DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF AN ELECTRICAL OPERATED CASSAVA PEELING MACHINE

BY

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DEDICATION

This project work is dedicated to Almighty Allah who makes things possible and to my late parent Alhaji Mohummad Aminu Alfa and Hajiya Maryam Nnawoyisa.

ABSTRACT

An electrical operated cassava-peeling machine was designed, constructed and its performance evaluated. The objectives of this project were to design peeling machine that will effectively remove the periderm and cortex of cassava tuber without substantial loss of tuber flesh, and to evaluate the performance of the machine. Experiment s were undertaken to determine periderm and cortex thickness before and after peeling. The power requirement for operating it and components design were calculated. The machine was evaluated on the basis of its rate of operation and cassava periderm and cortex removed. The result obtained showed that the machine has peeling efficiency of 67%. Its rate of operation was 225kg/hr. The machine is capable of removing completely, the periderm and cortex of cassava tuber with diameter within the range of 55.5 to 68.5mm without leaving the traces of cortex for hand trimming, but not completely with those with diameter range of 25 to 48.5mm diameter.

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ABDULLAHI AMAMA ALFA

CERTIFICATION

I certify that this work was carried out by Abdullahi Amama Alfa in the Department of agricultural Engineering, Federal University of Technology, Minna.

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CHAPTER ONE

1.0 INTRODUCTION:

Cassava (Manihot esculant crantz) is one of the most important root crops grown in many African countries; Mozambique, Nigeria, Tanzania and Zaire are among the ten largest cassava-producing nations of the world. Cassava is a dicotyledonous plant that belongs to the euphorbriceac together with crops such as rubber and castor plant. It is best grown on sandy or sandy loamy soil with pH range of 5 – 9 and an annual rainfall exceeding 900mm falling over a period of 120 – 150 days. The crop is planted on ridges or flat, and it takes between 9 – 19 months to mature before harvesting. The size of the tuber depends on the variety and fertility of the soil (Onakunle, 1990). The tuber can be divided into three regions viz::

(i) The periderm: This is the outer most layer which is brown in colour and consists mainly of dead cells which covers the surface of the tuber.

(ii) The cortex: Which lies below the periderm, and is usually 1 – 2mm thick, white in colour.

(iii) The central portion of the tuber: This constitutes the greater bulk of the tuber and is composed essentially stored starch.

Cassava is processed in 'fufu', 'gari' and 'lafun', which a large population of people in the developing countries depend on as a stable food. Cassava is a valuable raw material in the starch and alcohol industries. The waste products (periderm and cortex) are used as livestock feed. The processing of the cassava into its various forms involve harvesting and peeling which poses a great problem.

The first step in processing cassava into any form begins with the peeling of the tuber, but unfortunately, peeling still remains a major setback in cassava processing both as the peasant and industrial levels of operations. The high moisture content of cassava tubers and their associated high rate of deterioration under short period after harvest and manual peeling call for an urgent peeling device to safeguard economic waste that has been the problem of peasant farmers who constitute the main cassava producers. This is necessary to minimize or reduce the level of drudgery, improve processing hygiene and to ensure the wholesomeness of the processed cassava products.

Many methods employed in the peeling of cassava include manual, chemical, steaming and mechanical etc., each of these methods has its own advantages and disadvantages. The manual method of peeling cassava is primitive and cumbersome. It is carried out with object with sharp edges (knife) to traverse the length of the tuber. This method is labour intensive and leads to the wasteful removal of tuber flesh.

The use of chemical is commonly adopted in the industries, factories and food processing companies. It comprises chemical action and thermal shock which leads to softening and loosening of the skin using caustic soda ($NaOH$). Some of the disadvantages of the method are:

(i) The cost of acquiring and producing caustic soda.

(ii) The control of penetration of chemical for proper removal of the peel.

(iii) The removal of traces of chemical used in the peeling as it may be poisonous. In the steam method, the tube is subjected to a high steam pressure over a short period of time to avoid partial cooking.

The hydration and subsequent cooking of the tuber loosen the flesh of the tuber. The disadvantage of the method is the subjection of the tuber beyond the time interval required which might lead to the cooking. It therefore, means that it requires skilled personnel.

Under mechanical method of peeling, machines like continuous process, abrasive belt conveyor and batch abrasion (models I, II and III) among others were designed and constructed, but such machines had the following shortcomings:

(i) Low peeling rate leading to uneconomically low capacity.

(ii) Unacceptably high loss of useful cassava tuber flesh.

(iii) Inability to effectively handle all sizes of cassava tubers together.

(iv) Low peeling efficiency necessitating labour intensive sorting and hand trimming.

(v) High operating cost.

1.1 STATEMENT OF PROBLEM:

There are many varieties of cassava cultivated in Nigeria and other tropical countries that yield root with wide variations in their physical properties such as size, shape and weight under different soil types or varying cultural practices. The strength of adhesion of the peel to the root flesh varies with the month of the year when the roots are harvested as well as the time elapsed after harvesting before peeling is done. Therefore, the main problem in the design of the cassava peeler is that of making the machine capable of handling all the roots from all sources all the year around despite variability in physical properties.

1.2 OBJECTIVE

This project is aimed at carrying out the design and construction of a cassava peeling machine using available raw materials.

To carry out the performance, evaluation of the machine.

1.3 JUSTIFICATION:

Peeling of cassava tubers is one of the most tedious operation in cassava processing, therefore, an effort to produce a cassava peeler will go along way in improving cassava processing technology, reduce drudgery, cost and consequently the quality of cassava.

CHAPTER TWO

2.0 LITERATURE REVIEW

CASSAVA

2.1.0 ORIGIN OF CROP

The origin of cassava can be traced back to South America. It was first introduced into central Africa during the last part of the 16th Century. It was introduced into West Africa in the early 18th century and into East Africa in the early 19th century (Jones 1956). It is relatively a new crop to African agriculture.

Cassava is said to be grown almost exclusively as food in the 39 African countries, stretching in a wide belt from Madagascar in the South-East to Senegal in the North West (Hahn and Keyser, 1985), where the annual rainfall exceeds 900mm, falling over a period of 120-150 days and the altitude ranges from sea level to 200m. Statistics indicates that four African countries namely, Monzambique, Nigeria, Tanzania and Zaire are among the 10 largest cassava producers in the world (Hahn et al).

The introduction of cassava and the subsequent development of the crop into staple food from the 18th century to 19th and 20th century was largely activated by the development of a local method for processing the tubers into a non-poisonous product before deteriorating. This technique was carried out by repatriated Brazilian slaves, who improved on an already existing method by putting the gyrated root tubers already peeled into jute bags and squeezing out the liquor by using heavy stones that are placed on the sacks. In the course of this, fermentation takes place and a product with a characteristic flavour like that of 'garri' is produced. It is possible to correlate the expansion of cassava production with diffusion of the knowledge of garri-making Beck (1971).

Within Africa, the boundaries of its cultivation correspond roughly with the 760mm rainfall per annum and a belt between 15^0N and 15^0S (Jennings, 1970). It was found that within these range of limits of both rainfall and latitude, the dominance of any root or tuberous root crop is more dependent upon sociological and historical condition, rather than adaptive or climatic condition (Agboola, 1968). In Nigeria, it has been found that both the tubers and roots contribute about 20 million metric tonnes (Onwueme, 1982)

2.2.0 BOTANICAL DESCRIPTION

Cassava (Manihot esculent crantz) belong to the family known as Euphornicaea in the dicotyledenous group; together with crops like rubber and castor plants. It is a woody, short-day, erect perineal shoot with lobbed leaves (Norman et, al, 1984).

Whenever cassava is grown from seed, the plant develops a tap root which is characteristics of dicot-plants from which the tap-root now develops from the radical of the germatised. But for normal agricultural method of planting. Cassava is propagated by cutting the stem, this produces root giving rise to a fibrous root system. Initially after planting the internal structures like those of typical dicot plant penetrates to a depth of almost 1m, but by the second month, they take the form of developing fibrous roots and become tuberous (Onwueme, 1991).

Once a root becomes tuberous, it no longer participates actively in the absorption of water and mineral salts. Starch accumulation in the root begins near the point of attachment of the stem and progresses gradually towards the distal portion of the root. This accounts for the reason why tuber is fattest near its point of attachment to the stem; and tapers gradually towards the distant end. This portion of the tuber is slightly thickened and it makes up the tail. The cassava is connected to the stem of the plant by a short woody neck.

2.3.0 GENERAL MORPHOLOGY OF THE CASSAVA TUBER

Under very favourable condition, a mature cassava tuber may reach a weight of 15kg and a length of 1m depending on varieties, cultivation and stage of maturity.

The cassava plant cultivars has been characterised into two major groups namely the bitter and sweet varieties. The bitter variety has throughout its tuber a high level distribution of cyanogenic glucose while the sweet variety has low level distribution of mineral salt which is confined only to the peels (Oyefeso, 1985).

The tuber size depends mainly on the variety and how fertile the soil is internally; the cassava tuber can be divided into three regions namely:

1. The periderm: This is the outermost layer, brown in colour corky and consist mainly of dead cells which seals effectively the surface of the tuber which is later broken at various locations (Onwueme,1991).
2. The Cortex: This is internal to the periderm and is usually 1-2mm thick, white in colour but may at times appear pinkish or brownish.
3. The Central Portion: This constitutes the greater bulk and is essentially stored starch. (Onwueme, 1991)

The cassava leaves are arranged in a 2-5 spiral phylotabis along the stem. Each leaf persists on the plant for a relatively short period before it is shed. The length of this period is considerably reduced by adverse environmental conditions such as drought or nutrients deficiency (Onwueme, 1991).

