicing blade with a more efficient blade, adjustment of the plates on the shaft to increase the plate to cassava contact which will increase the capacity.

3 The design can be improved upon using a hopper so as to reduce cassava spills during processing operation.

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APPENDIX ONE

Table 1: Average Coefficients of Friction

Surface	Wood	Mild Steel	Aluminium
Periderm	0.663	0.577	0.404
Cortex	0.577	0.532	0.344
Flesh	0.404	0.364	0.213

Table 2: Range of Rolling Resistance Coefficients (mm)

Surface	Wood	Mild Steel	Aluminium
Periderm	6.00 – 8.73	6.00 – 9.38	5.20 – 7.80
Cortex	5.91 – 8.60	5.31 – 8.60	5.03 – 7.63
Flesh	5.57 – 7.85	5.27 – 7.85	4.71 – 7.23

Table 3: Some Mechanical Properties of Cassava Tuber

Property	Unpeeled tuber	Peeled tuber
Poisson's ratio	0.38	-
Shear stress N/mm^2	3.22	0.28
Peeling force N/mm^2	0.30	-
Cutting force N	500	140
Rapture stress N/mm^2	0.90	0.70

Table 4.0: The Ultimate Strengths of some Common Materials

Material	Density (kg/m)	UTC (MN/m^2)	ULC (MN/m^2)	USS (MN/m^2)	Yield stress (MN/m^2)
Steel	7850	650	-	240	400
Cast iron	7200	200	700	250	-
Aluminui alloy	2720	400	-	250	-
Brass	8930	300	-	250	350
Concrete	2400	10	30	-	-
Glass	2200	-	50	-	-
Rubber	900	15	-	-	-

Source: Mechanical of Solids, (Roger, 1990)

APPENDIX TWO

Capacity = weight of cassava processed

Time taken

Test 1 Chipping operation

1st weight of chips gotten 1.2 kg

2nd weight of chips gotten 1.1kg

3rd weight of chips gotten 1.0kg

Average weight of chips gotten =1.1kg

Time taken= 60secs= 0.01hr

Chipping capacity = 110kg/hr

Test 2 Grating operation

1st weight of grated pulp 1.2kg

2nd weight of grated pulp 1.3kg

3rd weight of grated pulp 1.1kg

Average weight of grated pulp = 1.2kg

Test 3 Slicing operation

1st weight of cassava slice 0.40kg

2nd weight of cassava slice 0.35kg

3rd weight of cassava slice 0.45

Average weight of slice gotten= 0.4kg

Slicing capacity= 40kg/hr

$$\text{Chipping Efficiency} = \frac{\textit{weight of good chips}}{\textit{weight of total chips gotten}} \times 100$$

Weight of good chips gotten 0 .66kg

Weight of total weight of chips gotten

Chipping efficiency = 55%

$$\text{Grating efficiency} = \frac{\textit{weight of grated cassava}}{\textit{weight of total cassava}} \times 100$$

