DESIGN AND CONSTRUCTION OF MANUALLY OPERATED CASSAVA CHIPPING MACHINE

BY

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CERTIFICATION

This is to certify that this project work was carried out by Busari, Rasheed Amao in the department of Agricultural Engineering, Federal University of Technology, Minna, Niger state.

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DEDICATION

This work is humbly dedicated to almighty God who has been with me throughout the duration of this programmed. Also dedicated to my beloved parent Alh (chief) Busari Agoro and Mrs Hassanah Busari

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Glory and honour be unto Almighty God for his infinite mercies, blessings and protections over me throughout the duration of this programme. My sincere gratitude goes to my Project Supervisor Engr. Fatai Akande, whose immense contribution, information and supervision had led me to the success of this project from planning, design stage and finally to construction stage.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Design and fabrication of Cassava Chipping machine was made mainly from locally available materials. Reducing the size of tubers to be processed into a food product which requires fermentation and drying has been recognized as an effective method of reducing processing time and improving the quality of the products. The machine gave capacity of 100Kg of peeled cassava per hour with minimum amount of sub-standard (or fine) chips and the chipping efficiency is 80% while uniformity index is 0.7. Using the equipment, chipping can be accomplished with relative ease and subsequent operations can be done more quickly. Fermenting time traditionally require 4-5 days and has been reduced to 1-2 days. Chipped material dried in 8-10 hours depending on the loading density and weather condition. The chips dry uniformly, whitish with sweet floury aroma and are friable.

CHAPTER ONE

1.0 INTRODUCTION

Presently in Nigeria, significant portions of preserving our farm products such as yam, cassava, potato and sweet potato, are still below expectation. Also, the expected revenue that needs to be generated by preserving these products is below what is being generated due to lack of preserving and unsafe keeping.

Cassava is widely grown in Nigeria, being one of the major stable crops in many parts of the country. The extremely perishable nature of cassava tubers poses a serious problem to storage. Cassava tubers once detached from the growing plant will not normally keep for more than a few days (40-48 hours), before deterioration gets in. the deterioration is caused by microbial infections and physiological factors like loss of moisture. Also, processing is necessary to eliminate or reduce the poisonous cyanide contained and to improve palatability of the food products (Kwatia, 1986).

However, the importation of wheat in sub-Saharan Africa has significantly increased in the past 10 years and the depreciation of Africa currencies during the same period has made such importation a heavy burden on the local economies. At the same time, cassava production in the region has increased substantially. Many studios have demonstrated the technical feasibility and economic advantages of using cassava as a partial or total replacement for wheat in bread – making (F.A.O., 1992).

These traditional products have the advantage that they can be produced relatively cheaper using less sophisticated equipment. However, the major draw backs associated with them is that the flour is not of a high quality for use in other food products (e.g. bakery products) and the methods used are labour intensive (Smith, 2000).

The few methods currently available for processing roots and tubers limit these crops from reaching their full potential as a source of both food and income. Development and introduction of new processing technologies offers the potential to improve access to markets for cassava producers thereby increasing their incomes.

Chip production is relatively simple. It calls for no major investments and provides an effective means for producers to boost the value of their crop. Yam chips are stabilized products with a moisture content of around 12% and can be kept for up to a year when stored under insect-proof conditions. The cassava chip produced by the chipping machine dry quickly, are of high quality, reduce labour input involve in processing, easy to transport to the market, contains less cyanide and have improved palatability. The crop has about 69% moisture content and transportation from the rural area to urban area for marketing is usually difficult. The processed product are easier to store, than the raw cassava, they need less storage space and can be stored for a longer period of time.

A method that was found efficient in hastening the dry rate and improving the quality of product is chipping the tuber into smaller pieces called "chips".

In recent years, the consumption of leavened wheat bread has rises enormously in Nigeria as a result of increasing populations, urbanization and changing food habits.

However, Nigeria for climatic reason cannot grow wheat suitable for bread making and relies on expensive wheat imports, paid for with scarce foreign currency. The first attempts to effectively reduce the outflow of funds towards temperate countries were aimed at the partial substitution of wheat flour with flour from indigenous crops such as cassava and yam (Smith, 2002).

Also cassava chips are used in the 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).

1.1 Justifications for the Study

The development and introduction of this new processing technology "***Cassava Chipping Machine***" offers the potential to improve market for cassava producers thereby increasing their incomes. This method which was found efficient in time of hastening drying rate is cutting the tuber into chips, increase labour productivity and improve product quality, chips produced are of full potential as a source of both food and income.

Rural – urban drift is also counter-balanced by new income perspectives in the villages and to enhance the availability of raw materials to feed the cassava processing industries.

1.2 Objective of the Project

The objective of this project is to improve the existing slicing of tubers with knives to cassava chipping machine (Manually powered). This is achieved by design and construction, using mostly local available material for cassava chipping machine for the rural community and to carry out test and performance evaluation of cassava chipping machine.

CHAPTER TWO

2.0 LITERATURE REVIEW

The growing urban population in Africa represents a vast potential market for local food crops, provided that stable processing transport and marketing networks can be established between rural and 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 quantities 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 carbohydrate/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, and 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 restrict 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 restrict its uses.

2.1.0 Existing Cassava Chippings Machine

Some designs for chipping machine are already available from southeast Asia, especially Indonesia, Malaysia and Thailand (Ajibola et. al, 1987).

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 these machines are usually irregular. The demand for chipping machine in Nigeria indicates that there is support for local production of machine. Hence the focus on the development works at Obafemi Awolowo University, Ile-Ife, Nigeria (Ajibola et. al, 1987).

(Aseogwu, 1981) has studied the growing habit and responses of cassava tuber in creep and stress relaxation and has proposed model to represent those "behaviour" He measured such properties as stress relaxation modulus and creep compliance.

(Igbeka, 1984) has also conducted extensive work on the mechanical and rheological properties of cassava. He has studied such properties as modulus of deformation, shear strength, hysteresis loss, degree of elasticity and failure energy as affected by moisture content.

2.2.0 Cassava as a Crop (*Manihot Esculenta)*

Cassava is the major stable food crop 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 glucoside 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 influenced by the location where is planted (Elsevier, 1989).

2.2.1 Climate

Cassava does well in warm area, with an average daily temperature of 25-29^{0}C and it needs a minimum of 500mm of well distributed rainfall. Otherwise, the crop can adapt itself to wide variety climate and soil. It is also draught resistant, but if draught continues for several months this will affect the yield. Cassava cannot withstand frost. Variations in day and night temperatures promote carbohydrate storage in the tubers (Elsevier, 1989).

2.2.2 Soil

The crop responds well to soils with a good structure, a good internal drainage and a high organic matter content. Fairly light soil is needed for root formation. The pH may vary between 5 and 9. If the pH is lower than 5 liming is necessary (Elsevier, 1989).

2.2.3 Planting and Planting Material

The land should be hoed or ploughed well and mounds or ridges prepared because this make digging easier at harvest time.