2.4.0 PERIOD OF PLANTING

Cassava which is perennial crop is normally grown last in cropping sequences before bush fallow because of its ability not to respond to good soil as cereals (Hahn et al, 1986). Usually, it is planted on ridges and on the flat but the ridge method of planting is more common.

The cuttings of about 20 - 30cm long are inserted for about half their height often at an angle of 30 - 45 degree. Cutting sprouts 7-14 days after planting while root bulking begins during the second month after planting.

Under local practice, the period of planting and harvesting vary considerably. The crop is either planted in May or June and the harvesting follows by September to December or either planted in late September to December, while harvesting is by October to December (Kowal and Kasam, 1978)

Furthermore, under local practice, cassava is grown both as a sole crop and in mixture of 2 - 6 crop practice, including such crops as sorghum, maize, groundnut, cowpea, yam, sweet potatoes, vegetables and kenaf (Kowal and Kassam, 1978). While in tropical Africa, it is inter-cropped with yam maize, cowpea and melons (Onwume, 1991). It is often planted vegetatively from hardwood stem cutting usually of about 30cm long and can grow to height of 1.5m high.

When cassava is inter-cropped with a non-tuber crops such as maize or cowpea, the cassava tends to occupy the top of the ridge or mound, while the inter-crop is planted on the slop. If inter-cropped with crops like yam however, the cassava may be found in a sub-tropical position on the ridge or mound, or in the space between mounds (Onwueme, 1991).

2.5.0 PERIOD OF HARVESTING

Usually, cassava is hardly ever harvested during the same season in which it was planted and as such cassava is usually the main crop that occupies the field during the dry season. The crop mature for harvest in 9 - 19 months depending on the cultivate but if left unharvested, the cassava planted will continue to grow as a perennial. When inter-cropped with yams, it is planted several months after the yam and still remains on the field long after the yam has been harvested (Onwueme, 1991).

The time of harvesting cassava is determined by not only the optimum for a particular genotype planting time, environment or grafting system but also by the farmer's dietary or financial need.

The shortest duration from planting to harvest of which we are aware is that of the land-race. "Three mun", which is harvested at 3/12 months in the Gazelle Peninsula of New Guinea (French and Bridle,. 1978). Usually in the wet tropics e.g. Nigeria, harvesting is done at 12 - 16 months.

The harvesting of cassava is done by digging up the tubers by hand after detopping the plant, with large scale production they can be mechanically ploughed up, but yields are often reduced because a higher percentage of tubers is left in the ground.

The difficulty with machine harvesting is that tubers are spread 120cm or more and their depth of penetration in the soil is 45 - 60cm and once harvested, the tubers deteriorating and begin to rot after 40 hours (Kowal and Kasam, 1978)

2.6.0 SOIL REQUIREMENT

Cassava requires a soil, which allows for the development of an adequate rooting volume for the bulking of tubers and for easy harvesting. It has been found to grow best on sandy-sandy or sandy-loam soils but will perform satisfactorily on any soil with pH of 5 - 9 provided it is not saline and not waterlogged when grown on heavy clay soils, the plant produces stem and leaf growth at the expense of the root and many cultivars give poor yields (Kowal and Kassam, 1978)

Cassava has been found to grow predominantly on ultisols and exisols in the low land, humid areas of tropical Africa (Hahn et al, 1986). It has also said to possess the ability to produce appeasable carbohydrate yields on soils too poor to sustain the growth of other crops. This implies that cassava only comes later when the soil fertility is too low for the profitable production of other crops.

Cassava also has the ability to obtain water from a greater soil depth whenever the soil is dry. During drought stress, cassava follows a conservative pattern of water used by reducing leaf area index and closing its stomata, hence reducing potential transpiration (Cock, 1978).

Cassava has been found not to tolerate excess soil water and it thus grow on well-drained uplands or on large mounds or ridges in waterlogged soils. (Hahn et al, 1986) and can grow well in infertile soil but can remove significant quantities of nutrients. (Cork and Hawel, 1978). There is also the possibility of high run-off and erosion to take place when cassava is grown as a sole crop than when it is inter-cropped.

2.7.0 AREA WHERE MOSTLY GROWN

Cassava is an important crop across a wide-range of tropical environments. It is grown both as a subsistence energy crop, though often not the primary one and as a cash crop for starch, alcohol, cattle feed etc. (Beck 1971).

Also in Asia and America, described by (Kumar and Hishe, 1979) for India and (Morene and Hart, 1979) for Central America respectively. In all, it has been found that Brazil produces more cassava than any other country, to the extent of establishing National Alcohol Programme that will use plants such as sugar cane, cassava and sweet-potatoes (Hahn et al, 1986). While Thailand is the world's largest exporter of cassava (Jennings, 1970), because little of the crop is consumed and cassava growing is a cash crop.

2.8.0 BIOCHEMICAL PROPERTIES OF CASSAVA

Cassava is a carbohydrate food which composed of hydrogen (H), Carbon (C) and oxygen (O) in certain proportion. It possesses an acid called prussic acid (HCN), a poison, which is said to be mostly concentrated at the back of the cortex. This means that quite large amount of this poison could be got rid of, by removing the back (cortex) and this process of removing the cortex is called peeling.

2.8.1 IMPORTANCE OF PEELING ON CASSAVA PROCESSING

Peeling is a unit operation in cassava processing that cannot by any means be skipped as it helps to remove the cortex, which contain the highest percentage of the toxin that is usually contained in cassava.

Traditionally, cassava roots are processed by a variety of methods into different products, according to local customs and preferences (Hahn, 1989).

Compared with fresh cassava tuber, the processed products have increased shelf-life, are easier to transport and market, contain less cyanide and are more palatable. Fresh roots tuber can not be stored for long because they do not within 3 - 4 days after harvest, and because they are bulky with about 70% moisture content, transportation of the roots from rural to urban areas for marketing is very difficult and expensive. Both roots and leaves contain varying amount of cyanide, which is toxic to human and animals and they are not palatable when raw.

Cassava as a low cost staple food in urban centres and as a source of steady real income for rural hose holds will be a large extent depend on how far it can be presented to urban consumers in an attractive form at prices which are competitive with those of cereals.

2.8.2 NUTRIENT VALUE

Cassava is considered inferior by many eaters and non-eaters of cassava simply because it is low protein, although cassava leaves as a vegetable contain 26.1% protein on a dry weight basis (Hahn et al, 1983). Despite this, cassava plays an important role in the local diet during periods of food shortage and has also provided the most valuable fine reserve crop during poor and erratic rainfall or severe attack from locust (Kowal and Kassam, 1978). Though, the real potential of using the cassava in animal feed at a limited level of about 5-40% depending on the species, age of animal and the country (nestle, 1978).

It has been reported in literature that cassava root meal compares favourably with maize in terms of caloric value and digestibility (Hahn et al, 1986) (Nestle, 1975) resorted that cassava has been widely used as a major source of energy for livestock in Asia, Africa, Europe and South America.

2.9 METHODS OF PEELING

Before the cassava tuber is utilised, it is almost invariably peeled. The peel comprises 10-20% of the tuber weight (Odigboh, 1976). Therefore, peeling in its actual sense is the removal of the outer layer of fruits, vegetables or tubers as the case may be, and can be done in so many ways as described below:

2.9.1 MANUAL OR HAND METHOD

This is a traditional method of peeling. It is primitive and cumbersome. It is a means of using an object with sharp edge (knife) to traverse the length of the fruit, vegetable or tuber in removing the peel (Onakunle, 1990). The disadvantage of this method is that it is tedious, time consuming and wasteful removal of tuber flesh.

2.9.2 CHEMICAL METHOD

This method is commonly adopted in the industries, factories, and food processing companies. It simply employs the effort of chemical action and thermal shock for loosening and softening of the skin. The chemical normally used is caustic soda. The tubers are immersed in the hot solution of caustic soda and left for a period of time, during which the surface of potatoes must have softened and easily be washed or wiped off with the use of water spray. This method is not limited to potatoes, but other root crops cassava inclusive (Adesanya, 1992).

The disadvantages of this method includes the cost of acquiring and producing caustic soda (lye); the control of lye penetration for proper removal of the peel and traces of lye from the peeled product must be removed.

2.9.3 STEAM METHOD

This method works under the principle of subjecting the tuber to a high pressure of steam for a short period of time to avoid partial cooking. The hydration and subsequent cooking of the tuber losses the peel of the tubers. It has been found to be effective when used on cassava tuber but has its own disadvantages which includes the possibility of the tubers becoming cooked during the operation and requires handling by a skilled personnel.

2.9.4 MECHANICAL METHOD

This is method, when employed has produced low efficiency and yield losses (Odigboh, 1976). This is due to the irregularity in the shape, variation in peel, thickness, texture, strength of the adhesion to the root flesh and the size. The mechanical peeling process has become a bottleneck in the processing of the cassava (Odigboh, 1976).

2.9.5 A CONTINUOUS PROCESSING PEELING MACHINE

Odigboh (1976) designed, constructed and also tested a continuous process peeling machine. The cassava tubers enter through one end of the machine unpeeled and comes out through the other end peeled. The efficiency of the machine was found to be about 95% at 135kg/hr. Suspending springs tensioned in a way as to allow for different root sizes were attached to the rollers of the machine. The advantages of this are that it has the highest peeling efficiency and non-waste of the tuber flesh. The disadvantages are that the sorting and peeling are manual operations. Some of the pieces not wholly peeled have to be resorted and repeeled as well, and an intensive labour involved in the slicing operation.

