UNIVERSITY OF EDUCATION, WINNEBA

DESIGN AND FABRICATION OF COCONUT FIBRE COCONUT DEHUSKING MACHINE

IBRAHIM YUSSIF

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UNIVERSITY OF EDUCATION, WINNEBA

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IBRAHIM YUSSIF

(190000203)

A Dissertation in the Department of MECHANICAL AND AUTOMOTIVE TECHNOLOGY EDUCATION, faculty of TECHNICAL EDUCATION, submitted to the School of Graduate Studies in partial fulfilment of the requirements for the award of the degree of Master of Technology (Mechanical Engineering) in the University of Education, Winneba

MAY, 2020

DECLARATION

STUDENT'S DECLARATION

I, **IBRAHIM YUSSIF**, declare that this Dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for an-other degree elsewhere.

SIGNATURE: .....……

DATE: …….....

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Dissertation as laid down by the University of Education, Winneba.

NAME: **MR. C. K. NWORU**

SIGNATURE: .....……

DATE: …….....

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DEDICATION

I dedicate this work to my lovely children; Shamimatu Ibrahim, Alimatu Ibrahim, Abdul Hafiz Ibrahim and Faruza Ibrahim.

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ABSTRACT

Coconut is a main crop of Central region and dehusking of coconut is very necessary step in making the coconut ready for further utilization. Coconut dehusking involves removing of the husk from the coconut. Traditional dehusking is time consuming and difficult process. To overcome these limitations, to improve the automation and to provide safety for the operator, a new design of dehusking machine is introduced and fabricated. This dehusker comprises usage of two horizontal rollers with series of sharp tools which would shear the husk from coconut when rolling against each other. Shear force is required for dehusking of mature green coconut and dry brown coconut. Shear force required is more for mature green coconut than dry coconut. Torque and speed reduction required for dehusking is calculated by using the force required for shearing coconut. Optimum number of spikes is arranged on the rollers to dehusk the coconut with minimum force.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Coconut (Cocos nucifera) is one of the world's most useful and important perennial plants. The coconut fruit is made up of an outer exocarp, a thick fibrous fruit coat known as husk; underneath is the hard protective endocarp or shell. Almost all the parts of coconut are useful. The meat of immature coconut fruit can be made into ice cream while that of a mature coconut fruit can be eaten fresh or used for making shredded coconut and livestock feed. Coconut milk is a refreshing and nutritious drink while its oil is used for cooking and making margarine. Coconut oil is also very important in soap production. The shell is used for fuel purpose, shell gasifier as an alternate source of heat energy. The husk yields fibres used in the manufacture of coir products such as coir carpets, coir geo-textile, coir composite, coir safety belts, coir boards, coir asbestos and coir pith. Coir is a versatile natural fiber extracted from mesocarp tissue, or husk of the coconut fruit. Generally, fiber is of golden color when cleaned after removing from coconut husk. Coir is the fibrous husk of the coconut shell. Being tough and naturally resistant to seawater, the coir protects the fruit enough to survive months floating on ocean currents to be washed up on a sandy shore where it may sprout and grow into a tree, if it has enough fresh water, because all the other nutrients it needs have been carried along with the seed. Although coconut is of immense economic importance to both the industrialist and rural dwellers, separation of its husk from the nut (dehusking) constitutes the first, most difficult and dangerous operation in its processing. The use of cutlass which is the popular traditional method for coconut dehusking poses threat and danger to the life of people involved, since on the process of dehusking, some cut their hands, and face as the cutlass usually bounces back on

hitting the husk. The use of metal spike was later developed to overcome these negative features of dehusking of the fruit with matchet but this later development focused only on extraction of coconut meat even though accident, time and energy consumption was reduced. The search for a device that will enable effective recovery of other products of this fruit such as the milk, shell and fibre continued due to the importance of these coconut by-products in modern technological applications. Though, rural small scale farmers constitute the major source of coconut fruits supply to the nation the budget of this category of farmers cannot carry the huge investment requirement in both electric generator and costly motorized coconut dehusking equipment which are mostly of foreign origin. Also, the problem scarcity of petroleum-based fuels such as petrol and diesel in this country since 1993 makes the operation of this electric powered equipment difficult. Thus, most Nigerian coconut farmers still use the crude method of dehusking by cutting with cutlass despite the adverse features of this technique. It is therefore of economic sense if a manually operated machine that can dehusk the fruit without nut breakage and distortion of the extracted fibre length is developed from standard and locally sourced materials to ensure affordability to rural based small scale coconut farmers of this nation and other developing nations in both acquisition and maintenance. Hence, objective of this study is to develop a coconut dehusking machine.

1.2 Statement of the Problem

Need for the improvement in present method of coconut dehusking is the lack of sufficient manpower. This necessitates the use of appropriate machinery to aid in various tasks in coconut plantation. Traditional devices currently in use, such as the blade and spear are dangerous and minimally productive. Based on this realization, a machine is fabricated that simplifies an important process as well as increases the

productivity of the coconut industry. This new mechanism will indirectly boost any economy that relies on coconut plantations. The machine includes a base or a frame positioned on a support surface. Two rollers have spiked tool separated by a small distance, substantially parallel relation with each other. A drive is directly engaged to rollers. Interconnection forces it to rotate in opposite directions. Roller rotates in a direction towards centre, shearing the husk from coconut.

This machine is useful to the coconut estates and co-operatives, coconut growers and coconut processing factory. The machine can provide faster work rate and less human interaction. This machine is expected to increase the coconut dehusking rate, hence an additional income to coconut growers. It does not require direct human force as in normal methods because in this the spiked rollers which are rotating are made to enhance the force at the head of the coconut to put pressure for dehusking. Also, coconut of any size and shape can be dehusked easily. It is easy to operate, does not need skilled labour, rapid, safe operation and simple maintenance. It can be easily assembled and disassembled and is portable. The cost of this machine is lesser as compared to the present available machines. Also, these available machines require external electrical power supply. Advantages are to remove the husk effectively and easily, to increase productivity, to reduce manual power, to reduce risks and accidents, to reduce labour cost and time consumption.

This coconut dehusking machine peels off the coconut husk to obtain a dehusked coconut via mechanically controlled dehusking devices called as spiked rollers. To transmit the power from motor to cylindrical rollers gear and chain and sprocket transmission system shall be incorporated. The dehusking unit is consisting of cylindrical rollers attached with tynes (cutting pins) over the surface. The coconut is

placed in the intermediate distance between rolling cylinders. The rollers will rotate in such a way that there will be tearing of coconut fiber from the shell. With proper meshing of fiber with tynes effective dehusking is achieved while consuming lesser time. The shape and size of coconut is considered while designing the machine. The rollers are interconnected to each other by means of a spur gear arrangement. The rollers are kept apart with a centre distance depending on the average diameter of coconut shell, so that the coconut shell should not pass in between the rollers. The whole set up is mounted on a rigid frame made of mild steel.

However, through overview on coconut fiber dehusking, leads to some problems immerging from the traditional way of dehusking coconut in this project which can be summed up in the following sentences;

Traditional coconut processors lack basic tools for dehusking coconut

More human energy is require3d

Process involved is slow

Low production

1.3 Aim of the Project

The aim of this project is to design and fabricate a simple coconut dehusking machine for the traditional fiber processors. It is aimed at reducing the human intervention in the process thereby minimizing the rate of accident.

1.4 Objective of the Project

The broad objective of the project is to reduce the hindrance that is affecting the local coconut processors.

