THE DESIGN AND FABRICATION OF COCONUT DE-HUSKING MACHINE

BY

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MAT.NUMBER: PG/ENG 1917363

A PROJECT SUBMITTED TO THE DEPARTMENT OF PRODUCTION ENGINEERING

UNIVERSITY OF BENIN

BENIN CITY

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TITLE PAGE

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A RESEARCH SUBMITTED TO THE DEPARTMENT OF PRODUCTION ENGINEERING, FACULTY OF ENGINEERING, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF POST GRADUTE DIPLOMA IN PRODUCTION ENGINEERING UNIVERSITY OF BENIN

SUPERVISOR

PROF.J.A. AKPOBI

MARCH, 2024.

CERTIFICATION

This is to certify that this project work was done **by IKOGWE BRIGHT** with **MAT.NO. PG/ENG 1917363** of the Department of Production Engineering, Faculty of Engineering, **University of Benin, Benin City, as part of requirement for the award of Post Graduate Diploma in Production Engineering.**

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DEDICATION

This work is dedicated to God almighty for breath of life and His unending love towards me. Also to my families for their unwavering support and encouragement which has been my pillars of strength throughout this journey, I say thanks you for your love and for believing in my abilities. Your constant inspiration has fueled my determination to reach new heights. Thank you for being my rock.

ACKNOWLEDGEMENT

I would like to express my sincere appreciation to all those who contributed to the completion of this project. Special thanks to my project supervisor Prof. J.A Akpobi for his invaluable guidance, support, and expertise. I appreciate Dr. C. I. Eboigbe (Assist. Dean), Dr. E. Ebojoh and the entire team at the Department of Production Engineering for their unwavering encouragement and collaborative efforts throughout the journey. This project wouldn't have been possible without the collective contributions of each team member. Thank you for being an integral part of this endeavor and for helping turn ideas into reality.

ABSTRACT

The main objective of this machine is to remove the coconut shell and to eliminate the skilled labour involved in de-husking. The coconut outer shell is a fibrous husk one to two inches thick. This paper deals with the design and fabrication of Electric motor operated coconut de-husking machine. This project is aimed at producing an efficient and more economical machine for coconut industry. The coconut is known for its great versatility as seen in many domestic, commercial, and industrial uses of its different parts. Coconuts are different from any other fruits because they contain large quantity of tender and when immature they are known as tender-nuts or jelly-nuts and may be harvested for drinking. When they mature they still contain some water and can be used as seed nuts or processed to give oil from the kernel, charcoal from hard shell and coir from fibrous husk.

One traditional method used for coconut de-husking is using a machete. This is done by using human energy. This method is risky and tedious and yet requires skills. Hence an alternative is suggested in our project which reduces time involved in coconut de-husking and human effort. Depending upon the survey different sizes of coconut are determined. The machine is designed to accommodate different sizes of the coconut that are cultivated anywhere in the world.

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CHAPTER ONE

1.0 INTRODUCTION

Coconut is the fruit of the coconut palm tree which has the scientific name as *Cocos nucifera*, belongs to the family *arecaceae*. Philippines are the world largest producer of coconut. It is found in the tropic and sub-tropic areas (Chan and Elevitch, 2006). Coconuts are large, dry drupes, ovoid in shape, up to 15" long and 12" wide. The coconut is smooth on the outside, yellowish or greenish in color. Within the outer shell is a fibrous husk one to two inches (2.5 to 5cm) thick. The inner shell is brown and hard, surrounding the white coconut meat. Coconut husks are the rough exterior shells of the coconut. This outer shell or husk has to be removed for the usage of coconut. The coconut is known for its great versatility as seen in many domestic, commercial, and industrial uses of its different part. They are part of the daily diet for many people. Coconuts are different from any other fruits because they contain large quantity of water and when immature they are known as tender-nuts or jelly-nuts and may be harvested for drinking. When they mature they still contain some water and can be used as seed nuts or processed to give oil from the kernel, charcoal from hard shell and coir from fibrous husk.

Fig1.0: Coconut fruits

Coconut palm is grown throughout the tropics for decoration as well for it many other uses. Virtually every part of the coconut palm can be used by humans in some manner and has significant economic value. Coconut versatility is sometimes noted for its naming. In Sanskrit, it is kalpa vriksha (the tree which provides all the necessities of life); in the Philippines, the coconut is commonly called the "tree of life" (Margolis, 2006).

The various parts of the coconut have a number of culinary uses. The seed provides oil for frying, cooking, and making margarine. The coconut water is consumed as a refreshing drink throughout the humid tropics and is gaining popularity as a sports' drink. Coconut water can be fermented to produce coconut vinegar.

Coconut husks are 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 coconut husk can be utilized in several ways. The coconut husk has become a very useful substance in light of today's environmental and economic concerns.

1.1 BACKGROUND OF STUDY

Coconuts are especially high in manganese, which is essential for bone health and the metabolism of carbohydrates, proteins, and cholesterol (8). They are also rich in copper and iron, which help form red blood cells, as well as selenium, an important antioxidant that protects human cells.

1.2 STATEMENT OF THE PROBLEMS

In the present coconut de-husking machines many problems and difficulties are faced during the de-husking operation. These problems cause adverse effect on the working and productivity of the machine. It also affects the operator operating the coconut de-husking machine. Many limitations are present in the previously occurring machine. Those limitations decreases many parameters of the machines such as productivity, durability, efficiency, ease of operation, etc. Also it tends to increase the human fatigue to the operator operating the coconut de-husking machine.

The limitations in present machines are:

a) **Possibility of accident**: Due to the human interference in the operation of the machine there may be possibilities of accidents. In de-husking the coconut with spike or machete it may cause injury to human because of carelessness.

b) **Less production rate**: In previous coconut de-husking machines the idle time required is more and takes more time for de-husking operation. Also the interference of the human is more so it takes more time for operation, so that the production rate is less.

c) More time is required for de-husking the coconut.

d) **Skilled labor required:** To de-husk the coconut manually i.e. by using spike or machete is risky operation. So there is need of concentration during the operation, otherwise it is harmful to the operator. So the skilled labor is required.

e) Idle time is more.

1.3AIM AND OBJECTIVE

1.3.1 AIM

To design and fabrication coconut de-husking machine.

1.3.2 OBJECTIVES

- ❖ To design a coconut de-husking machine
- ❖ To fabricate the coconut de-husking machine
- ❖ To improve number of nuts produced per hour
- ❖ To analyze spiked roller unit with the help of ANYSIS software

1.4 SCOPE OF WORK

The design and fabrication of coconut de-husking machine is considered with only a working model (prototype) commercialization and marketability is not inclusive. The work is subjected to improvement.

1.5 PROBLEM GOING TO BE SOLVED

At present, the de-husking of coconut is carried out by various machines like spike, traditional tool, pedal operated machine, etc. From all above methods of coconut de-husking we understood that there are many limitations which create difficulties during coconut de-husking. To overcome these difficulties and to increase production rate, we have decided to make "Automatic coconut de-husking machine." And also for removing the shell of coconut, the special attachment is provided. The problems or limitations in the present machine and the improvements are represented in the following table.

Table 1.1

LIMITATIONS OF PREVIOUS MACHINES	IMPROVEMENT
Accident occurs.	Accidents are eliminated.
Less production rate.	Increase in production rates.
More time is required.	Less time is required.
Nasty system.	Clean system.
Idle time is more.	Idle time is less.

CHAPTER TWO

2.0 LITERATURE REVIEW

Coconuts are grown in more than 93 countries of the world, with a total production of 5.4 billion tons per year. An individual coconut fruit is made up of an exocarp, India is the second largest country to grow the coconut palms. De-husking is the process of removing the outer covering called husk from the coconuts. The de-husking is necessary for matured coconut towards further utilization. Due to the complication in size the studies are still in initial stage. The commercially available machines like motorized and hydraulic coconut de-husking machines costs more, this has become major limiting factor in our country. The electric motor system has gained a large amount of importance in last few decades. This convenience in operating the electric motor system has made us to design this machine.

Fig2.1a: Husk of a Coconut

Fig. 2.1b : **De-husked Coconut**

2.2 COCONUT PRODUCTION

Coconut is a popular member of the palm family Arecaceae which originated from Asia. It was imported into Nigeria during the colonization era. There are many varieties of coconut in the world with the West coast tall and the dwarf varieties being the two most common types. This review examined the problems and prospects of coconut plantation development in Nigeria. There is a large unexploited opportunity in the local and international market due to some problems that need urgent attention before the coconut resources in Nigeria fade away. The current state of coconut production and uses in Nigeria does not match up to its international counterpart and therefore there is a need to tap into the unlimited riches that the "tree of life" has to offer. On the 18th position on the world coconut production country index currently, Nigeria can only boast of 265,000 metric tonnes of coconut production, a country that is bestowed with an arable rainforest zone fertile for a crop that is non-indigenous to it. Thus, the nation has the chance to meet the increasing market demands globally.