2.9.6 A BATCH ABRASION PEELING MACHINE

In order to remove the problem of slicing, a batch abrasion peeler was constructed by (Odigboh,1976). Advantages of this machine are that hand peeling is effectively eliminated because the spray water simultaneously washed the peeled cassava tuber to give a clean product. Also irrespective of the size and shape of tuber then there is uniform and thorough peeling better than manual.

The disadvantages of this machine are that the peeling rate is low, being a maximum of about 180kg/hr when the time spent on loading and unloading the tuber are discounted. The machine is big and expensive if constructed on a large scale and sold to the farmers and the majority of cassava tuber users.

2.9.7 AN ABRASIVE BELT CONVEYOR PEELING MACHINE

Ezekwe (1976) examined the possibility of using an abrasive belt conveyor for the peeling of cassava and yam. The tubers are first cut in slices before being introduced into the machine. The system consists of a conveyor, which carries blades and moves the slices over a counter moving horizontal belt. As the slice rotates a continuous slip occurs between it and the conveyor blade and pad, and leads to its subsequent peeling.

2.9.8 MANUAL OPERATED CASSAVA PEELING MACHINE

A manually operated cassava machine was designed constructed and evaluated Awobanjo and Odoemene (1995). The machine consists of a frustum-shaped hopper, a cylindrical peeling unit, a discharge outlet and a handle that served to transmit manual power to the peeling unit. The peeling unit consists of an inner cylinder eccentrically placed on the shaft. Brushes are arranged on the surface of the inner cylinder and on the inside of the outer cylinder. Cassava tubers of about 100mm length are placed inside the hopper from where they fall into the peeling until when they are peeled, and fall out through the discharge unit. As the handle is manually rotated, it turns the inner cylinder at about 40rpm while the outer cylinder is fixed. The cassava tuber is peeled by the scrubbing action of brushes on it.

This machine has an average of peeling 0.3kg/sec over manual peeling method, which is 0.03kg/sec. Its disadvantage is that only 15% of the cortex is removed, the 85% is left on the tuber flesh.

2.9.9 A BATCH ABRASION PEELING MACHINE MODEL II

The basic features of the model II peeler developed in 1980 are essentially the same as that of model I earlier described. However, the drum of model I built of 3mm thick galvanised mild steel sheet has a larger volumetric capacity, a bigger length – to – diameter ratio and a smaller weight per unit volume. Another modification is that the eccentricity of mounting in the model II is less than in model I. Also, balls of expanded metal are used as abrasive materials, instead of pieces of stones or pebbles. The increase in drum capacity and reduced eccentricity of mounting are both intended to increase the rate of abrasion. The balls of expanded metal are lighter and more durable abrasive than the pebbles or the pieces of stone. Another advantage of the cage structure of the model II peeler is that it facilitates visual inspection of the cassava tubers while peeling is in progress. This helps to prevent over peeling or excessive loss of useful tuber flesh. The peeling rate is improved only to about 220kg/hr, which is still considered low.

2.9.10 A BATCH ABRASION PEELING MODEL III

The development of the model III peeler was undertaken mainly to achieve further improvements in the peeling rate. The model III consists of a drum of 5x5mm rhombic expanded metal folded and attached to the inside surface of a cage framework of 21mm out diameter mild steel pipes. The drum is mounted with same eccentricity as the model II peeler, on a shaft. The special feature of the model III peeler is the provision of four abrasive cylinders of expanded metal, mounted inside the peeling drum and driven by a planetary gear arrangement to rotate about their axis at four times the rpm of the drum. The complex shaking motions of the drum, together with the resultant faster rotation of the four abrasive cylinders, in addition to the fast bombardments of the abrasive balls of expanded metal, lead to rapid peeling of the cassava tubers. Water is continuously added to wash away the finely abraded peels.

The model III peeler achieves uniform and thorough peelings, irrespective of sizes and shapes of the cassava tubers at a peeling rate of about 300kg/h discounting time spent in loading and unloading. Being a batch-process machine, the model III cassava peeler has a high operating labour input requirements for loading and unloading the cassava tuber and the abrasive balls

Other various cassava peeler design efforts include the following.

(i) The Newell Dunford peeling machine of the British Company. Newell Dunford deals with machines for processing of gari.

(ii) The GATINEAU EPUCHEUSE abrasive EA8 peeling machine - a French product.

(iii) NIVOBA CASSAVA Cleaning Machine, a component of NIVOBA gari processing plant, NIVOBA being a Dutch Manufacturing Company.

(iv) Societe Bertin-Sodepalm Cassava Peeler, manufactured by a French Company.

(v) Marquina D'Andrea is one of the Cassava Processing Machines manufactured in Brazil.

(vi) PRODA Cassava Peeling Machine, PRODA is the Project Development Institute in Enugu, Nigeria.

(vii) FABRICO Cassava Peeling Machine, FABRICO stands for Fabrication Engineering Company Nigeria Limited - a Nigerian Manufacturing Company.

(viii) NRCPC Cassava Peeler; NRCPC is the National Root Crop Production Company Ltd, based in Enugu, Nigeria.

(ix) Cruz Cassava Peeling Machine, built by S.R. Cruz, a researcher in the Philippines.

After the evaluation of the above machines, the results obtained on their shortcomings are:-

(a) Low peeling rate leading to uneconomically low capacity.

(b) Unacceptable high loss of useful cassava tuber flesh.

(c) Inability to effectively handle all sizes of cassava tubers.

(d) Low peeling efficiency, necessitating labour intensive sorting and hand trimming.

(e) High operating cost.

It is due to these shortcomings that no satisfactory cassava-peeling machine has been successfully introduced into the world market. Thus in spite of the indicated strong world-wide research thrust, the development of a technically or economically acceptable cassava peeler continues to pose a challenging problem.

CHAPTER THREE

3.0 METHODOLOGY

3.1 DESIGN CONSIDERATIONS

To avoid minimum damage to the tuber roots and enhance effectiveness of the machine components, some physical and engineering properties of cassava were considered.

Cassava tuber is averagely cylindrical in shape and covered by a moderately strong peel of thickness of about 1.5mm to 2.5mm, with other physical properties such as average diameter of the tuber and weight per tuber. All these properties are taken into consideration in the design analysis and especially the depth of the peel, length and weights. The diameter, length and weight of sample tuber roots is shown in Table 1.

3.2 DESIGN ANALYSIS

The following were determined in analyzing some component parts of peeling machine. They are:

(i) determination of diameter of the machine pulley

(ii) determination of total load exerted by the pulley and resultant tension on the belt.

(iii) determination of the approximately length of the belt needed by the machine.

(iv) determination of speed of peeling drum

(v) determination of torque on the machine (torsional moment).

(vi) determination of bending moment of shaft

(vii) estimation of power requirement and selection of motor.

(viii) determination of shaft diameter needed by the machine.

3.3 DESIGN CALCULATION OF COMPONENT PARTS

3.3.1 Determination of Speed of Peeling Drum

$N_M D_M = N_E D_E$ .... (1)

Where:

N_M = Speed of Peeling Drum - rev/min.

N_E = Speed of Electric Motor - rev/min.

D_M = Diameter of Machine Pulley - min.

D_E = Diameter of electric Motor Pulley - min.

N_M = ?

N_E = 1420 rpm

D_M = 355mm preferred diameter (Ref. Table J3)

D_E = 55mm

From equation (1)

$N_M \times 355 = 1420 \times 55$

$$\therefore N_M = \frac{1420 \times 55}{355} = 220\text{rpm}$$

$\therefore$ The speed of peeling drum = 220rpm

3.3.2 Estimation of Power Requirement

(i) Cutting Speed:

To determine the cutting speed, it is calculated with respect to the number of revolution per minute and the given diameter of the peeling drum. Therefore:

Power = Cutting Force x Cutting Speed

$P = F_C \times V_C$

but Cutting Speed = V_C = Wr

Where W = angular velocity and number of turn and r is the radius of peeling drum.

$$W = \frac{2\pi \times 220}{60}$$

$$V_C = \frac{2\pi \times 220 \times 0.15}{60}$$

$$V_C = 3.5\text{m/s}$$

$\therefore$ The Cutting Speed = 3.5 m/s

(ii) Force on Peeling Drum

The estimated cutting force can be calculated as:

Since 1.5HP electric motor is used and 1HP = 0.746KW

then 1.5HP = 1.119KW ~ 1,119Watts

From

Power = Torque x angular Velocity

P = TW

But Power = P = 1.119kW

$$\therefore \text{Torque} = \frac{\text{Power}}{10} = \frac{1.119}{10}$$

$$\text{and } W = \frac{2\pi \times}{60} 1420 = 149 \text{ rad/sec}$$

$$\text{Torque} = \frac{1.119}{149} = 0.0075 \text{ kNm}$$

Torque = T = 0.0075 kNm

Torque = 7.5 Nm

Torque (T) = Force x radiu (r)

$$\therefore \text{the Cutting Force} = \frac{\text{Torque}}{\text{radius}}$$

but diameter of peeling drum = 300mm

therefore, radius of drum = 300/2 = 0.15m

$$F = \frac{\text{Torque}}{\text{radius}} = \frac{7.50}{0.15} = \underline{\mathbf{50N}}$$

At 600mm drum length, this gives

$$= \frac{50}{0.6} \; \frac{N}{m} = \underline{\mathbf{83.33\ N/m}}$$

The cutting force is 50N and cutting force per unit length is 83.3N/m

(iii) <u>Power to Operate Peeling Drum</u>

Power = Torque on drum x angular velocity

$$P = T \times W$$

but Torque (T) = 7.5 Nm

$$\text{and } W = \frac{\pi\, 220}{30}$$

∴ Power to operate peeling drum

$$P = \frac{220 \times \pi \times 7.5}{30} = 172.7\ \text{k}$$

$$= 173\ \text{Watts}$$

Power to operate peeling drum = <u>**0.173 kW**</u>

3.3.3 <u>DETERMINATION OF MINIMUM CENTRE TO CENTRE BELT DISTANCE</u>

Provision has been made to vary the belt tension. This was achieved by making slots in the motor seat so that the distance between the two pulleys can be varied with supports and moved along the slots.