The specific objectives of the study are to:

Design and fabricate simple coconut dehusking machine for local coconut processors

Reduce drudgery in dehusking coconut by the traditional folk

Speed up the process in dehusking coconut

Increase production rate

1.5 Significance of the Project

1. The work will add new information to already existing knowledge
2. The study will serve as a reference document for further research
3. The research work ultimately is to make known the problems people in the study area encounter, so as to help find lasting solution to them.

1.6 Delimitation of the Project

The study should have discovered two or more alternative dehusking machines but due to time and financial constrains it is limited to only one dehusking machine.

1.7 General Overview of the Study

Chapter One deals with introduction and background of the study. Chapter Two deals with review of literature to the study while Chapter Three examines the methodology. Chapter Four look at the result at the result and discussion, final Chapter Five deals with the findings, summary, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Coconut

Coconut palm (Cocos nucifera L.), is a tree which belong to the palm family Arecaceae. It is one of the most important crops of the tropics, it is referred to as "The Tree of Life" (CRC, 2004).

Early Spanish explorers called it Coco, which means "monkey face" because of the three indentations (eyes) on the dehusked nut which resembles the head and face of a monkey. Nucifera means "nut-bearing" (CRC, 2004, UNCTAD, 2012). Punchihewa et al. (1999) referred to coconut as the "heavenly tree", "tree of life", tree of abundance" and "nature's supermarket" because it is the most important palm. The name coconut refers to the entire palm, the seed or the fruit (not a biological fruit, but a drupe), (UNCTAD, 2012).

Naturally there are two sub-groups of coconut simply referred to as: Tall" and "Dwarf" cultivars. Coconut trees are typical single trunked palms which can grow up to 50 – 100 ft. in height.

Coconuts are planted by seed and are usually planted 9 m (25 ft.) apart. Coconut tree can produce an average of 70 – 150 nuts per year and the tree can remain productive for 50 – 100 years (Yeboah, 2010; UNCTAD, 2012). The coconuts can tolerate drought but not cold weather. The plant thrives well in warm and humid climate with temperatures ranging between 70 – 80 ^{0}F (21.1 – 26.6 ^{0}C) with a relative humidity above 60% and with rainfall of 1,500 – 2,500 mm, which must be evenly distribution throughout the year. They grow well on light, medium and heavy soils as well as loams

and clays soils which are well drained and can tolerate saline and infertile soils (UNCTAD, 2012).

Wide range of pests and diseases affect coconsuts plants. The common pests are boring insects, rhi8noceros beetles (Oryctes rhinoceros and Scapanesaustralis), red palm mite (Raoiellaindica), coconut leaf caterpillers, palm weevil, moth borers and ants (Azteca spp.). Some of the diseases are Phytoplasmal (fungal) diseases, Bacterial bud rot caused by Erwiniaspp and Lethal yellowing disease which is caused by mycoplasmas (virus disease). The Lethal yellowing disease is locally referred to as the "Cape St Paul".

Wilt Disease" (CSPWD), which has spread through Caribbean, Central America, West Africa, East Africa and part of southern India (UNCTAD, 2012). Coconuts fruits fall from the tree when they are fully mature and are easily picked from the ground. Coconuts intended for copra or oil production are split open with a cutlass, discarding the water (juice) and exposing the kernel. Nearly one third of the world's population depends on coconut as their source of food and their economy (CRC, 2004). Most people living on islands use coconut as a staple in their diet which provide them with juice, milk, oil and a nutritious source of meat that has fed and nourished population around the world (CRC, 2004). As the Jamaicans says "coconut is a health, tonic, good for the heart" (Fife, 2004). The coconut is a very versatile crop, which requires little care with many uses such as food, fibre, fuel, water and shelter also for landscapes and home beautification. In addition, for Agro-forestry uses, it includes coastal stabilization and windbreaks (UNCTAD, 2012).

The coconut palm is widely distributed throughout Asia, Africa, Latin America, the Caribbean and the Pacific region and it is not grown in Europe and Australia (UNCTAD, 2012). Coconuts are produced in about 92 countries worldwide on about 11.8 million hectares (29.5 m acre) of lands. World production has been estimated at 61.7 million tons with an average yield of 5.2 tons /ha. Furthermore, Punchihewa et al., 1999 stated that Papua New Guinea, Tanzania and Brazil are the leading producers in South Pacific countries, Africa and Latin America respectively. About 50 percent of the world production of coconut is processed into copra. While a small portion is processed into desiccated coconut and other edible products, the rest is consumed as fresh nuts. Furthermore, the coconut palm also provides a lot of by-products such as fibre, charcoal, vinegar, alcohol, sugar, handicrafts, furniture, roofing and fuel, which provide an additional source of income to the farmers (Punchihewa et al., 1999)

2.2 Brief History of Coconut Industry in Ghana

Coconut is an important crop in the economy of the people in coastal areas of Ghana (Yeboah, 2010). It is believed that coconut was first introduced into West Africa by the Portuguese missionaries in the 16th Century. In Ghana, the missionaries first planted coconut trees in the Volta Region and when it survived on the beach, which was very poor to other plants due to its high salinity and porosity of the soil, the then Department of Agriculture under the colonial administration during the Gold Coast, promoted the mass cultivation of coconut on the coast, Westwards to the Western Region (Yeboah, 2010.

Apart from the coast, the coconut also grew very well inland in the forest zones. Although coconut was first introduced in the Volta Region, the majority of its production now comes from the Western Region, particularly the Jomoro District

(Yeboah, 1010). Some of the coconut varieties cultivated are the popular West African Tall (WAT), Vanuatu Tall (VTT), Sri Lankan Green Dwarf (SGD), the newly hybrids Malayal Yellow Dwarf crossed Vanuatu Tall (MYD x VTT) and Sri Lankan Green Dwarf crossed Vanuatu Tall (SGD x VTT) coconuts, established between 1981 and 1983 with the latter in 1995 (Dare et al., 2010).

The West African Tall (WAT) which is a local coconut variety, that is mostly cultivated in Ghana, is very high-yielding both in quality of the food and oil extraction as well as quantity of the nut. As a result, many of the people who went into the cultivation of coconut became very rich (Yeboah, 2010).

The good agronomic characteristics of the SGD x VTT hybrid as coupled with its high resistance to the Cape Saint Paul Wilt Disease (CSPWD) proved its suitability as alternative planting material to revamp the coconut industry in Ghana (Dare et al., 2010).

Due to the outbreak of the CSPWD about quarter of the country's 45,000 hectares coconut plantation had been wiped off by the disease from the eastern part of the country (Yeboah, 2010). However, the Coconut Sector Development Project (CSDP) in 1999 sought to reverse the devastation of farms by CSPWD by providing new planting materials, replanting, intensification and improvement of farm management, improvement of small-scale oil processing and research (N.E.M.A., 2006).

The name of the disease in Ghana was derived from Cape St. Paul, a small village near Woe in the Volta Region, where it was first detected in 1932. Within 10 years of its detection, it spread to many parts of the Volta Region, specifically Keta. The disease

was confined to the keta area until 1964 when it showed up again at Cape Three Points in the Western Region, again wrecking large acres of coconut plantations (Yeboah, 2010). The Ministry of Food and Agriculture (MoFA), (2013), maintained and conducted coconut hybridization nursery fields at Anyinasi where there are 20 ha of Malayan Yellow Dwarf (MYD) and 10 ha of Sri Lanka Green Dwarf (SGD) varieties fields at Bonsaso. At the close of the year 2013, 212 hectares had been re-planted for 266 individual farmers in the Western and Central Regions by the "Restoration of the Livelihood of Coconut Farmers" (RESTOLIFE) project (MOFA, 2013). It is aimed at reducing poverty by helping farmers replant coconut plantations destroyed by the Cape Saint Paul wilt Disease (CSPWD). In the production and marketing of coconut products, COFPMAG (2006) identified the following findings; lack of oil products in Ghana, local consumption of coconut product is increasing, export of coconut products is increasing and with good prices for the farmers. However, about 4.2% of the population of Ghanaian depend on coconut for their livelihood (Adams et al., 1996). In the Western Region, it is estimated that only 20% of the rural dwellers depend on coconut for their sustenance (Adams et al., 1996).

