DESIGN AND FABRICATION OF A D.C POWERED MELON SHELLER

BY

AGIDIGBI VICTOR OHIREIMEN.	**ENG1905575**
EDEKI GODSPOWER YOME.	**ENG2002435**
AJAYI JOSEPH SEGUN.	**ENG2002421**
EDISON OHIOSUMUAN OVBUDE	**ENG1904957**

DEPARTMENT OF MECHANICAL ENGINEERING

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CERTIFICATION

This is to certify that the project work **DESIGN AND FABRICATION OF A D.C POWERED MELON SHELLER** was carried out by;

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EDEKI GODSPOWER YOME.	**ENG2002435**
AJAYI JOSEPH SEGUN.	**ENG2002421**
EDISON OHIOSUMUAN OVBUDE	**ENG1904957**

Of the department of Mechanical Engineering, Faculty of Engineering, University of Benin, in partial fulfilment of the requirement for the award of Bachelor of Engineering, (B.Eng)

Sign ____________________ ________________

PROF. S.A ALIU. Date

PROJECT SUPERVISOR

Sign______________________ ________________

ENGR. MARTIN OSIKHUEMHE. Date

PROJECT COORDINATOR

Sign_________________ ________________

PROF. E.G SADJERE. Date

HEAD OF DEPARTMENT

DEDICATION

We dedicate this project to our beloved families, whose unwavering support, encouragement, and sacrifices have been our greatest source of strength throughout this journey. Their belief in us has kept us motivated and determined to achieve our goals.

We also extend our heartfelt gratitude to our project supervisor, Prof. S.A Aliu, for his invaluable guidance, patience, and expertise. His insightful advice and continuous support have been instrumental in shaping this project into what it is today.

Also, to the department of Mechanical Engineering whose guidance and dedication in leading us through various training and lectures has played a pivotal role in shaping the individuals we have become.

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We would like to express our deepest gratitude to Almighty God for granting us the strength, knowledge, and perseverance to successfully complete this project.

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Furthermore, we extend our heartfelt thanks to our families for their continuous encouragement, patience, and sacrifices.

We also appreciate our friends, colleagues, and everyone who contributed in one way or another to the successful completion of this project. Your support and assistance have been truly invaluable

Lastly, we thank the faculty of engineering for creating an environment condusive for learning and innovation, and we are committed to upholding the values instilled in us.

ABSTRACT

This project focuses on the design and fabrication of a DC-powered melon shelling machine to improve the efficiency and productivity of melon seed shelling, thereby reducing manual labour and increasing the production capacity of small-scale farmers and entrepreneurs in Nigeria. Melon seed shelling is a crucial process in the production of melon seeds, which are a vital ingredient in various food products. However, the traditional manual method of shelling is labour-intensive, time-consuming, and often results in seed damage. Therefore, there is a need for a mechanized solution to improve the efficiency and productivity of melon seed shelling.This project adopted a design and development approach, involving the conceptualization, design, fabrication, and testing of a DC-powered melon shelling machine. The machine was constructed primarily from mild steel, with additional components such as bolts, nuts, bearings, and a blower. The system is powered by a 12V, 75Ah battery, which gets recharged with the aid of a built-in charging module.

The performance of the machine was evaluated through a series of tests, including shelling efficiency, seed damage, and feed rate. The results showed that the machine achieved an average shelling efficiency of 71.8%, an average seed damage of 15.6%, and a feed rate of 55.10 kg/hr. The results of this project demonstrate the potential of the DC-powered melon shelling machine to improve the efficiency and productivity of melon seed shelling. The machine's cost-effectiveness, energy efficiency, and ease of operation make it a viable solution for small-scale farmers and entrepreneurs in Nigeria. The successful development and testing of this machine provide a significant contribution to mechanized agriculture, improving efficiency and reducing manual labor in melon seed shelling. This project has the potential to transform the melon seed production industry in Nigeria, enhancing the livelihoods of farmers and entrepreneurs.

Furthermore, this project demonstrates the importance of innovation and entrepreneurship in addressing the challenges faced by small-scale farmers and entrepreneurs in Nigeria. The development of this machine highlights the potential for indigenous innovation to drive economic growth and development in Nigeria.

In conclusion, this project has successfully demonstrated the feasibility of designing and fabricating a DC-powered melon shelling machine for improved efficiency and productivity in melon seed shelling. The machine's performance, cost-effectiveness, and ease of operation make it a viable solution for small-scale farmers and entrepreneurs in Nigeria.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Melon (Citrus Vulgaris) is widely cultivated in Nigeria among other seedlings during the planting season yearly. According to Odigboh (1979), the melon seed can be grounded into thick paste for making soup or stew as well as serving as a raw material in the production of margarine, salad, "robo cake", baby food, livestock feeds, local pomade, soap and its shells can be used as poultry litter. Despite the large productivity and nutritional potentials of this crop, there has been a hindrance to the use of melon for large scale production of oil and protein sources. This is as a result of inability to shell melon to meet the capacity required for industrial purposes. The seed called Shelling of melon as a unit operation is therefore an important step towards the processing of melon to its finished products. Most farmers, who cultivate this crop both in Nigeria and West Africa alike, encounter several processing challenges of shelling this crop, as it requires a relatively high expenditure and human manual shelling energy which is a major concern.

Several tons of melon seeds are gathered each harvesting period but only a very small percentage of the total harvest are dried by atmospheric drought and bagged for storage. A high percentage of waste is usually incurred in melon seeds processing and storage facilities (Adekunle 2009, Akoh et al., 1992). Melon seeds when processed yield a lot of by-products, which could be used as food, feed or as raw materials for the small, medium and large-scale industrial manufacture outputs (Adekunle et al., 2009). However melon processing and seedling remain Labour-intensive and time-consuming, affecting the efficiency and profitability of melon-based industries. The major problems encountered in the processing of melon seeds are the removal of the yellow outside shell and the separation of the broken shells from the wheat seeds. Locally, in the current situation, manual methods are being used for the commercial shelling and separation of melon seeds.

The crop comprises a white edible seed coated with a light weight brownish shell. The white part is of much nutritional value majorly used for consumption (Idehen, Kehinde, Wang & Oyelakin, (2014) whereas the shell has been reportedly used for several purposes such as a metallic alloy do pant. Adeyemi, (2020), livestock feed Ogbe, & George, and crude oil remediation Adekunle, Ohijeagbon, &

Olusegun, (2009). Machines are preferably used for separating the seeds from their shell (shelling) because the use of hand (manual separation) could be stressful and time consuming.

Also, the little mechanized approach available presently is not efficient because the melon seeds are broken and no longer uniform upon removal from the de-husking machine. Therefore, an efficient and mechanized method of de-husking (shelling) and separation processes is capable of increasing productivity, reducing processing time and bringing down human labor input to the nearest minimum (Adekunle 2009, Akoh et al., 1992). In Nigeria substantial research has been carried out on mechanical melon devices to ease the shelling processes and operation. Fashina (1971) constructed a melon seed shelling machine which works on the principle of feeding seeds through sets of rollers having ridges on their surfaces. Odigboh (1979) designed an impact Egusi-shelling machine that works on the principles of impact force for spinning discs. Also, Fadamoro (1999) constructed a manually operated melon Sheller that works by friction forces between rotating and stationary disc. Melon shelling by extrusion method was discovered by Obienwe (2002). Other researchers that have tried shelling melon mechanically are; Rotimi (2006), Kafi (1980), Adamu (1981), Mohamed (1989) and Adekunle et al., (2009). Most of these machines developed were found to have low shelling efficiency by high speed damage. Machine-crop parameters such as moisture content, crop variety and inclination of configuration of beaters were identified as factors affecting machine shelling efficiency and percentage seed damage (Fashina, 1971; Odigboh, 1979; Adamu, 1998, Mohammed 2003 and Okon et al., 2010). Another major problem faced in the operation of a shelling machine is the supply of power to initiate the motion of the motor for turning the Sheller. Hence, this project was intended to design a motorized DC powered Sheller, having the features of adjusting to addressing the limited power supply in Nigeria. It also uses locally served material capable of high efficiency and low seed damage.

As new machines were developed over the years, various investigations showed that different factors affected their performance efficiency. The type or specie of seed had different shelling efficiencies for the machine designed by Sobowale, Adebiyi & Adebo, (2015). Also, the moisture content of the melon seed was found to positively affect the performance efficiency of the machine. Akusu, & Chibor, (2020), Adekunle, Ohijeagbon & Olusegun, (2009), Agberegha, Afoegba & Onwuamaeze, (2018). The duration that the melon was soaked and left to drain has an effect on its performance as well (Udom & Okon, 2018). A final factor which affects the machine performance is the shelling speed, according to Asibeluo & Abu, (2015), Kilanko, Oko & Lemaro, 2019. Several investigations are thus needed to improve machine performance for different influencing factors. This work aims to develop a melon peeler with greater efficiency and less seed breakage using locally available materials.

1.2 PROBLEM STATEMENT

In Nigeria, a small portion of melon produced is kept for household consumption and seedlings. This is primarily due to the lack of appropriate and efficient melon Sheller. If surveys were to be conducted, most farmers will acknowledge that they have never seen or used any mechanical melon Sheller.

Melon shelling in Nigeria's small holder sector is predominantly done by hand. Though hand shelling keeps the rate of kernel breakage low, it is labor intensive. The manual melon shelling process poses several problems including;

- Low efficiency and productivity
- High labor cost and injuries
- Inconsistent quality of melon pulp
- Significant waste generation

1.3 AIM AND OBJECTIVE

1.3.1. AIM

The aim of this project is to design and construct a DC-powered melon shelling machine that enhances shelling efficiency, reduces labor, and operates reliably in off-grid areas, making it accessible and effective for small to medium-scale melon seed processors.

Also to design, develop and evaluate the performance of a melon shelling machine that;

- Increases efficiency and productivity
- Reduce labor costs and injuries
- Improve quality of melon pulp
- Minimize waste generation

1.3.2. OBJECTIVES

The specific objectives of this study are to;

- Design and develop a prototype melon shelling machine
- Evaluate the machine performance in terms of efficiency, productivity and quality
- Compare machine performance with manual shelling machine
- Identify area of improvement and future development
- To compute the financial analysis of the melon sheller

1.4 SCOPE OF STUDY

The development of small-sized power shellers have a good scope for shelling of farm produce at farm level and small scale processing level. Therefore, this study has been undertaken to develop a suitable power melon sheller for farm level and industrial level usage.

The study investigates the sizing of components of the sheller and its usability on products of uniform sizes. It also gives analysis on the cost varying benefits of the sheller to the person who fabricates and uses such a machine.

The study builds a conceptual framework on the possibility of using a DC power annexed to run the motor and the sheller unit.

The study is to apply all engineering aspects that is; mechanical, kinematics, mechanics of materials and design of machine elements to help bring the concept into reality.

CHAPTER TWO

LITERATURE REVIEW

The shelling of melon seeds, especially seeds from the Egusi melon, has been a well established custom in numerous African social orders, with both social and culinary importance. Regardless of headways in agrarian handling, manual melon shelling stays pervasive, particularly in rustic networks. The customary techniques and developments encompassing melon shelling have been archived by different scientists and researchers, underlining both the arduous nature and the resourcefulness associated with the process. Traditional Strategies for Melon Shelling concentrates on note that the earliest known strategy for shelling melon seeds included hand-breaking. As depicted by Ayodele (1998), this cycle was much of the time a shared movement, wherein relatives or whole networks would assemble to physically shell enormous amounts of melon seeds utilizing their nails or teeth. This work concentrated process, however sluggish, guaranteed insignificant seed harm and took into account social holding inside networks.

Further ethnographic records uncover that over the long haul, simple apparatuses were embraced to work on the productivity of melon shelling. As indicated by Chikwe (2005), little stones, wooden loads up, or privately created metal instruments were in some cases utilized to apply controlled strain to the seeds, breaking the shells without harming the pieces. These devices, however straightforward, diminished actual strain and marginally sped up shelling.

Water-Helped Techniques: A striking improvement in customary shelling rehearses arose with the reception of water-helped strategies. Scientists like Okafor (2003) have defined the most common way of splashing melon seeds in water to relax the shells, which makes them simpler to eliminate the hard way. In this strategy, frequently alluded to as "drifting," the lighter shells float while the denser seeds sink, considering more straightforward detachment. The concentrate by Bello et al., (2011) features this procedure as especially pervasive in districts of Nigeria, where it is still generally rehearsed because of its straightforwardness and adequacy.

Adeleke and Orelaja (2020) carried out the design, construction, and performance evaluation of an improved melon seed sheller with a continuous separator.

Traditional melon shelling methods are time-consuming and labor-intensive, leading to low productivity and efficiency. Melon seeds, commonly known as "egusi" in Nigeria, are valuable for food and industrial purposes. However, the difficulty in shelling them has been a significant barrier to their large-scale utilization.

This research explores an improved design for a melon seed sheller with a continuous separator to address inefficiencies in traditional shelling methods. Melon seeds, or "egusi," are vital in Nigerian cuisine and industry for their oil and protein content. The improved melon sheller described in the study aims to address the challenges of traditional shelling by introducing a machine with a continuous separator that minimizes manual labor, reduces seed breakage, and maintains hygiene standards. This machine was constructed using affordable, locally sourced materials like mild steel, ball bearings, angle iron, pulleys, and belts. Its main components are: conical hopper, shelling unit, frame, and blower.

The primary objectives were to develop a sheller that reduces manual labor and human contact to maintain hygiene, minimizes seed breakage during shelling, provides a continuous separation mechanism to increase shelling speed, utilizes locally available materials for cost-effectiveness.

Raji and Kehinde (2020), conducted a study presented at The Federal Polytechnic Ilaro's School of Engineering's 4th National Conference. This study reveals the importance of melon, a crop widely cultivated in Nigeria, as a valuable agricultural product. However, melon shelling, an essential process for using the seeds, is labor-intensive and costly for small-scale farmers due to the lack of affordable processing equipment. The study aims to design and fabricate a melon shelling machine that is economical and suitable for local farmers, which could contribute to agricultural development by increasing productivity and reducing labor demands.

The study describes the material selection process, emphasizing durability, cost-effectiveness, and efficiency. Mild steel was used for the machine's exterior, while stainless steel was chosen for parts in direct contact with melon seeds. The design considered electrical requirements, weight, cost, and local material availability. For the power requirements, formulas for torque and velocity were used, calculating that a 5.5 hp engine would suffice.