The plants are propagated vegetatively. Any mature part of the stem is suitable for cuttings; the middle portion is the best, while use of the top part should be avoided. Cuttings are 20-30cm long and contain 4-6 nodes. Planting material should be taken from virus free plants cuttings can be planted in a vertical, oblique or horizontal position. A spacing of 1metre x 1metre is generally used where cultivation is done by hand, but the spacing can be changed to suit mechanical cultivation methods. One hectare of cassava can supply planting material for 3-4ha.

2.2.4 Growth Period

Growth period varies between 12 and 24 months. In case of direct consumption, cassava is usually lifted about 12 months after planting. For industrial processing, this is done at a later stage when the crop is 16-20 month old. (Elsevier, 1989)

2.2.5 Plant Population

Plant population is between 10,000 and 30,000 plants/hectares (Elsevier, 1989).

2.2.6 Fertilizer Requirements

Cassava is not very exacting in its fertilizer requirement. In case of intensified agriculture a considerable amount of fertilizer is needed, especially nitrogen and potassium. The nutrient removed by a crop of 20 tonnes of roots per hectare are 125kg of N, 30kg of P_2O_5, 150kg of K_2O. (Elsevier, 1989)

2.2.7 Weed Control

Mechanical weeding are not advisable since the root system of cassava is rather superficial. At least two precisely timed weeding are needed to achieve optimum yield. Early weeding is important in cassava production.(Elsevier, 1989).

2.2.8 Pests and Diseases

Pests, Red mites are widespread. Rot attaching grubs are frequently reported. Monkeys, wild pigs and rodents feed on the roots. Green spider mite has become a major pest in Africa. Some control is achieved by varietal resistance and introduction of natural enemies. Diseases; Mosaic Virus (Manihot Virus) transmitted by white flies (Bemisia spp) is the main disease.

There are disease tolerant cassava varieties. Bacterial wilt is also well known to cause severe yield losses. (Elsevier, 1989).

2.2.9 Yields

The average world yield is about 10 tonnes/ha but varies greatly from 7t/ha (Zaire) to 19t/ha (India) under suitable climatic conditions and with proper cultivation practice yield and reach 25 tonnes of roots/hectares (Elsevier, 1989).

2.2.10 Harvesting

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

2.2.11 Labour Requirement

Depending on the type of soil, from 90 to 120 man – days/ha are required, provided soil preparation is done mechanically. Home processing may take a further 200 man – days/ha (Elsevier, 1989).

2.2.12 World Production

Table 2.1 The world's greatest producers of cassava in order of importance are:

Brazil	24,935 thousand tones per year
Indonesia	13,100
Thailand	12,500
Zaire	12,000
Nigeria	11,500
India	6,053

Total world production is 117,201 tonnes per year (Macdonald and Low).

In West Africa, the four leading producers, in order are Nigeria, Ghana, Cameroon and Togo. Most of the cassava produced in West Africa is consumed locally and very little of it enters into international trade (Macdonald and Low, 1984)

2.3.0 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 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 world's total cassava production is in Africa and its has been estimated that 37% of the energy in the diet in tropical comes from cassava (UNIFEM, 1989).

Chemically cassava is composed of water (60-70%) and starch with minor amount of protein, fiber, mineral, vitamins and toxic component linamarin – a cyanide containing glycoside. The presence of this toxic tractor demands special processing procedures 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 cyanide. During subsequent fermentation stages, almost a total breakdown of the glycoside occurs and the final frying, roasting or boiling step drives off the hydrogen cyanide.

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 Gari (West Africa), Fufu (Nigeria, Ghana, Zaire), Chikwange

(Central Africa), Lafun (Nigeria), starch etc. Almost every household in rural Nigeria is involved in one or another form of cassava processing to satisfy the household 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 a 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.

2.4.0 Objectives of Cassava Processing

Cassava processing activities are undertaken 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 24-48 hours of harvest (Cock, 1985).
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.

3. Removal of the inedible parts.
4. Processing leads to the conversion of the perishable roots into stable products of prolonged shelf life.
5. Processing also improves palatability and increase variety in the diet by providing a range of attractive flavours, colours, aroma and texture in food.
6. Reduce transportation cost because cassava is bulky and heavy hence expensive to transport over long distances.
7. Provide raw materials for small – scale cassava based rural industries.
8. Improve the net economic value of the product by raising its quality.

2.5.0 Principle of Processing Techniques

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

2.5.1 Peeling

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

2.5.2 Washing

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

2.5.3 Drying

Drying is the elimination of excess water from the material in order to bring the total moisture content to a level considered to be 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, have 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 be taken in and out, or left in the rain causing harmful deterioration and loss of quality due to formation of fungi.

2.5.4 Grating

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

2.5.5 Frying or Roasting

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

In gari processing, proper roasting is important to ensure a good quality product. Both frying 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.

2.5.6 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 rapidly throughout Nigeria, resulting in every village having one or a few millers who perform custom service at fixed charges. After preliminary processing, including slicing or shredding and drying, the cassava roots can be grind to a floor which are being used in many traditional dishes such as fufu, lafun etc. Also pounding changes the texture of the previously prepared cassava to a more palatable, paste-like consistency

2.5.7 Sieving

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

2.5.8 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 root releasing hydrogen cyanide. The condition at the end of this first stage allow the growth of a range of microorganism that produce compounds which give gari its characteristics flavour. Much of the cyanide is lost during fermentation, the remainder being largely driven off during the final roasting step.

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

2.5.9 Dewatering

Dewatering as the name implies, involves the removal of internal liquid from the 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 method uses presser such as screw press or hydraulic press.

2.5.10 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.

2.5.11 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.