Coconut marketing in Ghana is shared among the various stakeholders in the value chain. There are four market situations; the fresh nut (drinking) market, dry nut market, copra oil market and the husks and shells market (COFPMAG, 2006). The fresh nuts are sold by the farmers themselves, wholesalers and retailers in towns and cities. The dry nuts are sold to the local coconut oil processors, coconut oil mills and exported to Nigeria. The marketing of dry nuts to Nigerians has evolved very quickly and resulted in significant increase of income to the coconut farmers (COFPMAG, 2006). The husks and shells were mostly bought by WIENCO Fibre Factory (Jomoro District) for

processing. According to COFPMAG (2006), there are three copra processing factories in Kumasi; Vester Oil Mills Ltd in Abuontem, A.B. oil mills in Abuakwa and Golden Web oil mills in Boankra. These factories mostly sell the oil to soap factories in Burkana Faso. The local coconut oil processors produce mainly for local consumption and for the market. Their produce is mainly marketed in Accra (Abobloshie), Kumasi (Railway Station), Tarkwa and Obuasi, (N.E.M.A.; COFPMAG, 2006). However, due to the inefficient technology used the oil recovery rate is quite low (N.E.M.A., 2006).

The wholesalers of coconut oil buy the oil from the processors in the villages in drums (210 litres) and jerrican (62 littres), (MoFA, 2004). The wholesalers and retailers of coconut oil are organized into associations and for example about thirty wholesalers from Nzema East District in Accra and fifty in Kumasi and also about one thousand oil retailers in Accra (COFPMAG, 2006).

2.3 Composition of Coconut

Coconut is botanically a drupe from the family Arecaceae and can naturally be propagated by seeds. The main agents of dispersal of coconut are animals (man) and water (sea, rivers and others). Domestic varieties include Vanuatu Tall, Sri-Lankan Green Dwarf, Malayan Yellow Dwarf, Equatorial Green Dwarf and West Africa Tall. Apart from West Africa Tall being a pure breed, the others are hybrids.

2.3.1 Physical Properties

The coconut fruit is made up of 35%wt husk, 28%wt copra, 12%wt shell, 5%wt milk and 20%wt water Bradley and Huang, 2006). This implies that the edible part of the coconut fruit is made up of the copra and water, forming 53%wt of the coconut fruit with specific composition as 33%wt as copra (original copra weight and milk weight) and 29%wt as juice.

The non-edible part of the coconut fruit is also made-up of the husk and shell summing up to 47%wt of the whole coconut fruit, specifically as 35%wt husk and 17%wt shell. One third of the coconut fruit's make-up is the husk which envelops the hard-shell structure of about 3.5 mm thickness (Ganiron, 2013). The external appearance of the husk varies from decidedly dull brown when fully ripe to bright green when immature. There are other varieties of coconut whose husks are either golden yellow or yellow brown. The husk is full of long, coarse fibers, all running in one direction.

2.3.2 The Coconut Husk

A coconut husk is made up of the outermost layer (exocarp) and the inner layer (endocarp) that wraps the fruit. The husk is composed of 70%wt pith, a lignin which behaves like phenolic resin and 30%wt fibre, also made from lignin but with a fibrous morphology (Snijder, 2005). The phenolic resin exhibits good properties of an adhesive. The husk also contains cellulose, pyroligneous acid, gas, charcoal, tar, tannin and potassium.

2.3.3 Coconut Fibre

The coconut fibre is of a thread-like pattern found in the coconut husk. The 30%wt fibre consists mainly of lignin and celluloses. Lignin is responsible for the stiffness of the coir and the cellulose is a water-soluble element that absorbs water about ten times its weight in water.

2.3.4 Coconut Shell

The coconut shell is the hardest layer of the fruit that houses the copra and juice. According to (Hasanah et al., 2012), the coconut shell is also made up of hebicellulose, cellulose and lignin.

2.3.5 Copra

Thecopra is composed of 50%wt of water, 33%wt of coconut oil and 17%wt of white meal (Bradley and Huang, 2006). The water contains nutritious elements of low fats and high levels of electrolytes for rehydration. The iodine and cetane number of coconut oil puts it on top of options as the best choice for bio-diesel (Diaz, n.d.). The iodine number denotes how finely it will burn in a diesel engine with few particle emissions, while the cetane number denotes how well it will burn at higher temperatures and pressures. The copra also serves as feed for humans and some animals such as pigs and poultry.

2.3.6 Uses of coconut and its husk

To the pregnant woman 7% of the content of the juice that contains calcium helps in bone formation in the foetus and about 85 g of water which help prevent dehydration. It also contains 7% of magnesium that prevent hypomagnesia that is usually experienced during pregnancy and 7% of sodium that help retain water in order to prevent dehydration (http://ndba.nal.usda.gov/). In as much as the copra supplies food to man, it also contains oil that is used for cooking, beauty make up (dressing the hair, skin moisturizer), and making biodiesel. This same oil is used as pest resistant in crop storage structures by smearing it on wood to repel pests away from a crop. Coconut oil is also used to generate electricity especially on small scales (Raghavan, 2010). Before the 20th century, the coconut husk was widely utilized for the making of thatched roofs, ropes and yarns, door mats, sacks, menial aesthetic constructions and mulching plants. In this 21st century, the uses of coconut are more evident in the fabrication of car seat covers, stuffed chairs, and fibres for clothing to replace polyester fibres. In addition, coconut husk is now employed in the conversion to fuel which is used to power cars, control soil erosion and flood, fertilizers and as aquarium filter. This clearly shows that

the utilization of coconut husk has gained more improvement in these present days than the past.

2.4 Coconut Waste Management and Utilization

Waste Management is the collection of all thrown away materials in order to recycle them and as a result decrease their effects on our health, our surroundings and the environment and enhance the quality of life (Eyzaguirre, 2016). Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers (Golush, 2015). Waste Management flows in a cycle: monitoring, collection, transportation, processing, disposal or recycle. Through these steps a company can effectively and responsibly manage waste output and their positive effect they have on the environment (NPCS, 2008). According to Monney (2014), wastes generated in Ghana are collected to the landfill sites. However, solid waste management deals with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that conforms to the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations and that are also reactive to public attitudes (Monney, 2014). The coconut is a 'no-waste tree' because even its waste products provide ample opportunity to augment farmers' income. Wastes have been put into use and even turned up to be an income Generating industry (Eyzaguirre, 2016). Coir dust, the major by-product of coir production and considered a pollutant, is now being sought to conserve the environment (Eyzaguirre, 2016). It is now used as substitute for peat as a potting medium for plants. Coir peat or dust is now being exported and is becoming a significant foreign exchange earner in Sri Lanka. Coconut wastes are by-products produced during cultivation and processing of coconuts. According to Fiagbenu (2014),

coconut sellers in Ghana are unknowingly carrying a whole industry that can potentially turn around Ghana's economy. It is time for coconut growers to begin to think about the coconut industry and its ability to generate wealth, offer employment, and nurture people in the art industry. Co9conut industry can be oxygen for Ghana's economy or a solution to the unemployment situation (Fiagbenu, 2014).