Performance evaluation measured the shelling efficiency, defined by the ratio of unshelled to shelled seeds. Soaking seeds for 8 minutes was found to be optimal, achieving an efficiency rate of up to 82.96%. The machine’s capacity was also assessed, based on the mass of shelled seeds per hour.

The shelling machine was found to be efficient and operable with minimal technical skill, making it accessible for small-scale farmers and industries. The power requirement was met with a 5.5hp engine, and shelling efficiency varied with seed soaking time. Overall, an 8-minute soaking period provided the best results. The machine is robust, easy to maintain, and capable of meeting the needs of local melon producers.

The study concludes that the newly designed melon shelling machine can alleviate labor challenges for farmers, with benefits including improved productivity and economic growth for local agricultural sectors. Routine maintenance is recommended to maintain optimal performance. Future research could focus on further innovations to enhance machine efficiency and adaptability. This machine represents a practical solution for melon shelling and could inspire similar innovations in other agricultural processes.

Aggrey and Beem (2020) Designed and fabricated a bicycle-powered Sheller for rural Ghanaian farmers. In their study, they stated that various methods can be leveraged to mechanize the shelling process. Power for such mechanization could come from electricity, a combustion engine or even renewable energy such as solar power or human power. Historically, internal combustion engines have been heavily relied upon for mechanization purposes. They however reiterated that the production of noise and fumes from these engines can be harmful to the health of the device operator. In the context of designing for the rural Ghanaian farmer, they placed priority on selecting a power source that was cheap, convenient, and posed minimal damage to the health of the machine user. Also, since the invention is intended for use in rural areas, when a fault arises, the power selection needs to be repaired easily by the user since spare parts may not be readily available. Considering clean energy such as pedal power, not only does it reduce health hazards but it also removes repair complications when juxtaposed with electric or combustion engines For most subsistence farmers in rural areas, their farms do not have electricity lines running through them. They also added that for most rural farmers in Ghana, bicycles form a major part of their commute from their homes to farms, and are therefore readily available. Hence, pedaling was selected as the power source for the device operation since it is both available and cheap. The engineering design process was employed in their study by an identified feasible shelling mechanism. The brainstorming stage led to the emergence of three top candidates for the shelling mechanism. All three were drawn in SolidWorks, and then prototyped using steel sheets in order to facilitate welding. Each prototype was mounted in a test stand and maize cobs were fed through, while the prototypes were rotated by hand. This experiment was used to get an initial idea of each one’s efficacy in shelling maize. The first prototype is a 30cm-diameter grater. It can be described as a grater that shells corn kernels by rotating at a fixed position. In testing this prototype, the design resulted in more than a 50% kernel damage, and as such it was disregarded.

The second Shelling Mechanism Prototype used is a single 160mm-diameter cylinder with pointy ends, to test its shelling ability, a maize cob is press-fitted through the pointed edges and then gradually rotated by the user. This prototype shelled the maize with almost 35% kernel damage, however, because of its increased number of sharp edges, operators were always getting injured. The final prototype they used was a shaft with chains welded on to it. As the shaft rotates, the chains beat the kernels off of the maize cob. Oheneba Aggrey and Heather Beem used these observations to create a Pugh chart so as to comparatively rank them against the design criteria. The specific list of design criteria was based on the author's own observation as trials were being conducted on the prototypes. The shelling mechanism with chains had the highest score, and was therefore moved to the next stage of fabrication. Upon selection of the top shelling mechanism to be employed, a full-scale device was fabricated. The shelling mechanism itself was fabricated using a 1.5in- diameter steel pipe with welded chain-links which are 5-in length each. The mechanism was placed inside of a 13in-diameter metal cylinder which was made from an old barrel. Furthermore, a perforated foil was placed inside to serve as an outlet for the kernels. Two bearings were press- fitted at the ends of the steel pipe to reduce friction. A frame was built for the shelling barrel to be mounted above the ground. This was attached to a used bicycle, which was modified by removing the tires and welding steel square pipes as a support. The device was designed to be heavy, so as to aid stability during pedaling. This was done by welding steel stock instead of aluminum to the base of the sheller.

The machine can be operated by a minimum of one person, and this is easily carried out by the user. As they sit on the device, they can simultaneously load the maize cobs in and pedal, transmitting power to the shelling unit through the chain. After the assembly, characterization was done on the prototype by conducting trials on low moisture maize cobs. This is because during quality control, low moisture content is the most imperative especially in the control of fungus infestation Moreover, for the experimental setup, the bicycle was pedaled by one individual at an average of 60 rpm for a total of 4 minutes to obtain values for the parameters. Lastly, since it would have been difficult to count all the kernels, an electronic weight scale was used to accurately determine the parameters for the variables captured. These parameters included weight of shelled, unshelled and damaged kernels. They concluded their study by stating that the need for farm produce processing machines is imperative because of its ability to speed up post-harvest processing and that the idea of a low-cost, pedal-powered shelling design was conceived and fabricated to aid local production, which was built using an old barrel, a bicycle from the scrapyard, two bearings, square pipes, chain-links and a round pipe as the shaft. They pointed out that after harvest, if a low-cost maize Sheller is coupled with the production process, it stands to save significant time and cost, adding that the shelling can be done 20 times faster, and the cost savings will be 5 times less, because of both the lower cost of machine and also not having to hire extra labor to help out during the shelling process of farm produce.

Muhammad et al., (2018) Conducted a Study on design and development of a power groundnut Sheller. The study, which focuses on development of the machine, also carried out tests on the performance of the sheller. The machine was designed having the strength and stability of materials of construction in mind so as to meet up with the required standard. The developers noted that there are good numbers of groundnut sheller machines available in the market but they are large in size, costly and not suitable for domestic applications. They are suitable for industrial applications where mass production is required this remark was attributed to (Walke et al., 2017). In most of the cases the postharvest manual shelling operation of groundnut is done by women in rural area. In their study, they highlighted the work of BARI who developed a manual groundnut sheller in 2010, noting that Power sheller was designed and fabricated executing the recommendation after development of manual sheller (Hoque et al., 2011). Also, Operation of manual groundnut sheller was generating human drudgery for which it required 5minutes rest after every 10-15minutes operation. The manual sheller was also unable to separate husk from the grain and also unable to clean the grain from the unshelled groundnut. It was further stated that at present, there is no power groundnut sheller at farm level in Bangladesh. The development of small, power sheller has a good scope for shelling of groundnut at farm level and small-scale processing level. This problem prompted the undertaking of such study to develop a suitable power groundnut sheller for farm level and industrial uses. Muhammad et al., (2018) therefore Designed power groundnut sheller for shelling about 100 kg groundnut per hour. The engineering drawing of the sheller was drawn with SolidWorks Software 2013 and fabricated at the workshop of the Farm Machinery and Postharvest Process Engineering Division of Bangladesh Agricultural Research Institute, Joydebpur, 8 during 2011-2012. It was made of locally available materials. Mild Steel (MS) angle bar, MS flat bar, MS rod, MS sheet, MS shaft, rubber pad, ball-bearing, 0.37 kW electric motor and other small parts were used to fabricate the groundnut sheller. Design and drawing of various parts are necessary for fabrication of quality machines. The machine was operated with a single phase electric motor. Unshelled groundnut pod was fed in the feeding hopper. The sheller was started with a switch after giving due connection of this sheller with a domestic electric line of 220V of AC power. With the electric motor, the movable threshing pad was operated within the threshing cylinder. The groundnut was inserted in the threshing cylinder and after shelling fell into the sieving tray. The broken husk of groundnut was separated with air blow which was flown from the blower. The shelled grain was separated with the sieve by shaking with a rotating cam. Performance evaluation of the groundnut sheller was done with replicated experiments during 2012-13 in the laboratory of Farm Machinery and Postharvest Process Engineering Division, BARI, Gazipur. The performance of the power groundnut sheller and manual groundnut sheller was tested with Dhaka-1 and BARIBadam-8 collected from local market of Gazipur Sada. Moisture content of the groundnut was measured by oven dry method drying for 72 hours at 1030C (Koushkaki et al., 2017). Initial moisture content of the groundnut was around 7% which was reduced by oven and then packet in poly bags. The moisture content of the groundnut during testing was maintained at around 7.50% (wb) since Kushwah et al. (2016) and Oluwole et al. (2007) found better dehulling efficiency and crackability of groundnut with similar moisture content. The sample size of each batch was 10 kg. The testing was replicated five times for each variety. The weight of shelled grain, weight of unshelled grain, weight of cracked grain, frequency of oscillation of the shelling pad, time of operation and moisture content of grain were recorded during testing of the groundnut sheller. Capacity, breakage and efficiency of the groundnut sheller were calculated. The power groundnut sheller was then tested at two upazilla (Nagarbari and Sujanagar) of Pabna district. The machine was evaluated with Dhaka-1 and BARI Badam-8 similarly. The Study concluded by stating that the power groundnut sheller was operated without any trouble of the machine. The shelling capacities of power groundnut sheller were 110 and 115 kg/h for Dhaka-1 and BARI Badam-8, respectively. The maximum breakage of groundnut was found to be 2% at 11.5% moisture content (wb) in laboratory tests at FMPE Division, BARI, Gazipur. The maximum and minimum unshelled percentage in power sheller was found to be 12.4% for Dhaka-1 and 9.18% for BARI Badam-8, respectively. The shelling efficiency of the power groundnut sheller for Dhaka-1 and BARI Badam-8 were 86.6 and 88.82%, respectively at 7.5% moisture content (wb). Winnowing efficiency was found to be 99% in the power groundnut sheller. Shelling capacities of the groundnut sheller were found to be 124 and 128 kg/h. Mohammed et al., reiterated that The use of power groundnut sheller can reduce the cost of shelling by 76% over the manual groundnut sheller.

Chukwudi et al., (2022) during their study on the Designing and fabrication of Low-cost Melon Seed De-husking Machine using locally sourced Materials applies engineering principles in producing a desired output which is the shelled melon. The study reiterated that melon is one of the most consumed soup ingredient in Nigeria which means a greater consideration must be taken to provide a controlled fabrication process as to prevent breakage of the melon or food poisoning due to corrosion of metal sheet. Therefore, for optimum performance and easy maintenance of the melon shelling machine, Chukwudi et al., (2022) provided the following factors, which was given by (Starkey, 1988) as what will be taken into consideration for the design. These factors include; Simplicity of design to meet the required standard and specifications, Mechanical strength of the materials used to ensure their durability and reliability, Cost of the materials used, Construction method used to ensure reliability and durability of the product. The following are some parameters which were taken into consideration while designing the machine. Such as the type of material used for each component, Soaking period, Compaction of equipment, Mobility of equipment, Speed of the shaft and shelling disk was put into consideration. Therefore a 1hp motor was used. The performance evaluation was carried out using the fabricated melon shelling machine to shell melon in both wet and dry conditions electrically and mechanically (manually). The Machine Performance was Evaluated. A number of analyses were done using the machine to test for its shelling efficiency, likelihood of damaged seeds and effect of moisture content on the shelling efficiency of the machine. The Shelling Efficiency was also evaluated. This is a factor of the number of shelled seeds obtained after shelling operation. The same quantity of melon is fed into the shelling drum at a varying feed rate. This is done by adjusting the shelling drum inlet.

Adekunle et al., did a modification and development of a manually operated and motorized melon seed shelling/separating machine. This project aimed at improving the traditionally manual process used in many parts of the world, especially in Nigeria. Manual shelling of melon seeds is labor-intensive, time-consuming, and can cause physical strain, making it challenging to scale up production. The machine, created by Adekunle and colleagues at Lagos State Polytechnic, was designed to address these issues, providing an eff icient and cost-effective solution for both domestic and small-scale commercial purposes. The machine's construction relies on locally available materials and comprises two primary units: the shelling unit and the separating/cleaning unit. The shelling unit, which functions through impact force, includes a hopper, shelling drum, vanes, a shelling disc, and other components like a motor, belt, and pulleys. The shelling unit's design focuses on breaking the hard shells of the seeds by causing them to collide with rough surfaces. The separating/cleaning unit features a high-speed blower fan to remove chaff, allowing only the shelled seeds to pass through the outlet. A 1 HP motor drives the system, achieving speeds optimized for effective shelling and separation.

The machine was evaluated for its performance in shelling melon seeds in both dry and wet conditions. Tests revealed that wet conditions, with a moisture content of 17.6%, yielded a shelling efficiency of 86.7%, whereas dry conditions achieved a lower efficiency of 71.4%. Notably, wet shelling resulted in fewer broken seeds, with 60% of seeds fully shelled without breakage compared to 7.1% in dry conditions. This data indicates that moistening the seeds before shelling optimizes performance, likely due to the reduced brittleness of the seed coat.

The design and fabrication process prioritized durability, cost-effectiveness, ease of use, and local material availability. The machine operates either manually or with an electric motor, making it adaptable to different power sources and user preferences. The research concluded that adopting this mechanized shelling method could significantly enhance melon seed processing and support increased production of melon-derived products, such as vegetable oil, which holds nutritional and economic value. This innovation offers a promising alternative to labor-intensive traditional methods, potentially boosting productivity and efficiency in melon seed processing in Nigeria and other regions with similar agricultural needs.

2.1 THEORETICAL FRAME WORK

The theoretical framework for the design and fabrication of a D.C.-powered melon-shelling machine can be developed using theories and principles from mechanical engineering, material science, and electrical engineering. Key theories involved include:

2.1.1 Force and Impact Theory:

Understanding how the shell of the melon seed can be broken without damaging the seed inside is crucial. The impact force required must be sufficient to crack the shell but not so high as to crush the seed. This will involve calculating the mechanical properties of the melon shell and applying controlled forces that align with these properties.

2.1.2. Energy Conversion Theory:

Since the machine uses D.C. power, it’s important to optimize the electrical-to-mechanical energy conversion. Principles of electrical circuit design will be applied to ensure that energy from the D.C. source is efficiently transformed into the rotational or linear motion required for shelling.

2.1.3. Kinematics and Dynamics of Machine Elements:

The machine will likely incorporate moving parts such as belts, gears, or rollers. Kinematic and dynamic analysis will guide the design of these parts, helping to determine optimal speeds, friction coefficients, and material choices that ensure longevity and functionality.