Average weight of cassava grated 1.2kg

Weight of cassava gotten 1.5kg

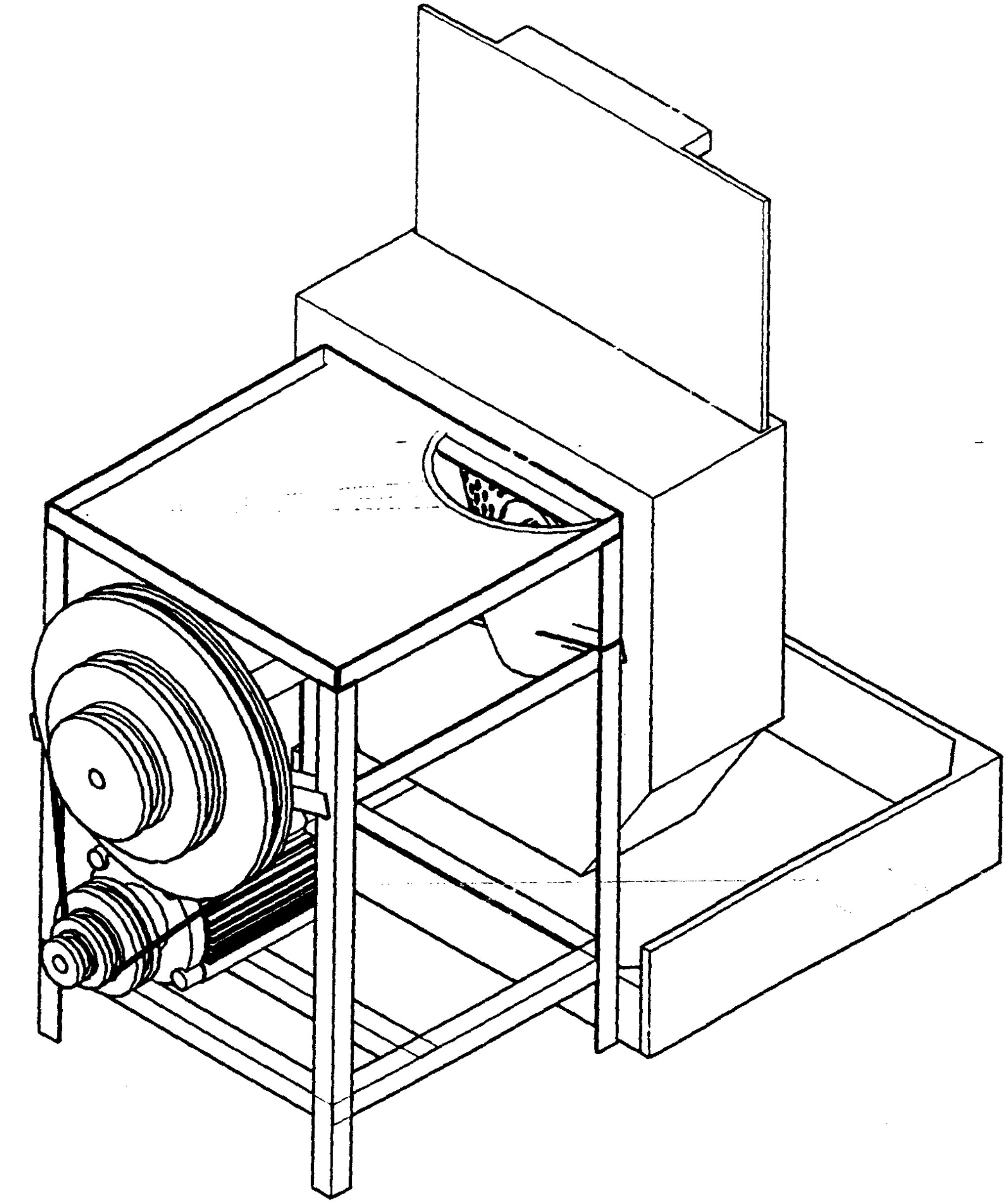
Grating efficiency 80kg

$$\text{Slicing efficiency} = \frac{\text{weight of good cassava slice}}{\text{weight of total cassava slice gotten}} \times 100$$