2.4.1 Industry

Industrialists in most of the coconut producing countries hail the economic, environmental and technological benefits of utilizing coconut farm wastes (UCOL-GANIRON JR, 2013). The use of coconut husks, which are now most often considered as waste, is used as a resource to produce building materials to substitute wood products offers many advantages. The coconut husks are processed into fuel, mulch and coir while the shells are also processed into charcoal, handicrafts and activated carbon. Some of these products have not been fully commercialized but have the potential to increase the overall productivity of the industry (UNCTAD, 2009). Activated charcoal is also used for water filtration and cleaning machines that expel air (Yeboah, 2010).

2.4.2 Agriculture

Coconut husks are the rough exterior shells of the coconut. While the husks are not used for food, like the meat and liquid found within the exterior shell, the husk can be used in several ways, including creating enriched potting soil and as chips that can be used to provide ground cover for flower beds (Exporters, 2011).

2.4.3 Energy

The shell provides fuel for various purposes. According to Madadson et al., (2012), coconut is becoming an important agricultural product for tropical countries around the world as a new source of energy (biofuel). Previously, coconut shell was burnt as a means of solid waste disposal which contributed significantly to CO2 and methane emissions. However, as the cost of fuel oil, natural gas and electricity supply has increased and become erratic, coconut shell has come to be regarded as source of fuel rather than refuse. Presently in Nigeria, coconut shell is used as a source of fuel for the boilers and residual coconut shell is disposed of as gravel for roads maintenance. Black smiths also buy the coconut shell as fuel material in their casting and forging operation (Madakson et al., 2012). Researchers estimate that replacing synthetic polyester fibers with coconut husk fibers, known as coir, will reduce petroleum consumption by 2 to 4 mi8llion barrels and carbon dioxide emissions by 450,000 (Cimons, 2014).

2.4.4 Domestic Use

It is possible to purchase mass produced husk products or create the products at home using the shells of fresh coconuts (EITC, 2011).

2.4.5 Health Benefits

In contemporary medicine, study is now confirming the use of coconut in treating many health conditions due to its wide range of health benefits (Nonor, 2016). A study on coconut in modern medicine and modern medical science, conducted by scientists of the Coconut Research Centre in Colorado Springs, in the United States of America (USA), has confirmed the use of coconut in treating many health problems, including abscess, asthma, baldness, bronchitis, bruises, burns, colds, constipation and cough. It is also used in treating dysentery, fever, flu, irregular or painful menstruation, jaundice,

kidney stones, lice, malnutrition, nausea, rashes, scabies, scurvy, skin infections, sore throat, swelling, syphilis, toothache, tuberculosis, tumors, typhoid, ulcers, stomach upset, body weakness and wounds (Aklorbortu, 2013).

2.5 Usage of the Major Components of Coconut Palm

The coconut plant has valorization potentials in both food and non-food applications contributing to the economy of many communities and nations. Many smallholder farmers regard this plant as the "tree of life" because of its value chain which is an important source of income as well as nutrition (Chan et al., 2006).

2.5.1 Coconut Shell

Coconut shell constitutes about 15% of de-husked coconut. The shell is a hard, fine grain substance which can be used for the production of cups and some artworks. In many coconut producing communities, these shells are left unattended to and are usually given to women who use them as a source of energy for home cooking (NARI, 2004). The shell charcoal is obtained by burning the coconut shell obtained from a fully grown coconut in an environment where there is a limited supply of oxygen. The shell is also an important raw material for obtaining active carbon for gas production, deodorization and bleaching (Fife et al., 2011). It is also used to obtain coconut shell powders by pulverizing the mature shells (Muralidharan and Jayashree, 2011). This is used as an Electromagnetic Interference absorbing material (Siti et al., 2016).

2.5.2 Coconut Husk

Coconut husks act as an important material to protect the endosperm of the coconut fruit. It is composed of fibers which are tightly packed. The fibers are called coir. The fibers are 15 to 35 cm long (Muralidharan & Jayashree, 2011). When this coir is soaked in salt water, they separate and can be used in the making of different items such as

ropes, rugs, mat and chairs. In other applications, the coir can be grounded to be used as soil mixes in greenhouse plants. The coir fiber has some characteristic properties which make it useful for different applications. These properties include elasticity and resistance to mechanical wear (Fife et al., 2011).

2.5.3 Coconut Leaves

The leaves of coconut grow up to 6.1 meters in length. They are used for shading seedlings and covering up nursery beds. The leaves are also used in the making of rooftops and fences. The thin leaf strip can be weaved into clothing and furnishing (Fife et al., 2011). They have also been used in the feeding of elephants. Also, the dry leaves are used as a source of fuel (Gunn et al., 2011). Many rural communities where coconut trees are cultivated utilize the leaves for the production of baskets, brooms and brushes.

2.5.4 Coconut Water

Coconut water volume is dependent on the maturity of the coconut fruit. It is higher in immature fruit but as the fruit matures, the coconut water is gradually absorbed into the meat and the meat solidifies more (NARL, 2003). Coconut water is found to contain numerous amounts of both macro- and micro nutrients. The main macro nutrients are the soluble sugars such as sucrose, glucose and fructose, proteins, water (95.5%) and little amount of oil which makes the coconut water to have low energy value of 44 kcal/1 (Thampan & Rethinam 2004).

According to Loki and Rajamohan (2003), the micro-components are majorly inorganic ions such as K (290 mg %), Na (42 mg %), Ca (44 mg %), Mg (10 mg %), P (9.2 mg %). Fife et al., (2011) reported that coconut water contains vitamin C which could vary from 20-40 mg/1which helps in reducing the rate of oxidation but at a limited rate due

to the small quantity. Coconut water also contains vitamins from group B, including nicotinic acids, pantothenic acids, biotin, riboflavin, folic acid, trace amount of thiamine and pyridoxine. Furthermore, the water is said to have some amino acids such as alanine, cysteine and serine (Fife et al., 2011).

Coconut water might be applicable for rehydration due to its electrolytes content such as potassium and sodium. It also has application as a growth medium for certain microorganisms such as Acetobacterxylinum, as medicine in the management of certain diseases such as high blood pressure, and as a biocatalyst which helps in the synthesis of proteins (Prades et al (2012); NARL, 2003).

2.5.5 Coconut Kernel or Meat

The coconut kernel is often the most commercially processed component of the coconut plant. The whitish, firm substance found inside the coconut fruit is highly nutritious containing a substantial amount of fats and proteins (Fife et al., 2011).

Through different processing methods, various kinds of products can be obtained from the kernel. They include desiccated coconuts which are obtained through the removal of the brownish coat of the kernel. The whitish substance obtained is disintegrated and dried to a moisture content of less than 3%. Its commercial usage in food industries has gained popularity all over the world (Muralidharan and Jayashree, 2011). Also a whitish liquid (coconut milk) can be obtained from the coconut kernel that has been subjected to milling followed by squeezing with or without the inclusion of water. The milk has application in the production of coconut cream and sauces (Fife et al., 2011). Furthermore, virgin coconut oil VCO), which is a highly sought-after product in the international market can be made from the coconut kernel. It is obtained from the fresh,

hard and mature coconut with or without the application of heat. The different processes used in its production must exclude the application of techniques such as bleaching, deodorizing and other forms of chemical treatments so as to keep its natural properties (Divina et al., 2016).

VCO is currently used as food supplement and has application as cosmetics. A number of physiotherapists also use it for massage. The increase in its demand may have been linked with the report of the health benefits of the medium chain triglycerides (MCT) present in the oil (Muralidharan and Jayashree, 2011). However, there are also contrary rep0orts on the possible negative health implication of the coconut oil MCT on Total Cholesterol levels (Lawrence et al., 2013).

