

**DESIGN AND FABRICATION OF CORN DEHUSKING AND SHELLING
MACHINE**

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CERTIFICATION

This is to certify that this report is a detailed design report, undertaken by **OGUIKE MARY CHINWENDU**, matriculation number **ENG1504068**, in partial fulfilment of the requirement for the award of Bachelor of Engineering (B.ENG) degree and has been compiled in accordance to regulations guiding the preparation of report writing in the department of Production Engineering, of the faculty of Engineering, University of Benin.

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DEDICATION

This project work is dedicated to the ALMIGHTY GOD for his guidance and protection whose loving mercy has kept me this far during the course of this project and to my ever supportive family.

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My greatest acknowledgement goes to GOD ALMIGHTY, the author, and finisher of my faith, who has always been there for me and who has made me what I am today and also for the success of this project work.

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ABSTRACT

A corn dehusking and shelling machine presented in this paper helps to dehusk the corn cob from its husk and separate corn from the cob. The fabricated design consist of a body casing drum, shelling unit, dehusking unit, grain and cobdischarge unit, machine frame, hopper (feeding chute), bearing as some of the major component, it is expected to be powered by 1Hp electric motor connected via a belt drive which transmits torque from the electric motor to the shelling and dehusking units. The fabricated design is expected to be at least 89% efficient with an operating capacity of about 63.95kg/hr. The design is expected to be relatively cheap, simple and portable when compared to imported product of similar capacity.

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LIST OF SYMBOLS ABBREVIATIONS AND NOMENCLATURE

b	width of belt
C_m	capacity of machine
C	Centre diameter
D, d	Diameter of motor
F_a	correction factor for industrial service
F	Force of shelling
g	Acceleration
h	vertical height of the hopper
K_θ	correction factor for arc of contact
K_L	correction factor for belt length
L	Length Of pulley and belt
L_c	length of shelling portion
L_i	inside length of belt
M	Mass of shelling bars
n_b	number of belt
N_p	total number of spikes on the shelling portion
N_1	Speed of rotation of motor
N_2	speed of shaft driven
N_3	speed of screw conveyer
P	Pressure
P_m	Power of motor
R	Radius of shaft
r_b	radius of hopper top
S_s	allowable stress of belt

T	thickness of belt
T	Tension
T_s	Torque On shaft
V	Volume of pulley, velocity of belt, Belt speed
V_B	Velocity of belt
μ	Coefficient of friction
θ	Angle of lap on smaller pulley
ω	Angular velocity of shaft
ρ	Density
η	Efficiency
2β	groove angle of the pulley
W_p	Weight of pulley

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Maize which is referred to as corn (is an important cereal crop which belong to a grass family Graminae) in the third world (Anirudha et al. 2015). It provides humans and animals with nutrients, saves as a raw material for starch, protein, oil, food sweeteners and alcoholic beverages (Kedge et al, 2016). In many African countries, maize is used to alleviate hunger in the form of flakes, pap, maize flour and sadza (Oriaku et al. 2014).

Maize production in Nigeria is of great importance. With the increase in population and use of maize grain, the market demand for maize grain also increases. However, maize shelling in developing and underdeveloped nations has been and remains a serious problem as it is tedious and often requires considerable labour hours (Abdulkarim and Kalkat 1987).

As the ear of the maize reaches maturity, the individual grains swell and harden to form a closely-packed cylindrical cob. The kernels on the cob are within the husks, which give some degree of protection from damage by insects, fungi and the ambient climate. The recovery of the grains requires the removal of the husks, moisture reduction in the field, shelling and cleaning. Shelling is, therefore, one of the essential processes in maize production (Galinat 1988).

In recent years, farmers in Nigeria have been faced with difficulties in substantial production of maize, one among which is shelling. Most farmers in the country still operate at a subsistence level, whereby shelling is done traditionally at the farm level by hand or by beating sacks stuffed with cobs. These operations are time wasting and energy consuming. Not only this, but their hands may get bruised while shelling (Kareem 2011).

Maize is one of the most important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic value. Maize is a major important cereal being cultivated in the rainforest and the derived savannah zones of Nigeria. Maize has been in the diet of Nigerians for centuries. It started as a subsistence crop and has gradually become a more important crop. Maize has now risen to a commercial crop on which many agro-based industries depend for raw materials (Iken and Amusa, 2004). Maize is the most important cereal in the world after wheat and rice with regard to cultivation areas and total production (Purseglove, 1992; Osagie and Eka, 1998). Maize can be classified according to the structure of the grain. We have sweet corn, flint corn, popcorn, dent corn, soft or flour corn and pod corn.

According to IITA (2001) report, maize contains 80percent carbohydrate, 10percent protein, 3.5percent fiber and 2percent mineral. Iron and Vitamin B are also present in maize.

The demand for maize as a major raw material in most industries requires that its production be stepped up. Hence, there is a need to develop an effective method of shelling maize properly with a minimal amount of damaged grain.

According to Khawar et al, (2007), maize has a variety of uses. Its grain is a rich source of starch, vitamins, proteins and minerals. The starch extracted from maize grain is used in making confectionary and noodles. Corn syrup from maize contains high fructose and act as sweetener and retains moisture when added to certain foods.

Shelling is the process of removing seed or grain from their respective cobs for both human and industrial use. Shelling is best attained when the moisture content is as low as 13% (Ashrae, 1998). Shelling is an indispensable process which is undertaken to maximise space and promote the easy handling of grains. Maize shelling, if done manually, is one of the most labour intensive processes in the post-harvest handling of corn. The existing maize shellers are normally large and heavy, which requires a high power input for their operation and also

results in a low product quality in terms of percentages of seed breakage and purity (Bilanski et al. 1962).

Damaged kernels are susceptible to insects and moulds, thereby increasing the incidence of aflatoxin contamination. Thus, there is a need to develop a maize sheller with higher efficiency and better product quality, which is powered with a small engine (Collins et al. 1940)..

1.2 Statement of the Problem

Traditional shelling methods don't support large scale shelling of corn, especially for commercial purposes. The highest producing corn in terms of region in Nigeria is the northern part of the country and it was observed that most shelling of corn was done manually, which consumes a lot of time even with some hand operated simple tools. As a result, the emergency of developing modernized corn shelling machine temporarily phased out the other types of shelling operations. This modern corn sheller operate with a higher efficiency of mass production and is more reliable than the other types. It is usually powered by an electric motor which is connected to the machine and to the power supply source vice-versa. It is based on this type of design that we embarked on the design and fabrication of a corn shelling machine. However, this design is a modification of other existing design, in that a dehusking chamber is incorporated to tackle the manual dehusking of corn. In other words, we considered the feasibility of the design from every engineering details to economics and aesthetics. The machine is therefore designed to be quite reliable, durable and cheap to build and run.

1.3 Aim of the Study

The aim of this project is to design and fabricate a corn shelling machine that is easy to operate, with a high degree of efficiency and flexibility in order to achieve high volume of production within a short period of time.

1.4 Objective of the Study

The objectives of the research work are to;

- Design a corn shelling machine that will operate with minimum noise.
- Construct a corn shelling chamber that will effectively separate the corn from the cob, reduce breaking effect of cob.
- Increase efficiency and reduce time to shell the corn.
- Design belt drive and pulley system for dehusking and shelling operation.
- Perform test on corn having different moisture content.
- Design separation zone for corn shells and seed.

1.5 Scope of the Study

A Corn Shelling Machine presented in this project helps to separate corn from the cob at higher speed than manual beating. The fabricated design consists of a body casing, frame, drum, dehusking unit, shelling unit, grain and cob discharged unit, hopper, bearing as some of the major component. The project “Design and Fabrication of Corn Shelling Machine” is indeed an essential one, in a time like this when almost all human endeavour is embracing technology for efficiency and reliability. This innovation was made to be more desirable and economical. The electrical and controlling system is totally environmentally friendly and contains no hazard.

1.6 Significance of the Study

The expectation of this research is to solve the problem of manual shelling of corn and other short comings noticed in some of the existing design viz loss of corn during processing, cost of production as well as manual dehusking of corn before shelling. This corn shelling machine was therefore designed to incorporate dehusking chamber to address the dehusking of the corn by manual means, thereby reducing the cost of labour.

CHAPTER 2

LITERATURE REVIEW

Corn shelling is the most important aspect of post-harvest operations of corn. Shelling is one of the most important crop processing operations to separate the grains from the ear heads or the plants and prepare it for market. Traditionally, dehusking and shelling of maize are carried out manually which involves a lot of drudgery. The grains were detached from dried cobs by manual or mechanical device, which is known as shelling. This operation is however highly labour intensive and more drudgery in addition to losses of grains in terms of quantity and quality. With an increase in the shelling drum speed, the shelling efficiency increases and vice-versa. The increase in the shelling efficiency is not only due to the increase in the speed, but to an increase in the feed rate and applied force.