2.1.4. Material Science Principles:

Material selection for the machine's components is critical for ensuring durability, especially in high-wear areas like the shelling mechanism. Additionally, the choice of materials will influence weight, cost, and manufacturability.

2.1.5. Sustainable Engineering Practices:

With a focus on energy efficiency and portability, sustainable engineering practices will guide the selection of D.C. sources, possibly favoring solar-charged batteries as an eco-friendly option. The design will aim to maximize the machine's lifespan and minimize energy consumption.

2.2 CONCEPTUAL FRAME WORK

A D.C.-powered melon-shelling machine aims to address the problem of efficiently and safely removing shells from melon seeds, a critical process in many regions where melon seeds are a staple for various culinary and commercial uses. Traditional shelling methods, which involve manual labor or basic mechanical devices, often result in high labor costs, low throughput, and potential seed damage. The conceptual framework involves integrating principles of mechanical design, seed-shell interaction dynamics, energy efficiency, and ergonomics.

This machine design is powered by a direct current (D.C.) source, which is suitable for areas with limited or unreliable access to alternating current (A.C.) electricity. D.C. power, typically sourced from batteries or solar power, offers a portable and sustainable solution, making the machine ideal for rural or remote settings. The design and fabrication will focus on optimizing the machine for low energy consumption, ease of use, high shelling efficiency, and affordability. The shelling machine consist of the following basic units, power unit, frame, feeding unit, shelling unit, winnowing unit and delivery unit.

Power Unit: In the power unit, single phase electric lines supply power to run the motor, for this particular machine, electrical power is in watts or Horsepower. A horsepower is a unit of power equal to 746 watts.

2.2.1 Motor Unit:

This is powered by a single phase electric line supply. In other words, we first of all calculate the system inertia. It’s not very difficult since most systems can be idealized into shapes that have simple formulas for calculating inertia.

To size AC motors, the simple formula is given as;

$$TA = JN/6t$$

Where;

TA =Tangential Acceleration (m/s^2)

J = Inertia ($Kg.m^2$)

N = RPM (usually 1800)

t = seconds, acceleration time

Once the constant torque is measured, and calculated the acceleration torque, we add them together. The value obtained is multiplied by some safety factor, usually about 1.5. A motor having a starting torque about equal to this value and a rated torque greater than the constant torque is selected.

2.2.2 Feeding Unit: It is the upper through which the unshelled pods are introduced into the shelling chamber. The pods to be shelled fall into the shelling unit by gravity through the Upper.

2.2.3 Shelling Unit: The shelling unit comprises the shelling cylinder and the sieve. This unit carries out the function of actually breaking the pod, releasing the nut from the pod.

2.2.4 Delivery or Collection Unit: The delivery unit ensures that the shelled nuts and kernels are channeled to the collecting pan or sac. The chaff and kernel mixture are separated by winnowing.

2.2.5 Frame: It carries the components of the machine. It is a triangular shaped form. The frame also provides stability and reduce vibration.

2.3 DESCRIPTION AND OPERATION OF THE SHELLER

The major components of the sheller as earlier mentioned are the hopper, shelling chamber, and the cleaning chamber. The hopper is made up of four welded metal sheets slanting towards an opening to form a trapezium. It has two openings, the largest upper opening is for introducing the melon seeds into the sheller while the smaller lower opening connects the hopper to the shelling chamber. The shelling chamber consists of the concave and the cylinder (convex), which is powered by an electric motor. The concave is made from mild steel and the inner part is lined with tiny metal rods, while the cylinder is lined with flat metal blades. The cleaning chamber is made up of galvanized mild steel plate folded to form a pipe. A regulated fan is installed at one end of the pipe to supply air to separate the chaff from the cotyledon after shelling.

The sheller employs the principle of energy absorption by the melon seeds, as a result of collision between the seeds and the stationary wall of the drum and this causes the cracking and removal of the husk from the seed. Unshelled melon seeds are shared into the hopper of the sheller. When the sheller attains a suitable speed of about 950rpm, the seed control device is opened to allow the seeds to fall directly into the shelling chamber. The melon seeds which are dropped into the shelling chamber from the hopper move anti clockwise in the space between the vaned rotating disc and the rough stationary drum, since the average thickness of melon seeds is 2.5mm, the seed will tend to move in a single row. The rotation of the impeller causes the removal of the coat from the cotyledon of the seeds as they run against the rough surface of the fixed wall of the drum. The chaff and cotyledon fall by gravity into the cleaning chamber of the sheller. A regulated fan installed in the chamber blows off the chaff and the cotyledons fall by gravity and are collected at the seed discharge unit of the sheller.

2.4 AC- POWERED VS DC- POWERED MACHINE

Improvements on the use of A.C and other conventional Sheller Machine to a D.C powered sheller machine.

2.4.1 Enhanced Efficiency:

Reduced Power Loss: DC power systems typically experience lower energy losses during transmission and conversion compared to AC systems. This results in more efficient operation and reduced energy consumption.

2.4.2 Optimized Motor Performance:

DC motors can be precisely controlled to deliver optimal performance at various speeds and loads. This ensures efficient shelling without unnecessary power consumption.

2.4.3 Improved Control and Precision

Precise Speed Control: DC motors allow for finer control of the shelling speed, leading to more accurate and consistent shelling results.

2.4.4 Adjustable Torque:

The torque of DC motors can be adjusted to suit different types of grains and shelling conditions. This prevents damage to the grains and ensures optimal performance

2.4.5 Enhanced Safety and Reliability:

Reduced Electrical Hazards: DC systems, especially those powered by batteries, eliminate the risk of electrical shocks associated with high-voltage AC power.

2.4.6 Reliable Operation:

DC motors are generally more robust and less susceptible to damage from voltage fluctuations and power surges. This ensures reliable and long-lasting operation.

2.4.7 Battery Power:

DC-powered shellers can be easily powered by batteries, making them portable and suitable for use in remote areas or where grid power is unavailable.

2.4.8 Flexibility and Mobility

Diverse Power Options: DC power can be sourced from various batteries, solar panels, or generators, offering flexibility in remote areas or where AC power is unavailable.

2.4.9 Reduced Reliance on Grid Power:

This independence from the grid makes the machine more suitable for off-grid operations, expanding its potential applications.

2.4.10. Smaller Components and light weight design:

DC motors and power electronics are generally smaller and lighter than their AC counterparts, reducing the overall weight and size of the machine.

2.4.11. Enhanced Safety:

Lower Voltage: DC systems often operate at lower voltages, reducing the risk of electric shock.

2.4.12. Reduced Fire Hazard:

DC motors are less prone to overheating and sparking, minimizing the risk of fire.

2.4.13. Environmental Benefits:

Reduced Carbon Footprint: DC-powered machines, especially those using renewable energy sources, can significantly reduce greenhouse gas emissions.

2.4.14. Lower Noise Pollution: DC motors tend to be quieter than AC motors, contributing to a more pleasant working environment.

2.5 OVERVIEW OF MELON SHELLING TECHNOLOGIES:

Various techniques have been developed for shelling melon seeds, each with its own strengths and limitations:

2.5.1 Manual Shelling: Manual methods are still common due to their low cost, but they are highly labor-intensive and inefficient for larger quantities. Moreover, manual shelling often results in inconsistent quality and high seed breakage rates, leading to economic losses for producers.

2.5.2 Impact Shelling Machines: These machines use a sudden force to crack open the shells. While effective in achieving high shelling rates, they can cause significant damage to the seeds, particularly for more delicate varieties. Additionally, impact machines are generally energy-intensive, consuming substantial power and often relying on a stable electricity supply.

Abrasive Shelling: This method uses rough surfaces to rub off the shells, which can be effective for tougher seeds. However, it poses risks for softer seeds like melon, leading to potential damage during the shelling process. Abrasive machines also require regular maintenance due to wear and tear.

2.5.3 Roller-Based Shelling: Utilizing rollers that apply controlled pressure, roller-based machines strike a balance between efficiency and seed preservation. However, many of these designs are intended for industrial applications, often using AC power, which limits their portability and accessibility for small-scale operations.

2.6 LIMITATIONS IN EXISTING RESEARCH:

Despite advancements in mechanized shelling technologies, several limitations in the current literature highlight the need for focused research on a DC-powered melon shelling machine:

The limitations of works cited above include:

Dependence on Optimal Moisture Levels: Some of these previously made melon shellers operate most efficiently with melon seeds at a specific moisture content (17.6%).

Inadequate or excessive moisture could decrease shelling efficiency or lead to increased seed breakage, requiring users to prepare seeds carefully, which may not always be feasible in varying environmental conditions.

2.6.1 Power Source Dependency: Although the machine can operate manually or with an electric motor, access to electricity might be a challenge in rural areas where melon processing often occurs. Manual operation could be labor-intensive, limiting the machine's effectiveness in areas with limited power supply.

Seed Variety Constraints: The machine’s design and impact shelling method may work best for certain types of melon seeds. Different seed sizes, shapes, or shell hardness may affect efficiency, requiring adjustments or limiting the machine's applicability to only specific melon varieties.

Mechanical Wear and Maintenance: Since the machine uses impact forces, frequent use may cause wear and tear on components like the shelling drum, vanes, and blower. Regular maintenance is necessary to sustain performance, which may increase operational costs and require technical knowledge that could be a barrier for some users.

2.6.2 Initial Cost and Accessibility:

Despite using locally available materials, the cost of construction and necessary components might still be high for small-scale farmers or local processors, potentially limiting widespread adoption unless affordable models or subsidies are available.

2.6.3 Chaff Separation Process:

The study found that optimum chaff separation required feeding the shelling unit multiple times. This repetitive process could reduce overall throughput and may be time-consuming, especially if larger batches of melon seeds are processed.

2.6.4. Power and Energy Constraints: D.C. power, especially when sourced from batteries or solar, may limit the machine's operating time and power capacity. Battery life, charging needs, and power output may restrict the machine's use in continuous operations or large-scale shelling tasks, especially in rural areas with limited access to reliable power.

Seed Variability:

Melon seeds vary in size, shell hardness, and moisture content. This variability may affect the shelling efficiency and lead to inconsistent results. The machine may require adjustments or calibrations for different seed types, which could complicate its usability and increase time spent in setup.

2.6.5. Material and Manufacturing Costs:

Designing a robust and durable machine using high-quality materials may raise costs, making it less affordable for small-scale farmers or users in low-income regions. Additionally, locally sourced materials or manufacturing capabilities might be limited, especially in remote areas, which can affect accessibility and scalability.

2.6.6. Seed Damage:

Achieving the optimal balance between shelling efficiency and seed preservation can be challenging. If the machine applies too much force, it risks damaging the seeds, reducing their market value and usability. On the other hand, inadequate force may leave the shells intact, reducing the machine's effectiveness.

2.6.7 Portability and Maintenance:

To make the machine portable, the design may need to be compact and lightweight, potentially limiting its processing capacity and robustness. Additionally, maintenance could be a challenge, especially in remote or rural areas where access to spare parts or technical expertise is limited.

2.6.8 Technical Complexity and Usability:

Ensuring that the machine is easy to operate without extensive technical knowledge may require design trade-offs. A more sophisticated machine may offer higher efficiency but could be harder for users to understand, operate, or repair. This complexity could limit adoption among the intended users.

2.6.9 Environmental Factors:

The machine's performance may be influenced by environmental conditions such as humidity, which can affect both the melon seeds (e.g., increasing shell hardness) and the machine components, especially if they are prone to rust or other forms of degradation in humid or dusty environments.

2.6.10 Dependence on Battery Life and Charging:

If powered by batteries, the machine will depend heavily on battery life and recharging capabilities, which might be an issue in off-grid locations or during poor sunlight conditions for solar-powered options. Battery replacement and disposal also raise long-term sustainability concerns.

2.6.11 Safety Risks:

Mechanical parts that move at high speeds or exert significant force pose a risk of injury, especially in rural settings where safety regulations and awareness may be limited. Proper safety mechanisms need to be in place, but these may complicate the design and increase costs.

These limitations highlight potential challenges in creating a melon-shelling machine that is efficient, cost-effective, user-friendly, and suitable for varied environments.

2.7 SUMMARY AND RESEARCH GAP ANALYSIS

Improvements on the use of A.C and other conventional Sheller Machine to a D.C powered sheller machine will help us achieve the following;

2.7.1 Enhanced Efficiency

Reduced Power Loss: DC power systems typically experience lower energy losses during transmission and conversion compared to AC systems. This results in more efficient operation and reduced energy consumption.

2.7.2. Optimized Motor Performance: DC motors can be precisely controlled to deliver optimal performance at various speeds and loads. This ensures efficient shelling without unnecessary power consumption.

2.7.3. Improved Control and Precision:

Precise Speed Control: DC motors allow for finer control of the shelling speed, leading to more accurate and consistent shelling results.

2.7.4 Adjustable Torque: The torque of DC motors can be adjusted to suit different types of grains and shelling conditions. This prevents damage to the grains and ensures optimal performance

2.7.5. Enhanced Safety and Reliability:

Reduced Electrical Hazards: DC systems, especially those powered by batteries, eliminate the risk of electrical shocks associated with high-voltage AC power.

2.7.6. Reliable Operation: DC motors are generally more robust and less susceptible to damage from voltage fluctuations and power surges. This ensures reliable and long-lasting operation.

2.7.7. Battery Power: DC-powered shellers can be easily powered by batteries, making them portable and suitable for use in remote areas or where grid power is unavailable.

2.7.8 Flexibility and Mobility

Diverse Power Options: DC power can be sourced from various batteries, solar panels, or generators, offering flexibility in remote areas or where AC power is unavailable.

2.7.9 Reduced Reliance on Grid Power: This independence from the grid makes the machine more suitable for off-grid operations, expanding its potential applications.

2.7.10 Smaller Components and light weight design: DC motors and power electronics are generally smaller and lighter than their AC counterparts, reducing the overall weight and size of the machine.

2.7.11 Enhanced Safety:

Lower Voltage: DC systems often operate at lower voltages, reducing the risk of electric shock. Reduced Fire Hazard: DC motors are less prone to overheating and sparking, minimizing the risk of fire.

2.7.12 Environmental Benefits:

Reduced Carbon Footprint: DC-powered machines, especially those using renewable energy sources, can significantly reduce greenhouse gas emissions.

Lower Noise Pollution: DC motors tend to be quieter than AC motors, contributing to a more pleasant working environment.