CHAPTER THREE

METHODOLOGY

3.1 Materials and Methods

This chapter focuses on the materials and methods used in the fabrication of the coconut dehusking machine.

3.1.1 Physical Properties of a Coconut

The design of the machine is mainly based on the physical properties of the coconut. The important physical properties under consideration are size, shape, weight, fiber toughness shell diameter and moisture content.

The coconut is graded based on its size as small, medium and large as shown in Table 3.1.

Size and shape

The shape of the coconut is important in deciding the shape and size of the cylindrical rollers and the spikes. Samples of twenty dried coconuts were selected for determining the size and shape.

Table 1: Classification of coconut based on size

Category	Size(diameter), mm	Length, mm
Small	<150	<220
Medium	150-170	220-250
Large	> 170	>250

Sphericity

Sphericity is a yardstick to measure the roundness or the spherical nature of an object. This parameter is responsible for movement of coconut between the rollers and the spike. Sphericity was determined using the following expression (Melisenin, 1997). Lengths of the intercept taken were those obtained under art;

Sphericity = $(lbt)^{1/3}/l$

Where,

l=the largest intercept, mm

b= the largest intercept normal to l, mm

t= the largest intercept normal to l and b, mm

Weight of coconut

A random sample for about 20 coconuts were selected and weighed on an electronic balance having sensitivity of 0.01g and the observation were averaged. The observations were recorded and weight was calculated.

Shell diameter

Shell diameter is determined by using measuring tape. On wrapping the tape measure along the circumference of the coconut, the diameter is calculated by using the equation 2. Random samples of husked nuts were selected.

$D = c/\pi$

Where,

D= diameter

C= circumference of the nut

Husk thickness

Husk thickness refers to the thickness of the mesocarp (husk) from the epidermis to the endocarp (shell). It is another parameter to design the spike (cutting pins). Table 2 shows the physical properties of coconuts.

Table 2: Physical properties of coconut

Particulars	Dry coconuts
Shape	Ovoid
Length(mm)	210-270
Distance (mm)	160-206
Weight kg	0.62-1.25
Shell diameter(mm)	80-120
Husk thickness-pedicel end	62
Husk thickness- at apex end (mm)	34
Husk thickness-1/4th distance from pedicel end (mm)	32
Husk thickness-1/2th distance from pedicel end (mm)	24
Husk thickness-3/4th distance from pedicel end (mm)	28

3.1.2 Materials

Material selection for this work is based on service requirement, fabrication and economic requirement. The service requirement implies the properties a material should have to serve the purpose for which it is designed for and some of these properties are; corrosion resistance, strength, toughness, maintainability, safety among others.

Fabrication requirement necessitates workable properties a material should have and these are; machinability, formability, malleability, ductility, weldability among others. Table 3 shows the choice of materials used in the work.

Table 3: Summary of the choice of materials selected

Parts	Material	Justification
Stand	Mild steel	➢ Availability of material ➢ Cost effective ➢ Easy to fabricate
Cylindrical rollers	Galvanized steel pipe	➢ Easy to fabricate ➢ It is strong ➢ Easy to machine
Spur gears	Cast iron	➢ Ease to cast ➢ Availability
Bearing	High carbon steel	➢ resistance to wear
Spikes	Mild steel	➢ easy to wear ➢ easy to machine ➢ availability of materials

3.2 Methods

The methods were considered while designing the machine. The coconut dehusker base assembly is fabricated using milling, grinding, and welding operations.

3.2.1 Design consideration

The following factors were put into consideration while designing the machines;

- The environment
- Material properties
- Material cost
- Availability of materials
- Material cost
- The end user
- The operation of the machine.

3.2.2 Design requirement

The following functional parameters and components are required in this work.

- High strength of materials
- Power required for the performance
- Main roller diameter
- Weight of the dried coconut
- Bearing size
- Shaft diameter
- Size of the spur gears

3.2.3 Design of the machine

This is the catia model of the coconut dehusking machine. The machine contains various components which are mainly used for dehusking the coconut. The components are;

- The frame
- The rollers with spikes
- Shaft
- Bearings
- Spur gears

Frame: this is part of the machine that carries the total load of the assembly. The material for the frame is cast iron. The frame is to be joined by welding.

Spur gears: the gears are commonly used to frames unit rotational motion between the machinery shafts. The spur gears which are design to transmit and power between parallel shafts are the most economical gears in power transmission.

Figure 1: Spur gears

Rollers with spines: the dimensions of the cylinders were designed in a manner to obtain effective mesh with coconut husk.

Assumptive used

1. Coconut contacts with cylinder at an average angle of 30- degrees contact sector.
2. One-sixthof the width of Coconut should be inserted into the informed rate space between the cylinders.

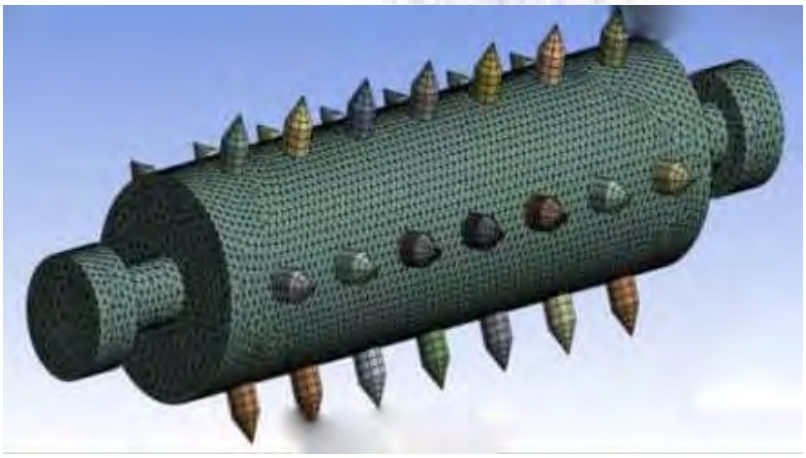

Figure 2: Roller with spikes

Cutting spines: the adhesion between fibers in the husk is greater than that between the shell and the husk: hence separation occurs at the husk-shell interface. The thickness of fiber is in the range of 20 -40mm. Both dimensions should be selected to get effective penetration with the Coconut.

The types can be attached to the cylinder rollers either by welding or by using fasteners.

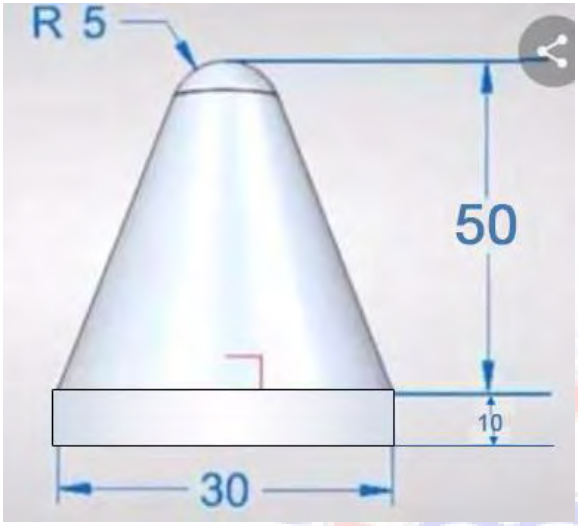

Figure 3: Spine

Bearing: this is the type of rolling element bearing that uses balls to maintain the separator between the bearing races. The purpose of a ball bearing is to reduce rotating friction and support radial and animal load. It achieves this by using at least two vases to contain the balls and transmits the loads through the balls in most applications, one vase is stationary and the other is attached to the rotation assembly, Isometric view of the pillow bearing.