2.5.12 Chipping

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

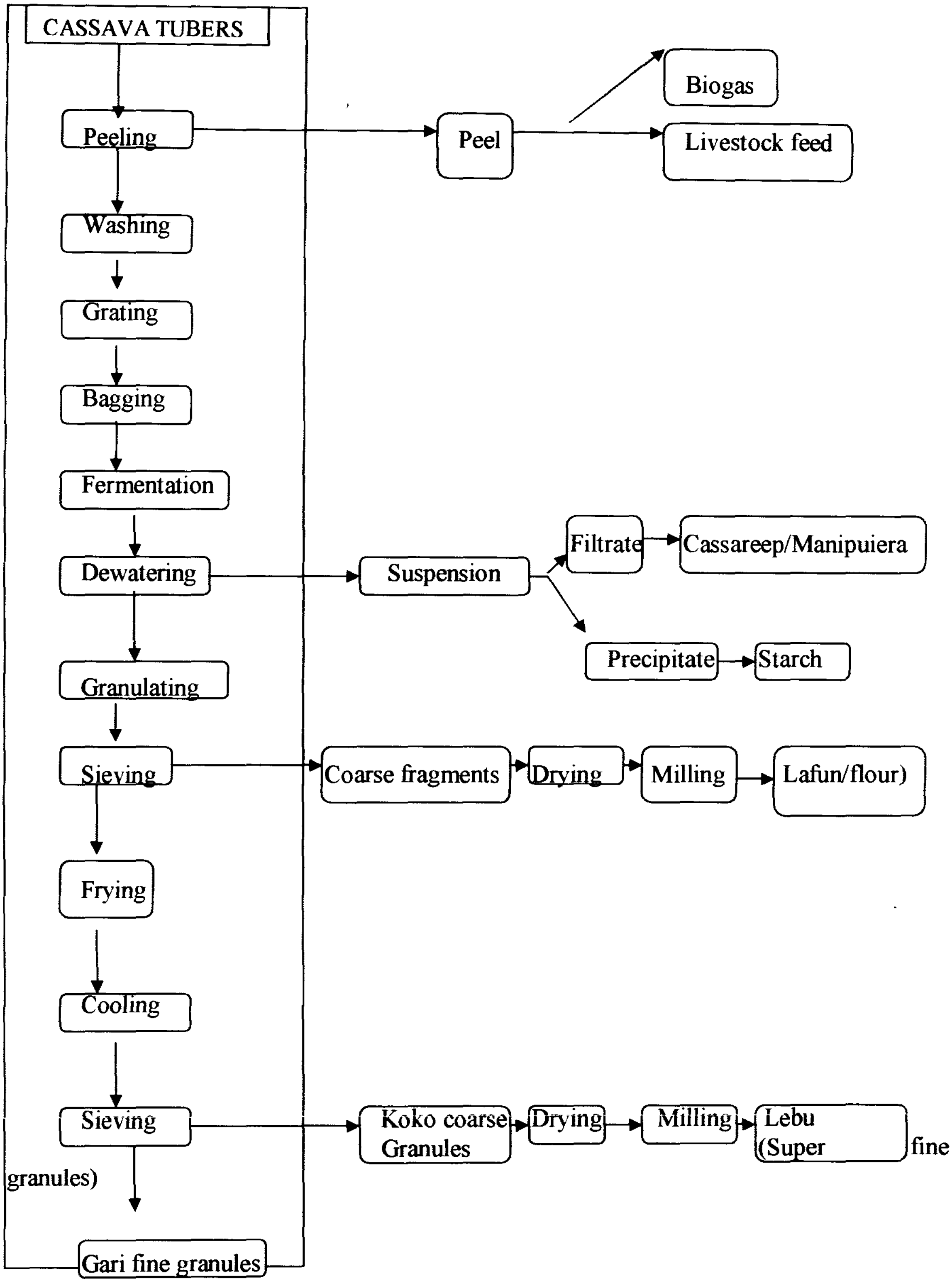


Figure 2.1: The by-products of gari processing (Oyewole et al, 1986)

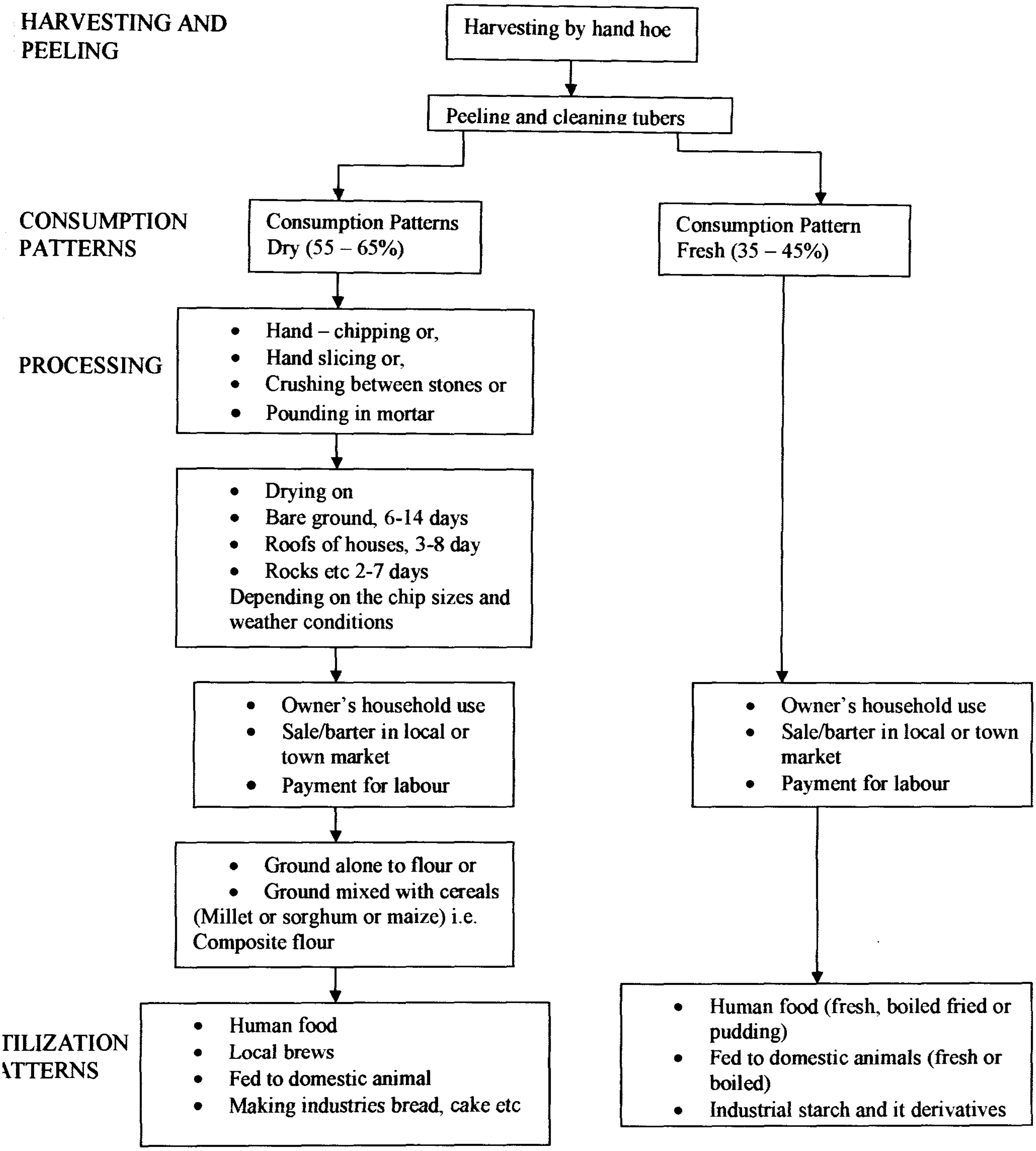


Figure 2.2: Flow chart on traditional processing and utilization patterns for cassava in Nigeria villages. *(Kwatia, 1986)*

CHAPTER THREE

3.0 METHODOLOGY

3.1 system design

Production design is the critical link between the chain of events that start with a creative idea and ends with a successful market product.

3.1.1 Material Selection

An improperly chosen material can lead not only failure of the parts or component, but also to unnecessary cost. Therefore, the selection of an appropriate material is part of the design process and the responsibility of the designer. The success of a design depends much on the choice of material which is often the most important deign problem.