CHAPTER THREE

MATERIALS AND METHODOLOGY

This chapter details the materials used in the design and fabrication of the DC-powered melon sheller, along with the various processes and equipment involved in its production. The choice of materials was influenced by factors such as durability, strength, machinability, and cost-effectiveness. The methodology outlines the step-by-step approach taken in constructing the machine, covering essential fabrication processes such as measuring, cutting, drilling, machining, grinding, welding, and assembly. Additionally, this chapter highlights the direct transmission system, the DC motor and battery setup, and the tachometer used for speed measurement.

3.1 RESEARCH DESIGN OVERVIEW

The melon shelling machine applies engineering principles in producing a desired output which is the shelled melon. As stated in previous chapter, melon is one of the most consumed soup ingredient in Nigeria which means a greater consideration must be taken to provide a controlled fabrication process as to prevent breakage of the melon or food poisoning due to corrosion of metal sheet. Therefore, for optimum performance and easy maintenance of the melon shelling machine, the following factors given by (Starkey, 1988) will be taken into consideration.

- Simplicity of design to meet the required standard and specifications
- Mechanical strength of the materials used to ensure their durability and reliability
- Cost of the materials used
- Construction method used to ensure reliability and durability of the product

3.1.1 Conceptual Design

SOLIDWORKS software was used to modelled the shelling machine. The outcome of the model is shown in the figure below. All values are in mm.

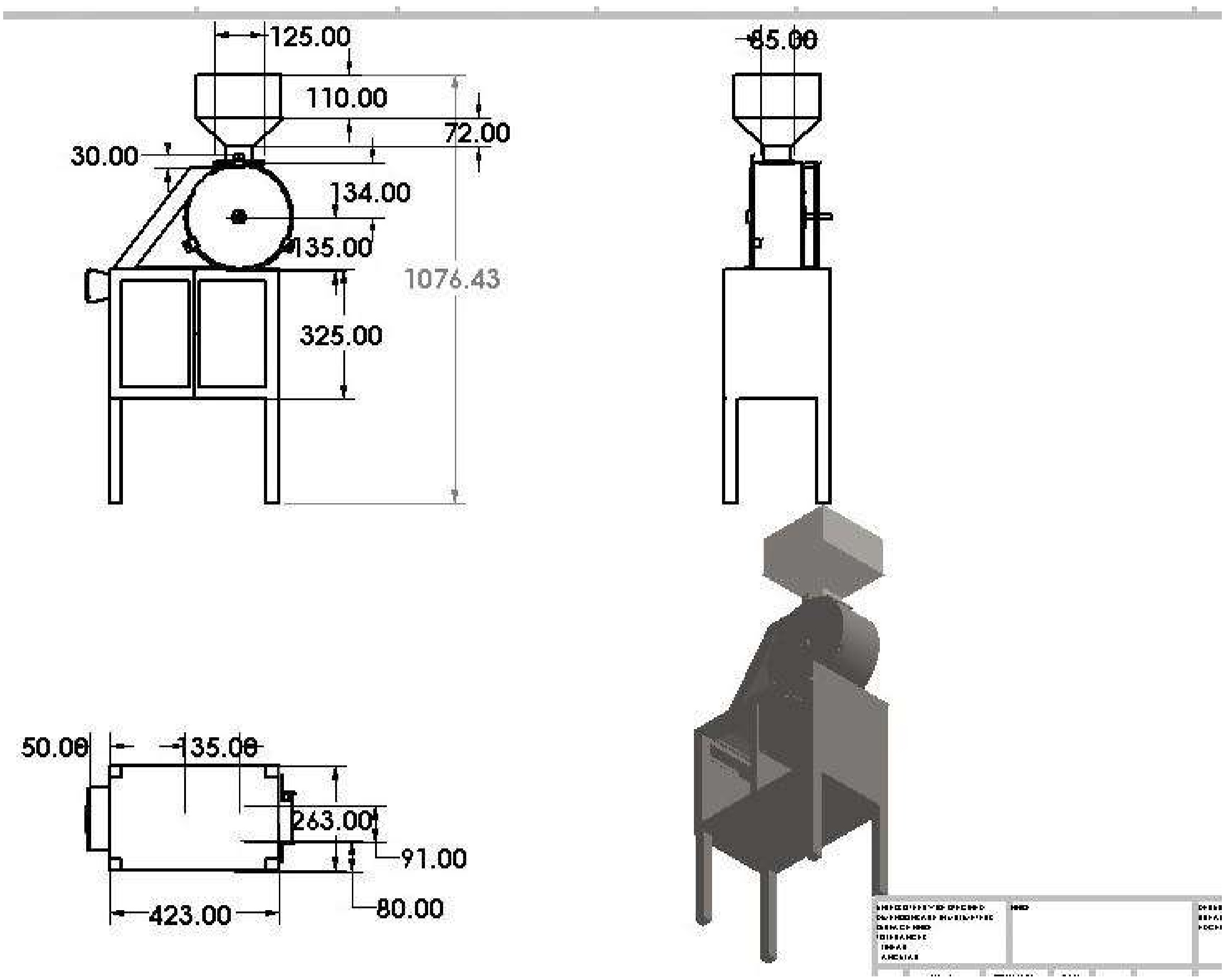

Fig 3.1 Assembly drawing of melon sheller

The Hopper: This is the uppermost unit of the shelling machine where the melon seeds are introduced and fed into the system.

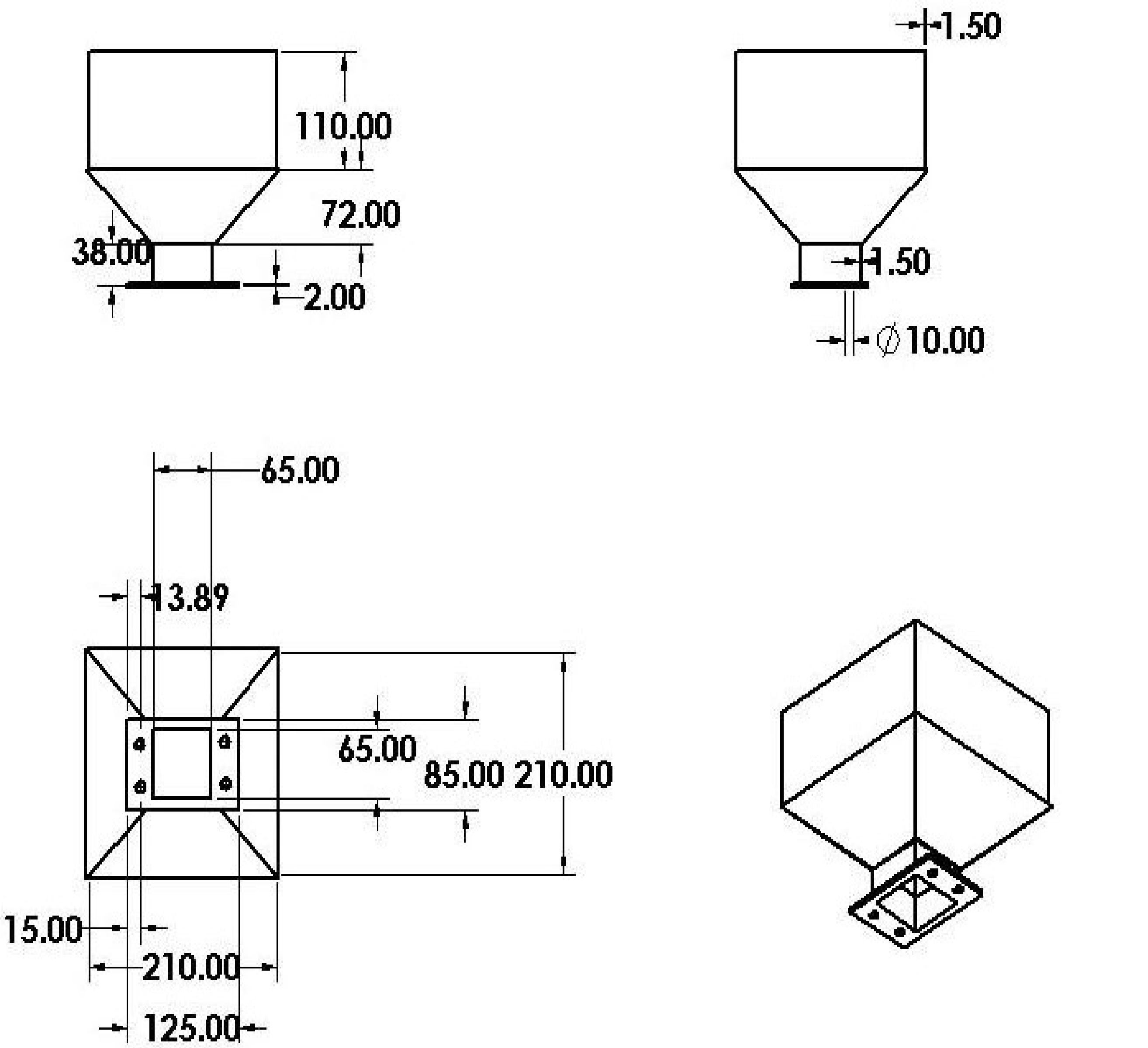

Fig 3.2 schematic drawing of the hopper

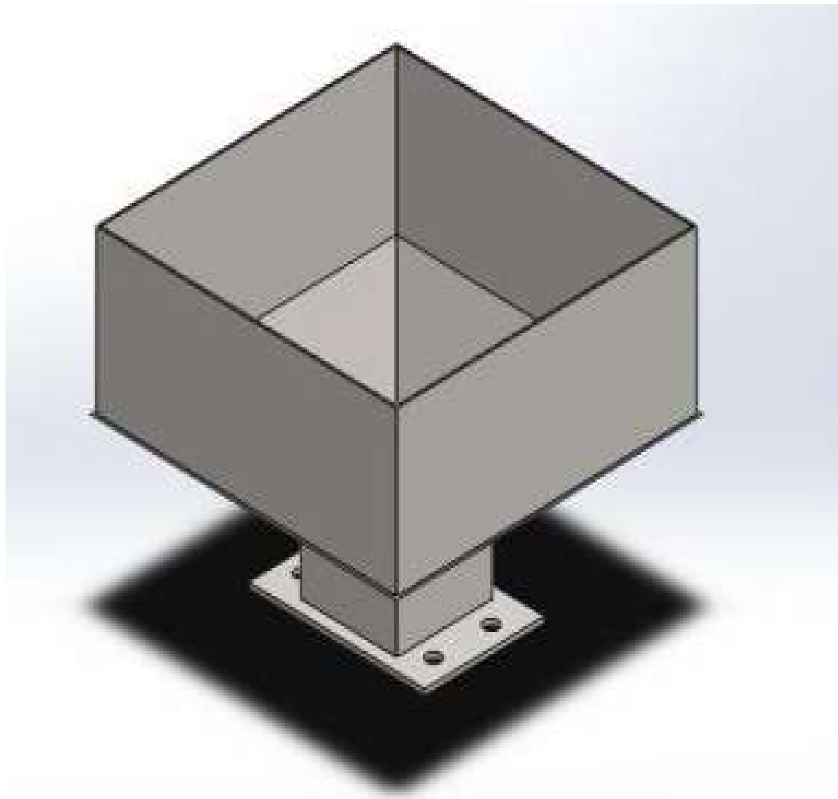

Fig 3.3 The Hopper

The Shelling drum: This is the housing for the shelling blade and the internal fan. The drum is of cylindrical type, which carries the melon through 180º degrees via the blade ad the shaft rotates. The drum is modelled in such a way that it can be opened for cleaning and maintenance. The drum is lined with 64 rods call deflectors of 5mm Diameter ta serve as crushers for the melon seeds.

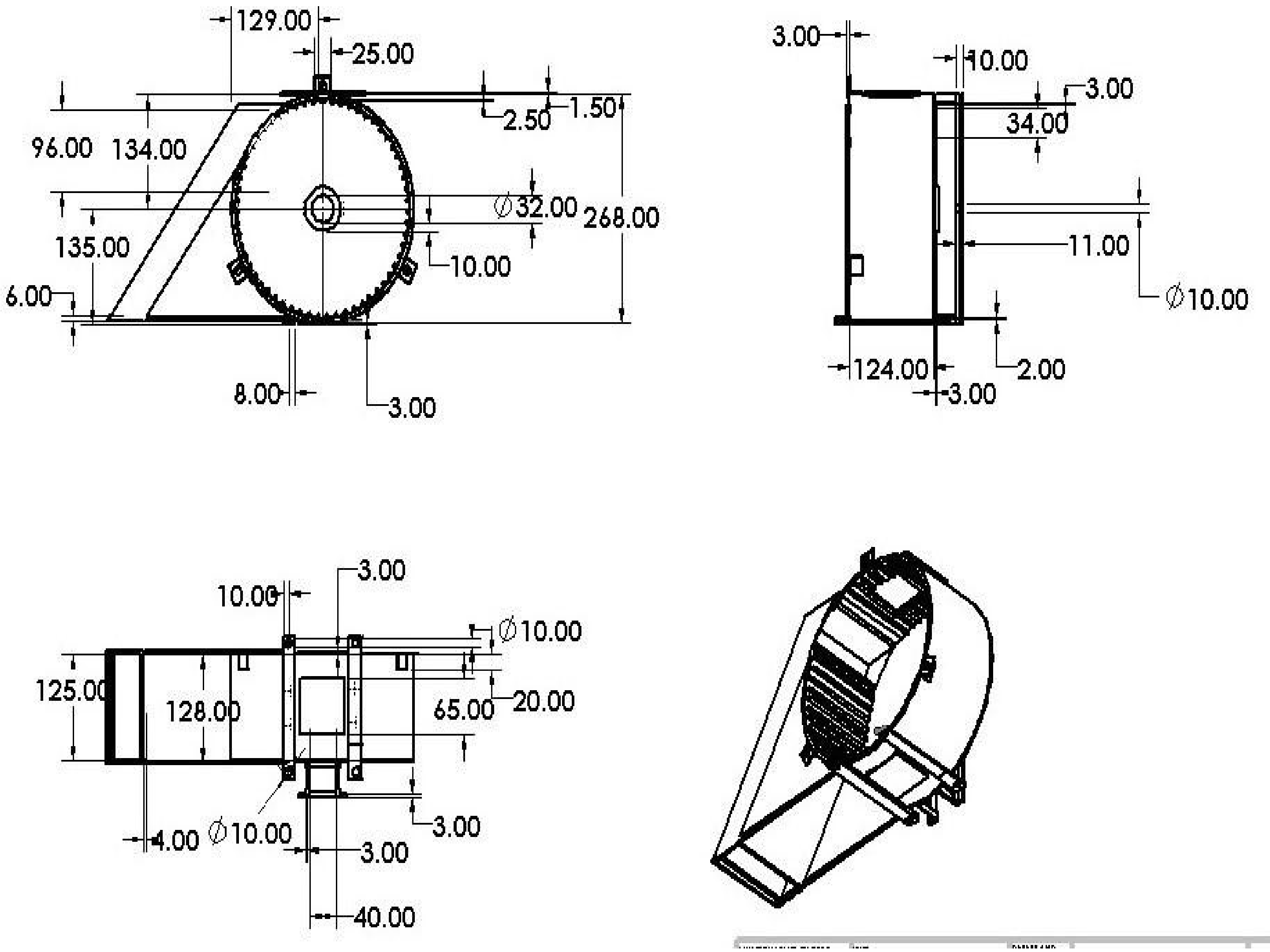

Fig 3.4 The Shelling Drum

The drum cover: This serves as a covering for the drum. It is firmly secured by three bolts equally spaced.