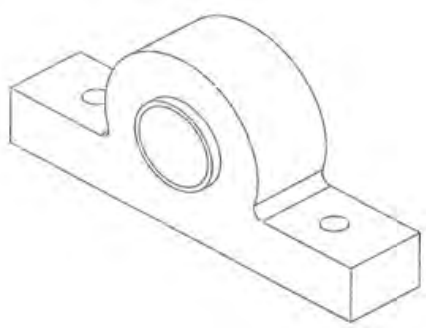

Figure 4 : Pillow bearing

Shaft: At both ends of the two rollers are the shafts. The diameter of the shaft is 30mm. This is because a bearing of the size 206 was used and the internal diameter of this type of bearing takes a shaft of diameter 30mm. The shaft is attached to the rollers by welding.

3.2.4 Developing process of the machine

Design of the various element of the machine was carried out here. Figure 5 shows isometric view of the Coconut dehusking machine

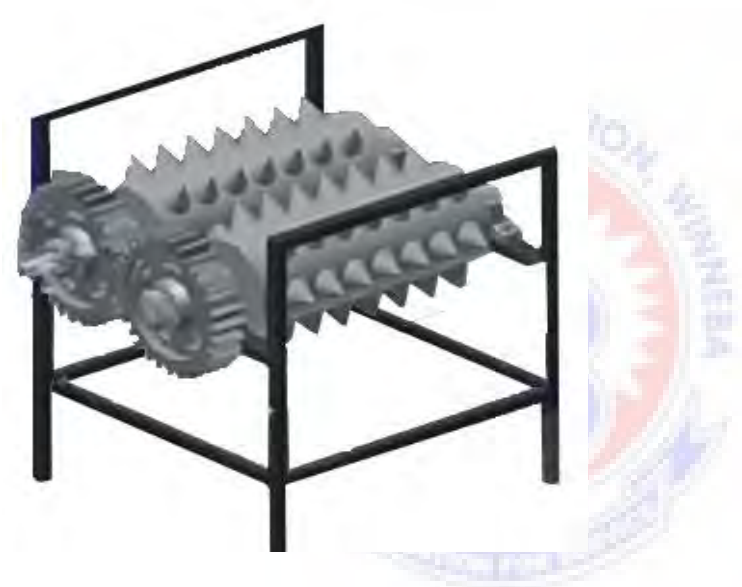

Figure 5: Isometric view of the coconut dehusking machine

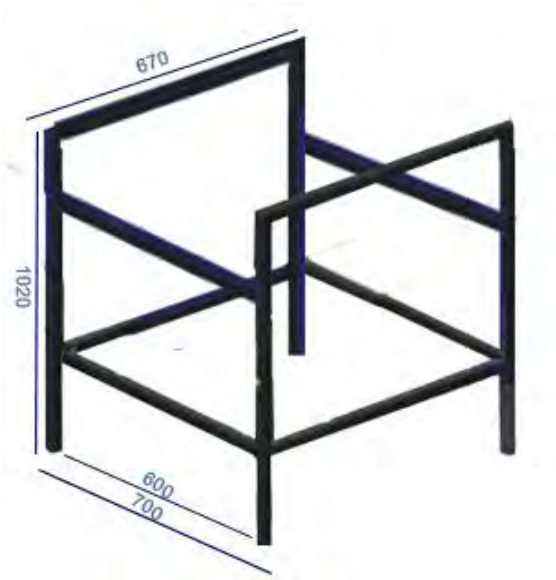

Figure 6: The main stand of the equipment

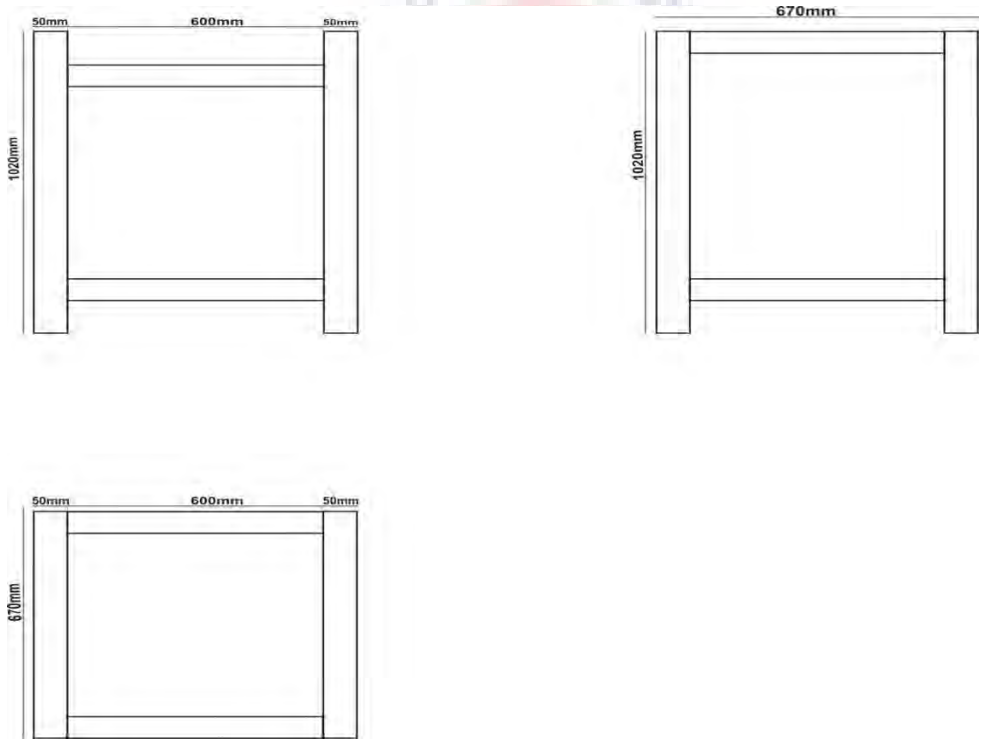

Figure 7: The front, plan and the end views of the stand

Details of how the stand frame is developed are as follows:

Materials and tools required

- 50x50 mm angle iron
- Welding electrode (G-10)

- Hacksaw
- Tape measure
- Try sequence
- Scriber

The height of the table is 1020mm and it has four legs. So to get the side of the legs a tape measure was used to measure 1020mm.

- With the help of the try square, the scriber was used to do the marking.
- The tool that was used to cut the angle iron is the hacksaw blade
- The table has four legs; a same procedure was used to do the other three.
- The table has a length and breadth of 700mmx 670mm respectively.
- The tape measure was used to take a measurement of 700mm (two) and 670mm (two)
- It was also marked and cut with the hacksaw
- The various cutting was welded by the electric arc welding machine.

For the table to be more robust there were some braces at the base of the legs.

On top of the table are four holes on the surface of the longer parts (opposite to each other) to make way for bolt and nuts when fixing the bearing.

Cylindrical rollers

The dimensions of the rollers is designed in a mummer to stain effective mesh with the Coconut husk.