The centre to centre belt driving is the minimum distance between driving and driven pulley to secure appropriate belt tension. The centre belt distance C is given by:

$$C = \frac{D + d}{2} + d$$

Where: D = Larger pulley diameter - mm

d = Smaller pulley diameter - mm

D = 355mm

d = 55mm

$$\therefore C = \frac{355 + 55}{2} + 55$$

C = 437.5 = **438mm**

Centre distance = C = 438mm

Belt length is given

L = 2C + $\underline{\pi}$ (d + D) – $\underline{D - d}$

2 4C

L = 2 x 438 + $\underline{\pi}$ (55 + 355) - $\underline{355 - 55}$

3 4 x 438

L = 876 + 644.11 - 0.171

L = 1519.93

Belt Length = 1520mm

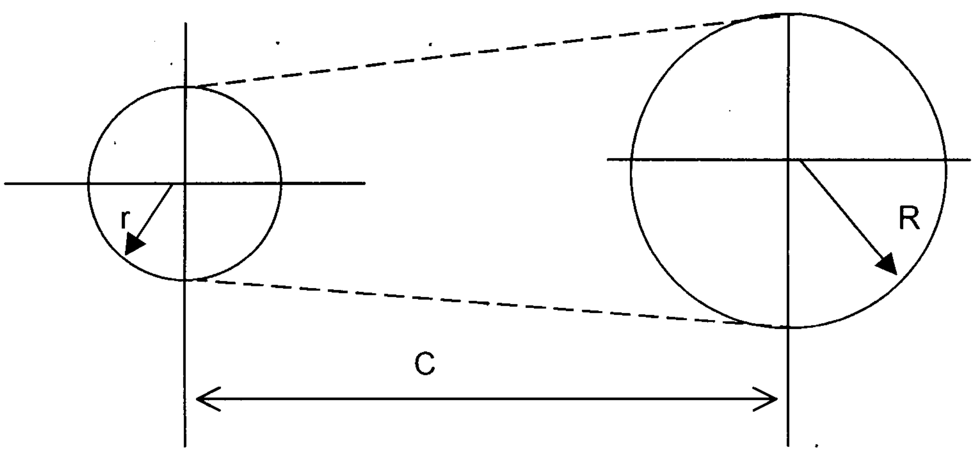

Fig. 1: Layout Centre distance C

3.3.3 Determination of Weight of Peeling Cylinder and Cover Plates

(i) Cylinder:

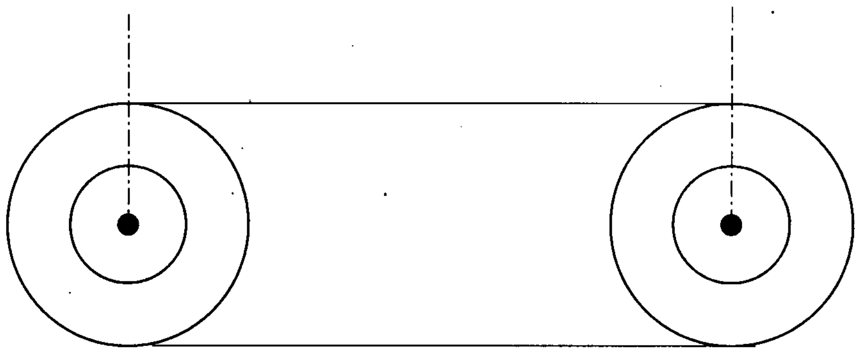

Fig. 2: Showing Peeling Drums

The diameter of cylinder = 300mm and length = 647.5mm

Volume = $V = \pi r^2 L$

$V = 3.142 \times 0.15^2 \times 0.6475$

Volume = $0.0458m^3$

But density of mild steel is $7.10kg/m^33$

Therefore, from Density = $\frac{Mass}{Volume}$

= $\rho = \frac{m}{V}$

Where: ρ = Density

m = Mass

v = Volume

Mass of cylinder (m) = $\rho \times v$

M = 7.10kg/m3 x 0.458m3

= 0.325kg

Weight of Cylinder = 0.325 x 9.0

= **3.25N**

(ii) **Cylinder Cover Plates**

R	=	Major diameter	=	150mm
r	=	Minor diameter	=	25mm

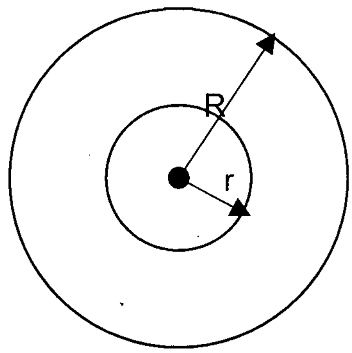

Fig. 3: Cover Plate

The Volume of cylinder cover plate can be calculated using:

$\pi R^2 L - \pi r^2 L$

L = thickness = 1

$V = \pi \times 0.15^2 \times 1 - \pi \times 0.025^2 \times 1$

$V = 0.0219m^3$

But Mass = M = Density x Volume

M = $\rho \times v$

M = $7.10kg/m^3 \times 0.0219m^3$

M = 0.155kg

Weight = 0.155 x 10

= **1.55N** = **1.6N**

For the two ends = 1.6 x 2 = **3.2N**

The total weight of cylinder and cylinder cover plates

= 3.25N + 3.2.N = **6.45N**

SHAFT DESIGN

3.3.4 Shaft Size Determination

The shaft is a rotating member carrying drum (peeling cylinder), pulley and belt.

The size of a shaft may be determined on the basis of both strength and rigidity. As mentioned above, the diameter must be enough to ensure satisfactory strength and rigidity when the shaft is transmitting power under various operating and load conditions. The shaft is inclined at an angle of 35^0 to horizontal and is subjected to tursional loading, therefore, in the determination of the required diameter, tursional moment, bending moment at both vertical and horizontal are used.

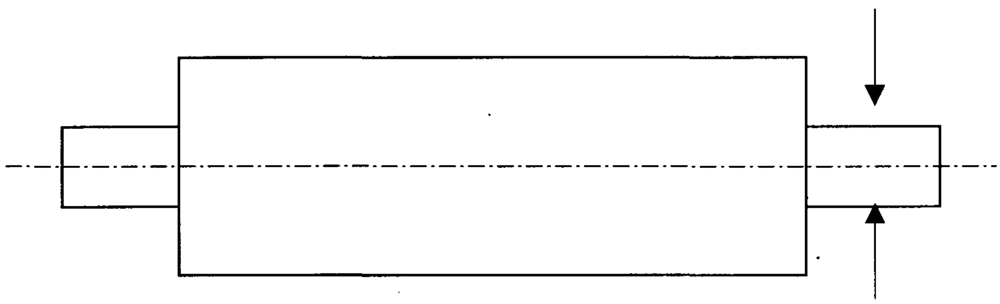

Fig. 4: Diagram showing Shaft

In this shaft size determination, it is assumed that the total weight of elements act as a uniformly distributed load on the shaft and are resolved horizontally since it is inclined.

The weights that are acting on the shaft are weight of peeling cylinder and cylinder plate cover, pulley and belt tension.

Weight of peeling cylinder plates = 6.45N

Weight of pulley = 12.25N

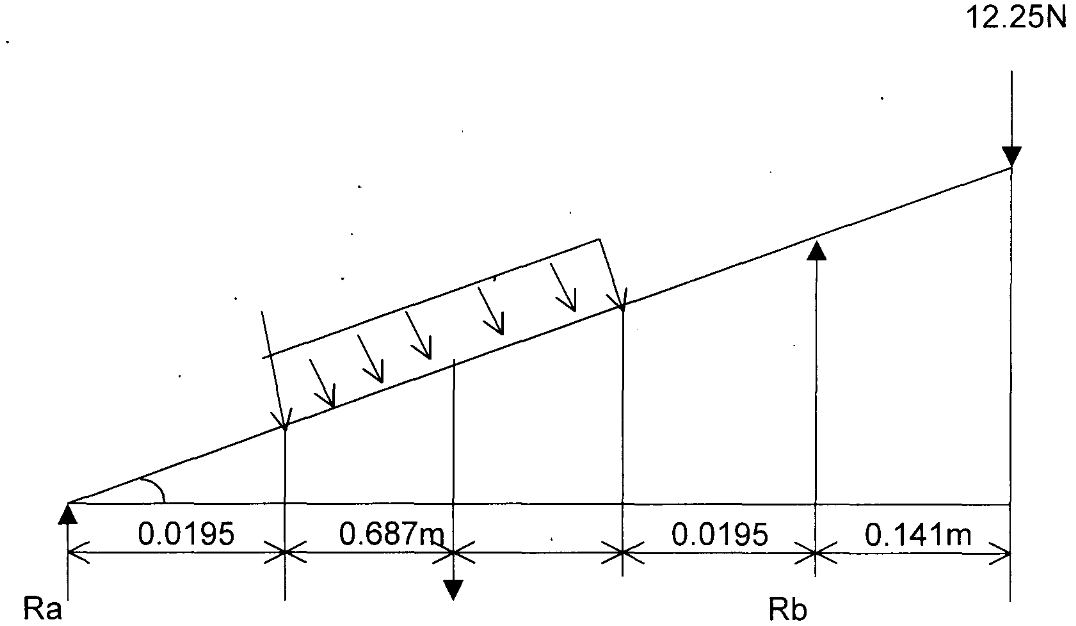

Fig. 5: Diagram showing all forces acting on the shaft and

Reactions at two bearing ends

CALCULATION:

STEP I: Resolve all forces actions on the shaft horizontally that is:

(0.195 + 0.687 + 0.0195 + 0.141) Cos 35^0

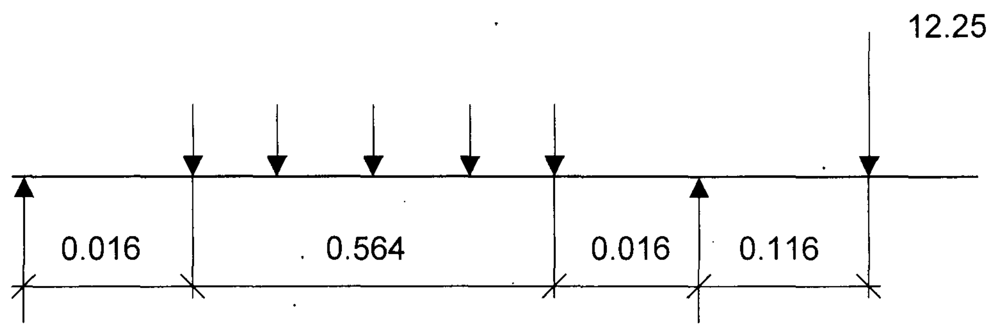

Fig. 6: Diagram showing resolved forces on the shaft

Since it is uniformly distributed load, the point load will act through the centre and distributed on 0.564m length of the shaft

$\therefore \dfrac{6.45N}{0.564} = 11.44N$

Then Resolving = 11.44N Sin 350 = 6.56N

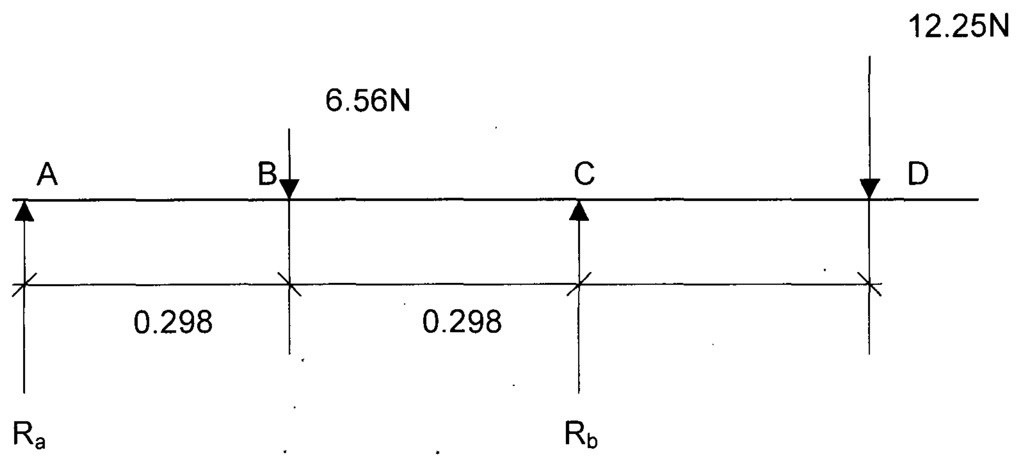

Fig. 7: Diagram showing vertical forces

To find the reactions at R_a and R_b for vertical axis:

$\left(\uparrow + Y = \right) 0 = R_a + R_b - 6.56 - 12.25 = 0$

$R_a + R_b = 6.56N + 12.25N$

$\therefore R_a + R_b = 18.81N$ ....(1)

$\left(M + = 0 \right) = 6.56 \times 0.298 - 0.598 R_b + 12.25 \times 0.712$

$= 1.95 - 0.596 R_b + 8.722$

$= 10.672 - 0.596 R_b$

$= R_b = \frac{10.672}{0.596} = 17.91N$

$\mathbf{R_b = 17.91N}$

Substituting for R_a in equation (1)

$R_a + R_b = 18.81N$

$\therefore R_a + 17.91 = 18.81$

$R_a = 18.81N - 17.91$

$R_a =$ $\underline{\mathbf{0.9N}}$

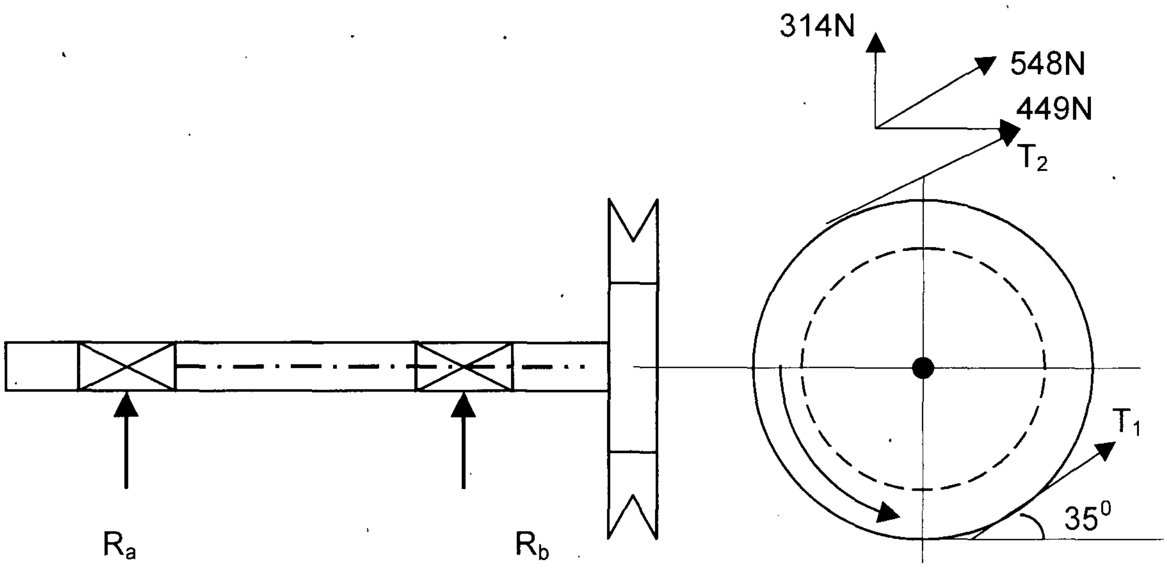

Fig. 8 Diagram showing position of Bearings and pulley on shaft.

Bending Moment at Vertical axis

(i) (0 - 0.298) = 0.9 x 0.298 = **0.268**

(ii) (0 - 0.596) = 0.9 x 0.596 - 6.56 x 0.298 = **- 1.419**

(iii) (0 - 0.712) = 0.9 x 0.712 - 6.56 x 0.414 + 17.9 x 0.116

0.001

The maximum bending moment for vertical axis

Mv = -1.42

Torsional Moment

The torsional moment acting on the shaft can be determined from

$$M_t = \frac{9550 \times kW}{Rev/min} \text{ Nm}$$

$$= \frac{9550 \times 1.5 \times 0.746}{1420}$$

The Electric motor used for this design is 1.5Hp = 0.746 x 1.5kW and has 1420 rev/min

$$\therefore M_t = \frac{9550 \times 1.5 \times 0.746}{1420}$$

M_t = **7.53Nm**

Torque on Shaft

The torque on shaft is calculated from

$M_t = (T_1 - T_2)R \quad Nm$

Where: T_1 = Tight side of belt on pulley = N

T_2 = Slack or loose side of belt on pulley = N

R = radius of pulley, M

For the purpose of this design, the ratio of the tensions in the belt is 3:1.

Therefore, $T_1 = 3T_2$ .... (1)

and $M_t = (T_1 - T_2)R$

$M_t = (3T_2 - T_2)R$

and $R = \frac{d}{2} = \frac{55}{2} = \frac{0.055}{2} = 0.0275m$

$R = 0.0275m$ and $M_t = 7.53Nm$

$7.53 = (T_1 - T_2)\ 0.0275$

$7.53 = (3T_2 - T_2)\ 0.0275$

$7.53 = 0.0825\ T_2) - 0.0275T_2$

$7.53 = 0.055T_2$

$\therefore T_2 = \frac{7.53}{0.055} = 136.91$

T_2 = **137N**

Substituting the value of T_2 into equation (1)