Weight of cassava sliced 0.4kg

Weight of good lice 0.14kg

Slicing efficiency = 35%



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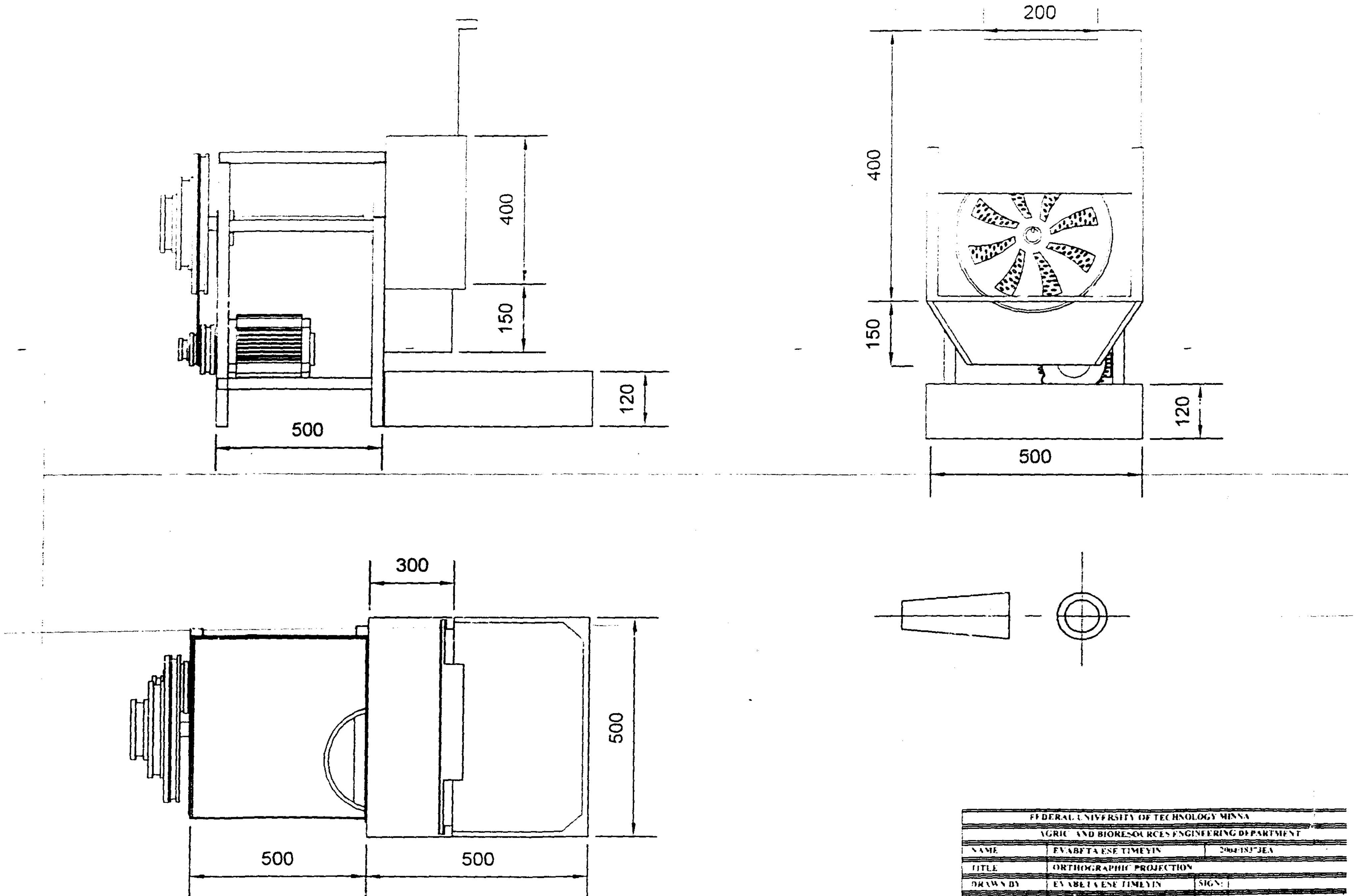