Figure 8: The arrangement of the rollers

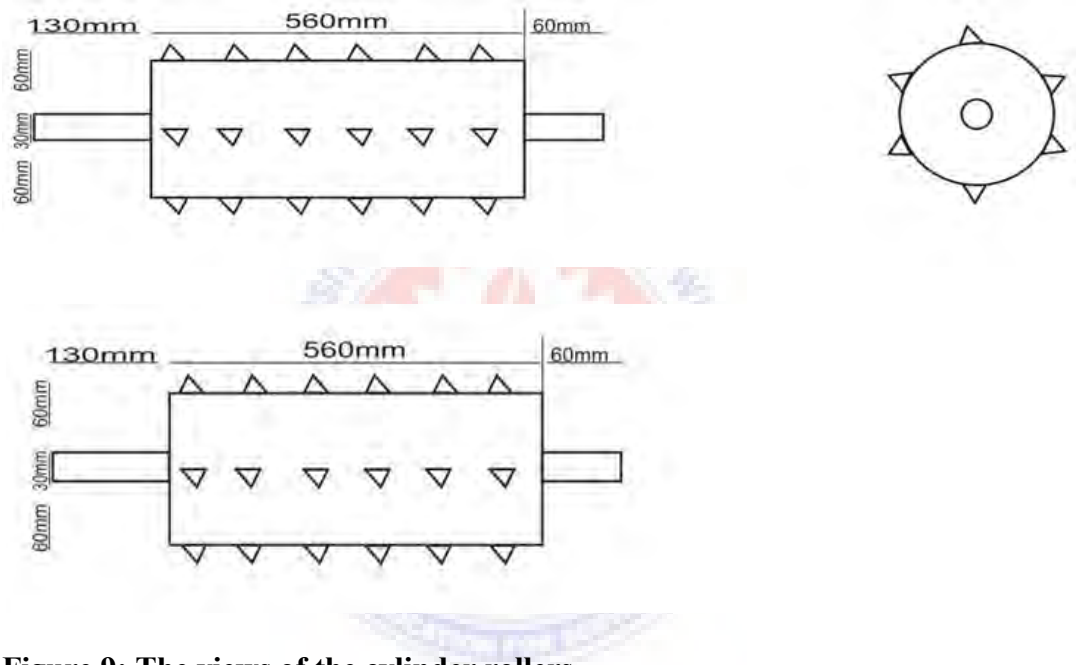

Figure 9: The views of the cylinder rollers

The materials required in fabricating the rollers cylinder are as follow;

Galvanized steel pipe

Galvanized thick plate

Galvanized steel rod

Tape measure

Pair of cylinders

Scribers

Process involved

A cylindrical galvanized pipe of 150mm internal diameter and 1220mm length was purchased from the local market.

Per the design, the length was supposed to be 570mm (two in number).

With the aid of the angle grinder and a cutting chic, 800mm of the pipe was cut off.

The remaining 1140mm was cut into two equal parts i.e. 570mm each.

A round plate of a diameter of 150mm was cut out of a thick plate (7mm).

Since the cylinders have four openings, ie two each, four round plate were cut to seal the ended. At the center of the four rounds plate are holes with a diameter 34mm to make way for the diameter 30mm shaft to be welded to the cylinder.

Grinding was done to give the welded joint a good appearance.

The shaft

Below are the materials needed for the preparation of the shaft.

Mild steel shaft

Tape measure

Scriber

Process involved

Mild steel with a length of 450mm and a diameter of 35mm was purchased from the metal shop of a local market

The thickness needed for the fabrication work is 30mm, so the steel shaft was sent to the lathe machine to be turned to 30mm.

The length of 60mm mild steel was welded to the cylinder end to take the bearing.

The parting off tool was used to part-off two –number 60mm, since the cylinders are two.

Another length of 120mm was also parting off. The shaft takes the bearing and one of the spur gears at the same time and it is also welded at the opposite end of the cylinder.

Another length of 170mm of the shaft was also parted off. At this stage the shaft takes a bearing, spur gear and a handle and it is also welded.

The spike

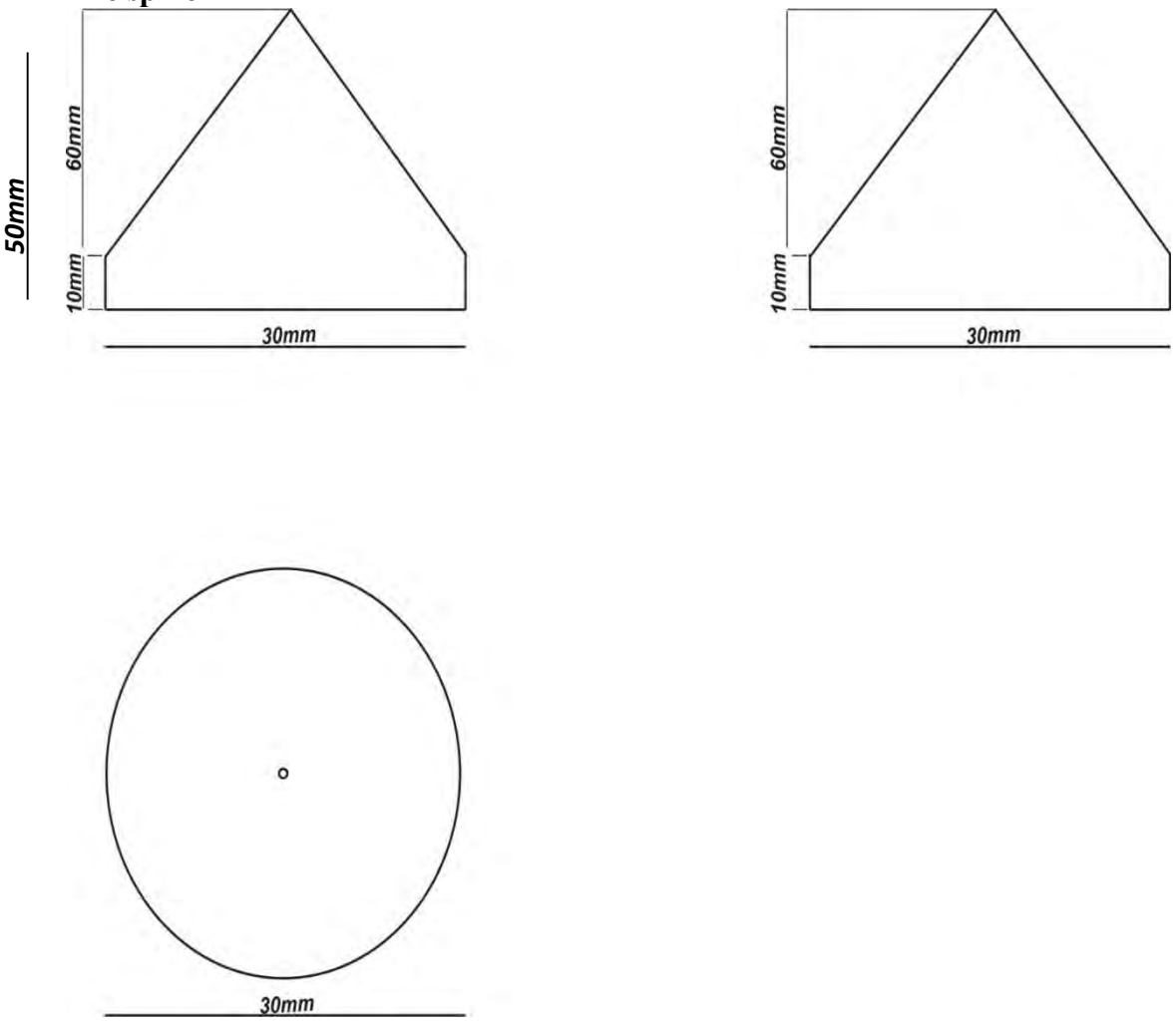

Figure 10: The Spike

The materials needed for the spike is a shaft of 300m diameter

Below is the process involved in producing the spikes

30mm diameter shaft was purchased from the local market.

The length of one spike is 60mm. so the lathe machine was used to do the cutting.

On each roller there are 36 spikes. Therefore, the number of shafts diameter 60mm cut are 72 pieces).

The pieces cut off were sent to a local black smith to produce the pointed edges for the cutting of the Coconut husk.