Materials are selected to provide characteristics that are essential to design and also desirable. It is also very important to make an intelligent choice of the best material to serve the design need. Also it is important to give careful thought to the factors that will have a bearing on the successful performance of the part that is made. Most often, the choice of materials dictates the manufacturing process to be used and the manufacturing cost of the product.

3.1.2 Selection of Appropriate Material

Successful material selection depends on the ability to satisfy the mechanical properties and factors, the following principal selection factors are:

(i) Mechanical properties (i.e. strength, durability)

(ii) Finishing and coating

(iii) Composition and density

(iv) Machinability

(v) Economy (i.e. material and production cost)

3.1.3 Steps of Materials Selection

(a) Analysis of material required – this includes mechanical properties and composition

(b) Identification of alternative materials

(c) Selection of the best materials

(d) Development of design, data for critical application

3.2 Machine Component

The cassava chipping machine is a machine designed for easy cutting of chips, such as yams, cassava, potato, sweet potato etc. The machine is hand-driven operation (manual). The machine consist of the following components feed chute, chipper plate, chipper mounting plate (chipping wheel), shaft, bearing and frame.

3.2.1 Casting (Chipping Wheel and Feeding Chute)

It is one of the important manufacturing processes used in mechanical engineering. The casting are obtained by remelting of ingot in a cupola or some other foundry furnace and the pouring this molten metal into metal or sand moulds. The various important processes for casting cassava chipping wheel and feed chute are;

(i) sand mould casting. The casting produce by pouring molten metal in sand mould called sand moulding casting. It is particular used for part of larger sizes

(ii) Permanent mould casting produce by pouring molten metal in a metallic mould is called permanent mould casting. It is used for casting aluminum pistons, cooking utensils.

3.2.1.1 Advantage of Casting

- it gives better surface smoothness
- the dimension may be obtained within tolerance
- complex shape can easily be easily produced
- the production rate is high

3.2.1.2 Disadvantage of Casting

- casting are costly
- only non-ferrous alloys are casted more economically
- it requires special skill of operation

3.2.1.3 Casting Design

An engineer must know how to design the casting so that they effectively and efficiency render the desired service and can be produced easily and economically. In order to design casting, the following factors must be taken into consideration;

- the function to be performed by the casting
- the soundness of the casting

- strength of the casting
- ease in its production
- consideration for safety and economy in production

In order to meet these requirements, a design engineer should have a thorough knowledge of production method including pattern making, moulding, core making, melting and pouring etc.

The best design will be achieved only when one is able to make a proper selection out of the various available methods.

3.1.2.4 Material Used For Casting

Aluminum is an element of the metal family known for its electrical conductivity, heat conductivity, and resistance to corrosion and light weight. In its pure form, the metal has a white colour. The melting point of aluminum is 660° C and the density of Aluminium is $2700 kg/m^3$

3.2.2 Feed Chute

Feed chute is in shape of a funnel or a frustrum cut in a slanting form, to give certain angle of inclination to chipper plate. This chute is bolted to the frame

3.2.2.1 Design of Feeding Chute

Feeding chute in a chipper is a component on which material to be chipped is first fed to the chipping mechanism.

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

- comfort in feeding
- regulate rate of feeding
- volume

3.2.2.2 Comfort for the Operator

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

3.2.2.3 Ease of Feeding

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

3.2.2.4 Volume

This is the capacity of feed chute; it should be designed by considering the physical parameters of the material to be chipped so as to achieve an optimum feed rate.

3.2.2.5 Advantage of Feeding Chute

(1) Ease of feeding the cassava, since feeding chute is inclined to the chipper plate

(2) The volume is average size of cassava

(3) Comfortable while feeding

(4) Greater chipping is achieved as a result

3.2.2.6 Disadvantages of Feeding Chute

(i) Greater labour is involved in casting

(ii) The cost is higher

3.2.3 Chipping Plate (Stainless Steel)

Stainless steel as that steel which when correctly heat treated and finished, resists oxidation and corrosive attack from most corrosive media. These steels are very tough and can be forged and rolled but after difficulty in machining. They can be easily welded, but after Welding, is susceptible to corrosive attack in an area adjacent to the weld. This susceptibility to corrosion is called inter-crystalline corrosion or weld decay. The steel provide excellent resistance to attack by many chemicals, it is extensively used in chemical, food, paper making, and dyeing industries. It has density of about 7900kg/m^3

The chipping mechanism is made from stainless steel of high tensile sheet of about GA 24, cut into circular plate 360mm diameter, and pressed to form alternative 4mm deep concentric grooves. Two rows of alternative punches of 10mm apart are made on each grove along eight equidistant radial line. (the punches or holes are 8 holes per row and 2 rows on each groves, the first and second row are arranged in special way) which make it 16 punches per groves for the eight, groves the total punches is 128 punches.

3.2.4 Chipping Wheel

Chipping wheel 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 chipper plate and to excrete chips of chipping mechanism.

3.2.5 Shaft

The shaft was made of mild steel rod of 25mm diameter and 400mm long, it is this shaft the carries the two bearing, the wheel, handle and chipper plate.

3.2.6 Frame

The frame structure of the machine are made up of mild steel (angle iron 1.5x1.5) cut into various size required or according to the dimension and joined by first tacking it and later welding. The frame dimension is 500 x 300 x 500mm.

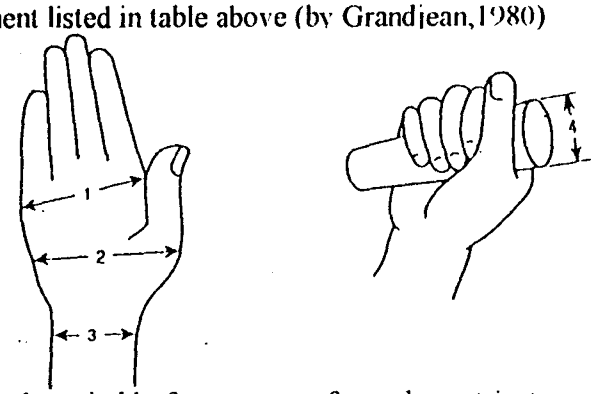
3.3 Design of Handle

In the design and evaluation of manually operated machine, tools control or machine guards. The sizes of different limbs must be considered that is hand size of user population.