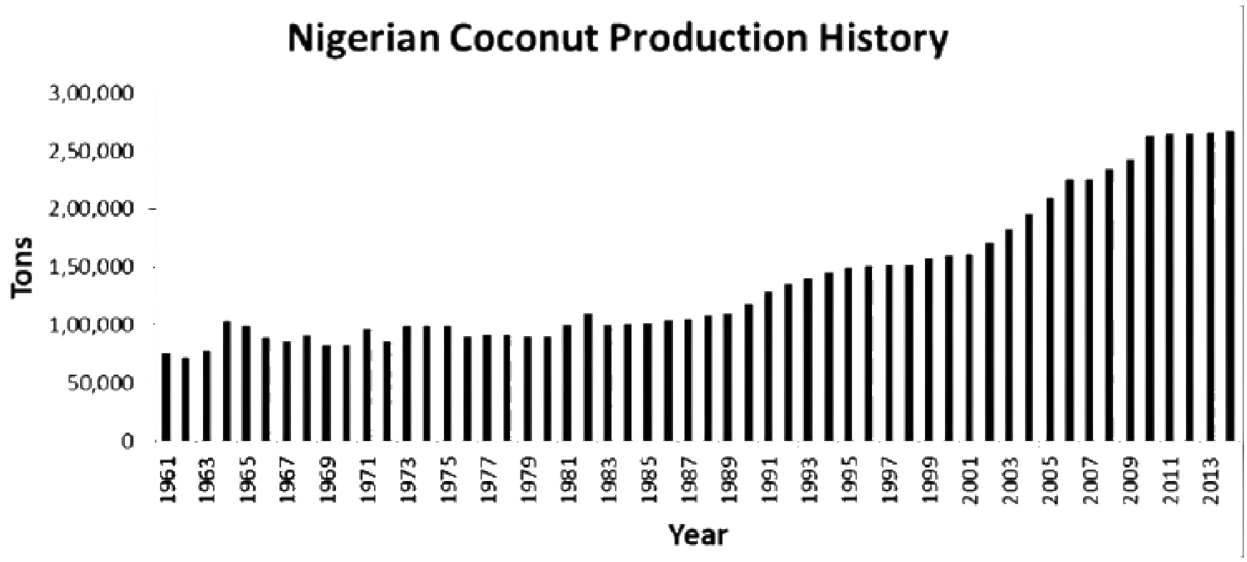


Figure 2.2 Coconut production

2.3 Coconut De-husking Making Machine by;

2.3.1 Venkataramanan S.A studied about the physical and geometrical aspects of coconut by using universal testing machine results. He published the UTM results of coconut in "Design and Development of Automated Coconut De-husking and Crown Removal Machine" which was found to be very helpful.

2.3.2 H.Azmi conducted a brief study on the need and importance of coconut de-husking machine in agriculture industries which shows the relevance of the fabrication of machine for both small scale and large scale industries.

2.3.3 M.D Akhir gives the design details and overall working performance of an internal combustion powered coconut de-husking machine. His discussion was on a very powerful machine which has a de-husking rate of 250-300/hour.

2.3.4 Anu S.C in 2006 said that, coconuts are de-husked manually using tools. These methods required skilled labor. Attempts made so far in the development of de-husking tools have only been partially successful and not only been partially successful and not effective in replacing manual methods. The reasons stated for the failure of these tools include unsatisfactory and incomplete de-husking and breakage of the coconut shell while de-husking. Based on this hand operated coconut de-husking machine is being designed to solve this problem. This machine takes into consideration the danger, hazards and risks involved in the de-husking the coconut which will be the efficient, productive, environmentally friendly, less laborious, easy to use and easy to assemble and disassemble, most importantly, cost effective in the production, maintenance and repair.

2.3.5 Luise cancel in 2000 said that, Coconut is a primary yield of konkan district and de-husking of coconut is essential process in preparing the coconut for additional usage. Coconut de-husking includes expelling of the husk from the coconut. Conventional de-husking is difficult and troublesome procedure. To beat these difficulties, to improve the robotization and to give security to the workers, another structure of de-husking machine is presented and created. This de-husker includes utilization of two flat rollers with arrangement of sharp apparatuses which would shear the husk from coconut when moving against one another. Shear force is required for de-husking of green coconut and dry darker coconut. Shear force required is more for green coconut than dry coconut. Torque and speed decrease required for de-husking is determined by utilizing the power required for shearing coconut. Ideal number of spikes is orchestrated on the rollers to de-husk the coconut with least power.

2.3.6 Chandra Dinath said that, a machine explicitly intended to remove the husks from the coconut natural product including a majority of rollers pivoting in inverse ways adequately toward each other wherein every roller incorporates a majority of infiltrating spikes honed to enter and viably connect with the husk segment of the coconut organic product. The connection of the rollers in blend with the holding activity of the spike serves to tear away the husk from the nut leaving the nut in class.

2.3.7 Sujay kumar said that Coconut de-husking includes expelling of the husk from the coconut. Conventional de-husking is tedious and troublesome procedure. To beat these restrictions, to improve the machining and to give security to the administrator, another structure of de-husking machine is presented and manufactured. This de-husker involves utilization of two even rollers with arrangement of sharp apparatus which would shear the husk from coconut when moving against one another. Shear power is required for de-husking of develop green coconut and dry dark colored coconut. Shear power required is more for develop green coconut than dry coconut. Torque and speed decrease required for de-husking is determined by utilizing the power required for shearing coconut. Ideal number of spikes is organized on the rollers to de-husk the coconut with least power.

2.4 Different methods to remove husk (shell) of coconut.

Currently there are different methods for de-husking of coconuts. These methods generally includes, coconut de-husked manually using either a machete or a spike. These methods require skilled labour and are tiring to use. Attempts made so far in the development of de-husking tools have been only partially successful and not effective in replacing manual methods. The reasons quoted for the failure of these tools include unsatisfactory and incomplete de-husking, breakage of the coconut shell while de-husking, spoilage of useful coir, greater effort needed than manual methods, etc.

2.4.1 Traditional Method of De-husking a coconut

The coconut husk, also known as the coir, has become a very useful substance in light of today's environmental and economic concerns. It can be used for repelling mosquitoes when burnt, if shredded, can used as pillows, mattresses and to provide the fiber for making clothing, to make filters for aquariums, the fiber can now be used in place of synthetic fiber for making automobile parts and as fuel. However the current traditional methods employed for de-husking the coconut leaves much to be desired. The figure below shows one of the traditional methods of de-husking coconut using a machete. This is done by using human energy. This method is risky and tedious and yet requires skills.

Figure 2.4.1 Traditional Method of De-husking a coconut

2.4.2 Foot Operated Coconut De-husking Machine

The Coconut palm is struck manually against the closed teeth blades. As the paddle accelerates, the clamp action takes place to de-husk the coconut into two pieces. In this method the core is completely separated in one or two sequential operation. This equipment is simple in construction, easily operated, and it is light in weight. It is so simple in construction such that it does not require power source as it is manually operated. The cost of this equipment is low and has higher efficiency compared to other manually operated methods.

2.4.3 Mechanical Coconut De-husking Machine

In this power transmission takes place to rollers through helical gears. The powered rollers mounted on right side of machine, the outermost one carries sharp slightly curved spikes on its periphery. As the pressure applied on the coconut it makes contact with the rollers and the shell gets detached. This results in complete de-husking of coconut. The de-husked coconuts are collected at outlets below the roller where there is a provision between the spiked rollers.

Figure 2.4.3 Mechanical Coconut De-husking Machine

CHAPTER THREE

DESIGN METHOLOGY AND ANALYSIS

3.1 MATERIALS AND METHODS

The coconut de-husking machine was designed and fabricated based on the following considerations:

1. The availability of materials locally to reduce cost of production and maintenance of the machine.
2. The screw conveyor was placed in between the rollers for effective twisting of the coconut fruit during de-husking and also for appropriate discharging of de-husked nut.
3. Tapering of the roller by increasing the length of spikes along the roller accounts for reduction in the size of the fruit to enable proper gripping as tearing of the husk progresses across the length of the machine.
4. It is desired that there should be no husk on the nut, no nut breakage and the removed husk should have its full length intact. Hence, the electric motor, gears, pulley and speed reducer were carefully selected to meet the required speed of the de-husking and conveying units to achieve this objectives.