Depending on the influence of agronomic, economic and social factors, shelling is done in different ways: (i) Shelling by hand, with simple tools; (ii) Mechanical shelling, with simple machines operated manually. (iii) Mechanical shelling, with motorized equipment. Going through history, one can emphatically say that design and fabrication of corn shelling machine had been in existence from time immemorial although during that time, the fabricated designs by local welders lacks technological acuity. The type of metals as well as other materials used in construction were not well evaluated, such that when the machine were subjected to stress and strain or being exposed to some environmental factors while in use may react quickly to corrosion and wear Oloko et al. (2002) developed a corn shelling machine driven electrically and 71% with the machine capacity of 54.5kg/hr. one of the limitations was that losses in corn during shelling was relatively high.

In today's developing world human being's innovative ideas has taken the world in all direction concerning about the production and safety in industrial establishments. Threshing/Shelling/Corn deseeding is the process of removing the kernels from the cob. It is the process of harvesting because the corn kernels, when harvested are attached to the cob which is hard. Most of the farmers who are having low acreage corn production meet several difficulties because of high labour expenditure and cost of foreign Corn Shellers. Some machines are of good qualities but more costly where are other somewhat hazardous methods, but it is not, the amount of time and money spent in the invention of device or the sophistication of its operation is important, but its convenience, utility and operational efficiency that are important in considering the device.

“Shelling is the process of separating the grains from the cob that holds them. The separation is obtained by friction and rotation. The difficulty of the process depends on the varieties grown and the moisture content and the degree of maturity of the grain” (De Lucia, 1994).

“The different methods of maize shelling can be categorized based on various mechanization technology used. These includes: hand-tool technology, and engine power technology. Shelling is best attained when the moisture content is as low as 13%” (Ashrae 1998).



Fig 2.1: Corn/Maize

According to Darudka (1955), In the early century, the traditional system for shelling corn was the manual operation which is either activated by using hand in contact with ears of corn or rubbing two ears of corn against each other. These methods require a lot of labour. However, it was calculated that a worker can hand shell only a few kilograms an hour. Another common shelling method was striking a bag full of corn with a stick. Corn can also be shelled by rubbing the ears and heads on a rough surface or use a perforated metal piece called grater. To facilitate speedy shelling of corn, mechanical shellers (corn shelling machine) are recommended because hand shelling can't support commercial shelling. The average kernel (grain) price is approximately twice the price of each cob. Hence, more income can be generated by farmers if corns are shelled and the grains are sold alone in the market. But in order for this to be possible there is need for a cheap, easily operated and efficient corn shelling machine.

According to Glon (2018), In making a choice for the type of engine to be used, petroleum (spark ignition) engines are mostly suitable because petrol engines runs at higher rotation speed than diesels, partially due to their lighter pistons, connecting rods and crankshaft and also due petrol burning more quickly than diesel. Also, according to Globapetrolprices.com on the 29th of October 2018, the price of a litre of petrol was ₦146.90 as opposed to diesel at ₦207.98. These differences in price is also a major factor for choosing a spark ignition engine since it is easier for rural farmers to afford. However, an electric motor will be the best engine to be used for such a corn shelling system because the cost of buying petroleum to power a spark ignition is unstable at the moment due to the happenings (covid-19) ravaging Nigeria as well as the rest of the world, affecting counties economy and also there's an increase in the availability of power supply. So therefore, the cost of buying petroleum often will be reduced.

In designing machine components, the slightest imperfections will cause parts to wear faster and eventually create breakdowns that reduce the effective life of the machinery that they constitute. Rough edges on machine parts can cause them to get stuck in unexpected places, which in turn can cause accident leading to unnecessary injury. Best case scenario of incident caused by non-deburred machinery will force costly delays in productivity while parts are replaced. None of this tends to sit well for production line managers and workers. Abrasive substances are used to rub against the metal and remove the thin shavings on the edges. This process can also polish the parts at the same time, which reduces overall production times and get parts finished faster.

Moisture content of corn seriously affects the shellability of corn. Another factor that affects the shellability of corn is the size of the corn cob. According to Joshi, H.C (1981), the various sizes of corn cob ranges from 50mm to 85mm depending on the variety. Engineering design factor, such as, design of the power transmission shaft, selection of the prime mover, type of pulley, appropriate belt design, key and selection of appropriate bearings support affect the design of mechanical shellers.

Therefore, a power operated machine is needed to improve productivity and reduce human effort. The following literature was studied for designing the project model to suit a preferable and marketable product.

According to Shigley, J.E (1986), the power delivered by a shaft is given by;

$$P = F \times V = F \times \omega r$$

Where, P = Power (Nms⁻¹), F = Force of shelling (N), V = Velocity (m/s)

r = radius of shaft.

The force required to shell the corn is given by;

$$F = Mw^2r$$

Where, M = mass of shelling bars (kg), $\omega =$ angular velocity of the shaft $\frac{2\pi N}{60}$, where, N is the speed of shelling (rpm).

The appropriate electric motor is determined or selected when the total power required is determined at an appropriate shelling speed.

The relationship between the driven pulley speed and the speed of the prime mover is;

$$N_1D_1 = N_2D_2$$

Where, N_1 and D_1 are speed and diameter of the driver (prime mover), N_2 and D_2 are speed and diameter of the driven pulley.

The weight of the pulley on the shaft is given by; Mass \times acceleration due to gravity

$$\text{Also, } m = \rho \times v$$

Where, m = mass of pulley, $\rho =$ density, and v is the volume of the pulley

$$\text{So therefore, } W_P \text{ (weight of pulley)} = \rho \times \frac{\pi d^2}{4} \times L_p \times g$$

Where, d is diameter of pulley, L_p is the length of pulley.

A belt provides a convenient means of transferring power from one shaft to another.

An appropriate belt selection will assist in effective power transmission.

The effective pull-on belt is given by $T = T_1 - T_2$, where, T_1 is the tension on tight side and T_2 is the tension on slack side.

The torque on shaft (T_s) is $F \times r$, where, F is the total force of shelling and is equal to the total torque requirement of the system, i.e., $T_s = T_m$

$$\text{Power of motor (P}_m\text{)} = \omega \times T_m$$

Thus, the effective pull (T) is $T = \frac{P_m}{\omega r}$

The power transmitted by belt is given by;

$$P = \frac{(T_1 - T_2)V}{550}, \text{ in horsepower} \quad \text{OR} \quad P = (T_1 - T_2) V, \text{ in Watts}$$

Where V is the belt speed $\left(\frac{\pi DN}{60}\right)$

$$\text{Also, } \frac{T_1}{T_2} = \exp(\mu\theta \csc \beta), \text{ for v-belt}$$

$$\frac{T_1}{T_2} = \exp(\mu\theta), \text{ for flat belt}$$

Where, β is the groove half angle, θ is the angle of lap, μ is the coefficient of friction.

Note, the μ for rubber belt on cast iron or steel operating on dry surface is 0.3.

The angle of lap for open v-belt drive is given as;

$$\theta = (180 - 2\alpha) \times \frac{\pi}{180}, \text{ in rad.}$$

$$\text{Also, } \sin \alpha = \frac{r_1 - r_2}{x}, \text{ where, } r_1 \text{ and } r_2 \text{ are the radii of larger and smaller pulley, } x \text{ is}$$

the distance between centre of two pulley.

The shelling machine is tested to determine its effective use with respect to the work to be done. Its performance is evaluated based on the throughput capacity, effective throughput capacity and its mechanical efficiency.

$$\text{The throughput capacity (T}_p\text{)} = \frac{W_T}{t_T}, \text{ in kg/hr.}$$

Where W_T is the total weight of material handled which include shelled or unshelled and t_T is the total time taken in handling the materials.

The effective throughput capacity is the ratio of actual weight of grains handled that was not damaged to the effective time of operation.

$$T_{pe} = \frac{W_a}{t_e}, \text{ in kg/hr.}$$

The efficiency in %, is the percentage of the ratio of the total weight of grain actually handled (output) to the total weight of grain to be handled (input).

$$\eta = \frac{W_a}{W_t}$$

2.1 TYPES OF SHELLERS

There are basically two types of corn shellers, namely;

1. The combine sheller
2. The stationary sheller

2.1.1 *The Combine sheller*

This is a powered form of machine driven by tractors and it combines several operations in a single machine. With the help of the combine sheller, harvesting and threshing are done simultaneously thereby eliminating several expensive operations formally needed such as binding, sticking, stacking, pitching, hauling crops to the sheller. Combine sheller performs six operations including cutting, conveying, separating, deshelling and cleaning. The major disadvantage of the combine sheller is that it is uneconomical and cannot accumulate straws in stalk for future use.

2.1.2 *The Stationary sheller*

The stationary sheller is a manual or power operated sheller which operates in a fixed position. It incorporates three units namely; the shelling unit, cleaning unit and the power transmission unit. The major limitation of this type is that it can only shell and clean grains and have comparatively low output capacity.