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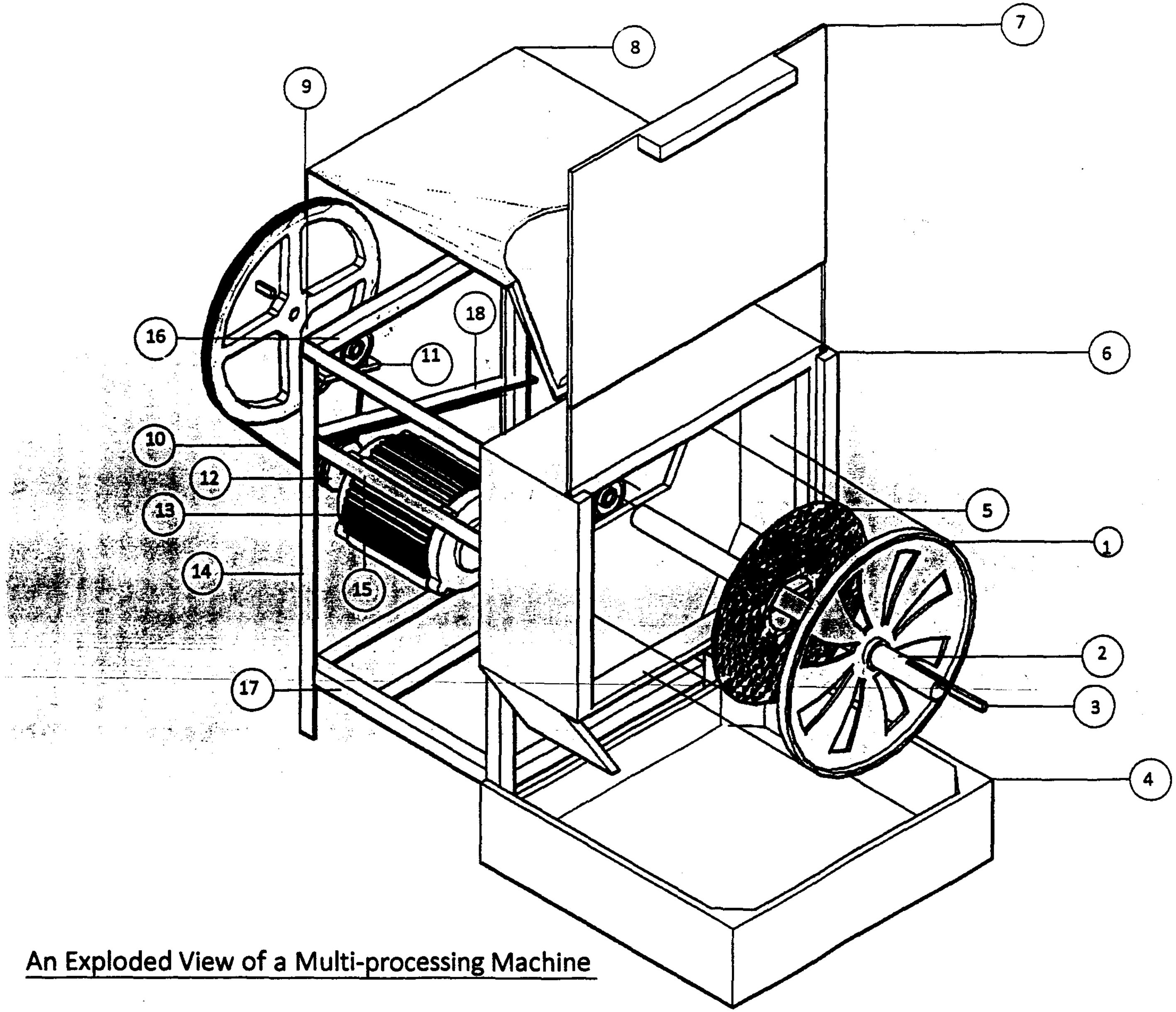

An Exploded View of a Multi-processing Machine

COMPONENT PARTS LIST

Items	DESCRIPTION	QTY
1	CHIPPER MOUNTING PLATE ASSEMBLY	1
2	SHAFT 30Ø x 560 lng. CRS	1
3	KEY	2
4	COLLECTION CHAMBER	1
5	CHIPPER PLATE, STANDARD	1
6	VERTICAL CHAMBER	1
7	VERTICAL CHAMBER COVER	1
8	TOP PLATE WITH FEED CHUTE Ga. 20 G.I. Sheet	1
9	DRIVEN PULLEY, 140 Ø Sect. 'B'	1
10	V-BELT, Sect. 'B'	1
11	PILLOW BLOCK BEARING, 30Ø	2
12	DIVER PULLEY, 60 Ø	1
13	ELECTRIC MOTOR	1
14	VERTICAL FRAME, 5 thk. x 25 M.S.	4
15	CONNECTING FRAME 5 thk. x 25 M.S.	1
16	TOP FRAME 5 thk. x 25 M.S.	4
17	REINFORCEMENT FRAME 5 thk. x 25 M.S.	4
18	MOUNTING FRAME 5 thk. x 25 M.S.	2