3.2 Materials Selection Technique

Selection of materials depends on many features such as the intensity and type of stress which the components are subjected to, whether it is flexible or rigid or it is to experience high temperature or corrosive action and how it leads itself to process of manufacture, i.e. forging, machine etc. Therefore, the designer selection will be influenced by the following factors:

1. Strength
2. Weight
3. Appearance
4. Manufacture
5. Cost of Production

These will also determine the variation between success and failure of the machine. We can further classify the above factor into four main classes:

a) Service Requirements
b) Construction Requirements
c) Economic Requirements
d) Maintenance Requirements

3.2.1 SERVICE REQUIREMENTS

Before a material is chosen for construction, it must possess some distinct properties which it exhibits when put to play. These properties are generally referred to as the service requirement. Some of these properties which should be appreciable while the material is in service are:

a) Toughness
b) Hardness
c) Strength
d) Stiffness
e) Resistance to corrosion
f) Conductivity and heat resistance

3.2.2 FABRICATION REQUIREMENTS

For fabrication process, a material must possess, a material must possess some distinct properties; these are mainly forge ability, malleability, ductility and weld-ability. Materials undergoing forge-ability are heated to a temperature close to its melting point then shaped to a desired structure. For malleability, it's required that the material should be made into a sheet like form while ductility requires the material to be drawn into a wire form. Finally, weld-ability can be described as the ability of the material to be easily welded. Therefore, the materials must be able to be joined by the process of welding.

3.2.3 ECONOMIC REQUIREMENTS

This is about the most important factor for the material selection because it determines the total cost of production which in turn affects the price of the product or retail cost and consumer choice. If the total cost of production is high, variably the price of the finished product will also be high. When the price of a product is high, consumers will seek for alternative cheap but similar goods. Bearing in mind that the two aims of production is, satisfying consumer wants and needs and also to make maximum profit, as a producer, one must judiciously select relatively cheap but reliable and appropriate materials for production. This will reduce the overhead cost of production therefore making it cheap in respect to other similar materials. Then we can comfortably harmonize the cost of production with the real price. One of the major considerations in engineering design is to design machines that are reliable, cost effective and the ability of the machine solving human problem. This was one of our considerations in this project work.

3.3 COMPONENT OF THE MACHINE

These are unit components of the machine that are assembled together to form the entire machine. The machine components include; frame, hopper and barrel cover, barrels, barrel shaft, gears, rollers with teeth, tray, belt and pulley, bolt and nut and the electric motor which was selected.

3.4 DESIGN FACTOR

This refers to some characteristics which affects or influence the design of the machine or some of the components. However, out of the numerous factors that affected the design, only one or few turned out to be the major factors and the minors ignored as they would have little or no effect in the design. These factors or characteristics are;

a) Thermal conductivity of the Material
b) Strength of the materials used
c) Overall weight of the machine in order to achieve its portability and machine size
d) Ease of maintenance
e) Noise and vibration
f) Resistance to corrosion attack
g) Finishing

3.5 Material selection of the material

S/N	MATERIALS USED	SELECTION CRITERIA
1	Stainless Steel	It has a very high resistance to corrosion, workability
2	Angle bar	It is very rugged and easily to fabricate
3	Guilloten and hand shearing machine	To obtain the different pieces required.
4	Electric Motor (3HP A.C motor)	To transmit the torque, with aid of V-belt
5	Bolt and nut	It is used to couple the frame together

3.6 DESCRIPTION OF THE PARTS OF DEHUSKING COMPONENT OF THE MACHINE.

The part of the machine includes the main frame, pin and spiral barrel , funnel, tray, electric motor, pulley with V-belt, gear etc.

3.7 PARTS AND OPERATION OF THE COCONUT DEHUSKING MACHINE

The coconut de-husking machine consists of two rotating barrel having pin and spiral on their periphery, which allows the coconut to remove the husk from it. Flash bars are added in-between the two barrels to give additional support. The de-husking machine can be operated with the help of 3H.P motor having AC power supply. The mechanical power is been developed from the AC motor and it is transferred to the pulleys; this is to achieve the required torque and also to reduce the speed of the machine. To obtain the required rotating direction, two spur gears are attached in between the pulleys and barrels. By that the pin and spiral barrels are rotated along with the gears. This implies the cutting teeth to de-husk the coconut.

The husk was removed from the coconut through the shear force exerted by the fixed two barrels in the machine. In relation to that, the amount of shear load required to de-husk the coconuts is been determined.

3.7.1 FRAME

The frame was made up off angle iron (45 x 45 x 5,4000mm). Cut to size using power hacksaw machine while arc welding machine was used for the welding, using gauge 12 welding electrodes. The frame has two lettings (funnel and tray) to accommodate the bearings for the pin barrel and spiral barrel. The frame is made up of iron to withstand any vibrations if such occur during working of the machine. The frame has been created such that there is no stress concentration due to sharp edges, or abrupt area change. This is also similar to the funnel which houses the drive shaft apart from the two barrels. Flash bars have been added between the barrels to give additional supports.

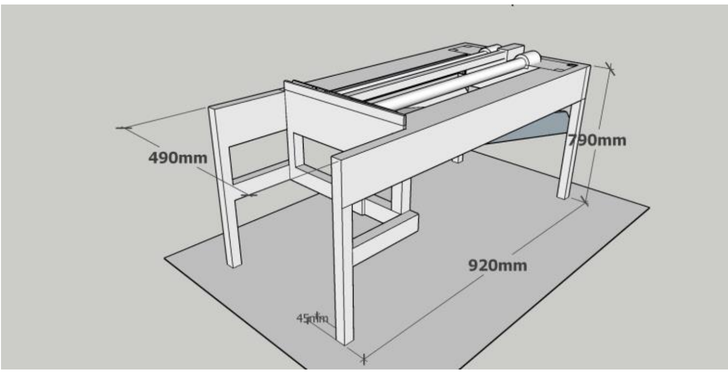


Figure 3.7.1 Frame

3.7.2 HOPPER AND BARREL COVER

The material used for the body is mild steel, sheet metal. The dimensions were marked out with the aid of a scriber. This was done for all the sheet metal of the unit.

Guillotine and hand shearing machine was used to cut the sheet metal to obtain the different pieces required.

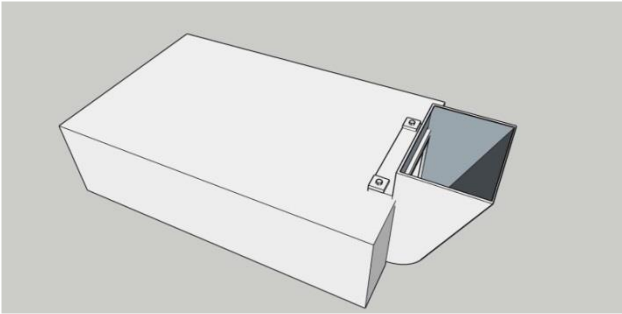


Figure 3.7.2 Hopper with cover

3.7.3 BARRELS

The barrel is made up of mild steel metal of (θ120 x 660cm), cut to size using a power hacksaw machine. The barrel was covered at both ends, using a disc of θ120 x 10mm and welded together with an arc welding machine while the hole on the disc was bore, using a drill bit of θ25mm on a lathe machine.

The barrel has been designed such that the length can accommodate one huge coconut for de-husking and an adjuster with screwed is placed at the top which helps to suit different sizes of coconut.

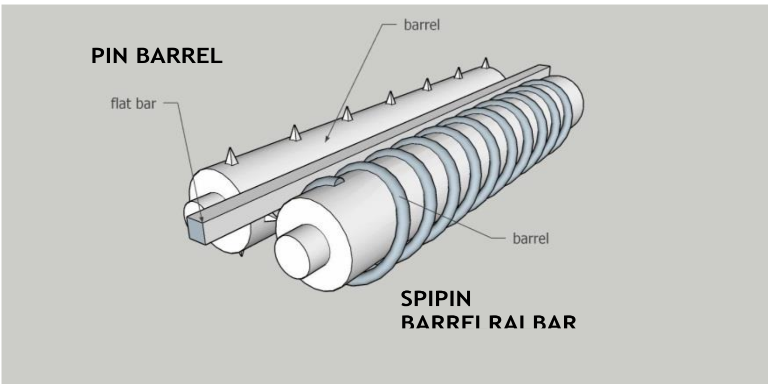


Figure 3.7.3 Barrel

3.7.4 BARREL SHAFT

Mild steel rod (θ25 x 1020mm) was cut to size, using a point hacksaw machine. The barrel shaft carries the two bearings.