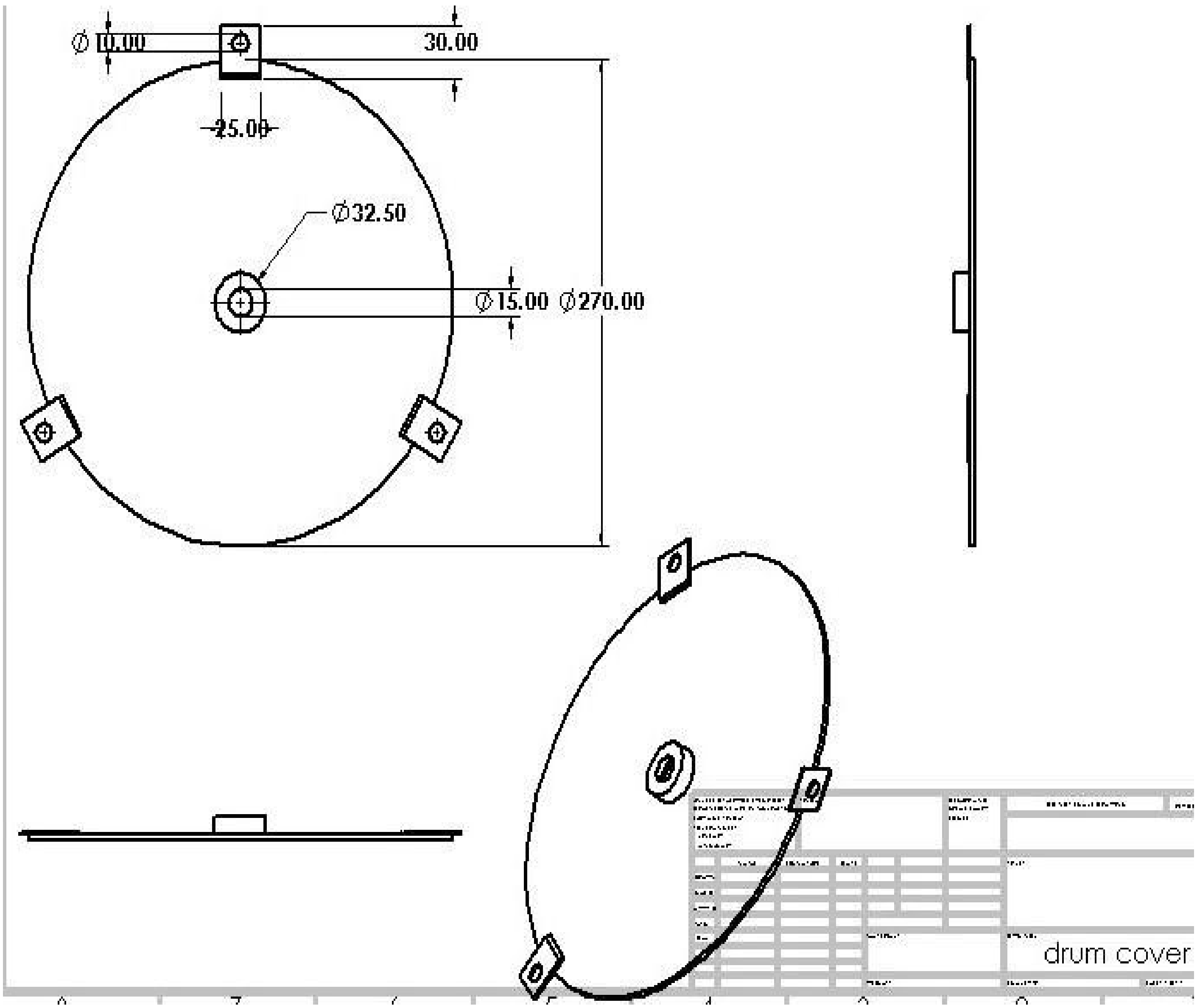

Fig 3.5 The Drum Cover

The shelling blade: The blade is responsible for the shelling of the melon. While rotating within the drum, the blades guides the flow and movement of the shelled melon around the drum, and at a point it reaches 180º, the shelled melon comes out through an opening on the drum face below.

Externally, the drum bears the blades (59 teeth) and internally, it bears the fan blades (40 teeth).

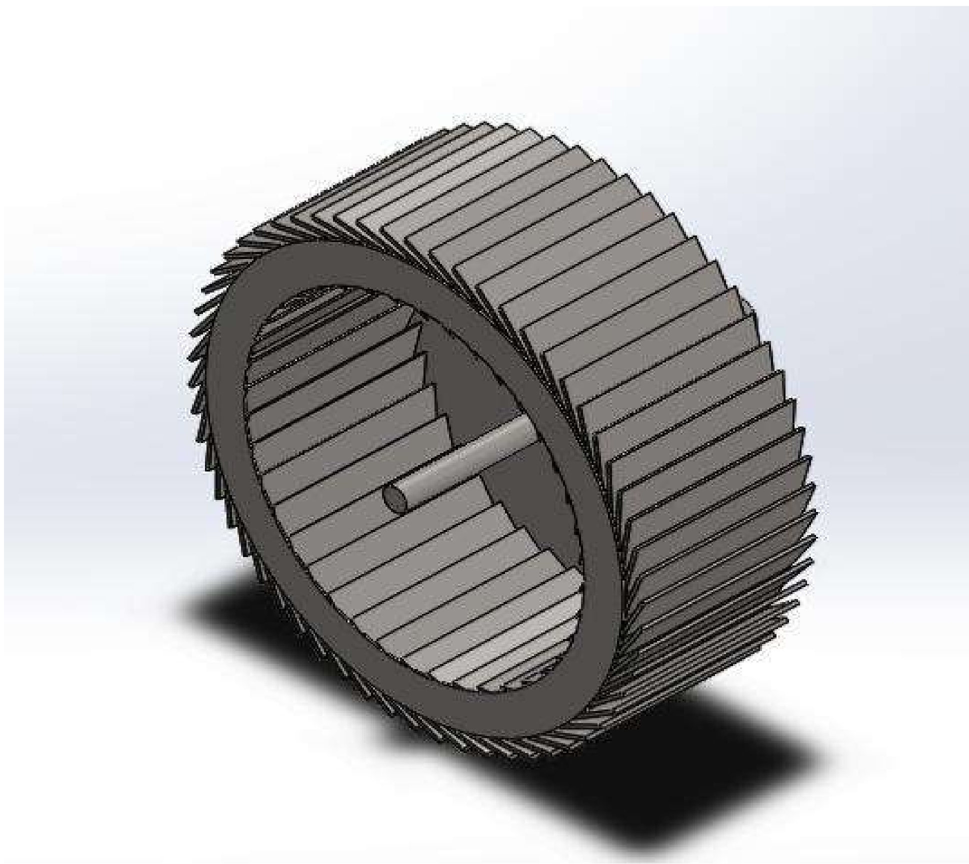

Fig 3.6 The Shelling Blade

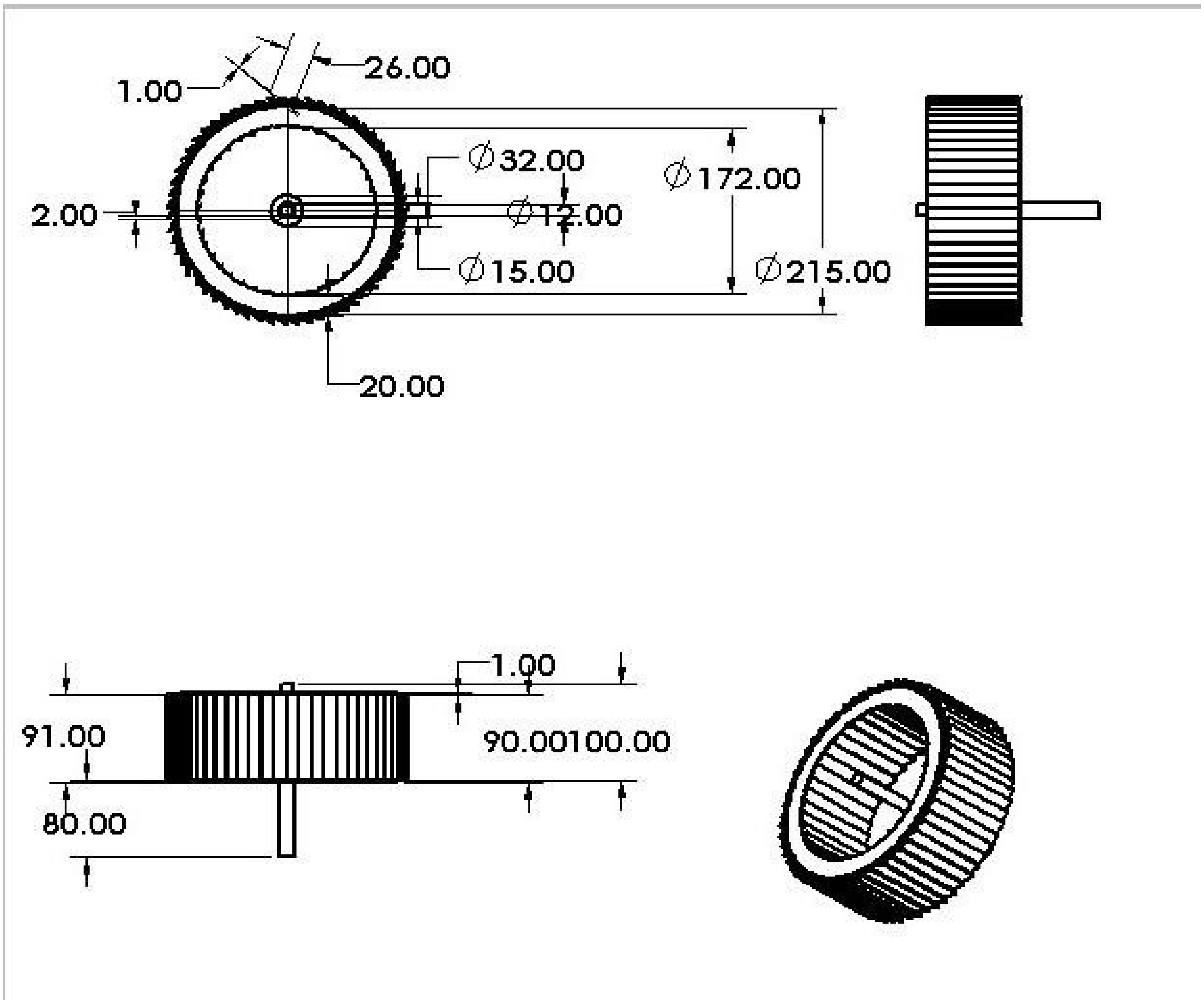

Fig 3.7 Shelling Blade Drawing

The collection part : This serves as a collection unit of the shelled melon and the pod or shell. It consist of two portion. One portion collect the clean melon, the other receives the pod via the separating mechanism using the fan or blower.