2.2 PRINCIPLES OF SHELLING CORN

The principles of shelling corn are;

1. Rotary impart principle
2. Frictional contact principle

2.2.1 Rotary impact principle

Corns are feed uniformly into the hopper. The corn fall by gravity on the rotating cylinder and the shelled impact of the beating bars are whirled round between the perforated concave and the rotating cylinder. The chaff and the grains fall through the concave opening and are directed to the grain outlet by the configuration of the casing.

2.2.2 Frictional contact principle

Frictional contact principle of shelling corn is done in two major way. They include;

- The use of helical conveyors

The corn is feed through the hopper and falls by the action of gravity on the rotary helical conveyor located within a stationary drum or cylinder with the concave or internal surface incorporated with rasp bars. The conveyor moves the cone in the direction parallel to the axis of rotation of the conveyor or when the corn come in contact with the rasp bars, the grains detach from the cob as a result of friction between the corn and the rasp bar. (Yusuf, 2017)

- The use of conical drum

Corn is held by hand within a rotating cylinder (conical drum) incorporated with prong at the concave surface. The cylinder is made to rotate about the fixed corn and the grains detach from the cobs as a result of frictional contact between the corn and the prong on the conical drum. (Yusuf, 2017)

2.3 PERFORMANCE OF CORN SHELLER

The successful design of a corn sheller depends upon the knowledge of the power requirement for the shelling operation and other parameters such as the shelling efficiency (mass of corn shelled per unit time), grain loss (mass of broken and unshelled corn), and output capacity (mass of grain collected at output per unit time). Also, a good corn shelled depends on the relationship between the crop and the working parts of the machine such as, the concave clearance between the sieve and the peripheral of the cylinder, speed of rotation and corn parameter such as, size, moisture content of the corn and bulk density.

2.4 SHELLING MECHANISMS

The two types of shelling mechanisms commonly used for field shelling of corn are the axial flow cage sheller and the cylinder-concave sheller. Both shellers have a relatively high capacity and the capability of shelling snapped (unhusked) ear corn. The popularity of the cylinder sheller has increased with the practice of field shelling high moisture corn. The cage sheller (Figure 2) consists of a cylinder with lugs, helical flutes, or paddles which turns inside a cage. The cage has a perforated surface with holes large enough to

let kernels fall through but retain the cobs. The ears are fed into an opening at one end of the cage. The helical flutes feed the ears through the cage and at the same time shell them by a rolling and crushing action against the cage surface and each other.

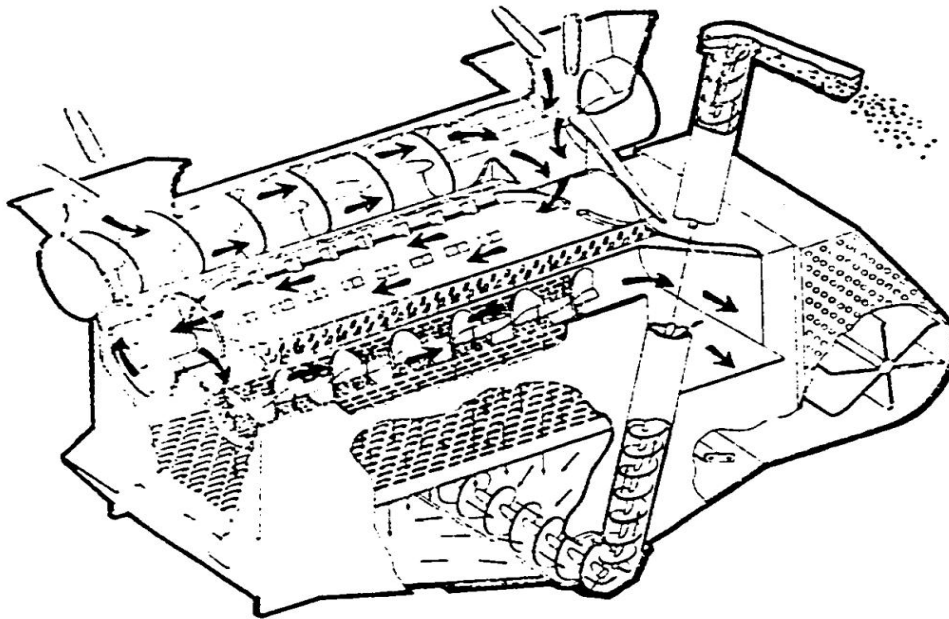


Figure 2.4a The axial flow cage type sheller

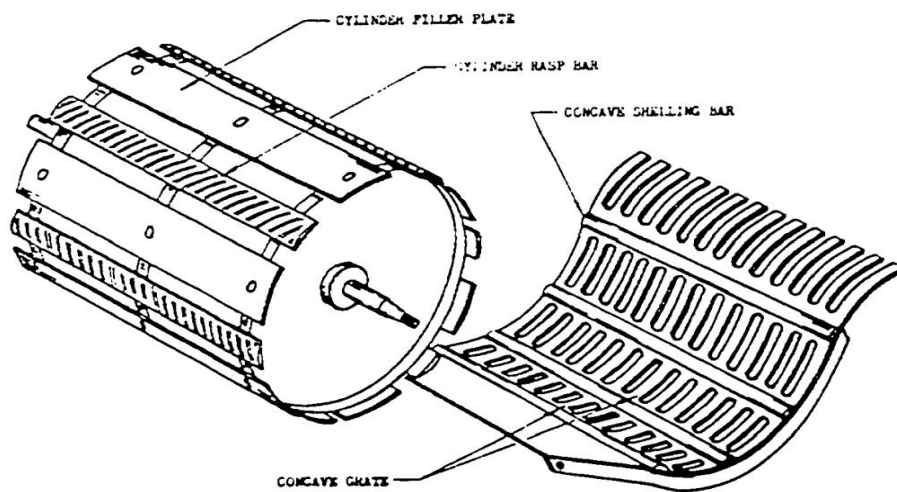


Figure 2.4b The rasp bar cylinder-concave sheller

An adjustable cob gate serves to retain the ears in the cage long enough to be completely shelled. The cages are usually from 27.9 to 38.1 cm (11 to 15 inches) in diameter and the cylinders have rotational speeds of 650 to 790 rpm. The capacity of these shellers is in the order of 4 to 5 metric tons per hour (150 to 200 bushels per hour). This shelling unit is generally used as a shelling attachment mounted on a two-row corn picker in place of the husking bed, although self-propelled corn harvesters using this type of sheller are available.

Ability to shell high-moisture corn is important when field shelling. Tests conducted by Burrough and Harbage (1953) showed cage sheller losses of 5 to 10% when kernel moisture was 29.6% and cob moisture was 56.5%, wet base. Part of the loss was due to unshelled corn remaining on crushed cob sections, and part to difficulty in separating the damp kernels from the cobs. The percentage of kernels left on the cobs and the percentage of kernels damaged by shelling were almost directly proportional to the moisture content of the kernels. The second basic shelling mechanism, commonly used in combines, consists of a cylinder and a concave (Figure 3). The corn is shelled by the impact of bars on the periphery of the cylinder as the corn is fed between the cylinder and the concave bars. The most common type of cylinder bar used is the rasp-bar. These bars were shown to cause less damage 10 than an angle-bar type cylinder (Pickard, 1955). These cylinders are commonly 55.9 cm (22 inches) in diameter and range from 61 to 152 cm (24 to 60 inches) in length, depending on the size of the combine. For corn shelling, they turn at speeds of 400 to 700 rpm.

2.5 MODIFICATION OF THE CORN SHELLER

The corn shelling machine available is such that, dehusking of corn is done manually (by hand) to remove the outer sheath before being transferred to the shelling chamber. The manual method of dehusking the corn involves more human stress and strain, the time required to shell the corn is more due to the corn being dehusked manually. Labour requirement or availability becomes a problem when the corn is to be dehusked in large quantity.

To overcome this problem of removing its outer sheath and dehusking the cobs this machine (Dehusking chamber incorporated) was developed. The machine basically comprises separate shelling chamber, de-husking chamber, collector and motor. The arrangement of these parts is connected by belt and pulley mechanism.



2.5 Modified Corn Sheller

2.6 WORKING PRINCIPLE

In operating the corn sheller, the prime mover (electric motor) has to be functional before it is started. The corn is introduced into the Dehusking chamber via the inlet (hopper), the corn is dehusked by two screw rollers moving in opposite direction to each other. After the dehusking of the corn, the corn is then introduced into the shelling chamber. The spikes teeth feed the maize through the cylinder casing and at the same time shell the maize by rolling, impact and shelling action against the concave and each other. The spike is a rod attached to the hollow cylinder. Under the sheller cylinder is the perforated concave which allows the grains to drop easily out of the shelling unit. The maize is fed into the hopper at one end of the shelling unit.