Table 3.1 Indication of measurement

Measure ment No	Part of hand measured	Men	Women		
		Mean cm	90% confidence interval	Mean Cm	90% confidence interval
1	Circumference of hand	21.1	19.3-23.0	18.7	17.5-20.1
2	Breath of hand	10.6	9.8-11.3	-	-
3	Circumference of wrist	17.1	15.5-18.8	16.1	14.3-17.9
4	Maximum grasp circumference	13.4	12.0-15.3	-	-

Indication of measurement listed in table above (by Grandjean,1980)



Equipment must be suitable for a range of people, not just people with average dimensions. Anthropometric data are, therefore usually presented as means with standard deviations or percentile values. Based on the above data the handle of cassava chipping machine was design to be 3.8 cm (38mm)

3.3.1 Design Calculation

Handle

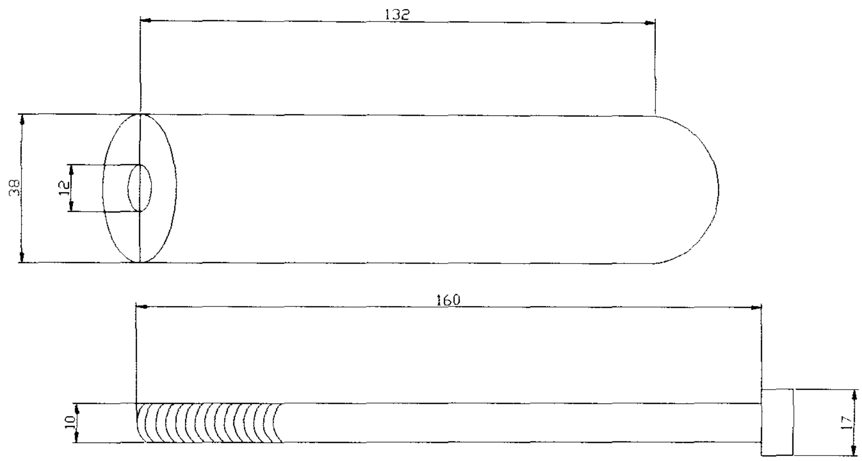


Figure 3.1 Handle of the machine.

The area of hollow wood = area of major diameter – area of minor diameter

Area of major (wood) $= \pi r^2$

$= 3.142 \times (19)^2$

$= 1134.262 mm^2$

Area of minor (wood) $= \pi r^2$

$= 3.142 \times (6)^2$

$= 113.112 mm^2$

Hence $(1134.262 - 113.112)\ mm^2$

Area of hollow wood $= 1021.15 mm^2$

Volume of hollow wood = 1021.15 x 132

$= 134791.8mm^3$

Density of wood (Sapele mahogany) = $640.13kg/m^3$

Mass = volume x density

= 1.347918 x 10 -4 x 640.13

Mass of wood = 0.08628kg

Area of Bolt $= \pi r^2$

$= 3.142 \times (5)^2$

$= 78.55mm^2$

Volume $= \pi r^2 l$

Volume of boil = 78.55 x 160

$= 12568mm^3$

Mass = volume x density

Density of mild steel = $7840kg/m^3$

Mass of bolt = 1.2568 x 10-5 x 7840

= 0.09853kg

Mass of the handle = Mass of wood + Mass of the bolt

= 0.08628 + 0.09853

= 0.18kg

3.3.2 Design of Chipping Wheel

The diameter of flat pulleys normally ranges from 40-5400mm (Khurmi &Gupta,2004). This design adopted an pulley (wheel) diameter of 380mm. the thickness of the wheel was determined from the relation $t = \frac{D}{300} + 6m$ (Khurmi & Gupta, 2004)

Where; D = diameter of the wheel = 380mm t =(380/200) + 6mm

t = 7.90mm

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

Dimensions of arms

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 = 12.73Nm

R – Radius of pulley = 0.19m

N – Number of arms = 8

$$= \frac{2 \times 12.73}{0.19 \times 8}$$

Wt = 16.79N

Maximum bending moment (M)

M = 2T/ n = 2 x 12.73/8 = 3.18N

Section modulus

$Z = \pi/32 \times b_i x\ a_i^2$

Where;

b_i minor axis (60mm)

a_i major axis (25mm)

$Z = \pi/32 \times 0.025 \times (0.06)^2$

$Z = 9 \times 10^{-6}\ m^3$

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 x 20 + 25

dh = 55mm

The length of hub (L)

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

$L = \pi/2 \times d$ where d = diameter of the shaft

L = 3.142/2 x 20

= 31.42mm

3.3.2.1 Weight of The Wheel

The wheel comprises of the Rim, Hub and Arms.

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

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

D1 major diameter, r_1 = D1/2, 55/2 = 27.5mm

D2 minor diameter r_2 = D2/2, 22/2 = 11.2mm

= 22/7(27.52-112)

A =1996.5mm^2

Volume of Hub = 1996.5 x 55 = 109807.5mm^3

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

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

D1= the major diameter = 380mm, r_1 = 190mm

D2= the minor diameter = 368mm r_2 184mm

$A = 22/7(190^2 - 184^2)$

= 7052.57mm^2

Volume of the rim = Area x thickness

= 7052.57 x 23

= 162209.14mm^3

Area of the rim = total area of the arm – removed area

Total area = πr^2

r = 190- 27.5 = 162.5mm

$22/7(162.5)^2 = 82991.10\ mm^2$

Removed area (area of sector x 8)

Area of a sector = $\dfrac{\theta x\ \pi r2}{360}$

θ=22.5degres, r = 105mm

$$A = \frac{22.5}{360} \times \frac{22}{7} \times (105)^2$$

$= 2165.63mm^2$

For 8 sector = 2165.63 x 8 = $17325mm^2$

Area of the arm = (82991.10 – 17325) mm2

=$65666.10mm^2$

Volume of arm = area of arm x thickness

T= 6mm

65666.10x6

$393996.6mm^3$

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

= 109807.5 + 162209.14 + 393996.6

= $666013.24mm^3$

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

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

2.0 kg

3.3.3 Design of Plates

The area of chipping is shown below. The area is given as πr^2

The plate thickness is 0.6mm and is of 360mm in diameter.

Required area = Total area – removed area

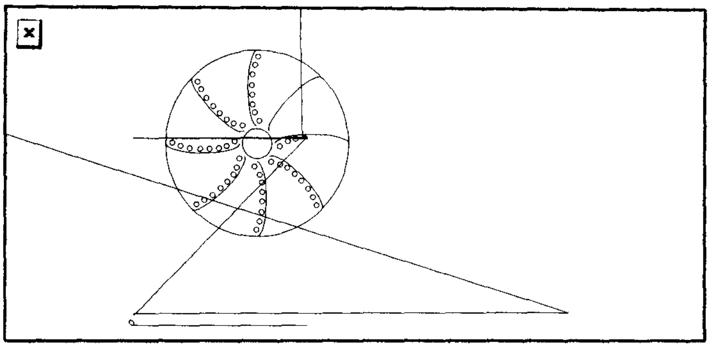


Figure 3.2 Chipping plate.

Total area $= \pi r^2$

$= 3.142 \times (180)^2$

$= 101800.8 mm^2$

The center diameter

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

$= 2642.422 mm^2$

The punches (128 punches)

Area = πr2

$= 3.142 \times (5)^2$

$= 78.55 mm^2$

Total area of punches = $78.55 mm^2 \times 128 = 10054.4 mm^2$

Therefore;

Required area = Total area – center remove – total punches

= 1018008 – 2642.422- 10054.4

$= 89103.978 mm^2$

The volume of plate = Area x thickness

= 89103.978 x 0.6

v $= 53462.38 mm^3$

$= 5.346 \times 10^{-5} m^3$

Mass of plate = Volume x Density

$= 5.34 \times 10^{-5} \times 7900$

$= 0.42kg$

3.3.3.1 Determination Of Number Of Punches On The 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 $= \pi r^2$

$= 3.142 \times 25^2$

$= 1963.75mm2$

Volume of cassava tuber =Area x length

$= 1963.75 \times 300$

$= 589{,}125mm3$

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 chips605mm

Area of strips (chips) $= \pi r^2$

$= 3.142\ (5)2$

$= 78.55mm2$

Volume of chips = area x length

$= 78.55 \times 60$

$= 4713.00mm3$

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

$$= \frac{589{,}125}{4713.00}$$

= 125punches or holes

Therefore 128 punches was considered which means at a complete rotation of chipping mechanism almost one cassava tuber is chipped

3.3.4 Design Calculation Of Feeding Chute

According to figure 3.10,

The volume of the frustrum = volume of the major cone – volume of the minor cone.