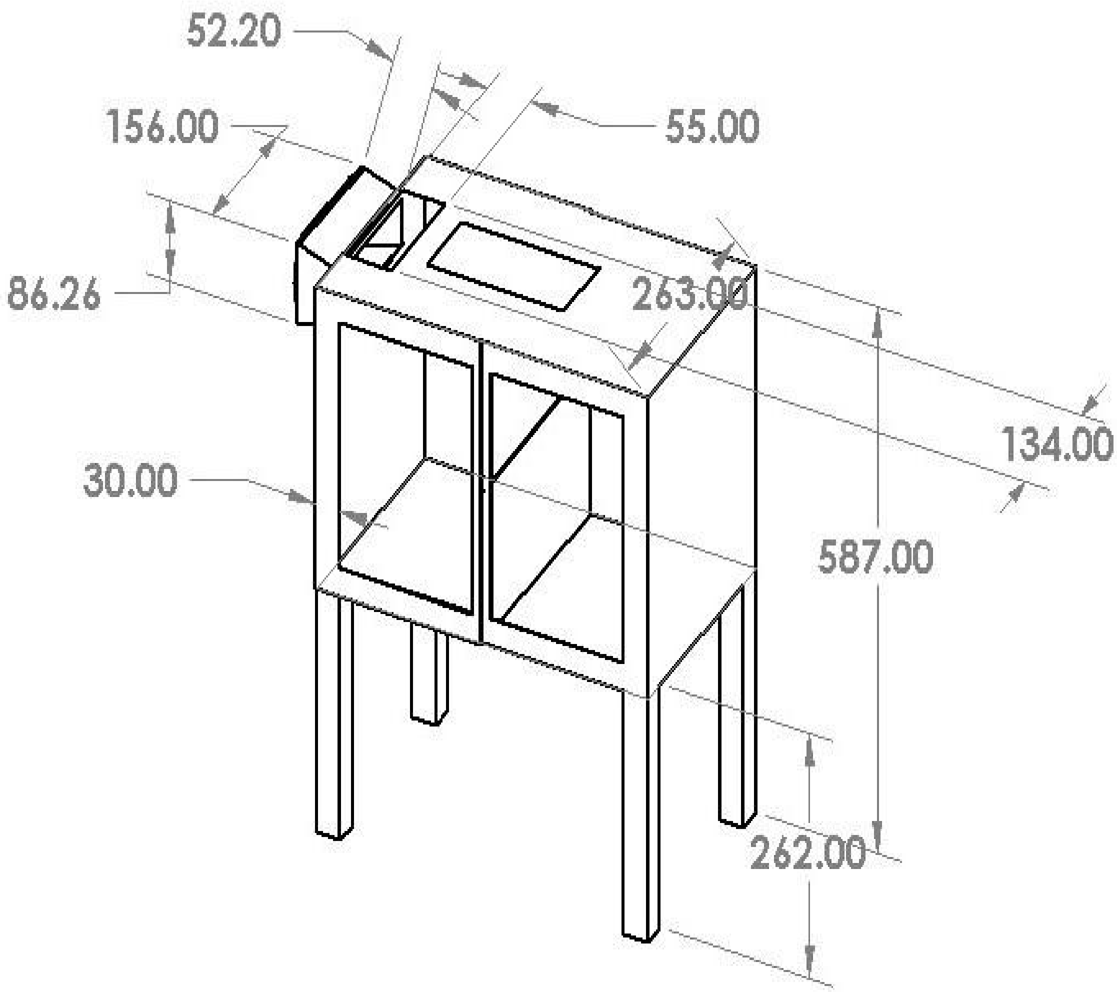

Fig 3.8 Schematic drawing of the Collection Unit

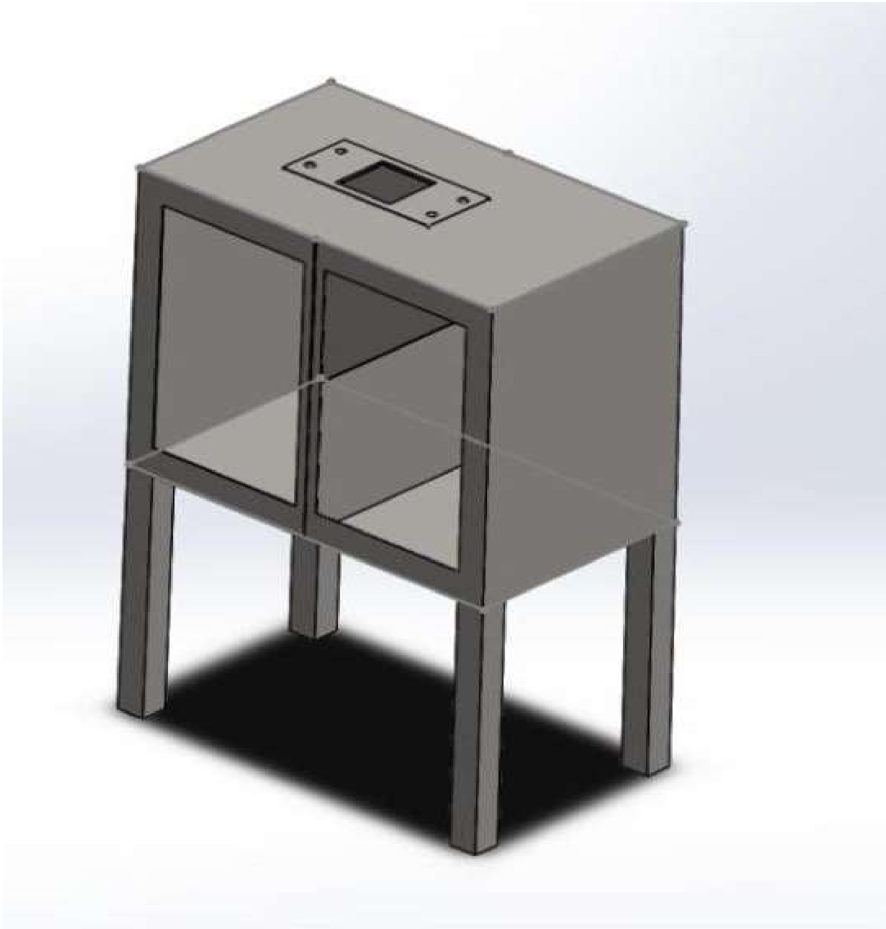

Fig 3.9 The Collection Unit

- The type of material used for each component
- Compaction of equipment
- Mobility of equipment
- Speed of the shaft and shelling disk parameters were put into consideration.

3.2 MATERIALS AND EQUIPMENTS

Materials Requirements for the melon sheller includes:

3.2.1 Dc Motor

A 1-horsepower (HP) DC motor was selected to drive the melon sheller due to its high torque, efficiency, and ability to operate on battery power.

3.2.1.1 Specifications of the Motor:

- Power Output: 1HP Voltage Rating: 12V DC

- Speed: Variable, controlled via a speed regulator
- Torque: High torque suitable for shelling application.

The motor's speed and torque characteristics make it ideal for direct transmission, eliminating the need for additional speed reduction mechanisms like pulleys or belts.

Fig 3.10 1 horsepower (HP) DC Motor

3.2.1.2 Functions of DC Motor in Melon Shelling Machine:

A DC motor plays a crucial role in the shelling process. Here are some of its functions generally in machine performance, which makes it suitable and desirable for the design of melon sheller according to Wikipedia.com:

- Powering the Shelling Mechanism: The DC motor provides the necessary torque and speed to drive the shelling mechanism, which typically consists of a rotating drum or cylinder with cutting or cracking elements.
- Rotating the Shelling Drum: The DC motor rotates the shelling drum at a controlled speed, allowing the melons to be cracked or cut open, separating the shell from the fruit.
- Adjusting Speed and Torque: The DC motor's speed and torque can be adjusted to accommodate different types of melons, shell thickness, and desired shelling efficiency.

- Providing Precise Control: The DC motor's precise control enables the shelling machine to handle delicate or fragile melons, minimizing damage and ensuring optimal fruit quality.
- Efficient Energy Use: DC motors are generally more energy-efficient than AC motors, especially in applications with variable speed requirements, making them a suitable choice for melon shelling machines.

3.2.1.3 Benefits of Using DC Motor in Melon Shelling Machine:

- Improved Shelling Efficiency: Precise control and adjustable speed enable optimal shelling performance.
- Reduced Energy Consumption: Energy-efficient DC motor minimizes power consumption.
- Increased Fruit Quality: Gentle handling and precise control help preserve fruit quality.
- Reliability and Durability: DC motors are generally more reliable and durable than other motor types.

3.2.2 Battery (12V, 75Ah)

- A 12-volt, 75-ampere-hour (Ah) battery was used as the primary power source for the melon sheller. The battery was selected based on the following considerations:
- High Capacity: Provides sufficient power to run the motor for extended periods.
- Recharge-ability: Ensures sustainability and reduces operating costs.
- Stable Voltage Supply: Delivers a constant voltage to prevent fluctuations that could damage the melon shelling machine.

3.2.2.1 Recharging the Battery

- The 12-volt, 75Ah battery, which powers the 1HP DC motor is replinished by the use of a charging module connected to an external power source. This enables a reliable and efficient power supply without requiring an onboard recharging mechanism. The charging module simplifies the power system while preventing unnecessary hiccup in operation

3.2.2.2 Working Principle of the Charging Module

The charging module is designed to convert AC power from an external soure into regulated DC output suitable for charging the 12V, 75Ah battery. The working principle involves the following stages:

i. AC to DC conversion: The module receives AC power (typically 220V) and converts it into DC voltage.
ii. Voltage Regulation: The module ensures a steady 12V output preventing overcharging or fluctuations.
iii. Current Control: It maintains an appropriate charging current , ensuring efficient energy transfer to the battery.
iv. Protection Mechanism: The module includes overload protection , short circuit protection and thermal shutdown to safeguard the battery and components.
v. Charging Indication: The module has incorporated LED indicator to show charging status and completion.

3.2.3 Materials Selections and Justification

Choosing the right materials for the shelling unit of melon seeds shelling machine is critical, especially when considering factors like cost, durability, and food safety. While stainless steel is often preferred in food processing applications due to its corrosion resistance and hygienic properties, mild steel was selected for specific reasons.

The primary material used for fabricating the melon sheller was plain carbon steel (mild steel). The choice of selection was based on the following good properties of mild steel, which makes it advantageous for the design in the course of selection. Due to its:

- High strength-to-weight ratio, ensuring durability and resistance to mechanical stress.
- Good weld-ability, allowing ease of joining components together.
- Availability and cost-effectiveness, making it a practical choice for fabrication.
- Corrosion resistance, especially when coated or painted to prevent rusting.

3.2.3.1 Other Materials/Components Used

Other materials/components used are summarized in the table below:

Table 3.1 Other materials and components used

Material	Purpose

Bolts (10mm and 17mm external diameter) and nuts	Used to fasten and hold the shelling unit securely
Bearings (32mm external diameter, 15mm internal diameter)	Reduce friction and ensure smooth shaft rotation.
Shaft (mild steel)	Transmits motion from the motor to the shelling mechanism.
Rubber padding	Used for vibration damping and noise reduction.
D.C motor (1hp)	Provides power for shelling operation
Battery (12v, 75Ah)	Supplies power while simultaneously being charged.

3.3 DIRECT TRANSMISSION SYSTEM

Unlike conventional belt-driven systems, the melon sheller utilizes a direct transmission mechanism, where the DC motor is directly coupled to the shelling shaft. The choice of direct transmission system was based on some advantages it has over belt transmission system.

3.3.1 Advantages of Direct Transmission

- Higher Efficiency: Eliminates energy losses associated with belt slippage and stretching.
- Compact Design: Reduces the overall space required for the machine.
- Lower Maintenance: No need for belt replacement or tensioning adjustments.
- Immediate Power Transfer: Ensures instant and precise torque delivery to the shelling mechanism.

3.3.2 Implementation in the Melon Sheller

The motor shaft is directly connected to the shelling drum via a rigid coupling, ensuring synchronized rotation. Bearings (32mm external diameter, 15mm internal diameter) were used to support the shaft, minimizing friction and enhancing smooth operation.

3.3.3 Advantages of this System

- Extends the operational time of the machine.
- Reduces the need for frequent external charging.
- Increases overall energy efficiency.

3.4 FABRICATION PROCESSES

The fabrication process involved several mechanical operations to ensure precision, durability, and efficiency. These steps included measuring, cutting, drilling, machining, grinding, welding, and assembly.

3.4.1 Measuring and Marking

Before cutting or machining, accurate measurements were taken to ensure that all components were fabricated to the correct dimensions. Proper measuring prevented misalignment, poor fitting, and mechanical failures.

Table 3.2 showing Measuring Tools Used

Measuring tool	Purpose
Measuring tape	Used for large-scale measurements like frame dimensions.
Steel ruler	Used for general linear measurements and marking.
Vernier caliper	Used for measuring diameters of shafts, bearings and drilled holes (accuracy: ±0.02mm).
Micrometer screw gauge	Used for measuring thickness and small diameters (accuracy: ±0.01mm).

Dial indicator	Used to check the alignment of rotating components (e.g straightness of shaft).
Tachometer	Used to measure the speed of rotation of the motor and shelling drum.

3.4.1.2 Procedures in Measuring and Marking:

- Design dimensions were referenced from engineering drawings.
- Marking tools (chalk, scribers, and punches) were used to highlight cutting and drilling points.
- Double-checking measurements ensured accuracy before proceeding to the next step.
- Importance of Accurate Measurements
- Ensures proper alignment of rotating parts, reducing friction and wear.
- Prevents loose or excessively tight fits, enhancing efficiency.
- Ensures that holes, shafts, and other components match design specifications.
- Cutting

Cutting was performed to shape raw materials according to design specifications.

Hacksaw Cutting: used for cutting small metal rods and pipes; suitable for manual precision cutting where machine tools were unnecessary or could be left out.

Fig 3.11 Hack Saw

Angle Grinder Cutting: Used for fast cutting of thick mild steel sheets and structural members; provided quick and efficient material removal.

Fig 3.12 Angle Grinder

3.4.2 Drilling

Drilling was necessary for creating holes for bolts, nuts, and shaft installations.

Bench Drilling Machine: Used for precision drilling, ensuring properly aligned holes. It provided stable and perpendicular drilling, reducing misalignment issues.

Hand Drill: Used for on-site adjustments and final assembly modifications.

Drill Bits: Ranged from 6mm to 15mm in diameter, depending on the hole size required.

Fig 3.13 Drilling Machine

3.4.3 Machining

Machining was required to achieve accurate shapes and finishes.

Lathe Machine: Used for shaft turning, ensuring smooth and balanced rotation. It ensured correct diameter and alignment for proper bearing fit, as well as proper alignment for the shelling blades in the shelling unit.

Fig 3.14 Lathe Machine

3.4.4 Welding

Welding was used to join structural components permanently. The welding method used was the:

Arc Welding (Shielded Metal Arc Welding – SMAW): Used to weld the machine frame, shelling chamber, and support structures. It provided strong, durable joints capable of withstanding mechanical loads.

3.4.5 Surface Finishing and Coating

Surface finishing was an essential step in the fabrication process, ensuring that the machine components had a smooth surface, improved aesthetics, and enhanced durability. This process also helped prevent corrosion, wear, and rough edges that could cause injury or mechanical inefficiencies. The finishing process was carried out in several stages:

Stage 1: Grinding and Smoothing of Welds

After welding, some surfaces had rough joints, excess weld material, and sharp edges that needed to be smoothed

Angle Grinder: Was used for grinding down excess weld deposits and rough areas. Bench Grinder: Used for fine-tuning and smoothing smaller components.

Process/Steps involved:

- The welded joints were inspected for any excess metal or irregularities.
- The angle grinder was used with an abrasive grinding disc to remove weld beads and projections.
- A bench grinder was used for smaller components to achieve finer finishes.
- The surface was checked by touch and visually inspected to ensure smoothness.

Outcome:

- Strong and smooth joints without sharp edges.
- Improved appearance and safety, reducing the risk of injury.

• Better adhesion for paint and coatings in later stages.

Stage 2: Filing and Sanding

To further refine the surface and remove burrs, scratches, and small imperfections, the components underwent filing and sanding.

Tools Used:

Hand Files: Used for manual smoothing of edges and corners.

Sandpaper (Coarse and Fine Grits): Used to achieve a progressively smoother finish.