2.6 POWER REQUIREMENT

The power requirement for a corn shelling machine ranges from different size and horsepower depending on its area of applications and the operation required to be carried out. For an electric motor, its power ranges from 0.5 – 10 horsepower. (Oriaku, 2004). For the design of the corn shelling machine, 1horsepower electric motor was used. But standard selection of motor is 1.5hp

2.7 DESCRIPTION OF THE MAIZE DEHUSKING AND SHELLING MACHINE

The maize sheller is a machine designed to shell maize (plate 1). It removes the maize grain from the cob. The functional component parts include: hopper, shelling concave (top),

shelling cylinder with spikes (drum), perforated concave (bottom), cob outlet, fan, discharge chute/collector, bearings, pulleys, belts, shaft, frame and electric motor.

CHAPTER THREE

3.0 METHODOLOGY

The method and principle used to conduct this project involves the design of the component parts, modification of the sheller (dehusking chamber incorporated), and the finishing of the component parts which take into account the design consideration. In order to obtain the desired output in terms of efficiency, effectiveness, reliability and acceptability during the operation and testing of the machine, the machine had undergone several important considerations for designing with respect to the fit, form and function of processing the Argo based products (Corn).

The components of the machine are as follows: cob outlet, chute/collector, bearings, pulleys, belts, shaft, rollers and electric motor.

The operations involved in the construction of the sheller include;

I. Welding

II. Grinding

III. Shearing

IV. Bending

V. Cutting

VI. Drilling

VII. Finishing

3.1 DESIGN CONSIDERATION

3.1.1 Design Factors

The design of any engineering component begins as a mere imagination and before it is actualized so many factors have been taken into consideration.

The following criteria were used:

I. The mechanical properties of the material

II. Machinability and Formability

III. Availability of material

IV. Choice of material

V. Cost of material

The following requirements were put into consideration for a good and effective design process.

a) Service Requirements

This has to do with the extent to which the machine/equipment is going to withstand the condition it is going to be subjected to. Fitness of the end product

b) Fabrication Requirement

This concerned with whether the material to be used can easily be fabricated using the available methods; whether heat treatment could be adopted to vary or induce certain properties

c) Economic Requirement

This takes into account the total cost of production, which includes the cost of raw material manipulation, joining, machining and labour. These determine the actual cost of the finished product and show whether the design is economically viable or not. Having considered all the above the construction has been made from mostly mild steel and the fabrication process used are mostly those available and economical.

3.2 DESIGN ANALYSIS

SHAFT DIAMETER: According to Kedar (2016), the shelling shaft diameter on the basis of strength was given as 25mm.

PULLEY MATERIAL: Cast Iron was selected due to the fact that it has a high damping property and offers greater friction between the belt and pulley.

SERVICE FACTOR: Since the machine is designed to function in a light duty condition for 10 – 16 hours, then a service factor of 1.2 (From Table 3.2) would be selected.

BELT SELECTION: The material used for belts must be strong, flexible and durable. It must have a high coefficient of friction. The material of belt selected was a rubber belt. Selecting suitable belt depends on the design power value with respect to the corresponding standard speed of the induction motor. Therefore, from manufacturer's catalogue, corresponding cross section of the belt was selected to be an A-type belt cross section.

- *NORMINAL TOP WIDTH*: The standard top width of belt (A-section) is found to be 13mm. Obtained from Table 3.1.
- *NORMINAL THICKNESS*: The standard thickness from the manufacturer’s catalogue of an A-section V-belt is found to be 8mm. Obtained from Table 3.1.
- Standard minimum recommended Nominal pulley diameter of the motor is found to be 70mm (From Table 3.1), but we choose 75mm.
- The recommended maximum velocity of belt is found to be 10m/s for light duty working condition.

Table 3.1. Dimensions of standard V-belts (Khurmi and Gupta, 2004)

Belt Section	Power range in KW	Min Pitch Diameter(mm)	Top Width(b) mm	Thickness (t) mm
A	0.7 - 3.7	70	13	8
B	2 – 15	125	17	11
C	7.5 – 75	200	22	14
D	20 - 150	335	32	19
E	30 - 350	500	38	23

Table 3.2. Standard service correction factor under different operating conditions (Standard V-Belt Manual, DIN Standard)

Operating Condition	Operating Hours Per day		
	3 -5	8 -12	16 -24

Normal Duty	1.0	1.1	1.2
Light Duty	1.1	1.2	1.3
Medium Duty	1.2	1.3	1.4
Heavy Duty	1.3	1.4	1.5

3.3 DESIGN CALCULATIONS

3.3.1 CALCULATION OF VELOCITY OF BELT

The velocity of belt is defined by;

$$V_B = \frac{\pi d_1 N_1}{60} \dots\dots\dots (3.1)$$

Where, d_1 = diameter of motor pulley = 75mm

N_1 = Speed of rotation of motor = 1440rpm

$$\begin{aligned} \therefore V_B &= \frac{\pi \times 0.075 \times 1440}{60} \\ &= 5.655 \text{ m/s.} \end{aligned}$$

NB: Since V_{max} = 10m/s is greater than V_B = 5.6m/s, the speed is satisfied.

3.3.2 CALCULATION OF SPEED OF DRIVEN (SHAFT) PULLEYS

The speed of belt is equal for both driver and driven. So therefore,

➤ *FOR SHELLING SHAFT*

$$V_B = \frac{\pi \times d_2 \times N_2}{60} \dots\dots\dots (3.2)$$

Where;

d_2 = diameter of shaft pulley = 200mm

N_2 = Speed of shaft (driven)

$$\begin{aligned} \therefore N_2 &= \frac{60 \times V_B}{\pi \times d_2} \\ &= \frac{60 \times 5.655}{\pi \times 0.2} \end{aligned}$$

$$\therefore N_2 = 540 \text{ rpm}$$

➤ *FOR SCREW CONVEYOR*

$$V_B = \frac{\pi \times d_3 \times N_3}{60} \dots\dots\dots (3.3)$$

Where,

d_3 = diameter of screw conveyor pulley = 250mm

N_3 = Speed of screw conveyor

$$\therefore N_3 = \frac{60 \times 5.655}{\pi \times 0.25}$$

$$N_3 = 432 \text{ rpm}$$

3.3.3 CALCULATIONS OF LENGTH OF BELT

➤ *FOR MOTOR (driver) AND SHELLING SHAFT (driven)*

The approximate centre distance;

$$C = 1.5 \times (d_1 + d_2) \dots\dots\dots (3.4)$$

$$C = 1.5 \times (75 + 200)$$

$$C = 412.5\text{mm}$$

The length of belt is given as;

$$L = \frac{\pi}{2}(d_1 + d_2) + 2C + \frac{(d_2 - d_1)^2}{4C} \dots\dots\dots (3.5)$$

$$L = \frac{\pi}{2}(75 + 200) + 2(412.5) + \frac{(200 - 75)^2}{4 \times 412.5}$$

$$L = 1266.44\text{mm}$$

In order to obtain the inside length of the belt, 36 was subtracted from the pitch length. 36 is the standard differences between the pitch length and the inside length which is gotten from manufacturer's catalogue.

$$L_i = 1266.44 - 36$$

$$L_i = 1230.44\text{mm}$$

The inside length of belt is given as 1230.44mm.

Obtaining the standard inside belt length from manufacturer's catalogue;

The nearest standard inside length of the V-belt is an A48 section \rightarrow 1232mm

\therefore The New Pitch length of belt is given as;

$$1232 + 36 = 1268\text{mm.}$$

Recall from equation 3.5;

$$L = \frac{\pi}{2}(d_1 + d_2) + 2C_1 + \frac{(d_2 - d_1)^2}{4C_1}$$

$$2C_1 + \frac{(d_2 - d_1)^2}{4C_1} = L - \frac{\pi}{2}(d_1 + d_2)$$

$$2C_1 + \frac{(200 - 75)^2}{4C_1} = 1268 - \frac{\pi}{2}(200 + 75)$$

$$2C_1 + \frac{3906.25}{C_1} = 836.03$$

$$2C_1^2 - 836.03C_1 + 3906.25 = 0$$

$$\therefore C_1 = 413.29\text{mm}$$

The recommended centre to centre distance between the motor pulley and shelling shaft pulley is 413.29mm.

➤ *FOR MOTOR (driver) AND SCREW CONVEYOR (driven)*

The approximate centre distance;

$$C = 1.5 \times (d_1 + d_3) \dots\dots\dots (3.6)$$

$$C = 1.5 \times (75 + 250) = 487.5\text{mm}$$

The length of belt is given as;

$$L = \frac{\pi}{2}(d_1 + d_3) + 2C + \frac{(d_3 - d_1)^2}{4C} \dots\dots\dots (3.7)$$

$$L = \frac{\pi}{2}(75 + 250) + 2(487.5) + \frac{(250 - 75)^2}{4(487.5)}$$

$$L = 1501.21\text{mm}$$

Inside length; $L_i = 1501.21 - 36$

$$L_i = 1465.21\text{mm}$$

So therefore, obtaining the standard inside belt length from manufacturer catalogue;

The nearest standard inside length of the V-belt is an A58 section → 1475mm

∴ The New pitch length of belt is given as;

$$L = 1475 + 36 = 1511\text{mm}$$

Recall from equation 3.7;

$$L = \frac{\pi}{2}(d_1 + d_3) + 2C_1 + \frac{(d_3 - d_1)^2}{4C_1}$$

$$\therefore 2C_1 + \frac{(d_2 - d_1)^2}{4C_1} = L - \frac{\pi}{2}(d_1 + d_2)$$

$$2C_1 + \frac{(250 - 75)^2}{4C_1} = 1511 - \frac{\pi}{2}(75 + 250)$$

$$\therefore 2C_1^2 - 1000.491C_1 + 7656.25$$

$$C_1 = 492.47\text{mm}$$

\therefore The recommended centre to centre distance between the motor pulley and screw conveyor is 492.47mm.