(a) **The volume of external frustrum**

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

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

$60(200+x) = 75x$

$12000 = 15x$

$$x = \frac{12000}{15}$$

x = 800mm

Volume of the major cone = $1/3\ \pi r_i^2\ hi$

Where $r_1 = 75$mm, hi = 1000mm

V major cone $= 1/3 \times 22/7 \times (75)^2 \times 1000$

$= 5892857\text{mm}^3$

Volume of the minor cone $= 1/3\ \pi r_2^2\ h_2$

Where $r_2 = 60$mm, h2 = 800

$= 1/3 \times 22/7 \times (60)^2 \times 800$

$= 3017143mm^3$

Volume of the external frustrum = volume (major cone – minor cone)

$= (5892857 - 3017143)\ mm^3$

$= 2,875,714mm^3$

Volume of the frustrum $= 2875714mm^3$

But for the feeding chute is half of the frustrum

Volume of external feeding chute = 2875714/2

$= 1437857mm^3$

The volume of internal frustrum

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

Volume of major cone $= 1/3\ \pi r_i^2\ h_i$

Where $h_i = 200+x$

To find value of x

$$\frac{200 + x}{70} = \frac{x}{55}$$

$55(200+x) = 70x$

$1, 1000 = 70x - 55x$

$1, 1000 = 15x$

$$x = \frac{11000}{15}$$

$x = 733.33mm$

Volume of the major cone $= 1/3\ \pi r_i^2\ h_i$

Where $r_i = 70mm$, $h_i = 933.33mm$

$1/3 \times 22/7 \times (70)^2 \times 933.33$

$= 4,791094mm^3$

Volume of the minor $= 1/3\ \pi r_2^2\ h_2$

Where r_2 = 55mm, h_2 = 733.33mm

= 1/3 x 22/7 x $(55)^2$ x 733.33

= $2,323,957.69mm^3$

Volume of internal frustrum = volume (major cone – minor cone)

= 4791094- 2323957.69

= $2,467, 136.31mm^3$

The volume of internal frustrum = $2,467,136.31mm^3$

The internal volume of feeding chute = 246736.31/2

= $1,233,568.16mm^3$

The volume of feeding chute = volume of external – volume of internal frustrum

= (1,437,857 – 1,233,568.16) mm^3

Volume of feeding chute = $204,288.84mm^3$

Mass of the feeding chute = volume x Density

The density of Aluminium = $2700kg/m^3$

Mass = 2.043 x 10^{-4} x 2700 = 0.7kg

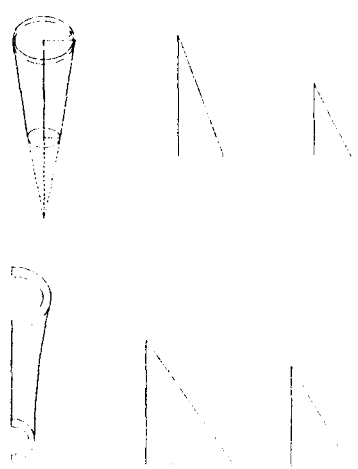


figure 3.3 feeding chute

3.3.5 Design Of Shaft

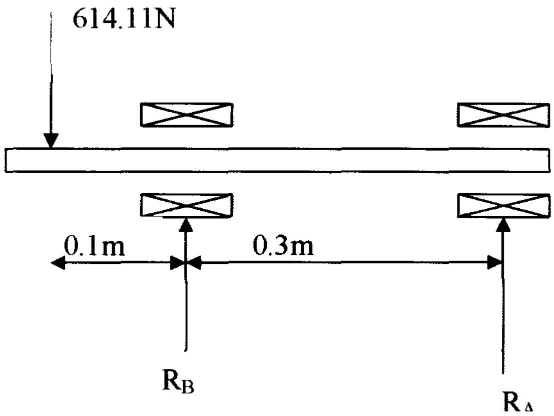
The load acting on the shaft = weight of the chipping plate plus the weight of wheel plus average weight of a man