Process/Steps:

- Hand files were used on edges and holes to remove sharp burrs left after cutting and machining.
- The surfaces were sanded with coarse-grit sandpaper (80–100 grit) to smooth rough areas.
- Finer sandpaper (200–400 grit) was used to polish the surfaces before painting.
- The components were wiped clean to remove any dust or particles before the next stage.

Outcome:

• Smooth edges and surfaces, making handling safer.

• Better paint adhesion, ensuring even application in the next step.

Stage 3: Cleaning and Degreasing

Before applying any coatings, the metal surfaces were thoroughly cleaned to remove oil, dirt, and dust.

Tools and Materials Used:

Degreasing Solution (Solvent or Acetone): Used to dissolve oils and grease.

Clean Cloth: Used to wipe or blow off dust and debris.

Process/Steps:

- The entire surface was wiped down with a degreasing solution to remove machine oils and fingerprints.
- Clean cloth was used to remove remaining dust.
- A final inspection was done to ensure no contaminants were left before painting.

Outcome:

- Contaminant-free surfaces, preventing paint defects.
- Improved adhesion for paint, ensuring a long-lasting finish.

Stage 4: Primer Application

A primer coat was applied to protect the mild steel from rust and improve paint adhesion.

Materials Used:

- Anti-rust Primer (Oil-based or Epoxy-based)
- Spray Gun or Paintbrush

Process/Steps:

- A thin coat of anti-rust primer was applied using a spray gun or brush.
- The primer was left to dry for several hours (as per manufacturer's recommendations).
- A light sanding was done to smoothen the primer surface before the final paint coat.

Outcome:

- Prevention of rust and corrosion on metal parts.
- Better bonding between the metal and paint, ensuring durability.

Stage 5: Painting and Coating

Painting was the final finishing stage, enhancing both the aesthetic appeal and protection of the machine against environmental conditions.

Materials Used:

Oil-based or Enamel Paint (for durability and resistance to wear).

Spray Gun or Paintbrush (for application).

Process: involved:

- A first coat of paint was applied evenly using a spray gun/brush.
- The surface was left to dry before applying a second coat.
- The painted structure was left to cure completely before assembly.

Outcome:

• Improved aesthetics, giving the machine a professional look.

• Protection against rust, wear, and environmental damage.

• Longer lifespan of the machine, reducing maintenance costs.

3.4.6 Assembly Of The Machine:

After fabrication, the parts were assembled in the following sequence:

• Frame Assembly: The mild steel frame was bolted and welded together.

• Shaft and Bearings Installation: The shaft was inserted into bearings, ensuring smooth rotation.

• Motor Mounting and Direct Transmission Setup: The DC motor was directly coupled to the shelling unit.

• Battery and Electrical Connections: The 12V battery was connected to power the system.

• Installation: The tachometer was mounted to monitor motor speed.

3.5 SAFETY CONSIDERATION

Safety measures followed during fabrication:

PPE Usage: Gloves, goggles, and welding helmets were worn.

Proper Ventilation: Ensured during welding and grinding.

Fire Safety: Fire extinguishers were placed in the workspace.

Electrical Safety: The motor and battery system were carefully insulated to prevent shocks.

3.6 BILL OF ENGINEERING MATERIALS (BEME)

This outlines the required materials, their quantities, unit costs, and total costs for the fabrication of the DC-powered melon sheller. It ensures proper budgeting and resource allocation for the project.

Table 3.3 Material Cost

S/N	Material	Specification	Quantity	Unit Cost (#)	Total Cost (#)
1	Angle bar	1.5 inch (mild steel)	1 length	8,000	8000
2	Sheet metal	1.2mm thickness	1 sheet	50,000	50,000
3	Plate metal	2.0mm thickness	1 sheet	30,000	30,000
4	Pipe	6.0mm thickness	1 length	25,000	25,000
5	Quarter rod	Mild steel	2 pieces	2,500	5,000
6	Fan 1	Steel type	1 piece	16,000	16,000
7	Shaft	Mild steel	1 piece	8,000	8,000
8	Bearings	32mm OD, 15mm ID	2 pieces	500	1,000

9	Electrodes	Mild steel (for welding)	1 pack	5,000	5,000
10	Bolts and nuts	10mm diameter	Assorted	400	400
11	Fan 2		1 unit	20,000	20,000
12	Paint	Anti-rust	1 gallon	7,000	7,000

Subtotal: #180,400

Table 3.4: Electrical components

S/N	Component	Specification	Quantity	Unit Cost (#)	Total Cost
1	D.C Motor	1hp	1 unit	85,000	85,000
2	Battery	12v, 75Ah	1 unit	70,000	70,000
3	Charging module, wiring and switches	Heavy duty cables, connectors	Assorted	45,000	45,000

Sub total: #200,000

Fabrication and Labour Costs (for cutting, drilling, machining, welding, grinding and surface preparation, painting and assembly:

Subtotal - #60000

Table 3.5 Total cost

Category	**Amount (#)**
Material cost	180,400

Electrical components	200,000
Fabrication and labour costs	60,000
Overhead cost	40,000
Grand total	**480,400**

CHAPTER FOUR

RESULTS AND DISCUSSION

The results of the experiments conducted on the DC powered melon seed shelling machine are presented and discussed in this chapter.

4.1 FINAL ASSEMBLY OF THE MELON SHELLING MACHINE

The final assembly of the DC powered Egusi melon seed shelling machine involved the integration of all the designed and fabricated components. The assembly process was carried out in a systematic and meticulous manner to ensure that all the components were properly aligned, compatible and secured. The assembly began with the installation of the DC motor, which was firmly led by an angle bar welded to the drum to provide stability and support. The motor was then connected directly to the shelling blade via a coupling. Next, the shelling chamber was assembled and attached to the hopper and the base (collection department). The blades were designed to separate the seeds from the shells, and the cylindrical body provided a smooth and efficient flow of the seeds and shells through the chamber.

The seed and shell separation system was then assembled and attached to the shelling chamber. This system consisted of air jets that worked to separate the seeds from the shells, and the air jets provided a gentle and efficient means of separating the seeds from the shells. Finally, the control system was assembled and installed, which consisted of a switch, a charging module and a DC power supply. The control system was designed to provide a safe and efficient means of operating the machine, and it allowed the user to easily start and stop the machine.

Fig.4.1 Final assembly of the DC powered melon sheller

4.2 PERFORMANCE TEST OF THE MACHINE

The performance testing of the DC powered Egusi melon seed shelling machine was conducted to evaluate its efficiency, effectiveness, and reliability. The testing was carried out under various operating conditions to simulate real-world scenarios.

4.2.1 Shelling Efficiency Test

The shelling efficiency test was conducted to evaluate the machine's ability to shell Egusi melon seeds effectively. The test involved feeding a known quantity of Egusi melon seeds into the machine and measuring the quantity of seeds shelled. The shelling efficiency was calculated as the ratio of the quantity of seeds shelled to the total quantity of seeds fed into the machine. The results of the shelling efficiency test are presented in Table 4.1

MC (%WB)	TIME (MINS)	N0	N1	N2	N3	N4	N5	%E	%D
30	30	1000	660	30	50	152	94	69.0	18.2
	40	1000	728	17	36	112	93	74.5	12.9

Table 4.1: Shelling Efficiency Test Results, (Results from decorticating machine)

N0 = the number of seeds in the sample is represented as:

N1 = number of shelled and unbroken seeds

N2 = number of shelled but broken seeds

N3 = number of partially shelled and unbroken seeds

N4 = number of partially shelled but broken seeds

N5 = number of seeds unshelled

%E = (N1+ N2) / N0 X 100%

%D = (N4+ N2) / N0 X 100%

Shelling efficiency $= \frac{Total\ melon\ shelled\ X\ 100}{Total\ melon\ fed}$

$$= \frac{(N1 + N2) * 100}{N0}$$

$$= \frac{(728 + 17) * 100}{1000}$$

= 74.5%

Average efficiency = $\frac{Eff\ 1 + Eff\ 2}{2} \quad = \quad \frac{69 + 74.5}{2} \quad = \ 71.8\%$

SHELLERS	**TIME (MINS)**	**N0**	**N1**	**N2**	**N3**	**N4**	**N5**
LADY 1	40	1000	100	0	0	13	887

LADY 2	40	1000	157	0	0	17	833
LADY 3	40	1000	202	0	0	23	775

Table 4.2 : manual seed shelling results (Number of manually shelled melon seeds) (Source: Larry et al, 2021)

NO = SEEDS TO BE SHELLED

N1 = SHELLED UNDAMAGED SEEDS

N2 = SHELLED BUT DAMAGED

N3 = PARTIALLY SHELLED AND UNDAMAGED

N4 = PARTIALLY SHELLED BUT DAMAGED

N5 = UNSHELLED

AVERAGE NUMBER OF MANUALLY SHELLED SEEDS = $\frac{Total\ number\ shelled\ seeds\ by\ all\ 3\ ladies}{Number\ of\ ladies}$

$$= \frac{100+157+202}{3}$$

$$= 153$$

Manual shelling efficiency = $\frac{Total\ number\ shelled\ X\ 100}{Total\ number\ of\ seed\ to\ be\ shelled}$

$$\text{Lady 1} = \frac{100\ X\ 100}{1000} = 10\%$$

$$\text{Lady 2} = \frac{157\ X\ 100}{1000} = 15.7\%$$

$$\text{Lady 3} = \frac{202\ X\ 100}{1000} = 20.2\%$$

Average manual shelling efficiency $\zeta\alpha$ = $(\zeta\alpha1 + \zeta\alpha2 + \zeta\alpha3)/n$

Where $\zeta\alpha1$, $\zeta\alpha2$ and $\zeta\alpha3$ represents the respective efficiencies of lady 1, lady 2 and lady 3.

$$\zeta\alpha = 15.3\%$$

The results show that the machine has an average shelling efficiency of 71.8%. This indicates that the machine is effective in shelling Egusi melon seeds.

4.2.2 Seed Damage Test

The seed damage test was conducted to evaluate the machine's ability to minimize seed damage during the shelling process. The test involved feeding a known quantity of Egusi melon seeds into the machine and measuring the quantity of damaged seeds.

The results of the seed damage test are presented in Table 4.1

SEED DAMAGED = $\frac{Total\ melon\ shelled,\ \ broken\ \&\ crushed\ X\ 100}{Total\ meloo\ fed}$

$$\frac{(N2 + N4)\ X\ 100}{1000} = \frac{(30 + 152)}{1000}$$

= 18.2%. for test 1

$$= \frac{(N2+N4)\ X\ 100}{1000} = \frac{(17+112)\ X\ 100}{1000}$$

= 12.9%. for test 2

Average seed damaged = $\frac{18.2+12.9}{2} = 15.6\%$

The results show that the machine has an average seed damage of 15.6%. This indicates that the machine is effective in minimizing seed damage during the shelling process.

4.2.3 Performance Testing Based on Moisture Content

The performance of the machine was also tested based on the moisture content of the Egusi melon seeds. The seeds were dried to different moisture levels, ranging from 5% to 15%, and then fed into the machine. The results showed that the machine's shelling efficiency and seed damage varied with the moisture content of the seeds.

According to the test carried out by (Larry et al, 2021), at 5.24% water content of the melon seeds tested, an efficiency of 71.5% was recorded, while 65.5% efficiency was recorded at 9.87% melon seeds water content, and at 13.53% water content of the melon seeds, an efficiency of 53.3% was recorded. This

indicates that the machine designed performances works better when the water contained in the melon seeds is 5.24%, thus, the more the water contained in the melon seeds the lower its performance as shown in the figure 4.3 – 4.5. However, testing revealed that it takes approximately 480 seconds to shell 2kg of melon seeds irrespective of the amount of water contained in it.

Number of Experiment	Moisture Content (%)	Mass of seed (St) (kg)	Time taken (sec)	Mass of completely peeled (Sc)	Mass of peeled but broken (Sb)	Mass of partially peeled (Sp)	Mass of unpeeled seeds (Su)	Mass of seed loss (kg)
1	5.24	2kg	482	1.23	0.21	0.20	0.33	0.03
2	5.24	2kg	473	1.19	0.19	0.23	0.35	0.04
3	5.24	2kg	489	1.27	0.24	0.19	0.29	0.03
Average			481	1.23	0.21	0.21	0.32	0.03

Table-4.3: Results of melon shelling test with 5.24% water conten

Number of experiment	Moisture Content (%)	Mass of seed (St) (kg)	Time taken (sec)	Mass of completely peeled (Sc) seeds (kg)	Mass of peeled but broken (Sb) seeds (kg)	Mass of partially peeled (Sp) seeds (kg)	Mass of unpeeled seeds (Su) (kg)	Mass of seed loss (kg)
1	9.87	2kg	474.	1.03	0.31	0.27	0.31	0.08
2	9.87	2kg	483	1.06	0.29	0.29	0.33	0.03
3	9.87	2kg	479	0.98	0.27	0.32	0.39	0.05
Average			478	1.02	0.29	0.30	0.34	0.05

Number of Experiment	Moisture Content (%)	Mass of seed (St) (kg)	Time taken (sec)	Mass of completely peeled (Sc) seeds (kg)	Mass of peeled but broken (Sb) seeds (kg)	Mass of partially peeled (Sp) seeds (kg)	Mass of unpeeled seeds (Su) (kg)	Mass of seed loss (kg)
1	13.53	2kg	472	0.74	0.34	0.34	0.47	0.11
2	13.53	2kg	488	0.71	0.32	0.38	0.50	0.09
3	13.53	2kg	481	0.77	0.33	0.41	0.44	0.05
Average			480	0.74	0.33	0.38	0.47	0.08

Table-4.5: Results of melon shelling test with 13.53% water content (Source: Larry et al, 2021)

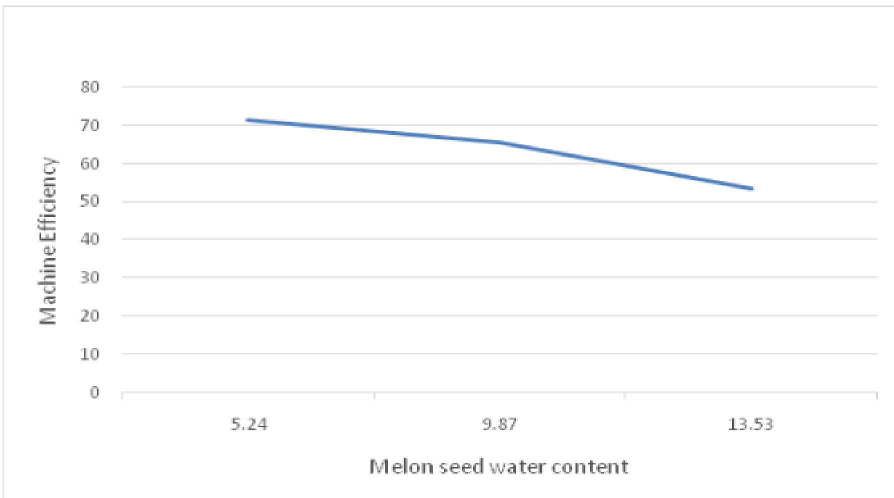

Fig-4.2: Melon water content versus efficiency graph (Source: Larry et al, 2021)

Table 4.3-4.5: Shows the Performance Testing Results Based on Moisture Content:

The results show that the machine's shelling efficiency increases with decreasing moisture content, while the seed damage increases. This suggests that the machine's performance is affected by the moisture content of the seeds, and that optimal performance can be achieved by controlling the moisture content. Results show that the higher the moisture content, the lower the damaged seeds.