3.3.4 THE TENSIONS ON THE BELT

Tension on the belt is given by;

$$2.3 \log \left(\frac{T_1}{T_2} \right) = \mu \theta \csc \beta \dots\dots\dots$$

(3.8)

Where;

T_1 = Tension on the tight side of the belt

T_2 = Tension on the slack side of the belt

μ = Coefficient of friction between belt and pulley

θ = Angle of lap of the smaller pulley

2β = Groove angle of the pulley

Assume groove angle is 35° $\beta = \frac{35}{2} = 17.5^\circ$

Coefficient of friction between belt and pulley is 0.25

➤ FOR MOTOR (driver) AND SHELLING SHAFT (driven)

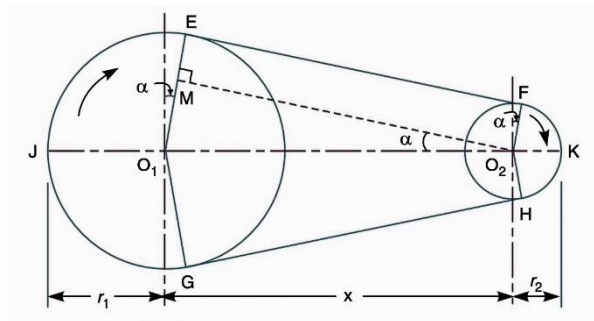


Fig 3.1

$$\sin \alpha = \frac{d_2 - d_1}{2c} = \frac{200 - 75}{2(413.29)}$$

$$\sin \alpha = 0.1512$$

$$\alpha = \sin^{-1} 0.1512$$

$$\alpha = 8.698^\circ$$

Angle of lap on smaller pulley;

$$\theta = 180 - 2\alpha \dots\dots\dots (3.9)$$

$$\theta = 180 - 2(8.698)$$

$$\theta = 162.6^\circ \approx 2.838\text{rad}$$

$$\therefore 2.3\text{Log} \left(\frac{T_1}{T_2}\right) = \mu\theta \csc \beta$$

$$2.3\text{Log} \left(\frac{T_1}{T_2}\right) = 0.25 \times 2.838 \times \csc 17.5$$

$$2.3\text{Log} \left(\frac{T_1}{T_2}\right) = \frac{2.359}{2.3}$$

$$\therefore \frac{T_1}{T_2} = 10.61$$

But; $T_1 = b \times t \times S_s$

Where;

$$b = \text{width of belt} = 13\text{mm}$$

$$t = \text{thickness of belt} = 8\text{mm}$$

$$S_s = \text{Allowable stress of belt} = 3 \times 10^6 \text{ pa}$$

$$T_1 = 0.013 \times 0.008 \times 3 \times 10^6$$

$$T_1 = 312\text{N}$$

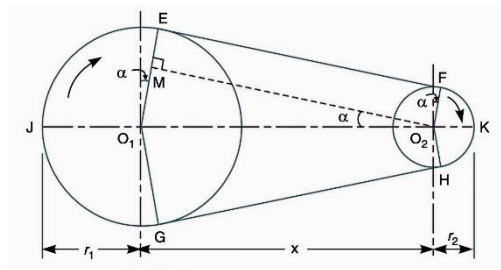
Recall;

$$\frac{T_1}{T_2} = 10.61$$

$$T_2 = \frac{T_1}{10.61}$$

$$T_2 = \frac{312}{10.61}$$

$$T_2 = 29.41\text{N}$$



➤ FOR MOTOR (driver) and SCREW CONVEYOR (driven)

Fig 3.2

$$\sin \alpha = \frac{d_3 - d_1}{2c} = \frac{250 - 75}{2(492.47)}$$

$$\sin \alpha = 0.178$$

$$\alpha = \sin^{-1} 0.178$$

$$\alpha = 10.23$$

Angle of lap on smaller pulley;

$$\theta = 180 - 2\alpha \dots\dots\dots (3.10)$$

$$\theta = 180 - 2(10.23)$$

$$\theta = 159.53^\circ \approx 2.784\text{rad}$$

Recall;

$$2.3 \text{Log} \left(\frac{T_1}{T_2} \right) = \mu \theta \csc \beta$$

$$2.3 \text{Log} \left(\frac{T_1}{T_2} \right) = 0.25 \times 2.784 \times \csc 17.5$$

$$2.3 \text{Log} \left(\frac{T_1}{T_2} \right) = 2.315$$

$$\therefore \frac{T_1}{T_2} = 10.15$$

Recall;

$$T_1 = 312\text{N}$$

$$\therefore T_2 = \frac{312}{10.15}$$

$$T_2 = 30.74\text{N}$$

3.3.5 POWER TRANSMITTED PER BELT

➤ *FOR MOTOR (driver) and SHELLING SHAFT (driven)*

$$\text{Power} = (T_1 - T_2) \times V_B \dots\dots\dots (3.11)$$

Recall;

$$\text{Velocity of belt; } V_B = 5.655\text{m/s}$$

$$\therefore \text{Power} = (312 - 29.41) \times 5.655$$

$$\text{Power} = 1598.05 \text{ watts} \approx 1.598\text{kw}$$

➤ *FOR MOTOR (driver) AND SCREW CONVEYOR (driven)*

From equation 3.9;

$$\text{Power} = (T_1 - T_2) \times V_B$$

$$\therefore \text{Power} = (312 - 30.74) \times 5.655$$

$$\text{Power} = 1590.53\text{watts} \approx 1.59\text{kw}$$

3.3.5 OBTAINING THE REQUIRED NUMBER OF BELTS

The required number of needed to drive the corn shelling machine depends on the base power rate required by the induction motor pulley, arc of contact correction factor and the belt length correction factor.

Therefore; calculating the required number of belts was obtained using the equation below;

$$n_b = \frac{F_a \times \text{Power transmitted}}{\text{KW rating of belt} \times K_\theta \times K_L} \dots\dots\dots (3.12)$$

Where; F_a = Correction factor for industrial services

K_θ = Correction factor for arc of contact

K_L = Correction factor for belt length

From the Table 3.5;

KW rating of belt = 0.96 kw

$$F_a = 1.2$$

➤ FOR MOTOR (driver) and SHELLING SHAFT (driver)

The Angle of lap as obtained in equation (3.9) is 162.6° , approximately 163° .

From Table 3.3;

The Correction factor for arc of contact K_θ is 0.96

From Table (3.4); Since the belt code / designated is on A-40 belt section. The belt length correction as obtained between A38 – A41 was found to be;

$$K_L = 0.89$$

From Table (3.5); the power rating of belt depended on the diameter and speed of the motor pulley. Therefore, the correcting power rating was found to be 0.98kw

The power transmitted per belt from equation (3.11) was given as 1.59kw approximately 1.6kw.

So therefore, the number of belts is given as;

$$n_b = \frac{1.2 \times 1.6 \times 10^3}{0.96 \times 10^3 \times 0.89 \times 0.96}$$

$$n_b = 2.34 \approx 2$$

Approximately, the number of belts required for the shelling chamber is 2 belts.

➤ FOR MOTOR (driver) and SCREW CONVEYOR (driven)

Since the angle of lap as obtained in equation (3.10) is slightly similar to that of motor and shelling shaft and the power transmitted per belt is equal. So therefore, it can be concluded that the number of belts required by the screw conveyor to dehusk is 2 belts.