$T_1 \quad = 3\ T_2$

$T_1 \quad = 3 \times 137$

$\mathbf{T_1} \quad = \underline{\mathbf{411\ N}}$

Therefore, $(T_1 + T_2) = (411 + 137) = \underline{\mathbf{548N}}$

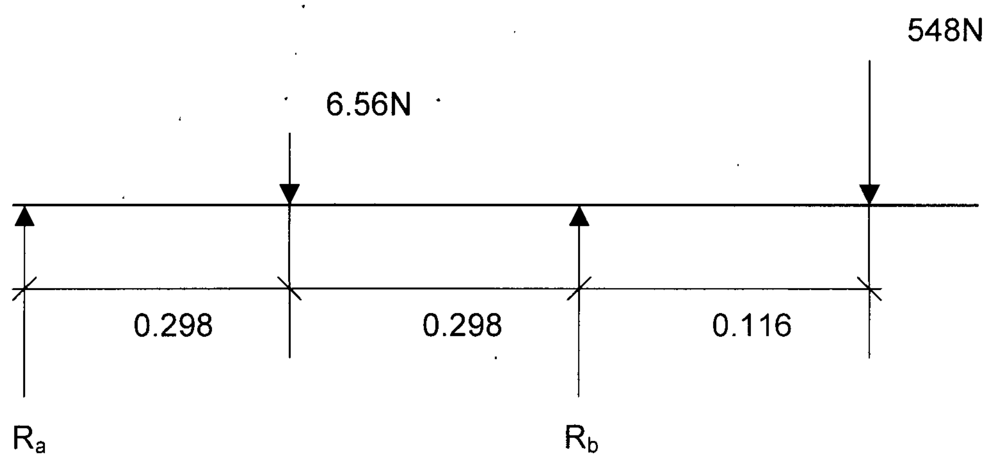

Fig. 9

To find the reactions at R_a and R_b

$$\left(\uparrow + Y = 0\right) = R_a + R_b - 6.56 - 548 = 0$$

$R_a + R_b = 555 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$

$$\left(\uparrow + M = 0\right) = 6.56 \times 0.298 - 0.596\ R_b + 548 \times 0.712$$

$$= 1.95 - 0.596\ R_b + 390$$

$$= 391.95 = 0.596\ R_b$$

$0.596\ R_b = 391.95$

$\therefore\ R_b = \dfrac{391.95}{0.596} = 657.6 = \mathbf{658N}$

$\mathbf{R_b} = \underline{\mathbf{658\ N}}$

Substituting the value of R_b in equation (1)

$R_a + 658 = 555$

$R_a = 555 - 658$

$R_a = \underline{\mathbf{-103N}}$

Bending Moment at Horizontal axis:

(i) (0 - 0.298) = - 103 x 0.298 = -3**0.69**

(ii) (0 - 0.596) = - 103 x 0.596 - 6.56 x 0.298 = **- 63.34**

(iii) (0 - 0.712) = - 103 x 0.712 - 6.56 x 0.414 + 17.9 x 0.116

= **-12.48**

M_H = -63.34N

Resultant Bending Moment

$$M_b\,(\max) = \sqrt{M_b V^2 + M_b H^2}$$

Where: $M_b V^2$ = Vertical bending moment

$M_b H^2$ = Horizontal bending moment

$$M_b\,(\max) = \sqrt{(-1.42)^2 + (-63.34)^2}$$

$$= \sqrt{2.02 + 4012}$$

$$M_b\,(\max) = 63.36 \text{ Nm}$$

Diameter of Shaft

The diameter of the shaft was determined from relationship:

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

The ASME code equation for a solid shaft

Where:

d = Shaft diameter - mm

S_S = axial stress (tension and compression)

M_t = torsional moment - Nm

M_b = bending moment - Nm

K_t = Combined shock and fatigue factor applied to torsional moment

K_b = Combined shock and fatigue factor in this design, the rotating shaft is to experience gradual application of load, therefore K_b = 1.5 and K_t = 1.0

Using the above formular, the diameter is determined

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

d^3 = ?

S_S = 55MN/m2 for shaft without key way

K_b = 1.5

K_t = 1.0

M_b = 63.36 Nm

M_t = 7.53 Nm

$$d^3 = \frac{16}{\pi \times 55 \times 10^6} \sqrt{(1.5 \times 63.36)^2 + (1.0 \times 7.53)^2}$$

$$d^3 = 9.26 \times 10^{-8} \sqrt{9032.6 + 56.70}$$

$$d^3 = 9.26 \times 10^{-8} \times 95.34$$

$$d^3 = 8.83 \times 10^{-}$$

$$d^3 = 8.83 \times 10^{-8}$$

$$d^3 = \sqrt[3]{8.83 \times 10^{-8}}$$

= 0.0206m

= 20mm

Comment: A mild steel metal shaft of not more than 20mm diameter recommended.

3.3.6 Bearing Selection and Design

Bearings are machine members or components that permit connected members to either rotate or translate relative to one another. The size of bearing is generally controlled by:

1. the shaft being stressed
2. the torsional stresses.

In other applications however, bearing load capacity is the determining factor.

The basic parameters for selecting bearing size are:

(i) the radial load (ii) the thrust load

(iii) speed (iv) the required life

(v) race rotation (vi) shock or vibration condition.

Factors affecting service life include

(i) mis-alignment

(ii) abnormal temperation.

(iii) contamination and poor lubrication

Ball bearings were selected for this design, based on the type of loading, life requirement and the speed.

The analysis for the selection of the type of bearing was done by determining the radial load.

To determine the radial load on the bearing R_L and R_R.

The effective sum of the belt tensions; $T_1 + T_2$, with the belt strands horizontal is $411 + 137 = 548N$

Resultant radial load on the left bearing

$$\sqrt{0.9^2 + (-103)^2} = \underline{\mathbf{103N}}$$

Resultant radial load on the right bearing is

$$\sqrt{17.9^2 + 658^2} = \underline{\mathbf{658N}}$$

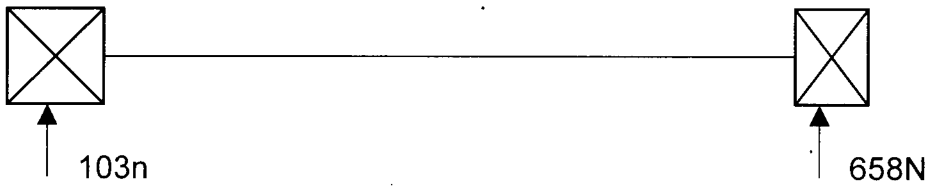

Fig. 10

To determine Rating Life Ln

Rating life is defined as the number of revolutions bearing will complete or exceed before the first evidence of fatigue develops.

SKF recommends a life of 20,000 to 30,000 hours for machines in general in the mechanical industries where machines are fully utilized for 8 hours service. Therefore, for this design 25,000 hours was recommended.

Therefore, Rating life Ln

$$= \frac{\text{No. of revolution per hour of shaft x Design Life}}{1,000,000}$$

$$= \frac{220 \times 60 \times 25,000}{1,000,000}$$

$$= 330 \text{ rev.}$$

$$Ln = 330$$

To determine the required Dynamic capacity C

The basic dynamic capacity is the constant stationery radial load which ball bearing with stationery outer ring can endure for a rating life of one million revolutions of inner ring (C).

The equivalent load is the constant stationery radial load which if applied to a bearing with rotating inner ring and stationery outer ring would give the same life as that which the bearing will attain under actual condition of load and rotation (P).

Therefore, the specific dynamic capacity required for each bearing is calculated using:

$$L = \left(\frac{C}{P}\right)^3$$

Where: $P = R_L$ for left bearing and $P = R_R$ for right bearing

$R_L = P = 103N$, and

$R_R = P = 658N$

$L = \left(\frac{C}{P}\right)^3$ for left

$$330 = \left(\frac{C}{103}\right)^3$$

$$C = 103 \sqrt[3]{330}$$

C_L = **<u>4547N</u>**

$L = \left(\frac{C}{P}\right)^3$ for right

$$330 = \left(\frac{C}{P}\right)^3$$

$$C_R = 658 \sqrt[3]{330}$$

C_R = **<u>4547N</u>**

The bearing size recommended was 22mm

CHAPTER FOUR

MATERIAL SELECTION, CONSTRUCTION AND OPERATION PRINCIPLE OF DESIGNED MACHINE

Material selection for particular engineering design is a complex process that requires a compromise of both economic, fabrication and service requirement according to specification. Material selection encompasses the basis from which design calculations and considerations are generated. For the design of power-operated cassava peeling machine, the following materials are based on the specific material properties:

4.1.0 SHAFT

Mild steel is used for the shaft because its high ductibility, toughness and fatigue resistant properties so that it can withstand rotational force it exerts on the peeling chamber as it rotates about the axis.

4.1.1 PEELING DRUM

Galvanised mild steel sheet was selected for peeling drums because of its resistance to corrosion, non-toxic to cassava and with a pleasant appearance. The attack of dilute hydro-cyanide contained in the cassava has little effect on the drum

4.1.2 PEELING DRUM CASING

Mild steel sheet was used in this construction because, it is easily cut and rolled into shapes and out can also withstand vibration induced by the turning action of the shaft. Additional criteria for the selection include its widely applications in similar construction. Mild steel is available and affordable at an optimum price.

4.1.3 Pulley Drive

The peeling unit requires a single groove pulley. The pulleys include the motor pulley, which are made of cast iron material to be able to withstand vibration and friction slip.

4.1.4 Belt Drive

The V - belt type was selected because of some of its advantages over the flat belts. Some of the advantages are:-

i. The V - belt is used with smaller sheave
ii. Its centre distance is smaller
iii. It is more durable and less costly
iv. V - belts have no danger of falling off the pulley

The v-belt type selected is made of leather material.

4.1.5 Bearing and Bearing Housing

Bearings are machine members or components, which permit connected members to rotate in the direction in which loads are applied. The life of bearings greatly depends on the purpose for which they are to be used.

Ball bearings were selected for this design because of the following:-

i. Have advantage where starting torques are high because of the rolling action of the balls
ii. Gives warning (by becoming noisy) when failure is imminent.
iii. Can take combination of radial and thrust loads.
iv. Can be pre-loaded when desirable (for instance, if the tubers are already in the machine before starting).
v. Failure of lubrication system with ball bearing is not calamitous as in others most especially in journal bearing.