ALL DIMENSIONS IN MM

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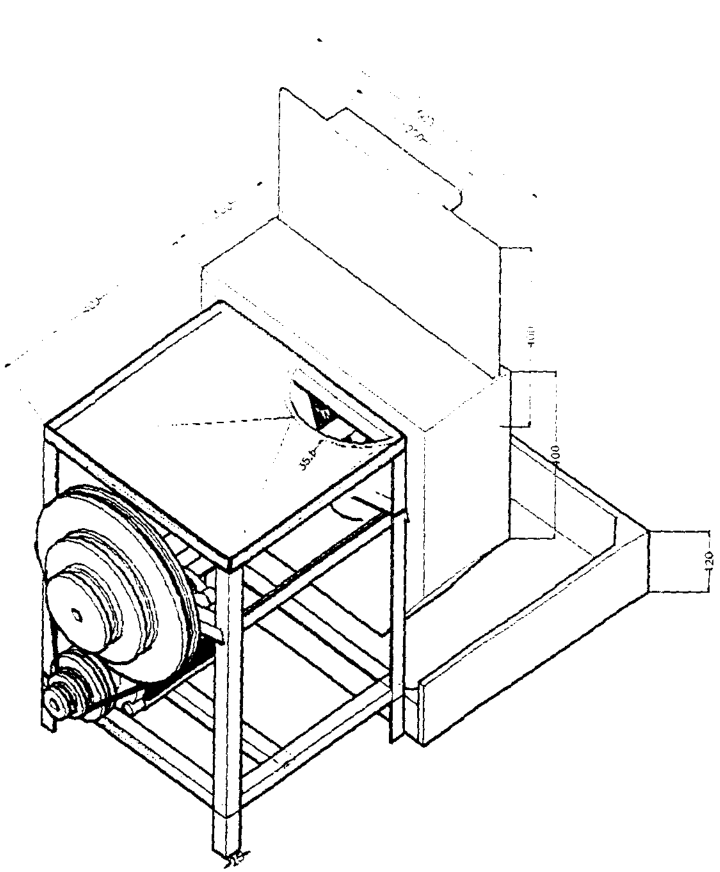

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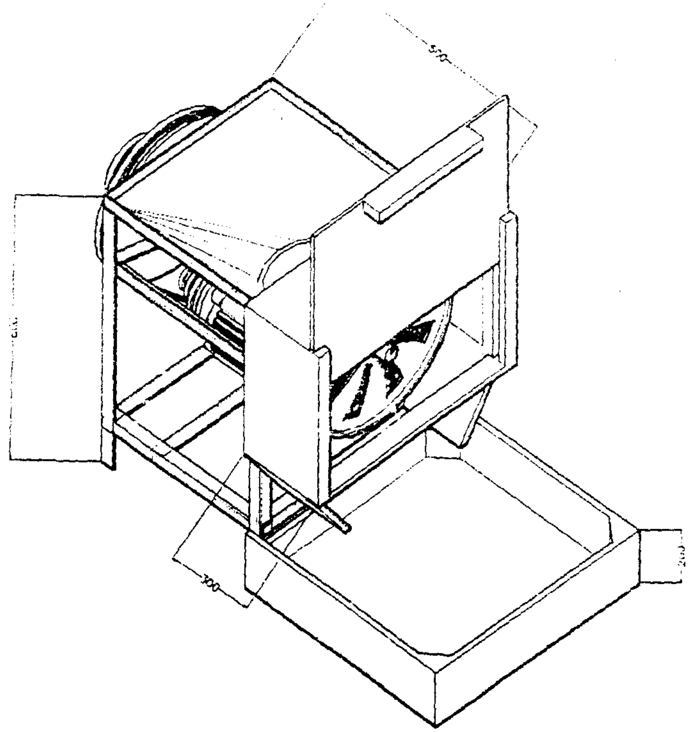

BACK

ISOMETRIC VIEWS

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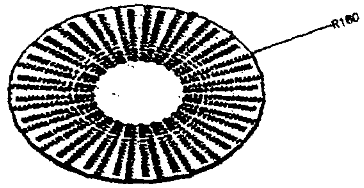
drawn: EVABETA ESE .T.	department: Agric/BioResources Engeering
checked: ENGR. PETER IDAH	matriculation number: 2004/18373EA
date: 05/01/10	ALL DIMMENSION IN MM