3.7.5 GEAR

A gear or cogwheel is a rotating machine part having cut teeth, or in the case of a cogwheel, inserted teeth (called cogs), which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears always produce a change in torque, creating a mechanical advantage through their gear ratio and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape.

The gears in a transmission are analogous to the wheels in a crossed, belt pulley system. An advantage of gears is that the teeth of a gear prevent slippage. When two gears mesh, if one gear is bigger than the other, a mechanical advantage is produced with the rotational speeds and the torques of the two gears differing in proportion to their diameters.

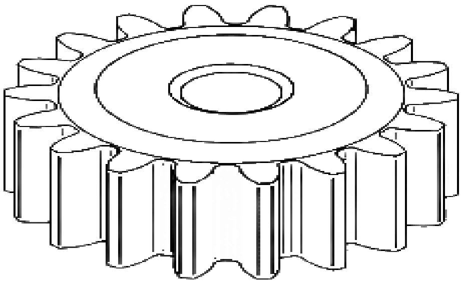


Figure 3.7.5 Gear

3.7.6TWO BIG SPUR GEARS

The spur gear was machine using a lathe machine for the turning and milling machine for cutting the gear teeth.

Heat treatment was carried out to increase the hardness and to reduce the wear rate.

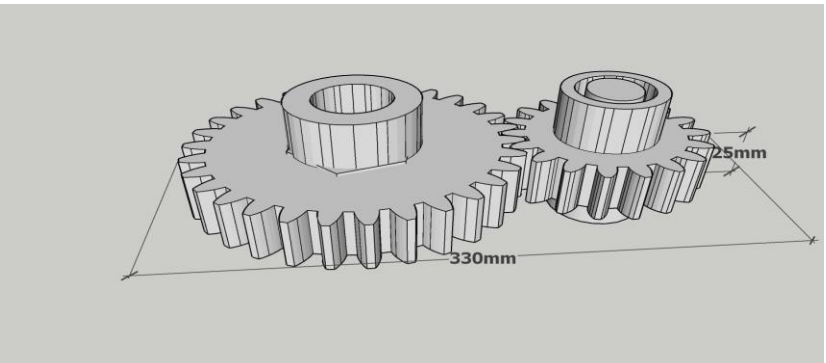
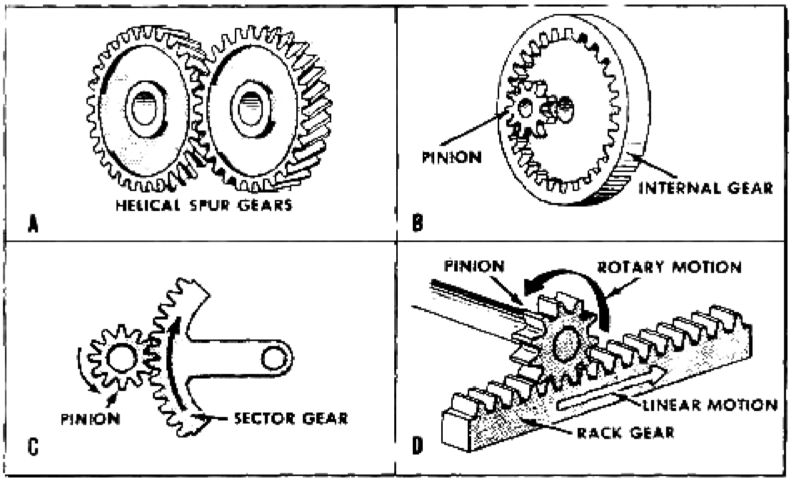


Figure 3.7.6 Two big spur gear



3.7.7 ELECTRIC MOTOR

An electric motor is an electrical machine that converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and electric current in a wire winding to generate force in the form of torque applied on the motor's shaft.

The motor is an electric motor driven by an alternating current (AC). The electric motor commonly consists of two basic parts: an outside stator having coils supplied with alternating current to produce a rotating magnetic field and an inside rotor attached to the output shaft producing a second rotating magnetic field. The rotor magnetic field may be produced by permanent magnets, reluctance saliency, or DC or AC electrical windings.

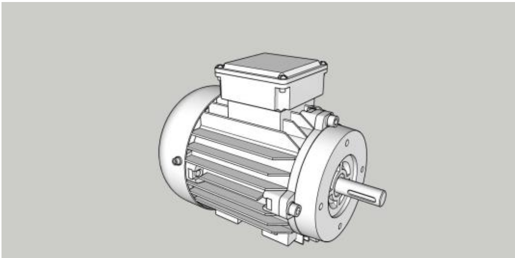


Figure 3.7.7 Electric Motor

3.7.8 TRAY

Mild steel 2mm thick was used for the tray. Cut to size using hand shearing machine.

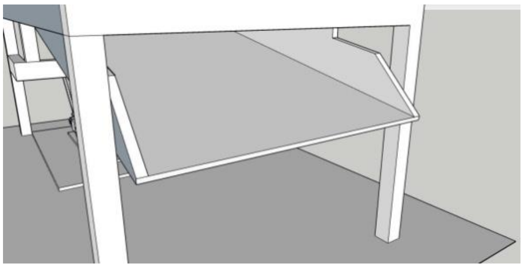


Figure 3.7.8 Tray

3.7.9 PULLEYS AND BELT

A belt and pulley system is characterized by two or more pulleys in common to a belt. This allows for mechanical power, torque, and speed to be transmitted across axles. If the pulleys are of differing diameters, a mechanical advantage is realized.

Power is transmitted from the driver pulley to the belt and from the belt to the driven pulley. Friction between belt and pulley surface limits the maximum power that can be transmitted. If this limiting value is exceeded, belt starts slipping.

V-belt is employed for this work because of its high power transmission capacity.

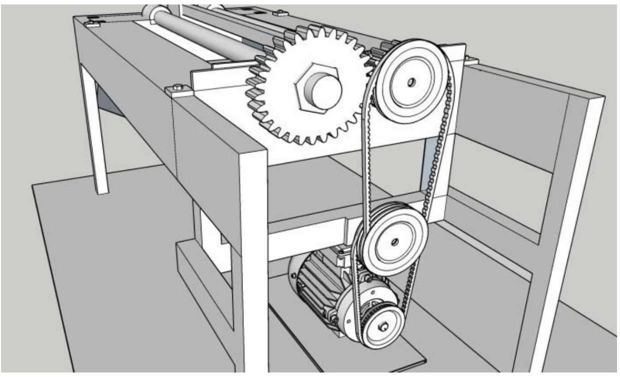


Figure 3.7.9 Pulley and belt

3. 7.10 ELECTRIC MOTOR COVER

Mild steel sheet 2mm thickness was used for the electric motor cover.

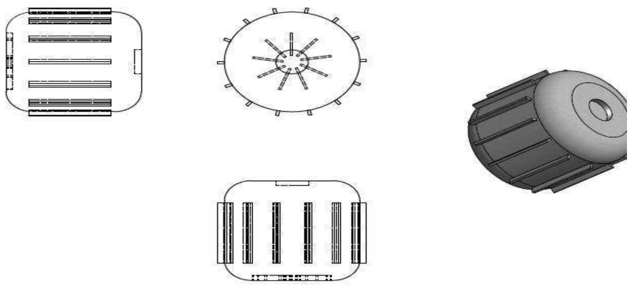


Figure 3.7.10 Electric Motor and cover

3.7.11 BOLT AND NUT

Bolt and nuts was purchase in other to fastening some machine parts together.

BOLT

Here, bolts were used to make a bolted joint. A combination of the nut was applied to an axial clamping force and also the shank of the bolt acting as a dowel, pinning the joint against sideways shear forces.

NUT

A nut is a type of fastener with a threaded hole. The nuts were used in conjunction with a mating bolt to fasten two or more parts together. The two partners are kept together by a combination of their threads' friction.