The housings were constructed using a 100 x 20mm flat bar. The housings were secured to the frame by means of bolts and nuts.

4.1.6 Machine Frame and Motor Adjustable Seat

The frame, which supports the machine is made of a 50mm x 50mm angle iron of mild steel. The adjustable motor seat is made of the same material.

4.1.7 Feed Tray and Outlet Chute

The freed tray and outlet chute were made of mild steel sheet of gauge 18. Reason for selecting mild steel sheet has been highlighted earlier.

4.2.0 DESCRIPTION AND OPERATION OF MACHINE

The cassava peeling machine that was designed consists of a perforated cylinder surface (A) eccentrically placed on a shaft and covered by casing (F). This arrangement was mounted on a frame (D) inclined at 35^0 to the horizontal as shown in plate (1). The machine is powered by an electric motor from which (A) is belt driven. The cassava tubers are introduced lengthwise through the feed-tray (C) down into the peeling chamber where the perforated cylinder shaft scrubes on it as shaft is being rotated by an electric motor.

For effective peeling, a certain amount of pressure on the cassava tubers is required. An arrangement that would provide this pressure without unduly restricting the rotation and flow of the tubers was chosen. It consists of wooden flat bar (B) bolted to the guardrail (E). Due to the tilting, the peeled tubers glide out through outlet chute (G). Exploded view shows all the essential components of machine.

4.30 TECHNICAL CHARACTERISTS OF MACHINE

1.	MACHINE:	Length	-	750mm
		Width	-	435mm
		Height-	-	695mm
2.	SHAFT:	Diameter	-	20mm
		Length	-	866mm
3.	BEARING	Diameter		20mm
4.	POWER (Watt)			1.5Hp (1,119) wt
5.	SPEED OF OPERATION			220 rpm
6.	PEELING EFFICIENCY			67%
7.	PRODUCTION CAPACITY			225 Kg/hr
8.	MAXIMUM TUBER DIAMETER			100mm

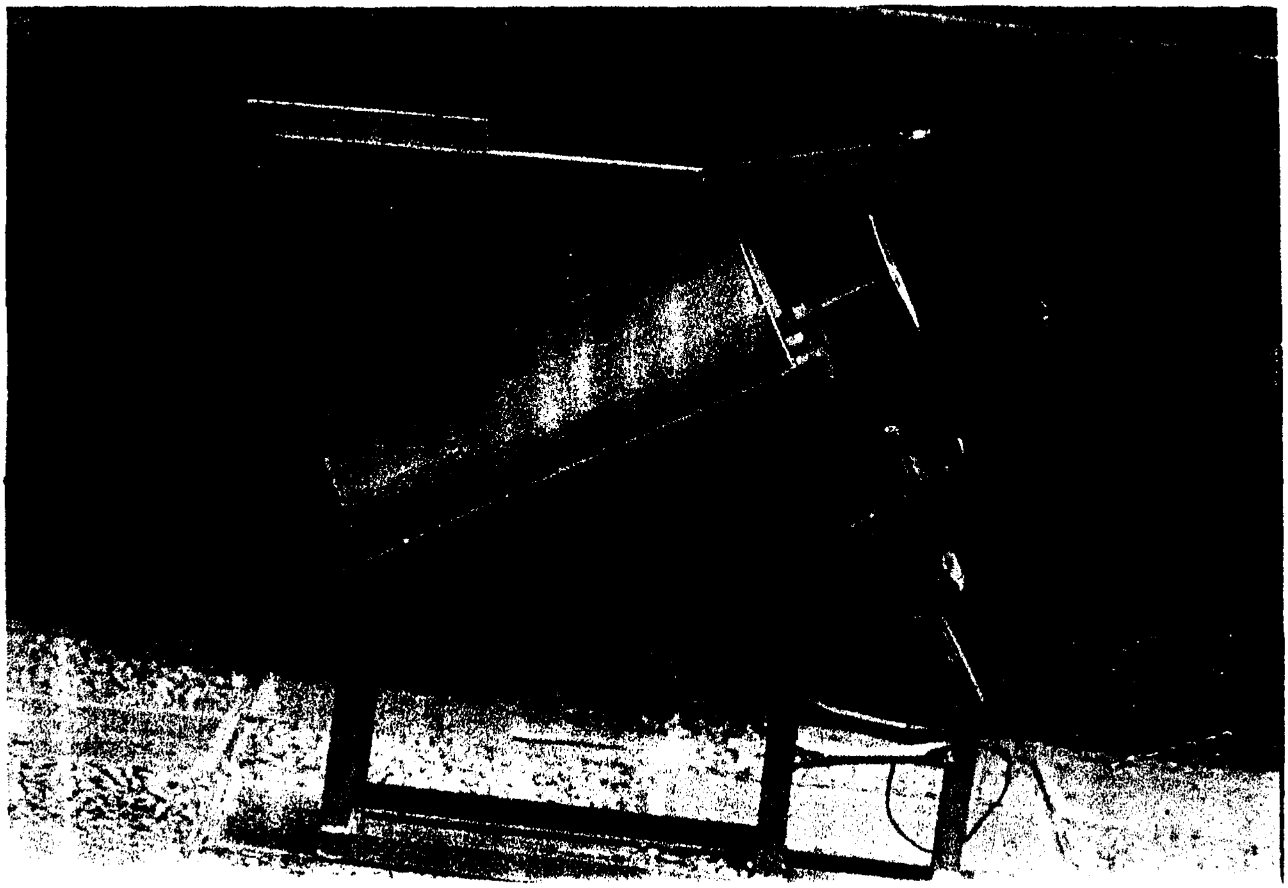

PLATE 1: Cassava peeling Machine

CHAPTER FIVE

PERFORMANCE EVALUATION

The constructed machine was evaluated on the basis of its peeling rate and quality of peel. Three replicates of 10 tubers of known weight were peeled one after the other and time taken for peeling determined by use of a stop watch. The quality of peel by the machine was evaluated by measuring 10 samples out of some peeled tubers. The diameters of the tubers before and after peeling were measured using a vernier calliper and thickness of periderm and cortex removed was determined. The results all shown in tables I, II, III, IV and V.

CAREFUL MANUAL (HAND) PEELING

The manual (hand) peeling of tubers was determined for 1, 2 and 3 using the same weight. Three replicates of 1, 2, and 3 were studied. The result is shown in table II.

RESULT AND DISCUSSION

The optimum peeling performance that may be expected of a cassava peeling machine is obtained when complete removal of the peel is achieved without removal of useful tuber flesh, Odigboh (1976).

The machine was evaluated using freshly harvested cassava tubers, which were fed into machine manually. The result of machine peeling rate of 225 kg/hr shown in table II indicates that there is an improvement over the reported peeling rate of 135kg/hr for continuous process peeling machine and 180kg/hr for batch type abrasive peeler, Odigboh (1976) .

The overall rating gives gross visual assessment of the peeling efficiency. It was observed that the larger root tubers with 55.5mm to 68.5mm diameter completely peeled with minimum losses of flesh while smaller sizes with 20mm diameter were incompletely peeled. For medium sizes of tubers with 25mm to 48.5mm diameter, some were peeled completely and others were not.

On the basis of the cassava periderm and cortex removed, the machine was capable of removing the periderm completely at about 73.5% moisture content leaving some traces of cortex. The thickness of the tuber removed by the machine was 2.25mm while the designed thickness to be removed was that of periderm (1.6mm) and cortex (3.1mm) Table V. It is desirable that the entire periderm and cortex (4.7mm) be removed because of cyanide contained in this portion of the tuber.

Manual hand peeling removes just cortex whose weight is just a certain fraction of the unpeeled tuber weight. The result of the careful manual hand peeling operation in Table II shows that the ratio of peeled to unpeeled weight of tubers used in the performance test was an average 0.787 or 78.70%. In other words, the peel (cortex) was 21.30% of the unpeeled tuber weight. Therefore, the constructed machine has peeling efficiency of 67% and output of 225kg/hr. However, hand trimming was necessary.

Plate (2) shows cassava tubers peeled by the machine.

PEELING EFFICIENCY

The peeling efficiency of the machine was determined by percentage losses of flesh from machine.

From Table (4), result from machine peeling showed that 52.40% of peel (cortex, periderm and flesh) was collected. And also from Table (3), the result showed that only 21.60% of peel (cortex and peridern) was removed through manual hand peeling.

Therefore, to determine the amount of flesh losses from machine, 52.40% was subtracted from 78.40% equal to 26.00%.

then, $\frac{26}{78.4} \times 100$ loss of flesh

$= \underline{\mathbf{33.16\%}}$

$\therefore$ Peeling efficiency $= 100 - 33 = \underline{\mathbf{67\%}}$

This 33% of flesh losses could be used for animal feeds.

PLATE 2: **Cassava Tubers peeled by the Machine**

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

1. The objective of increased peeling rate, which prompted the design of this type of peeler has been achieved to a satisfactory degree inspite of the hand trimming after peeling.
2. The machine can be useful in situations where considerable quantities of tubers have to be peeled in limited time and when complete removal of the peel is not indispensable.
3. The breakage of cassava tubers was minimised, but hand trimming, sorting for sized tubers and cutting to certain length before peeling were time consuming and its disadvantages.
4. The cost of construction and operation is minimum, which peasant farmers can afford.