$\frac{Dd-dd}{C}$	Contact angle on small pulley $\theta(^{\circ})$	$K\theta$
0.00	180	1.00
0.10	174	0.99
0.20	169	0.97
0.30	163	0.96
0.40	157	0.94
0.50	151	0.93
0.60	145	0.91
0.70	139	0.89
0.80	133	0.87
0.90	127	0.85
1.00	120	0.82
1.10	113	0.80
1.20	106	0.77
1.30	99	0.73
1.40	91	0.70
1.50	83	0.65

Table 3.3: Arc of contact

Length designation	Correction factor				
	A	B	C	D	E
20 ~ 25	0.77	0.72			
26 ~ 30	0.82	0.76			
31 ~ 34	0.85	0.79			
35 ~ 37	0.87	0.81	0.71		
38 ~ 41	0.89	0.83	0.73		
42 ~ 45	0.91	0.85	0.75		
46 ~ 50	0.93	0.87	0.77		
51 ~ 54	0.94	0.89	0.78		
55 ~ 59	0.96	0.91	0.80		
60 ~ 67	0.98	0.93	0.82		
68 ~ 74	1.01	0.95	0.84		
75 ~ 79	1.03	0.97	0.86		
80 ~ 84	1.04	0.98	0.87		
85 ~ 89	1.05	0.99	0.89		
90 ~ 95	1.07	1.01	0.90		
96 ~ 104	1.08	1.03	0.91	0.81	
105 ~ 111	1.10	1.04	0.93	0.82	
112 ~ 119	1.12	1.06	0.94	0.84	
120 ~ 127	1.13	1.07	0.96	0.85	
128 ~ 144	1.15	1.09	0.98	0.87	0.85
145 ~ 154	1.18	1.11	1.00	0.89	0.87
155 ~ 169	1.19	1.13	1.02	0.91	0.88
170 ~ 179	1.21	1.15	1.03	0.92	0.90
180 ~ 194	1.23	1.17	1.05	0.94	0.91
195 ~ 209	1.25	1.18	1.07	0.95	0.93
210 ~ 239	1.27	1.21	1.09	0.98	0.95
240 ~ 269	1.30	1.24	1.12	1.00	0.98
270 ~ 299	1.33	1.26	1.14	1.03	1.00
300 ~ 329	1.35	1.29	1.17	1.05	1.02
330 ~ 359	1.38	1.31	1.19	1.07	1.04
360 ~ 389	1.40	1.33	1.21	1.09	1.06
390 ~ 419		1.35	1.22	1.11	1.08
420 ~ 479		1.38	1.25	1.13	1.10
480 ~ 539		1.41	1.28	1.16	1.13
540 ~ 600		1.44	1.31	1.18	1.16
601 ~ 660		1.46	1.33	1.21	1.18

Table 3.4: Belt length correction factor

small pulley speed nd(rpm)	Basic power rating for small pulley datum diameter : Ps															Additional power rating for speed ratio (Pa)			
	Small pulley datum diameter dd (mm)															Speed ratio			
	71	75	80	90	95	100	106	112	118	125	132	140	150	160	180	1.01 to 1.05	1.06 to 1.26	1.27 to 1.57	1.57<
700	0.51	0.61	0.73	0.96	1.08	1.20	1.34	1.48	1.62	1.78	1.94	2.12	2.34	2.56	3.00	0.01	0.08	0.12	0.15
950	0.62	0.75	0.91	1.22	1.37	1.53	1.71	1.89	2.07	2.28	2.49	2.72	3.02	3.30	3.87	0.02	0.11	0.16	0.20
1450	0.80	0.98	1.21	1.66	1.89	2.11	2.37	2.63	2.89	3.18	3.48	3.81	4.22	4.62	5.40	0.03	0.18	0.25	0.31
2850	1.04	1.36	1.75	2.52	2.90	3.27	3.70	4.12	4.53	4.99	5.44	5.93	6.51	7.06	8.04	0.05	0.34	0.49	0.60
100	0.12	0.13	0.16	0.20	0.22	0.24	0.26	0.28	0.31	0.33	0.36	0.39	0.43	0.47	0.55	0.00	0.01	0.02	0.02
200	0.20	0.24	0.27	0.35	0.39	0.43	0.47	0.52	0.56	0.61	0.66	0.72	0.80	0.87	1.01	0.00	0.02	0.03	0.04
300	0.28	0.32	0.38	0.49	0.54	0.60	0.66	0.73	0.79	0.87	0.94	1.03	1.13	1.24	1.45	0.01	0.04	0.05	0.06
400	0.34	0.40	0.47	0.62	0.69	0.76	0.85	0.93	1.01	1.11	1.21	1.32	1.45	1.59	1.86	0.01	0.05	0.07	0.08
500	0.40	0.48	0.56	0.74	0.83	0.91	1.02	1.12	1.22	1.34	1.46	1.59	1.76	1.93	2.25	0.01	0.06	0.09	0.11
600	0.46	0.54	0.65	0.86	0.96	1.06	1.18	1.30	1.42	1.56	1.70	1.86	2.06	2.25	2.63	0.01	0.07	0.10	0.13
700	0.51	0.61	0.73	0.96	1.08	1.20	1.34	1.48	1.62	1.78	1.94	2.12	2.34	2.56	3.00	0.01	0.08	0.12	0.15
800	0.56	0.67	0.80	1.07	1.20	1.33	1.49	1.65	1.80	1.98	2.16	2.37	2.62	2.87	3.36	0.01	0.10	0.14	0.17
900	0.60	0.72	0.87	1.17	1.32	1.46	1.64	1.81	1.99	2.18	2.38	2.61	2.88	3.16	3.70	0.02	0.11	0.15	0.19
1000	0.64	0.78	0.94	1.27	1.43	1.59	1.78	1.97	2.16	2.38	2.60	2.84	3.14	3.44	4.03	0.02	0.12	0.17	0.21
1100	0.68	0.83	1.01	1.36	1.54	1.71	1.92	2.13	2.33	2.57	2.80	3.07	3.40	3.72	4.36	0.02	0.13	0.19	0.23
1200	0.72	0.87	1.07	1.45	1.64	1.83	2.05	2.28	2.50	2.75	3.00	3.29	3.64	3.99	4.67	0.02	0.15	0.21	0.25
1300	0.75	0.92	1.13	1.54	1.74	1.94	2.18	2.42	2.66	2.93	3.20	3.50	3.88	4.25	4.97	0.02	0.16	0.22	0.27
1400	0.78	0.96	1.19	1.62	1.84	2.05	2.31	2.56	2.81	3.10	3.39	3.71	4.11	4.50	5.26	0.03	0.17	0.24	0.30
1500	0.81	1.00	1.24	1.70	1.93	2.16	2.43	2.70	2.96	3.27	3.57	3.91	4.33	4.74	5.54	0.03	0.18	0.26	0.32

Table 3.5: Base power rating

3.3.6 CAPACITY OF MACHINE

According to Kedar (2016), the average shelling and dehusking capacity of the machine was 300kg/hr.

$$C_m = 300\text{kg/hr}$$

$$= \frac{300 \text{ kg}}{60 \times 60} = 0.083\text{kg/s}$$

3.3.7 VOLUME OF HOPPER

In calculating the volume of the hopper equation (3.13) was used,

$$V = \frac{1}{3} \pi (r_t \times r_b) h \dots\dots\dots (3.13)$$

Where; r_t = radius of hopper top = 200mm

r_b = radius of hopper bottom = 100mm

h = vertical of the hopper = 150mm

So therefore;

$$V = \frac{1}{3} \pi (0.2 + 0.1) \times 0.15$$

$$V = 0.0471 m^3$$

3.3.8 NUMBER OF SPIKES ON SHELLING CYLINDER

The design of the spikes on the shelling shafts was carried using equation (3.14),

$$N_p = \frac{L_c}{SS_c} \times \frac{\pi \times d_s}{SS_r} \dots\dots\dots (3.14)$$

Where; N_p = Total number of spikes on the shelling portion

L_c = Length of the shelling portion

SS_c = The spike spacing on the cylinder = 80mm

SS_r = The spike spacing in the row = 50mm

d_s = The diameter of the shelling portion = 25mm

So therefore;

$$N_p = \frac{950}{80} \times \frac{\pi \times 25}{50}$$
$$= 15.54$$

∴ The total number of spikes on the shelling portion is approximately 16.

3.4 MATERIAL SELECTION

Materials were selected locally and were selected based on strength, availability, durability and affordability. Bearings and other components that are vital to the design were carefully selected. Adequate care was taken in the selection of the materials for corn shelling machine as only the best material which serves the desired objectives at the minimum cost were considered.

S/N	PARTS	MATERIAL	QUANTITY
1	Body casing	Mild steel sheet	4
2	Hopper (feeding chute)	Mild steel sheet	1
3	Cob discharge unit	Mild steel sheet	1
4	Grain discharge unit	Mild steel sheet	1
5	Machine frame	Mild steel	10

6	Bearing	Cast iron	6
7	Pulley (driver)	Cast iron	3
8	Rollers	Mild steel	2
9	Electric motor		1
10	Shelling unit	Stainless steel	1
11	De-husking unit	Mild steel	1
12	Shafts	Galvanised Steel	1
13	V-Belt	Rubber	4
14	Gears	Mild steel	2