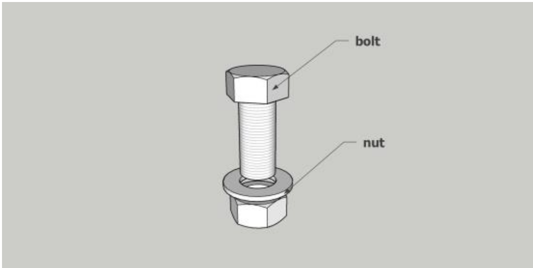


Figure 3.7.11Bolt and nut

3.8 Design of the De-husking unit

The de-husking unit is based on the rotating barrels, rotating in the opposite direction. The barrels are placed such that the flash bars line joining the centers is vertical. The two barrels are fixed using bearings to the two side frames. They rotate about their axes. The fixed barrels has pin and spiral designed to penetrate the husk and pull it apart. There is a small clearance (adjuster) between the top of the barrels. The barrels in the movable unit are fixed such that their centers are at an inclination. So, the two barrels are the same positions. This is in order to facilitate de-husking of different sizes of coconuts. The barrel derives it power from a motor through a pulley and a set of gearing. The barrels in the movable unit are free to rotate. The pin and spiral barrel rotates thus causing the process of de-husking to be accelerated. The coconuts can be dropped from the funnel. Once the coconut is held in between the two barrels, the pin and spiral barrel starts pushing the coconut thus aiding the de-husking process. A flash bar has been attached in between the barrels which aid the coconut not to move freely and then the husk is sent through the tray. As, there is time interval between two successive coconuts, the power required is not always the same.

The de-husking unit consists of the following major parts:

- Barrels
- Pin and spiral barrels
- Flash bar
- Funnel
- Tray
- Gears

- Pulley
- Adjuster
- Motor
- V-belt

3.9 DESIGN CALCULATION OF THE MACHINE

3.9.1 Calculation on Pulley and belt drive

It may be expressed, mathematically, as discussed below:

Let

d_1 =Diameter of the driver,

d_2 =Diameter of the follower,

N_1 =Speed of the driver in rpm.

N_2 =Speed of the follower in rpm.

∴ Length of the belt that passes over the driver, in one minute

$=\pi d_1 N_1$

Similarly, length of the belt that passes over the follower, in one minute

$=\pi d_2 N_2$

Since the length of belt that passes over the driver in one minute is equal to the length of belt that

passes over the follower in one minute, therefore

$\pi d_1 N_1 = \pi d_2 N_2$

and velocity ratio is given as

$$\frac{N_2}{N_1} = \frac{d_1}{d_2}$$

3.9.2 Slip of the Belt

The motion of belts and pulleys assuming a firm frictional grip between the belts and the pulleys. But sometimes, the frictional grip becomes insufficient. This may cause some forward motion of the driver without carrying the belt with it. This is called slip of the belt and is generally expressed as a percentage.

The result of the belt slipping is to reduce the velocity ratio of the system. As the slipping of the belt is a common phenomenon; thus, the belt should never be used where a definite velocity ratio is of importance (as in the case of hour, minute and second arms in a watch).

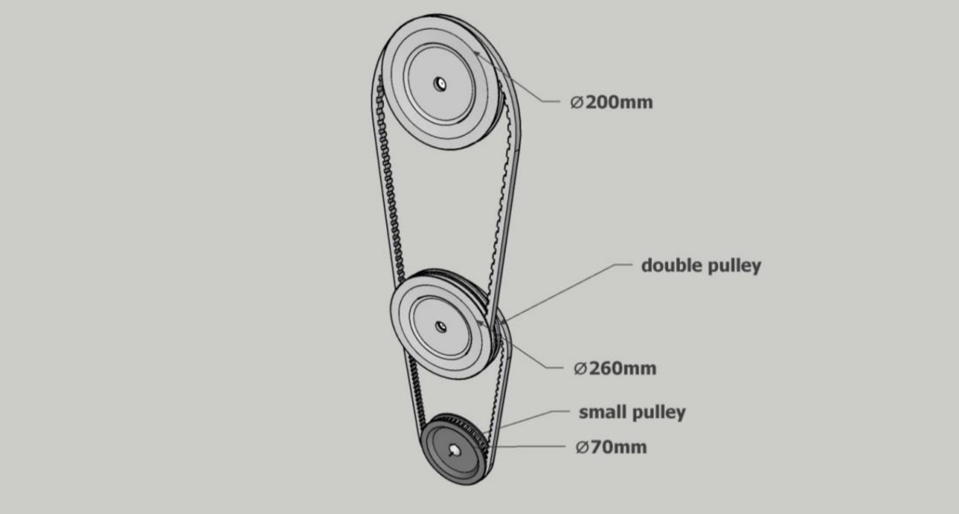


FIG. 3.9.2 Slip of belt

Given: N_1 = 1450rpm;

d_1 = 70 mm;

d_2 = 260 mm;

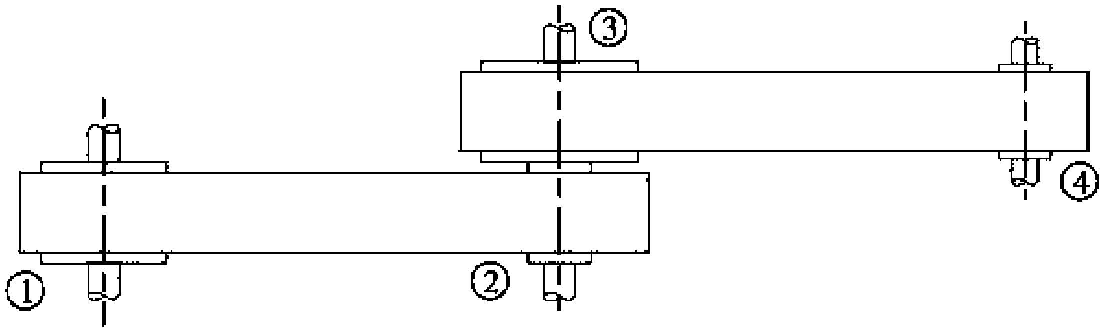
d_3 = 260 mm;

d_4 = 200 mm;

N_4 =? (Speed of the dynamo shaft)

s1 = s2 = 2%

The arrangement of pulley belt drive is shown in Fig 3.9.1 below



In case of a compound belt drive as shown in Fig. 3.9.1 the velocity ratio is given by

$\frac{N_4}{N_1} = \frac{d_1 \times d_3}{d_2 \times d_4}$ or $\frac{\text{Speed of lastdriven}}{\text{Speed of lastdriver}}$ or $\frac{\text{Product of diameters ofdrivers}}{\text{Product of diameters of driven}}$

1. When there is no slip

We know that

$\frac{N_4}{N_1} = \frac{d_1 \times d_3}{d_2 \times d_4}$ or $\frac{N_4}{1450} = \frac{70 \times 260}{260 \times 200}$

N_4 =1450 × 0.35 = 507.5 rpm.

2. When there is a slip of 2% at each drive

We know that

$$\frac{N_4}{N_1} = \frac{d_1 \times d_3}{d_2 \times d_4}\left(1 - \frac{s1}{100}\right)\left(1 - \frac{s2}{100}\right)$$

$$\frac{N_4}{1450} = \frac{70 \times 260}{260 \times 200}\left(1 - \frac{2}{100}\right)\left(1 - \frac{2}{100}\right)$$

N_4 =1450 × 0.33614 = 487.4 rpm.

3.9.3 Calculation on the gear drive

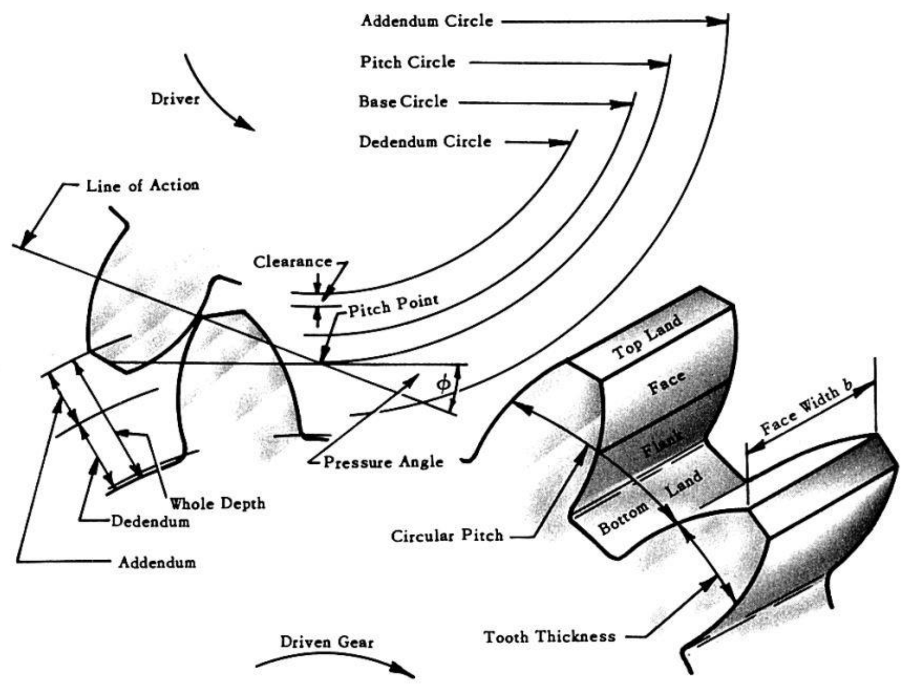


Figure 3.9.3 Gear Calculation

The principle parts of the gear teeth are denoted as shown in the figure above

1. **Pitch surface**: The surface of the imaginary rolling cylinder (cone, etc.) that the toothed gear may be considered to replace.
2. **Pitch circle**: A right section of the pitch surface.
3. **Addendum circle**: A circle bounding the ends of the teeth, in a right section of the gear.
4. **Root (or dedendum) circle**: The circle bounding the spaces between the teeth, in a right section of the gear.