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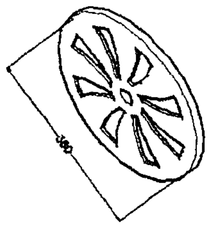
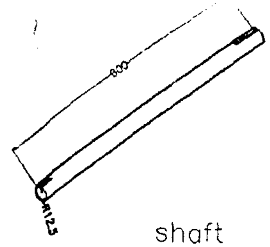
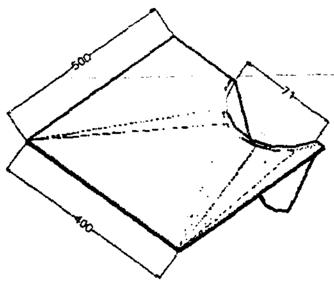


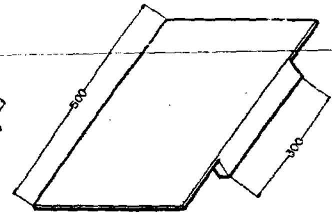
wheel



shaft



top plate and feed chute



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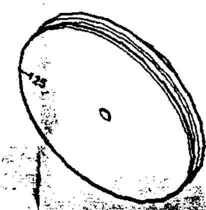
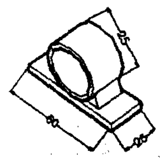
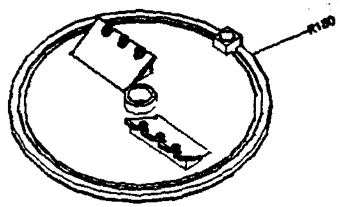


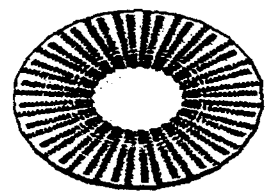
pulley



pillow block bearing



slicing plate



Grating plate

part drawing

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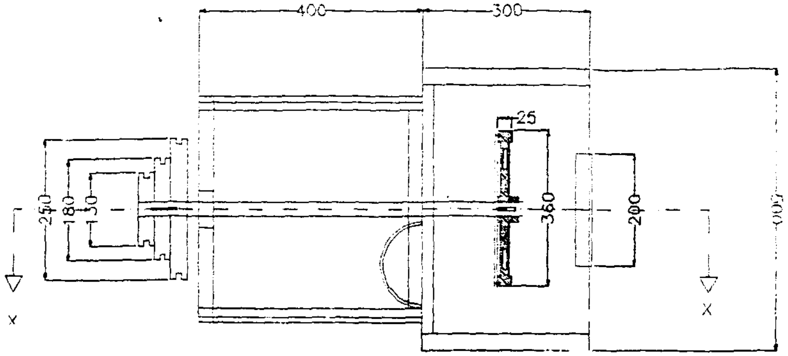
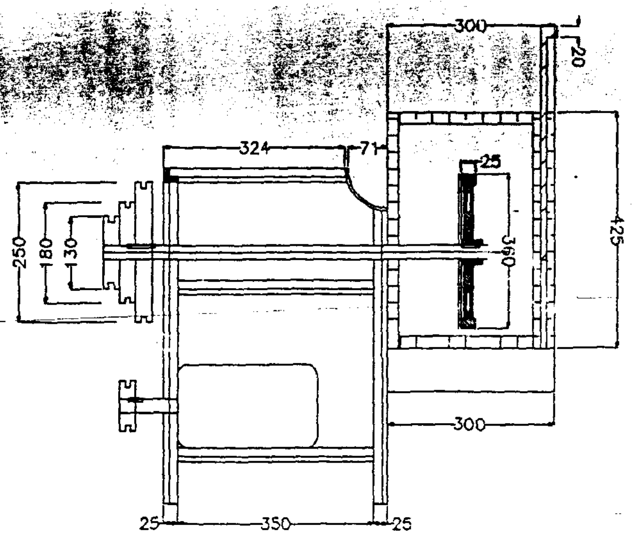


top view



SECTION X-X

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA	
designed by: EVABETA ESE .T.	project: DESIGN AND FABRICATION OF A CASSAVA MLTPROCESSING MACHINE
drawn: EVABETA ESE .T.	department: Agric/BioResources Engeering
checked: ENGR. PETER IDAH	matriculation number: 2004/18373EA
date: 05/01/10	title of drawing: orthographic/sectional drawing — scale: 1:1