After the black smith has finished the forging, they weld on the cylindrical pipe (rollers)

The spikes is weld to the pipe in that they are six in a roll and six columns.

There is a space in between the two spiked rollers to accommodate the dried Coconut.

The spur gears

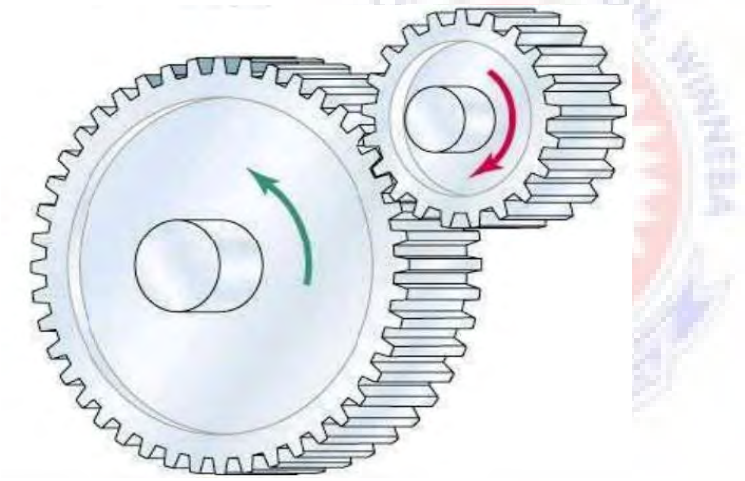

Figure 11: Spur gears

Direction of the movement of the spur gears

The bearings

The assorted components which were purchased from the local market are;

Pillow bearing

Shaft

Spur gears

Galvanized steel plate

Working principle of the Coconutdehusking machine

The dehusking process is very simple. The dried cocoanut is placed in between the rolling cylinders, rotating in opposite directions and pressed by manually operated linkage. As the cylinders rotate, spikes provided on the periphery penetrate the husk and tear it off.

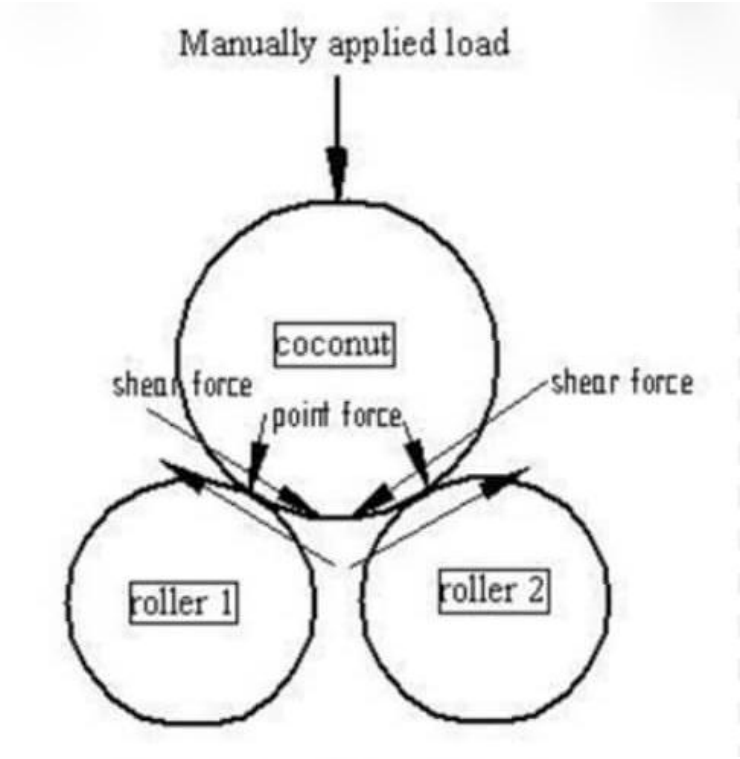

Figure 12:

CHAPTER FOUR

RESULTS AND DISCUSSION

The objectives of this project can be actualized by the De-husking capacity and efficiency of the Coconut dehusking machine. It was determined by 20 experimental runs. Number of nuts (NT) during the test with their respective de-husking time was recorded. The numbers of nut with full length of fiber Wgf, together with numbers of distorted fiberWt, were also recorded. The de-husking time was measured using a stop watch. Thereafter, the efficiency, and capacity of the machine was computed using the relations below:

$\eta\ \% = Wgf/\ NT$

$C\ (nuts/hr.) = NT\ t$

Table 4: Performance testing results

SN	No. Of Coconut DehuskedNt	No. Of Broken Coconuts	No. Of Dehusked Coconut with Fulllength Of FibreWgf	No. Of Dehusked Nut Withdistorted Fibre, Wt	Time (Seconds)	Efficiency Y	Capacity © Nuts/Hr.
1	4	0	4	0	125	100	111.2
2	4	0	3	1	120	75	120.0
3	4	0	4	0	112	100	128.6
4	4	0	4	0	108	100	133.5
5	4	0	4	0	124	100	116.1
6	4	0	3	1	121	75	119.0
7	4	0	4	0	126	100	114.3
8	4	0	4	0	118	100	122.0
9	4	0	4	0	120	100	120.0
10	4	0	4	0	120	100	120.0
11	4	0	3	1	115	75	125.2
12	4	0	4	0	117	100	123.1
13	4	0	4	0	114	100	126.3
14	4	0	3	1	119	75	121.0
15	4	0	4	0	120	100	120.0
16	4	0	3	1	121	75	119.0
17	4	0	4	0	122	100	118.0
18	4	0	4	0	125	100	115.2
19	4	0	3	1	117	75	123.1
20	4	0	4	0	128	100	112.5
	80	**0**	**74**	**6**	**2392**	92.5	**120.6**

4.1 Efficiency of the Machine

From the tests carried out. A total number of 80 dried coconut were taken and split into 20 sections of four number each of boiled palm fruits was taken, and fed to the machine when the machine was in operation.

Efficiencyη % = Wgf/ NT

(η %) = 74/80 x100

=92.5

Capacity = ∑C /N

Where C = number of nuts per hour

N= number of test

C = 2408.1

N = 20

Capacity (nuts/hr.) =120.5

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

A Coconut dehusking machine was designed and fabricated and performance evaluation carried out. The test result revealed that, the machine has an efficiency of 92%. The machine is made up of simple components that can easily be assembled. It is designed so that local users can purchase and easily carry out maintenance and at the same time operate the machine with ease for coconut processing.

5.2 Conclusions

In this modern world the time and cost have more weight age for each and every operation. So a new machine has been designed, fabricated and named ‘’ coconut de husking’’ machine.

By comparing with many types of existing methods, including traditional, and automatic, it can be concluded that this machine requires less human effort and the test result substantiated it.

The developed model is simple, efficient, requires less time and cost effective when compared to the existing available model.

It is important that developed models are user friendly in terms of operation and for safety. The rotation elements like belt, pulley and gears are provided with safety cover.

It can be concluded that the manual coconut de husking machine is more advantageous. Below are some of the reasons that makes the coconut de husking machine a stand out as compared to the other modes of removing the dried husk from the coconut shell.

- It is easy to operate
- It is cost effective
- Easy to maintain

5.3 Recommendations

The following recommendations arose out of the project.

- Short and medium- term loans should immediately be granted to farmers to enable them adopt this important innovation for mass production of coconut husk.
- Since the efficiency is above average the coconut de husking machine is recommended for end users of coconut production.

5.4 Suggestions for Future Research

There are a number of ways in which this study can be extended. This study only focused on the dehusking of dried coconut. The future study should examine the economic efficiency in the small scale coconut processing industry.

Also, in the future the study should examine how to converted coconut dehusk into biogas.

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