5. **Addendum**: The radial distance between the pitch circle and the addendum circle.
6. **Dedendum**: The radial distance between the pitch circle and the root circle.
7. **Clearance**: The difference between the dedendum of one gear and the addendum of the mating gear.
8. **Face of a tooth**: That part of the tooth surface lying outside the pitch surface.
9. **Flank of a tooth**: The part of the tooth surface lying inside the pitch surface.
10. **Circular thickness (also called the tooth thickness):** The thickness of the tooth measured on the pitch circle. It is the length of an arc and not the length of a straight line.
11. **Tooth space**: The distance between adjacent teeth measured on the pitch circle.
12. **Backlash**: The difference between the circle thickness of one gear and the tooth space of the mating gear.
13. **Circular pitch** p: The width of a tooth and a space, measured on the pitch circle.
14. **Angular velocity ratio (or transmission ratio)** is the ratio of the angular velocity of the pinion to the angular velocity of its mating gear. It is inversely proportional to the number of teeth on the two gears, and for spur gears it is also inversely proportional to the pitch diameter.

    Angular velocity ratio = $\frac{\text{number of teeth on the driving gear}}{\text{number of teeth on the driven gear}}$
15. **Diametric pitch** P: The number of teeth of a gear per inch of its pitch diameter. A toothed gear must have an integral number of teeth. The *circular pitch*, therefore, equals the pitch circumference divided by the number of teeth. The diametric pitch is, by definition, the number of teeth divided by the *pitch diameter*.

3.9.4 Systems of Gear Teeth

The following four systems of gear teeth are commonly used in practice.

1. $14\frac{1}{2}°$Composite system,
2. $14\frac{1}{2}°$Full depth involute system
3. 20˚ Full depth involute system
4. 20˚ Stub involute system.

$14\frac{1}{2}°$Composite system is used for general purpose gears. It is stronger but has no inter changeability. The tooth profile of this system has cycloidal curves at the top and bottom and involute curve at the middle portion. The teeth are produced by formed milling cutters or hobs. The tooth profile of the $14\frac{1}{2}°$. Full depth involute system was developed for use with gear hobs for spur and 1 helical gear. The tooth profile of the 20° full depth involute system may be cut by hobs. The increase of the pressure angle from $14\frac{1}{2}°$ to 20° results in a stronger tooth, because the tooth acting as a beam is wider at the base. The 20° stub involute system has a strong tooth to take heavy loads.

3.9.5 Standard Proportions of Gear Systems

The following table shows the standard proportions in module (m) for the four gear systems as discussed in the previous article.

Table3.9.5: Standard proportion of gear system

S/N	Particular	$14½^{0}$ composite or full depth involve system	20^{0} full depth involute system	20^{0} sub involute system
1.	Addendum	1m	1m	1m
2.	Dedendum	1.25m	1.25m	0.8m
3.	Working depth	2m	2m	1m
4.	Minimum total depth	2.25m	2.25m	1.60m
5.	Tooth thickness	1.5708m	1.5708m	1.80m
6.	Minimum clearance	0.25m	0.25m	1.5708m
7.	Fillet radius at root	0.4m	0.4m	0.2m

Module: it is the ratio of the pitch circle diameter in millimeters to the number of teeth. It is usually denoted by m. mathematically,

Module, $m = \frac{D}{T}$

The recommended series of modules in Indian Standard are 1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 16, 20, 25, 32, 40 and 50.

3.9.6 Minimum Number of Teeth on the Pinion in Order to Avoid Interference

We have seen in the previous article that the interference may only be avoided, if the point of contact between the two teeth is always on the involute profiles of both the teeth. The minimum number of teeth on the pinion which will mesh with any gear (also rack) without interference are given in the following table.

Table 3.9.6: Minimum number of teeth on the pinion in order to avoid interference

S/N	System of gear teeth	Minimum number of teeth on the pinion.
1.	$14½^0$ Composite	12
2.	$14½^0$ Full depth involute	32
3.	20^0 Full depth involute	18
4.	20^0 Sub involute	14

The number of teeth on the pinion (T_P) in order to avoid interference may be obtained from the following relation;

$T_P = \frac{2A_W}{G[1+\frac{1}{G}(\frac{1}{G}+2)Sin^2\emptyset-1]}$

Where

A_W=Fraction by which the standard addendums for the wheel should be multiplied

G= Gear ratio or velocity ratio = $\frac{T_G}{T_P} = \frac{D_G}{D_P}$

∅= Pressure angel or angel of obliquity.

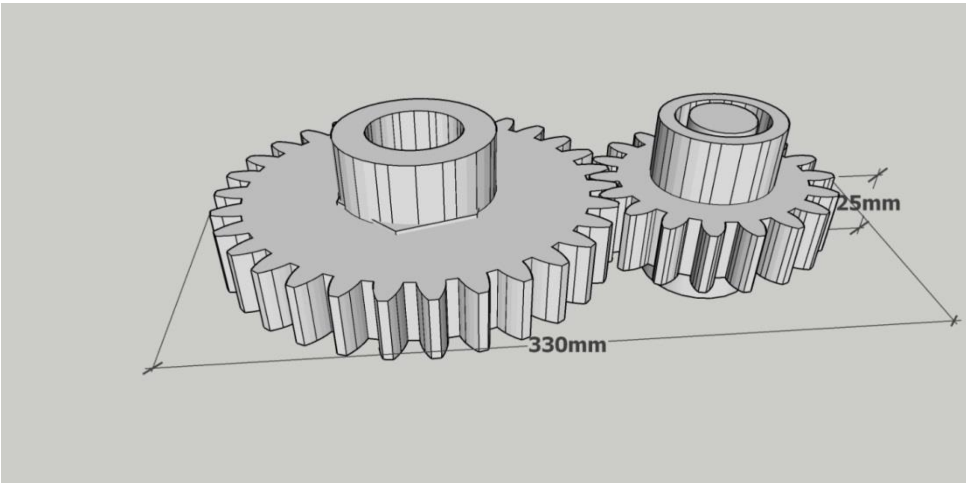


Figure 3.9.4 Gear Calculation

Given From the spur gear of our design

Number of teeth of the gear N_g= 25 teeth

Number of teeth of the pinion N_p=25 teeth

Diameter of the gear = 180mm

Diameter of the pinion =180mm

Number of speeds on the pulley (N_4) = 507.5 rpm.

Number of speeds on the driving gear (Z_e) =507.5 rpm.

Calculation for the transmission ratio

Angular velocity ratio (or transmission ratio) = $\frac{\text{Ng}}{\text{Np}} = \frac{\text{Number of teeth of the gear}}{\text{Number of teeth of the pinion}} = \frac{25}{25} = 1$

Therefore, the speed relation between two spur gears is determined by their gear ratio. You can calculate the output speed of one gear if you know the input speed of the other gear and their gear ratio.

1. **Gear Ratio i;** This is the ratio between the number of teeth on the driving gear (Ze) and the number of teeth on the driven gear (Zs). You can calculate it using the formula: $i = \frac{Z_e}{Z_s}$.
2. **Input Speed (Ns):** This is the rotational speed of the driving gear, typically measured in revolutions per minute (RPM).
3. **Output Speed (No):** This is the rotational speed of the driven gear in RPM.

Formula to Calculate Output Speed: $No = Ns * i$

Where:

N_o = Output speed (RPM) of the driven gear

$$No = 507.5 \times 1 = 507.5\ rpm$$

3.10 Drive calculation of the de-husking unit

From the experimental values Torque required for de-husking has been determined.