Fig 3.4 Corn Dehusking And Shelling Machine View 1

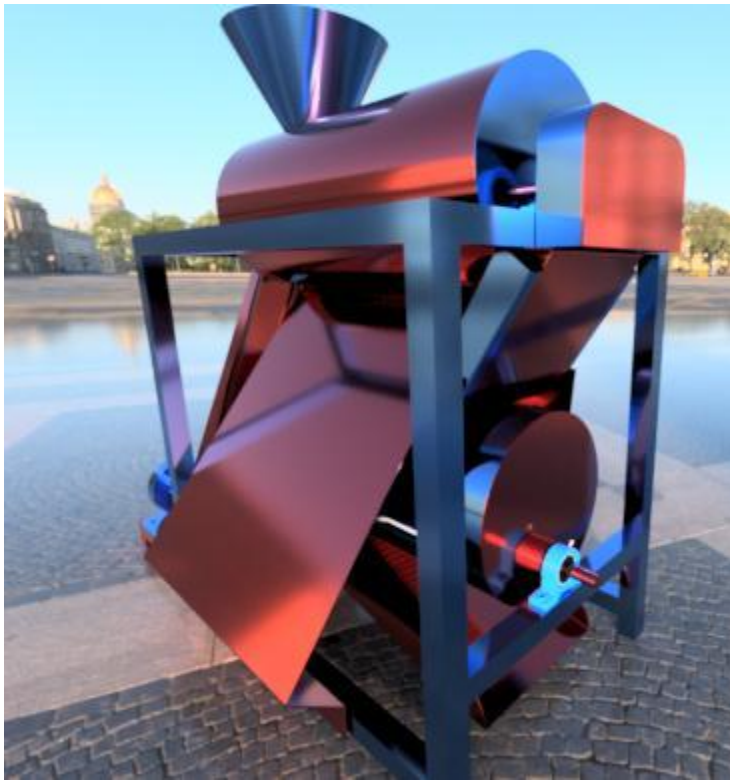


Fig 3.5 Corn Dehusking and Shelling Machine View 2

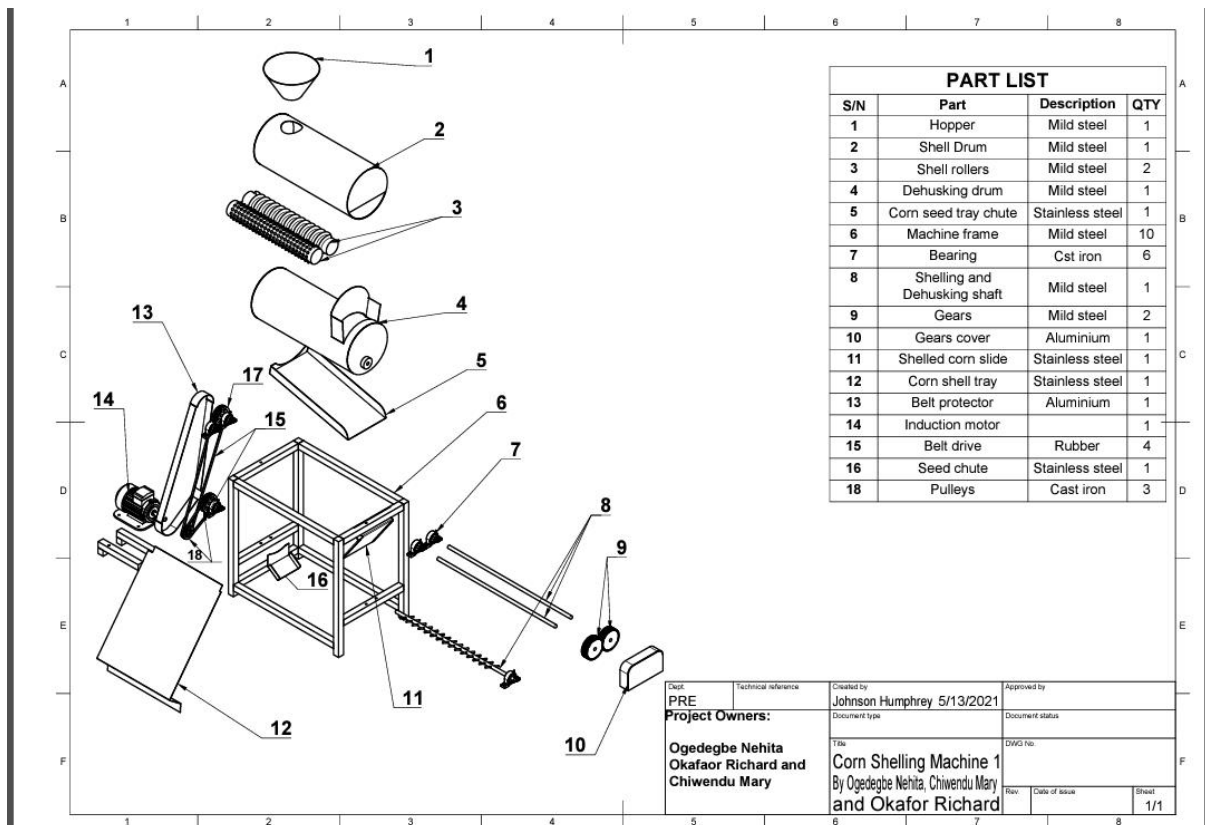


Fig 3.6 Exploded View of The Machine

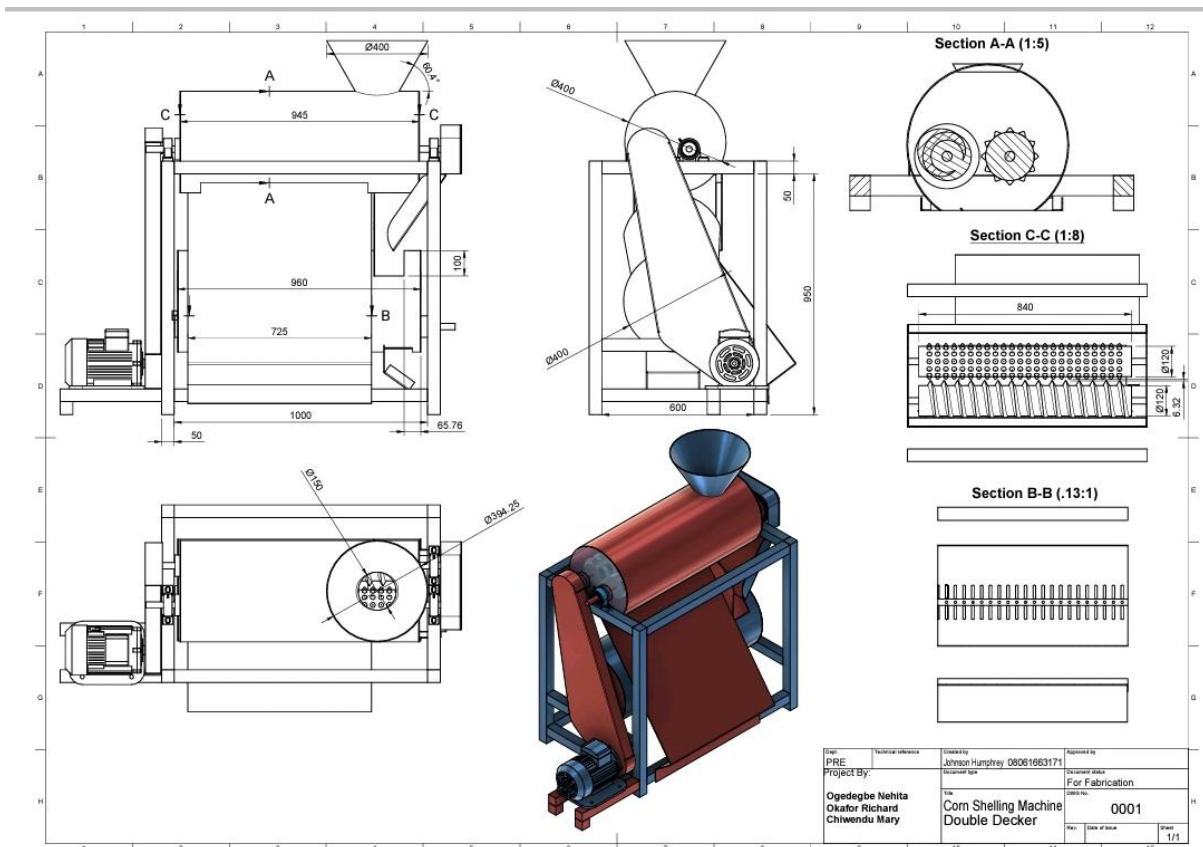


Fig 3.6 Orthographic View of The Machine



Fig 3.7 Machine Frame



Fig 3.8 Shelling Chamber.



Fig 3.9a Preliminary Assembly of Machine.



Fig 3.9b Final Assembly of Machine Showing the Maize Grain Outlet



Fig 3.9c Final Assembly Of Machine Showing The Cob Outlet

CHAPTER 4

RESULTS AND DISCUSSION

An improved corn shelling machine was designed, constructed and tested. The machine was portable enough for local dehusking and shelling of corn. The machine is easy to operate, repair and maintain. The dehusking and shelling rate of the machine is a function of the applied force of the corn from the hopper towards the spikes, the shelling speed, the geometry on the shaft inside the shelling cylinder and the angle of contact of the spike and the corn. The improvements made to the machine have allowed for easy removal of the husk of the corn and easy flow of the corn towards the spikes inside the shelling cylinder at an improved feeding rate. The sheller works based on the principle of rotary impact.