Average weight of man = 60kg x 9.81 = 688.6N

Weight component on the shaft = (0.42 + 0.18 + 2.0) kg = 2.60 x 9.81 = 25.51N

Total weight acting on the shaft = 25.51 + 588.6 = 614.11N

Summation of all vertical forces



Σf_y

$R_A + R_B - 614.11 = 0$

$R_A = 614.11 - RB$

Taking moment about point B

$\Sigma MB = 0$

$R_A \text{ X } 0.3 + 614.11 \text{ X } 0.1$

$R_A = - 614.11 \text{ X } 0.1 / 0.3$

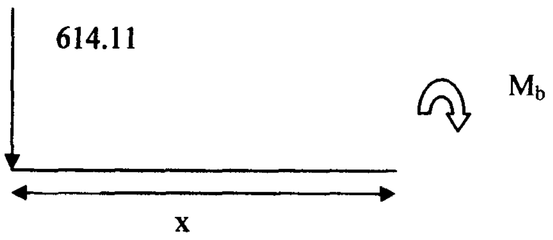
$= -204.7N$

$R_B = 614.11 - (-204.7)$

$= 818.8N$

Determination of maximum bending moment

$0 \leq x \leq 0.1$



$S.F = Fx + 614.11 = 0$

$Fx = -614.11N$

$M_b = -614.11x = 0$

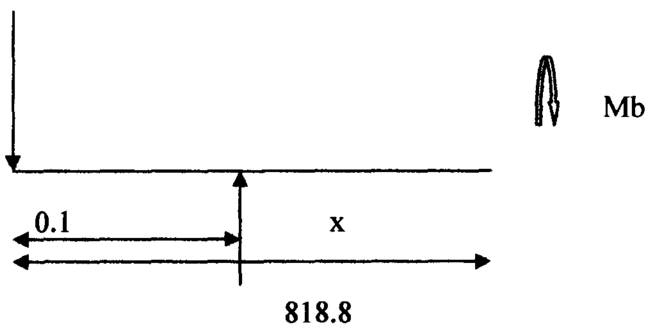
$M_b = 614\ .11x$

When $x = 0$, $M_b = 0$

When $x = 0.1$

$M_b = 614.11(0.1)$

$= 614 \times 0.1 = 61.411Nm$



$S.\ F_2 \ = -w + 818.8 = -614.11 + 818.8 = 204.7$

$M_b - 614.11(x) + 818.8\ (x - 0.1) = 0$

$M_b = 614.11(x) - 818.8(x-0.1)$

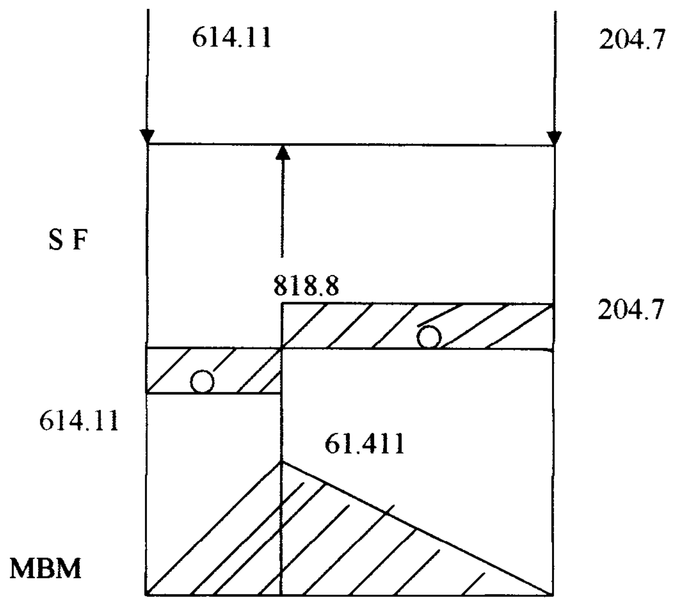
$M_b = 614.11$

When x = 0.4

$M_b = 614.11(0.4) - 818.8(0.3)$

$245.64 - 245.65 = 0$

Bending Moment and Shear Force Diagram



Determination of shaft diameter

For the solid shaft with little or no axial loading,

$d^3 = \frac{16}{\pi S_s} \sqrt{(k_b M_b)^2 + (k_t M_t)^2}$ (Khurmi and Gupta,2004).

Where

d = diameter of the shaft

S_s = Allowable shear stress for the shaft without keyed

$= 56 \times 10^6$ N/m^2

k_t = combined shock and fatigue factor applied to torsional moment

k_b = combine shock and fatigue applied to bending moment

M_b = maximum bending moment

M_t = torsional moment

For rotating shaft, load gradually applied kb = 1.5 kt = 1.0

$M_t = \frac{9550 \times kw}{N}$

Where kw = 80w

N = 60rpm

$M_t = 9550 \times 80/ 60$

$M_t = 12.73$Nm

$d^3 = 16 / \pi \times 56 \times 10^6 \sqrt{(1.5 \times 61.411)^2 + (1.0 \times 12.73)^2}$

$d^3 = 16 \times 92.99/ \pi \times 56 \times 10^6$

$d^3 = 8.457 \times 10^6$

$d^3 = 3 \sqrt{8.457 \times 10^{-6}}$

$d = 2.04 \times 10^{-2}$ m

d = 20.4mm

With a factor of safety of 1.5 and using standard shaft size, a shaft diameter of 25mm was used.

3.3.6 Ball Bearing Selection

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

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

Where

L = Rating life

C = basic dynamic load rating

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 (WA) is given by

$W = x . v . w_R + y . w_A$

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 bearing are 1 and o. but in this type of loading, thrust load are not applied, hence NA = 0 (Kurmi and Gupta, 2004)

But Wr = p/2πx 60/60 x 0.0125

= 1018.59N

but $w = x. v. w_R = y . w_A$

= 1x1x1018.59 + 0x0

= 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= 60x60x12, 000

= 432000.00 revolution

$C = 1018.59\ (43.2 \times 10^{6})^{1/3}$

= 3,574.1N.

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, 2004)

Therefore c x ks

3,574 x 1x 2.0

= 7148.1N

7.148kN

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

The dimensions for bearing Number 205 were the following.

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

3.3.7 Machine Description

The machine was constructed using locally available materials namely

1. Angle iron (mild steel)
2. Galvanized shaft gauge 16
3. shaft (rod) – mild steel
4. Handle – mild steel and wood
5. stainless steel
6. Aluminium

The basic features of the machine are:

- Feeding chute
- Chipping mechanism
- Drive component: shaft, bearing, handle and chipping wheel.

The feeding chute was cast from aluminium with capacity to accommodate different size of cassava tuber. It is bolted to the frame and directly feeding the chipping mechanism. The chipping mechanism consists of chipping plate and chipping. The chipping plate was made from stainless steel of about 360mm in diameter while the chipping wheel was cast from aluminium with diameter of about 380 mm. the two component are joined together with aid of riveting.

The handle is made up of 17mm bolt of about 160mm long and hollow wood of internal diameter of 12mm and external diameter of 38mm, tighten to the wheel. The shaft was machined to the required diameter of 25mm while the appropriate bearings were selected after determining the radial load capacity. The bearing numbers are 205.

The main frame gives support to other components and ensures stability of the chipper. The frame has dimension of 500x300x500mm.

3.3.8 Machine Maintenance

Proper care and maintenance of the chipping machine ensure quality chips under hygienic condition and increase its service life.

Basic maintenance includes.

Grease the bearing regularly (preferably weekly).

Check and tighten all bolt and nuts before each operation.

Always remove the remnant of chips after each operation.

3.4 Cost Analysis

This includes the cost of material and labour. The material used and their cost as at the time of fabrication of chipper are stated below

Table 3.2 material list and cost

S/no	Item Description	Quantity	Unit cost ₦	Total cost ₦
1	Angle iron(1.5 x 1.5 ft) (38 x 38mm)	1 length		2000
2	Chipping plate	1		6000
3	Chipping wheel (cast)	1		2500
4	Feeding chute (cast)	1		500
5	Bearing	1 pair	250	500
6	30mm shaft	1		500
7	Galvanized sheet (50 x 30)			200
8	Bolt and nut	8	37.5	300
9	Electrode (gauge 12)	40 pieces	5 for ₦20	200
10	Paint	1		500
	Sub Total			**13200**

Labour cost 15% of material cost = ₦1980
Overhead cost 60% of labour cost ₦1188.00

Total Cost = ₦16368.00

CHAPTER FOUR

4.0 PERFORMANCE EVALUATION

The performance or functional requirements of the project was first expressed in terms of physical, mechanical, and chemical properties.

The weight of the machine is one of the major factors that were considered. Many steps were taken to reduce the weight to minimum possible through the material selection and method of assembling (Aluminium was used for casting of chipping wheel and feed chute). To achieve maximum mechanical efficiency, care were taken in selecting material with correct shape and size (angle iron was used for the frame work). In case of corrosion chemical and other environmental factors (Galvanize sheet was used to cover the top and stainless steel was used for chipping plate). The welding portion and frame are painted.