From that torque the drive reduction between the motor and the rollers has been determined.

Torque required to de husk a coconut = Force required shearing the coconut x Perpendicular distance

= 450x80 = 36000Nmm = 36Nm

A factor of safety of 1.25 has been selected.

So, the Torque = 45Nm.

Power of the motor (P) = 3 HP (0.74 KW)

Speed of the motor (N) = 1400 rpm

Torque developed by the motor = $\frac{(60 \text{ x } P)}{(2 \text{ x}3.14 \text{ x } N)} = \frac{(60 \text{ x } 0.75)}{(2 \text{ x } 3.14 \text{ x } 1400)}$ = 5.05 Nm

$\frac{\text{Torque required to de-husk the coconut}}{\text{Torque supplied by the motor}} = \frac{45}{5.05}$ = 9.

Reduction ratio = 9

Speed of the barrel unit = $\frac{1400}{9}$ = 160 rpm

So, the de-husking rollers are designed to rotate at 160 rpm

3.11 Hopper design

There was the need to provide hopper, lever, and stopper in order to avoid scattering of the coconut during operation as well as the need to use a more durable material, such as mild steel. The hopper's trapezium shape was taken into account during design. After being fed through the hopper, coconut is pressed against its spines using a lever. Additionally, the hopper's mounting aids to stop thecoconut fibers from slipping while the de-husking process is being done.

Calculation of the hopper

V = ½ × (a + b) × H × L

Where, V = Hopper Volume,

L = Length of hopper,

b = Breadth of hopper (on both side),

H = Hopperheight.

V = ½ × (0.327+ 0.627) × 0.260 × 0.810

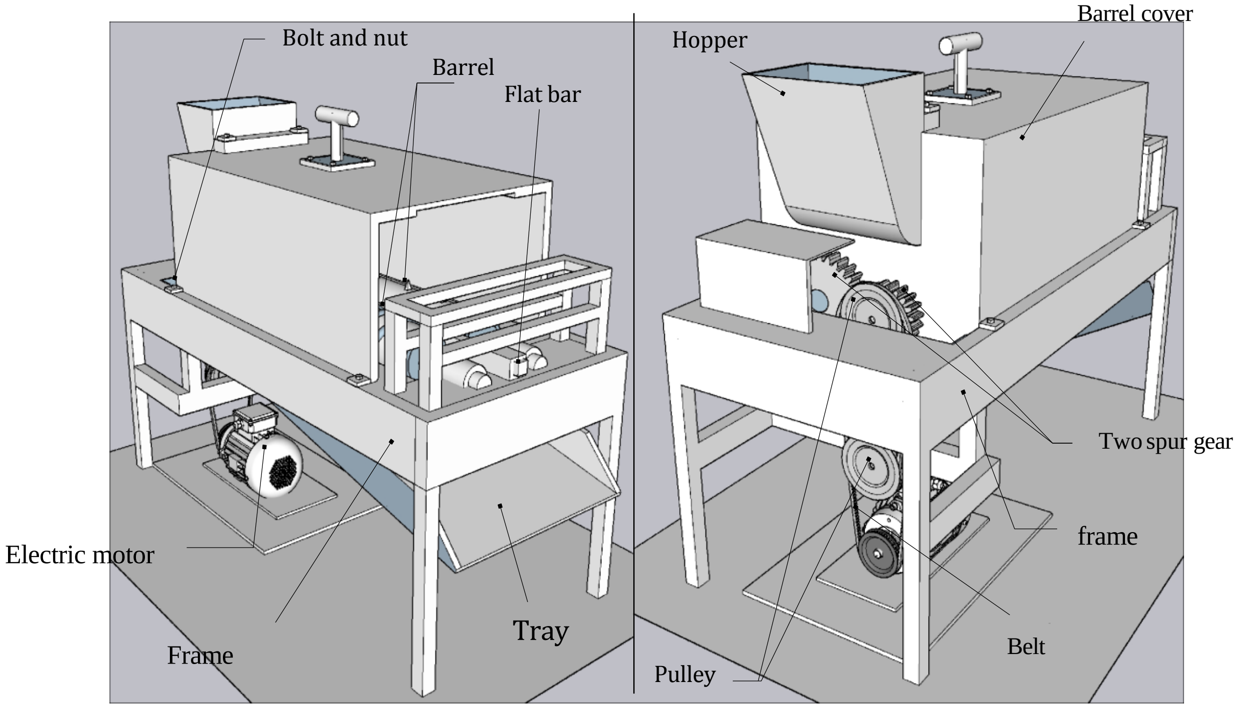


Figure 3.10 Drawing of side top and front view of coconut de-husking machine

CHAPTER FOUR
RESULT AND DISCUSSION

4.1 RESULT

In order to make it affordable and easy for peasant farmers to use, this machine was built with components purchased locally. It has the ability to de-husk locally accessible types that are available in arange of hardness and thickness. Ten experiment runs were used to assess the capacity of de-husking andeffectiveness of the machine.

Using a stopwatch, the de-husking period at each session was timed. Each test involved operating themachine and recording the total number of fruits de-husked. Numbers of well-de-husked nuts without distortion on the length of the husk extract andnumbers of complete de-husked nuts with distorted husk extract were counted in each of the procedures.

Performance Evaluation

The efficiency of the fabricated machine was determined. Results show that the machine performed above 80.1% efficiency in all the testscases as expected (Table 1).

The results of the performance test (Table 1) show that the machine performed above 90% efficiency in all the tests cases as expected. It is also obvious from this table that the capacity of the developed machine ranges between 79 and 141 nuts per hour depending on the operator; however, on average an operator de-husks 93 nuts per hour with this machine.

This machine was fabricated with standard and locally sourced materials thus, the machine is affordable to small scale farmers and maintainable.

Table 4.2: Result of the Performance Evaluation of Coconut De-husking Machine

S/N	Number of fruits de-husked	Number of fruits well de-husked	Number of fruits not de-husked well	Time (seconds)	Efficiency (%)	Capacity (fruits/hr.)
1.	6	4	2	196.67	66.67	109.83
2.	5	4	1	199.93	80.00	90.03
3.	4	4	0	179.95	100.00	80.02
4.	5	4	1	180.43	80.00	99.76
5.	5	3	2	177.88	60.00	101.19
6.	7	5	2	178.49	71.43	141.18
7.	6	4	2	179.86	66.67	120.09
8.	4	4	0	177.05	100.00	81.33
9.	4	4	0	180.49	100.00	79.78
10.	6	5	1	180.83	83.33	119.45
Average	5.11	4.11	1	181.66	80.81	93.44

The above table shows the number of fruits that were de-husked and the number of fruits that were not de-husked. The table also includes information on the de-husking time, efficiency, and capacity. Here's a detailed analysis of the data:

De-husking Efficiency: The de-husking efficiency ranges from 60% to 100%, with an average efficiency of 80.81%. This indicates that the de-husking process is successful in removing most of the fruits' husks.

De-husking Time: The de-husking time varies between 177 seconds (2 minute and 57 seconds) and 200 seconds (3 minutes and 20 seconds) per batch of fruits.

Number of Fruits De-husked: The number of fruits de-husked per batch ranges from 4 to 7.

Number of Fruits Not De-husked: The number of fruits not de-husked per batch ranges from 0 to 2 fruits. This suggests that the de-husking process has a low rejection rate.

Capacity (fruits/hr.): The table lists a capacity of 79 to 141 fruits per hour. This may be referring to the potential fruit put through the de-husking machine. The capacity was arrived at by converting the time in seconds to hours and dividing by Number of Fruits De-husked.

Overall Performance:

The machine successfully de-husked an average of 4 out of 5 coconuts per test (Efficiency 80.81%).