RECOMMENDATION

It is recommended that:

1. speed of peeling drum be reduced between ranges of 10 – 40 rpm.
2. the abraded peel from machine could be used for animal feed after de-water.
3. water be sprayed on to the tubers and abrasive from the drum shaft. This sprayed water will wash off and carry away the finely abraded peels through the perforation in the drum thereby prevent fouling and dulling of the abrasive surfaces.

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NOTATION USED

N_E	-	Speed of selected Electric Motor
N_M	-	Speed of Peeling Drum
D_E	-	Diameter of Electric Motor Pulley
D_M	-	Diameter of Peeling Drum
P	-	Power transmitted from motor
V_P	-	Peeling speed
F	-	Cutting force
T_1	-	Tension on tight side
T_2	-	Tension on slack side
C	-	Centre-to-centre belt distance
D	-	Smaller pulley diameter
L	-	Length of mild steel
P	-	Density of mild steel
R_a	-	Reaction of bearing A
R_b	-	Reaction of bearing B
M_t	-	Torsional moment
S_S	-	Allowable stress for shaft
K_b	-	Combined shock and fatigue factor applied to torsional moment
K_t	-	Combined shock and fatigue factor applied to bend moment
B_M	-	Bending moment
F_r	-	Radial load
W	-	Angular velocity
T	-	Torque
L_n	-	Rating life

COSTING

This is an estimate cost of producing the proposed machine in terms of material and labour cost based on the present market prices.

MATERIAL COST

S/no	Material & Specification	Qty	Unit Cost	Amount
1	18 gauge Mild Steel sheet	2	2,500.00	5,000.00
2.	Springs	10	15.00	150.00
3.	Angle bar			
	(50 x 50 x 6mm) (4500mm)	1	800.00	800.00
4.	18 Gauge Galv. Iron sheet	1	2,700.00	2,700.00
5.	Mild Steel shaft 25 by 920mm	1	350.00	350.00
6.	Ball bearings 25	2	2,550.00	250.00
7.	Pulley (135 cast iron single groove)	1	350.00	350.00
8.	Electrodes (gauges 12 & 14) 280		1.50	420.00
9.	M8 bolts	6	150.00	900.00
10.	Mx bolts	48	5.00	240.00

		~~1~~	~~750.00~~	~~750.00~~
12.	Colour paints (small tins)	2	150.00	300.00
13.	Electric motor 1.5hp	1	2,500.00	2,500.00
14.	Angle bar 2mm thick by 720mm	1	450.00	450.00
15.	V-belt	1	150.00	150.00
16.	Miscellaneous (transport and others)			1,500.00
	Sub-total	=		N16,250.00
	Add 10% inflation for possible increase in prices			1625.00
	Total cost			17,875.00

LABOUR COST

The following assumptions will be made for adequate labour costing, with respect to the labour situation in the country.

1. Engineer's Fee = N125/hr

II. Machinist fee = N50/hr

III. Technician/Welder's charge = N25/hr

S/No	Operation	Time(mins	No of Personnel	Rate	Total cost N K
A	Peeling Chamber				
	1. Cylinder Marking	40	1 Technician	25	16.67
	Cutting	15	1 Technician	25	6.25
	Rolling of the cylinder	15	1 Technician	25	6.25
	Welding	30	1 welding	25	25.50
	1 End plates				
	Making	20	1 Technician	25	8.33
	Cutting	15	1 Technician	25	6.25
	Drilling	25	1 Technician	25	10.42
	Welding	35	1 Welding	25	14.58
	3. Shaft				
	Cutting	20	1 Technician	25	8.33
	Machining	45	1 Machinist	50	37.50

B.	Cashing				
	Marking	20	1 Technician	25	8.33
	Cutting	15	1 Technician	25	6.25
	Perforating with nail	180	1 Technician	25	75.00
	Rolling of casing	15	1 Technician	25	6.25
	Welding	35	1 Welding	25	14.58
C.	Feeding Unit				
	Marking	15	1 Technician	25	6.25
	Cutting	15	1 Technician	25	6.25
	Welding	25	1 Welder	25	10.42
D.	Main Outlet				
	Marking	15	1 Technician	25	6.25
	Cutting	20	1 Technician	25	8.33
	Welding	15	1 Welder.	25	6.25

E.	Power Unit 1 Motor mounting Cutting Drilling Welding	 25 35 30	 1 Technician 1 Technician 1 Welder	 25 25 25	 10.42 14.58 12.50
2.	Motor Installation Bolting Pulley/V.belt	 15 15	 1 Technician 1 Technician	 25 25	 6.25 6.25
3.	Bearing installation Installation Welding	 25 15	 1 Technician	 25	 10.42
	Welding	15	1 Welder	25	6.25
F	Support Frame		 1		

11.	Flat bar 5mm thick by 750mm				
	Marking	30	Technician 1	25	12.50
	Cutting	50	Technician 1	25	20.83
	Welding	50	Technician	25	20.83
G.	Machine				
	Assembly				
	Peeling unit	45	1 Engineer	125	93.75
	Power Unit	30	1 Engineer	125	62.50
H.	Painting	90	1 Painter	25	37.50
	TOTAL				N595.82

Production Cost = Material cost + Labour cost =

17875 + 595.82 = N18,470.82

Add 10% contingency allowance to production cost

Total Production cost = 18470.82 + 1847.08 = N20,317.90

Plus 15% contingency to core designers and supervisors fee

Total production cost = N20,317.90 + 3047.69

N23,365.59

(TABLE 1) MEASUREMENT OF CASSAVA TUBERS EXPERIMENTAL DETERMINATION OF TUBER LENGTH DIAMETER AND WEIGHT,

S/n	Diameter (mm)	Length (mm)	Weight (gm)
1.	59.0	450	1256
2.	57.3	510	1184
3.	70.3	480	1878
4.	60.7	305	837
5.	56.3	335	895
6.	50.3	530	1370
7.	75.3	525	2065
8.	46.7	480	874
9.	42.7	260	433
10.	69.0	470	1632
11.	41.0	500	787
12.	48.3	490	1020
13.	41.3	120	157
14.	28.7	195	111
15.	30.0	205	175
16.	49.3	410	757
17.	40.0	350	408
18.	40.0	380	543
19.	48.0	120	189
20.	29.0	215	187
	Average-49.161	366.50	837.75g (0.658kg)
	Max-75.00	525.00	2065g (2.065kg)
	Min-28.70	120.00	187g (0.187kg)

TABLE II: EVALUATION OF PEELING RATE OF MACHINE

REPLICATES

SAMPLE	A	B	C	Total	Mean
Number of tubers	10	10	10	30	10
Weight of tubers (kg)	3.51	3.57	2.73	9.81	3.27
Time taken to peel (sec)	53.50	54.00	49.00	156.5	52.20
Time Taken to peel (hr.)	0.01	0.01	0.01	0.03	0.01
Rate pf peeling (kg/sec)	0.07	0.07	0.06	0.2	0.07
Rate of peeling (kg/hr.)	236	2.38	200	674	225

The peeling rate in kg/hr = 225

TABLE III: MANUAL (HAND) PEELING OF CASSAVA TUBER

REPLICATE	Average weight of 10 tubers unpeeled (kg)	Average weight of 10 tubers peeled (kg)	% of peeled to unpeeled tuber
1	5.50	4.30	78.18
2	3.75	3.17	84.50
3	4.25	3.12	73.42
TOTAL	**13.50**	**10.59**	**78.4**

78.4% of flesh and 21.6% of cortex

TABLE IV: RESULTS FROM CASSAVA PEELING MACHINE

REPLICATE	Average weight (kg) of a tuber before machine peeling	Average weight (kg) of a tuber after machine peeling	Difference	% Difference
1.	0.351	0.145	0.206	58.69
2.	0.357	0.2165	0.1405	39.36
3.	0.273	0.1115	0.1615	59.16

Average 52.40%

Table V **THICKNESS OF TUBERS PEELED BY MACHINE**

Samples Of Tubers

	Diameter of tuber before peel (mm)	Diameter of tuber after peel (mm)	Thickness of tuber peeled (mm)
1	6.93	6.82	0.11
2.	5.13	4.84	0.29
3.	4.96	4.89	0.07
4.	5.50	5.12	0.38
5.	3.50	3.36	0.14
6.	4.21	3.98	0.23
7.	3.10	2.95	0.14
8.	4.94	4.74	0.20
9.	4.60	4.29	0.31
10.	6.30	6.16	0.14
Mean	4.917	4.715	0.201

Table VI **EXPERIMENTAL DETERMINATION OF CASSAVA PERIDERM AND CORTEX**

MEASUREMENT OF PERIDERM **MEASUREMENT OF CORTEX**

SAMPLE No.	PERIDERM (cm)	SAMPLE No.	CORTEX (cm)
1	0.12	1	0.13
2.	0.11	2	0.12
3.	0.15	3	0.14
4.	0.52	4.	0.5
5.	0.12	5.	0.34
6.	0.11	6.	0.15
7.	0.14	7.	0.23
8.	0.09	8.	0.31
9.	0.10	9.	0.51
10.	0.50	10.	0.21
11.	0.11	11.	0.44
12.	0.10	12.	0.12
13.	0.16	13.	0.53
14.	0.13	14.	0.40
15.	0.11	15.	0.31
16.	0.15	16.	0.12
17.	0.21	17.	0.20
18.	0.21	18.	0.30
19.	0.14	19.	0.12
20.	0.15	20.	0.33
21.	0.10	21.	0.51
22.	0.11	22.	0.31
23.	0.13	23.	0.52
24.	0.15	24.	0.50
25.	0.14	25.	0.34
Total	4.04	Total	7.69
Mean	0.162 cm	Mean	0.308 cm