4.1 Results

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

Table 4.1 Results of the Test

Human Weight (Kg)	Revolution per minute (rpm)	Chipping Capacity(Kg/h)
50	45	68
55	50	72
65	60	100

4.2 Discussion Of Results.

A variation in the operating speed (Table 4.1). This observation is normal as a result of human factor. However, the size of tubers, particularly the diameter affected the cranking speed. The operation slows down when feeding bigger tubers because of the higher resistance due to increased area of contact with the chipping blade.

Based on the results obtained from the table the operation gave a chipping capacity of 68 kg of peeled tuber per hour for the average weight of 50 kg and 100 kg for average weight of 65 kg. The diameter of the tuber has effect on chipping capacity. This can be related to the feeding rate, small tuber can feed in batch compare to the big tubers which are fed one after the other.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The cassava-chipping machine has been designed, fabricated, and tested. The machine showed that it is a good substitute for the traditional methods of slicing cassava tuber. The design also showed that it is suitable or best for those in rural areas, as well as those in town and cities due to frequent power failure we are experiencing in the country.

The chipper was able to achieve a chipping efficiency of 80 percent and a uniformity index of 0.7. However with little and proper adjustment between the chipping plate and feeding chute machine efficiency will be more.

The machine was also designed considering the low cost involved and can be affordable to the rural community. Each component 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. Recommendation

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) An electric motor drive can be installed to facilitate the operation.

(2) The efficiency can be improved upon by proper adjustment between feeding chute and chipping plate.

(3) More of such machines can be constructed and made available to cassava flour producer at affordable cost or in form of loan under a co-operative society.

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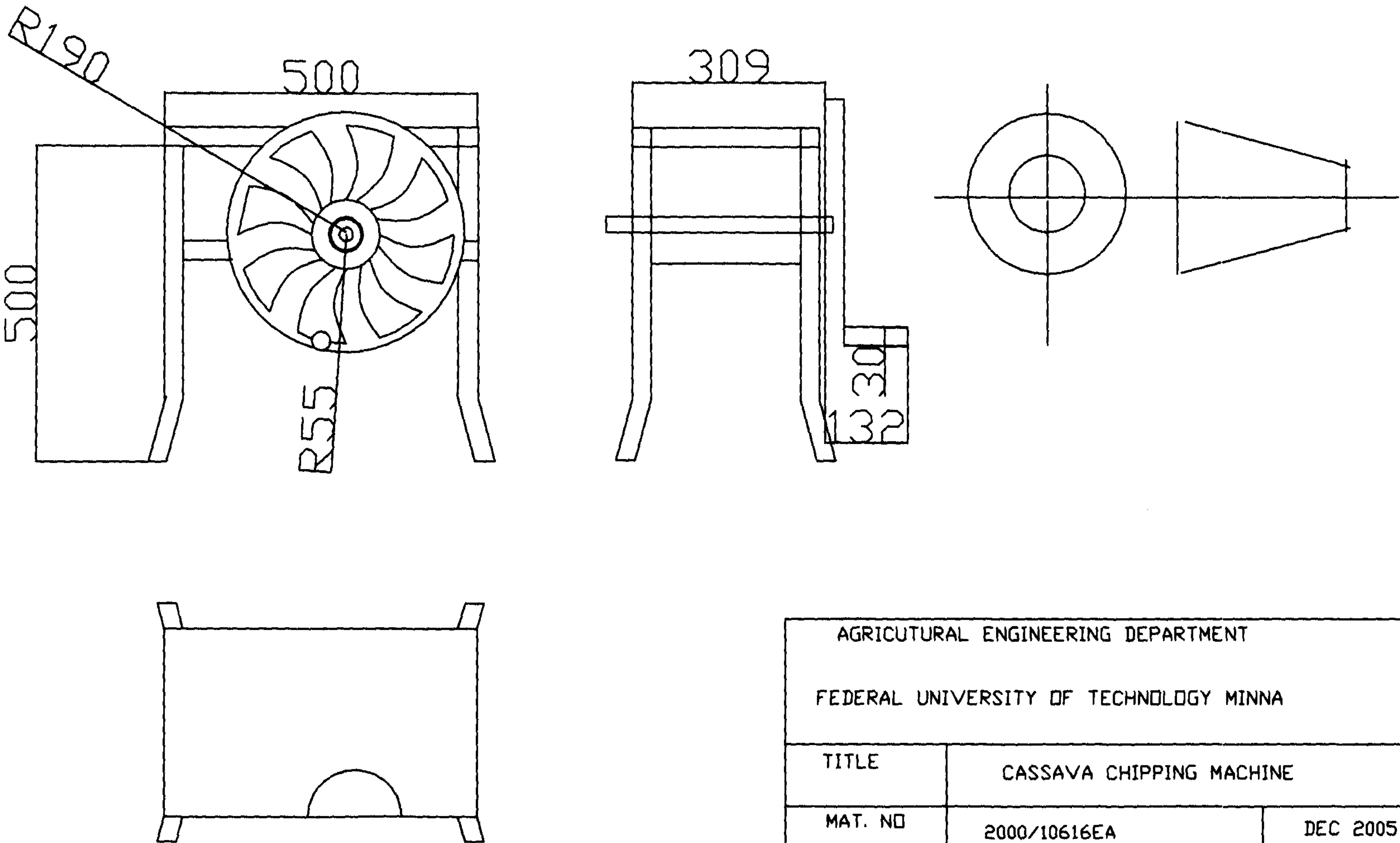

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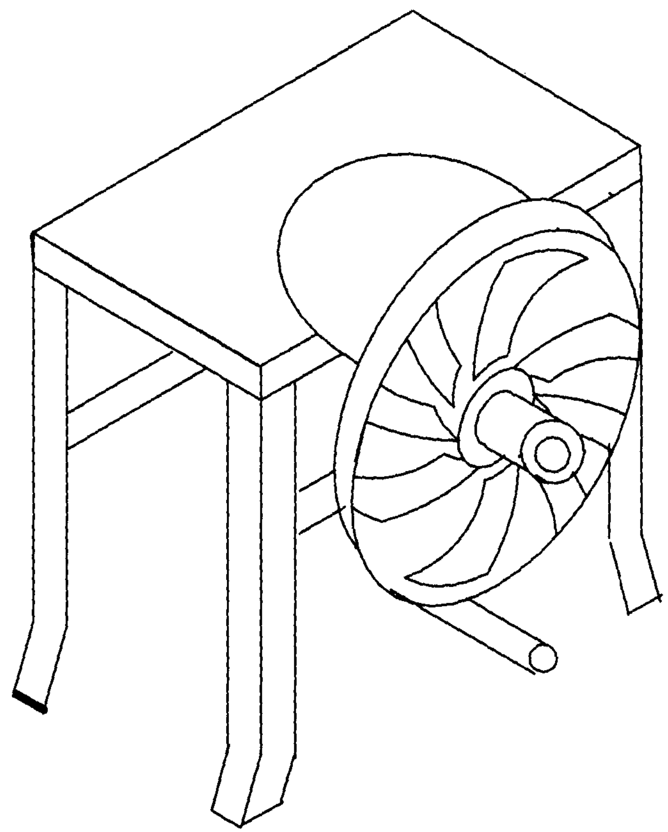

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