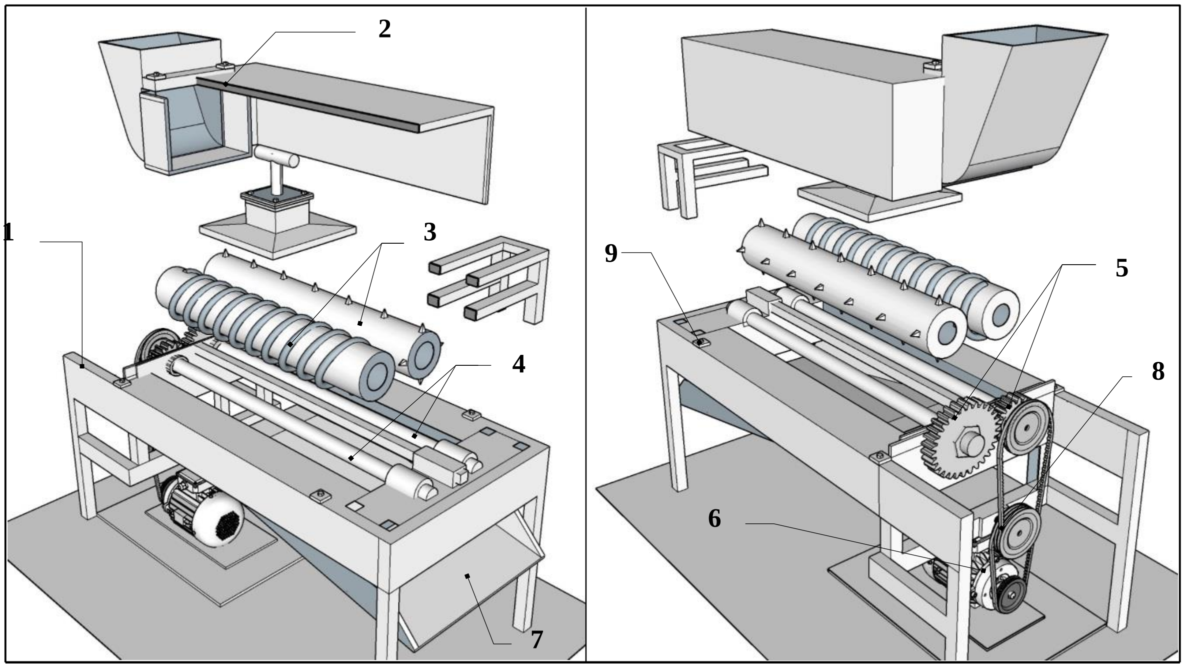
The average de-husking time was 181.66 seconds (3 minutes and 1 seconds) per test.

The average machine capacity based on the tests was approximately 93.44 fruits per hour.

Overall, the data suggests that the de-husking process is efficient with a low rejection rate. Furthermost if this machine was to be run for a complete day, that is a period of 24 hours (1440 minutes) without any delay time, an average total of 2256 Fruits will be de-husked, 1920 fruits will be de-husked well while 480 fruits will not be well de-husked.

TABLE 4.3 Materials Used

S/N	Description of item	Quantity used	Material selected
1	Frame	1	Mild steel
2	Hopper	1	Mild steel
3	Electric motor (3HP)	1	Purchased
4	Barrel	1	Mild steel
5	Barrel shaft	1	Mild steel
6	Welding electrode	100	Mild steel
7	Pulley	1	Purchased
8	Funnel	1	Mild steel
9	Tray	1	Mild steel
10	Rod		Mild steel



DESIGN AND FABRICATION OF COCONUT DE-HUSKING MACHINE Exploded Drawing	1. frame 2. hopper and barrel cover 3. barrels 4. barrel shaft 5. two big spur gears 6. electric motor 7. tray 8. pulleys and belts 9. bolt and nuts

Figure 4.1 Design and fabrication of coconut de-husking machine Exploded Drawing

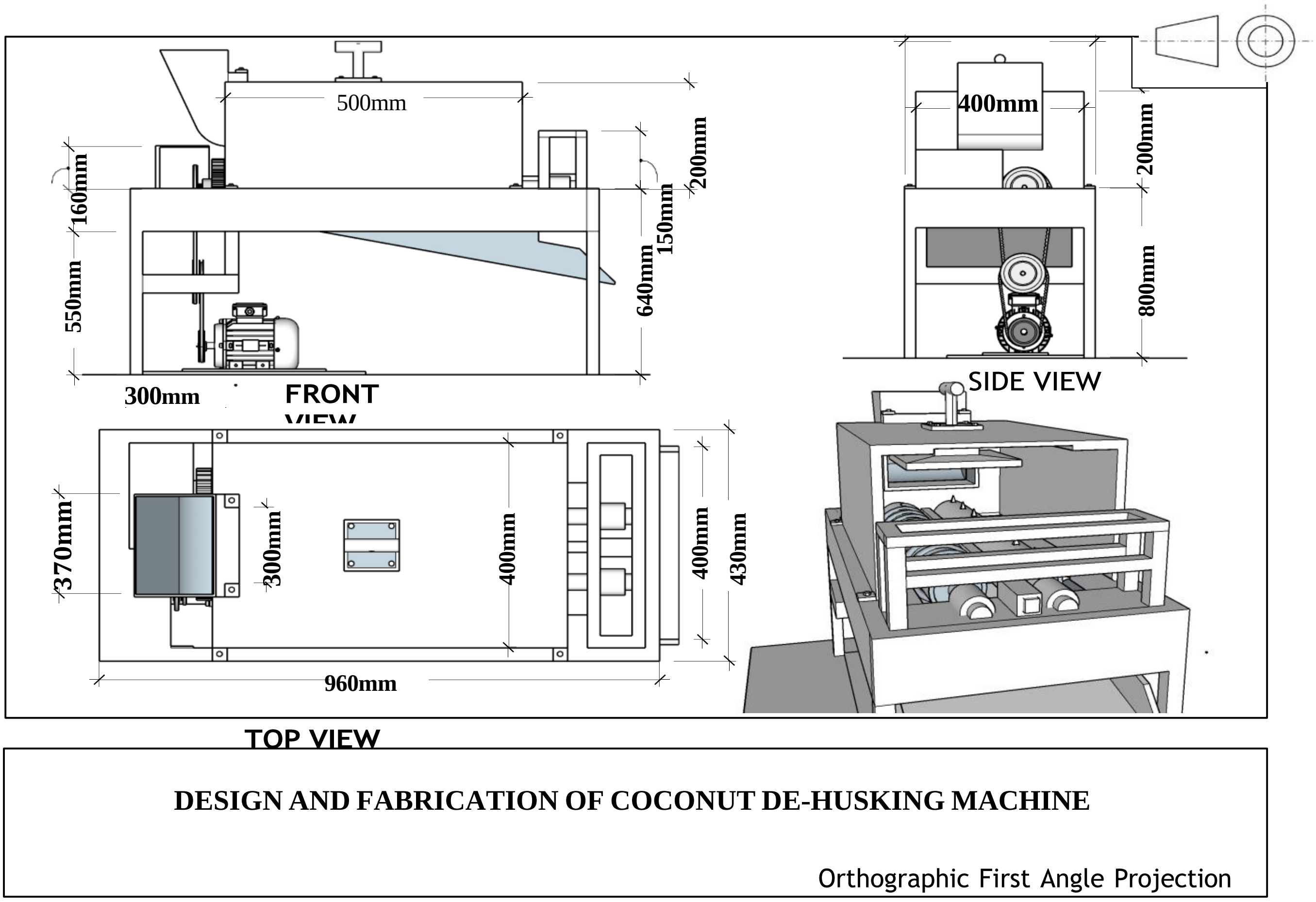


Figure 4.2 Design and fabrication of coconut de-husking machine Orthographic First Angle Projection

CHAPTER FIVE

CONCLUSION AND REFERENCE

5.1 CONCLUSION

A coconut de-husking machine which de-husks coconuts without nut breakage and distortion of the extracted husks was developed at the University of Benin, Benin City. The machine is easy to operate and performs with an average de-husking efficiency and capacity of 80.81% and 93 nuts per hour.

Introduction of this machine eliminates the problem of extracted coir fiber length distortion associated with the use of some mechanized equipment as well as drudgery and risks involved in the use of cutlass and spike for coconut de-husking. It also eliminates dependency on the epileptic public electric power supply in our rural areas.

A low-cost coconut de-husking machine has been fabricated for the small-scale farm holders in the agricultural and rural areas. The machine is appeared to be feasible, pollution less, economic. Number of nuts produced per hour dependsupon the slack time and speed of roller units. The operationof the machine is simple and the maintenance of the machine is also not expensive. Introducing this machinein the farm areas can reduce the risk involved in de-husking the coconut and also eliminates the skilled manpower required for de-husking the coconuts. Themachine can also be integrated along with the further processing steps of the nuts.

5.2 RECOMMENDATION

One of the challenges faced during the experimental testing was the inability to vary the speed of the electric motor. It is suggested that a variable speed drive be incorporated in future designs to allow users regulate the speed to achieve the kind of peel (de-husk) texture they need. Also, it is recommended that more detail bending moment analysis be carried out on the system to determine the barrels shaft design.

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