4.1 MACHINE CAPACITY

The capacity of the machine (M_c), in terms of the quantity of corn that can be shelled in the shelling chamber is the number of grains that can be shelled from the cob by the beater at optimum allowable time. The capacity of the machine using feed rate can be expressed as;

Considering the traditional way of shelling of corn, time and the manpower required in carrying out the operation, if it takes a minimum of 1 hour to shell a total of 3.2kg of corn manually (Igbinoba, 2019), it will take 180sec to shell the same quantity with greater output quality with this machine. Hence;

The rate of shelling is;

$$M_c = \frac{3.2 \times 60}{180} = 1.066\text{kg/min}$$

In one hour, the capacity of the machine is;

$$M_c = \frac{1.066\text{kg/min} \times 60\text{min}}{1} = 63.95\text{kg/hour}$$

In 24hours;

$$M_{c2} = 63.95 \times 24 = 1534.8\text{kg/day}$$

Since 1 tonne = 1000kg

It implies that 1.534tonnes per day is expected to be shelled.

4.2 THE EFFICIENCY (η) OF THE FABRICATED DESIGN (Shelling Chamber)

If a total of 3.2kg of corn with moisture content of 13% was fed into the fabricated design (Shelling Chamber), the efficiency of the machine can be expressed as follows;

Weight of shelled corn = 1.51kg

Weight of unshelled corn = 1.69kg

$$\begin{aligned}\text{Efficiency} &= \frac{\text{output}}{\text{input}} \times 100\% \\ &= \frac{\text{weight of shelled corn}}{\text{weight of unshelled corn}} \times 100\% \\ &= \frac{1.51}{1.69} \times 100\% = 89.35 \approx 89\%\end{aligned}$$

The Fabricated machine (Shelling Chamber) is expected to function at an efficiency of at least 89 percent.

4.3 DISCUSSION

4.3.1 Sheller Output

The high output of the sheller is due to the design of its concave drum that contributes to the removal of grains from cobs. The corn grain was removed by impact of the shelling drum and the rubbing action of the concave. The design of the concave also makes grain to drop off the shelling unit as soon as it is removed from the cob, thus reducing resistive forces in the shelling unit. The output of the sheller increases with an increase in shelling speed. At

high shelling speed the rate of removal of grain from the cobs is expected to be high due to the increased force of impact on the grain.

4.3.2 Shelling Efficiency

Corn shelling in the sheller is both by impact force of the shelling drum and rubbing effect of the concave drum. Due to the increased force of impact at higher shelling speeds, the sheller showed an increased shelling efficiency with increasing shelling speed. Shelling efficiency reduces as the moisture content increases.

The Corn dehusking and Shelling Machine is expected to function at a shelling(only) efficiency of at least 89%. The design is expected to have a capacity (Shelling Chamber) of at least 63.95kg/hour and about 1.534tonnes per day. The machine is effective and expected to be able to shell the grain at the tip of the cob as well as the remaining part of the cob. Materials used were locally sourced with reduced cost of production. The corn dehusking and shelling machine is expected to be widely used in the farms, homes and in agricultural sector in general, featured by small size, little noise, simple process and compact arrangement, etc

4.4 COST ANALYSIS

The estimation of production of engineering component costs plays a vital role in determining the general cost of an equipment/machine. This gives an insight into the economic viability of the product. In trying to make an estimate, the manufacturing cost is grouped into three categories.

- I. Material cost
- II. Labour cost
- III. Overhead cost

4.5 BILL OF ENGINEERING MEASUREMENT AND EVALUATION

The tabulation below shows the description of materials used during the fabrication process, the sizes, quantity and the cost of each material.

Table 4.1 Table of bill of Engineering Measurement and Evaluation

S/N	NAME OF COMPONENT	DIMENSION (Units)	QUANTITY	TOTAL COST (Naira)
1	Electric Motor	1hp	1	30,000
2	Mild Steel Angle Iron	5	3	10,000
3	Pulley		3	6000
5	Bearings	-	6	9000
6	Bolts and Nuts	M15/M16	12	2400
7	Stainless Steel Sheet	1000× 600 × 2	2	25,000
8	Belts	V – Belts, A31	2	1200
9	Timer	Analogue	1	2500
10	Paint	-	1	2500
11	Mild Steel Shaft	25mm	2	5000
12	Galvanised Rollers		1	1800
13	Miscellaneous	-	-	5000
14	Labour Cost	-	-	20,000
	TOTAL			120,400

MACHINE PERFORMANCE EVALUATION

Some varieties of dry corn were purchased from an open market in uselu, Benin city, Edo state. The machine was run at no load for 5 minutes to ensure satisfactory performance of all the parts. A total of 15 test runs were conducted on different weight of corn. Measured weight of corn was introduced into the machine and the time to complete each dehusking / shelling operation was recorded. The machine was turned off when no further material discharge from the exits was noticed. Each sample was completely dehusked, indicating high functionality of the incorporated dehusking chamber.

➤ Test performed on the machine

A total of 15 runs of different corn weights were performed on the machine and the allowable time required to completely dehusk and shell each corn was recorded. The results of the machine performance are as follows;

Table 4.2 Result of test run on machine

Sample No	Weight of corn (kg)	Time (sec) to dehusk & shell
1	0.15	17
2	0.18	19
3	0.20	20
4	0.21	20
5	0.23	21

6	0.25	23
7	0.26	23
8	0.28	25
9	0.30	28
10	0.31	29
11	0.32	29
12	0.34	32
13	0.35	32
14	0.38	35
15	0.40	39
Total	4.16	392

The total weight of corn tested = 4.16kg

The total time required to dehusk and shell the corn = 392secs

The total weight of grains collected = 1.8kg

The total weight of corn not completely shelled = 2.36kg

The total weight of broken cob = 2kg

➤ **Machine Capacity**

The capacity of the machine (Mc), in terms of the quality of corn that can be dehusked and shelled in the chamber, is the amount of grain that can be shelled from the cob by the beaters at optimum allowable time.

Considering the time and the man power required in carrying out the operation, the capacity of the machine using feed rate can be expressed as;

If a total of 4.16kg of corn was run on the machine for 392secs, the rate of shelling is;

$$\frac{4.16 \times 60}{392} = 0.637\text{kg/min}$$

In one hour, the capacity of the machine is;

$$\frac{0.637\text{kg/min} \times 60\text{min}}{1\text{hr}} = 38.22\text{kg/hr}$$

In 24 hours;

$$38.22 \times 24 = 917.28\text{kg/day}$$

Since 1 tonne = 1000kg

So therefore, it implies that 0.917tonnes per day can be dehusked and shelled if the above quantity is taken into consideration.

➤ **Efficiency of the fabricated design**

The mechanical efficiency of the machine can be determined using the formular below;

$$\eta = \frac{\text{weight of grains collected}}{\text{weight of unshelled corn}} \times 100\%$$

$$\eta = \frac{1.8\text{kg}}{2.36\text{kg}} \times 100\% = 76.27 \approx 76\%$$

∴ The efficiency of the fabricated design is 76%.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The designed and fabricated corn dehusking and shelling machine has a good efficiency, which decreases with reduced speed of operation. The materials used in the design and fabrication of the machine were locally available and affordable. The machine is therefore suitable for small/medium scale corn production in Nigeria.

The machine was found to be 76% efficient with a capacity of 38.22kg/hour and about 0.917tonnes per day.

The machine is effective and able to shell the grain from the tip of the cob to the remaining parts of the cob. Materials used were locally sourced with reduced cost of production.

Shelling corn is best at low moisture content (dry corn) when the stalk is brittle and grain size is of no significant difference across different maize varieties.

It is important to note here that some of the materials used for the fabrication may not be the best material available in the market but were selected based on cost efficiency, while ensuring that the materials used perform their function satisfactorily. Also, it is expected that with the low cost of this machine, an average salary earner can afford to purchase the machine at a considerably low cost also comfortably shell corn in a hygienic, stress free way with less consumption time.

5.2 RECOMMENDATION

It is recommended that all rural farmers in Nigeria should purchase at least one corn dehusking and shelling machine to save them from the stress of traditional dehusk and shell corn, while improving the quality of the grain. Further improvement however needs to be made on its capacity for more effective dehusking/shelling operations. Having procured the machine, machine maintenance is usually recommended to prolong the useful life of the machine.

The following machine maintenance is recommended;

- I. Regular cleaning of the machine before and after use.
- II. Lubricating the bearing often, for easy rotation of the shaft and other components connected through it.
- III. Repair and replacement of any faulty component of the machine or components that malfunction after sometime of usage.

To minimize problems encountered during operation, the following recommendations are offered:

- I. The shelling unit should be incorporated with a long shelling cylinder to ensure proper shelling before reaching the stalk outlet.
 - II. A vacuum evacuating device should be made available for the removal of large broken and crushed maize stalks from the shelling chamber when necessary.
- Some safety caution during machine usage include;
- I. Hands should never be put inside the chambers when beaters and rollers are rotating.
 - II. Do not attempt to lift or move the machine when in operation.
 - III. Never pour water into the dehusking/shelling chamber.

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