4.2.4 Machine capacity (Feed rate) test

Yakum, 2020 conducted a test on melon shelling machine to determine machine capacity. At a 30-minute seed spreading duration, experiments were conducted to assess the machine's efficiency based on two key metrics: shelling effectiveness and percentage of seed breakage. These performance indicators served as benchmarks for determining the optimal water-to-seed ratio during seed preparation, while also considering the throughput (or capacity) of the novel machine design. The machine's peak performance is achieved when it exhibits high shelling efficiency and Minimal seed damage, thereby ensuring a high feed rate of the melon shelling machine. The test results are shown in the table below.

Test	Seed Mass (Kg)	Exit Time (s)	Exit Time (hr)	Feed Rate (Kg/hr)
1	0.10	7	0.0019	52.63
2	0.20	13	0.0036	55.55
3	0.25	16.5	0.0046	54.35
4	0.50	31.5	0.0087	57.34
5	0.75	50	0.0139	53.96
6	1.00	65	0.0181	55.65

Table 4.6 Feed rate determination on the New Machine Design (source: Yakum, 2020).

From observation of the recorded feed rate values from table 4.6 above, an average feed rate for the new machine design is 55.10Kg/hr. The above registered exit times are the mean values obtained for the three different seed categories for the same seed masses.

4.2.5 Determination of Best Water-to-Seed Ratio

With further test and study while maintaining a constant quantity of melon seeds during shelling, and varying the water quantity added during seed preparation, the shelling efficiency and percentage of seed damage, values for the different melon seed categories were recorded as presented in the figure below:

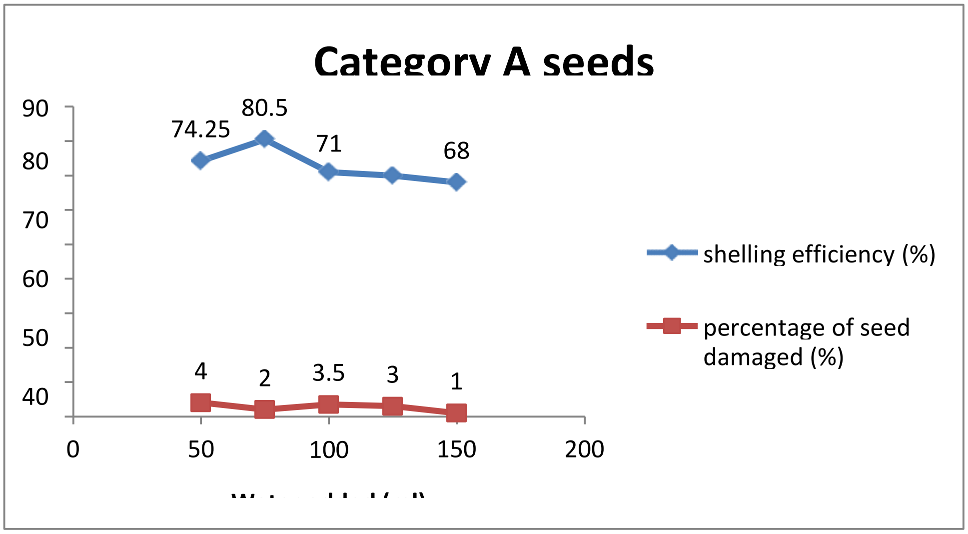

Figure 4.3"Water added against Machine Performance for Category A Seeds

Notably, as the water quantity increased for a constant seed mass, the cracking efficiency rose significantly (from 74.25% to 80.5%) while the percentage of seed damaged decreased substantially (from 4% to 2%). Conversely, excessive water addition led to a sharp decline in cracking efficiency to 70.5% and a rise in seed damage to 4%. Optimal machine performance was achieved at 80.5% cracking efficiency and 2% seed breakage rate. To achieve this optimal performance, seeds should be briefly soaked and then air-dried for 30 minutes prior to shelling.

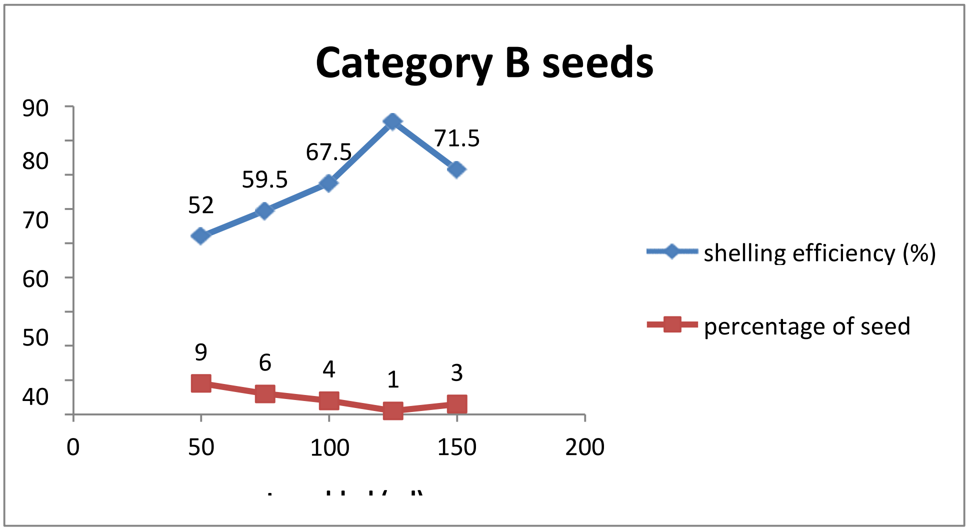

Figure 4.4 Water added against Shelling Performance

With consistent water addition, the cracking efficiency steadily increased (from 52% to 85.5%), accompanied by a steady decline in seed damage percentage (from 9% to 1%). However, exceeding these optimal values resulted in decreased cracking efficiency and increased seed damage. Consequently, peak performance was achieved at 85.5% cracking efficiency and 1% seed damage.

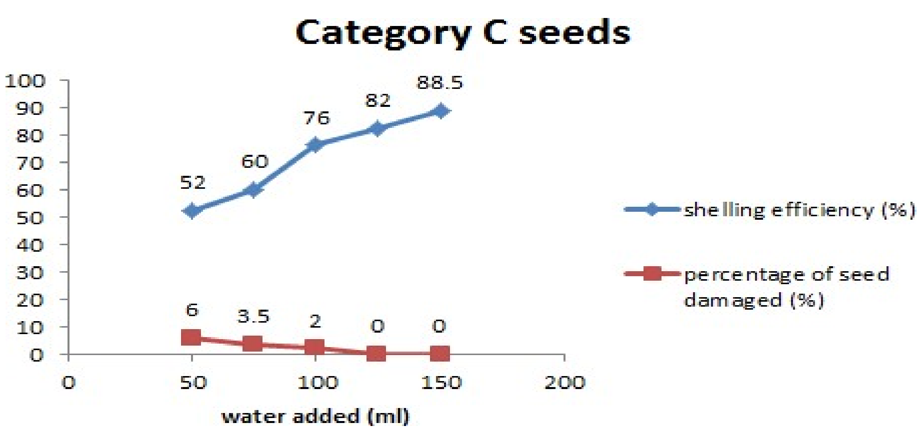

Figure 4.5. Water added against shelling performance (Source: Yakum, 2020).

It was noted that increasing the water quantity directly correlated with higher cracking efficiency and fewer broken seeds. In several instances, 0% seed damage was observed with continuous water addition. Furthermore, when seeds (category C) were soaked in water for over 20 minutes and then drained, cracking efficiency reached 100%.

4.3 RESULTS ANALYSIS AND PERFORMANCE EVALUATION

The results of the performance testing, presented in section 4.2, were analyzed to determine the machine's efficiency, effectiveness, and reliability. The analysis involved comparing the actual performance of the machine with the expected performance, and identifying areas for improvement.

4.3.1 Shelling Efficiency Analysis

The shelling efficiency results showed that the machine has an average shelling efficiency of 71.8% (Table 4.1). This indicates that the machine is effective in shelling Egusi melon seeds. However, there is room for improvement, as the machine's shelling efficiency can be increased by optimizing the design of the shelling chamber and the seed handling system via the feed rate, moisture content and shelling speed.

A closer examination of the shelling efficiency results reveals that the machine's performance is affectd by the moisture content of the seeds. The results show that the machine's shelling efficiency is higher when the seeds have a lower moisture content (Figure 4.1). This suggests that the machine's performance can be improved by controlling the moisture content of the seeds.

4.3.2 Seed Damage Analysis

The seed damage results showed that the machine has an average seed damage of 15.6% (Table 4.1). This indicates that the machine is effective in minimizing seed damage during the shelling process when compared to manual shelling at the same time interval. However, there is still room for improvement, as the machine's seed damage can be reduced by optimizing the design of the seed handling system.

A closer examination of the seed damage results reveals that the machine's performance is affected by the speed of the shelling chamber. The results show that the machine's seed damage is lower when the shelling chamber is operated at a slower speed.. This suggests that the machine's performance can be improved by optimizing the speed of the shelling chamber.

4.3.4 Overall Performance Analysis

The overall performance results show that the machine is effective in shelling Egusi melon seeds, minimizing seed damage, and consuming power efficiently. However, there is still room for improvement, as the machine's performance can be optimized by making design improvements to the shelling chamber, seed handling system, and electrical system.

The results of the analysis suggest that the machine's performance can be improved by:

- Optimizing the design of the shelling chamber to handle seeds with different moisture contents
- Optimizing the design of the seed handling system to reduce seed damage
- Optimizing the design of the machine's electrical system to handle heavier loads and reduce power consumption

These recommendations will be discussed in more detail in the next chapter.

4.4 COST ANALYSIS

The brief summary of the cost analysis of the DC powered Egusi melon seed shelling machine is presented below:

4.4.1 Material Cost

The material cost includes the cost of mild steel, quarter rod, copper wire, and other materials. The total material cost is approximately ₦385,400

Breakdown:

- Mild Steel and other welded metals (electrodes, quarter rod, angle bar etc.): ₦180,400
- Electrical components: ₦145,000
- Copper wire: ₦5,000

Total material cost: ₦350,400

4.4.2 Labor Cost

The labor cost includes the cost of skilled and unskilled labor. The total labor cost is approximately ₦60,000

4.4.3 Overhead Cost

The overhead cost includes the cost of workshop rental, electricity, transport, and miscellaneous expenses (such as feeding and refreshments). The total overhead cost is approximately 40,000.

- Workshop rental: ₦5,000
- Electricity: ₦5,000
- Transport: ₦15,000
- Miscellaneous expenses: ₦15,000

Total overhead cost: ₦40,000

4.4.4 Overall Summary of Cost

The total cost of the DC powered Egusi melon seed shelling machine is:

Material cost: ₦350,400

Labor cost: ₦60,000

Overhead cost: ₦40,000

Total cost: ₦430,400

4.5 DISCUSSION

The performance testing of the DC powered Egusi melon seed shelling machine has shown that the machine is capable of efficiently shelling Egusi melon seeds with a high shelling efficiency and low seed damage. The results of the performance testing are consistent with the design specifications and expectations. The analysis of the results has shown that the machine's performance is affected by the moisture content of the seeds, with higher shelling efficiency and lower seed damage observed at lower moisture contents. This suggests that the machine's performance can be optimized by controlling the moisture content of the seeds. The performance evaluation of the machine has shown that it meets the design specifications and expectations, with a high shelling efficiency and low seed damage. The machine's performance is also comparable to other similar machines in the market.

The cost analysis has shown that the machine is cost-effective, with a total cost of ₦485,400. The machine's cost-effectiveness is due to its simple design and use of locally sourced materials. Overall, the results of the performance testing, analysis, and evaluation have shown that the DC powered Egusi melon seed shelling machine is a viable and cost-effective solution for small-scale farmers and entrepreneurs in Nigeria. The machine's performance can be optimized by controlling the moisture content of the seeds, and its cost-effectiveness makes it an attractive option for those looking to invest in a melon seed shelling machine. The findings of this study have implications for the development of agricultural machinery in Nigeria, particularly in the area of post-harvest processing. The study highlights the importance of designing and developing machines that are tailored to the specific needs of small-scale farmers and entrepreneurs in Nigeria. Future studies can build on the findings of this study by exploring ways to improve the machine's performance and cost-effectiveness. Additionally, studies can be conducted to evaluate the machine's performance in different regions and environments in Nigeria.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This project focused on the design and fabrication of a DC-powered melon sheller, aimed at improving the efficiency of melon seed shelling through an electrically powered system. The machine was constructed primarily from mild steel, with additional components such as bolts, nuts, bearings, and a blower to enhance its functionality. The system is powered by a 12V, 75Ah battery, which gets recharged with the aid of a built-in charging module. A tachometer was incorporated to monitor the machine's speed and optimize shelling efficiency.

The major fabrication processes included cutting, drilling, machining, grinding, welding, and painting, ensuring a robust and durable machine structure. The machine's direct transmission mechanism, which eliminates the need for a belt, enhances efficiency by reducing power loss and maintenance issues. The surface finishing process, including grinding, priming, and painting, was conducted to improve aesthetics, durability, and resistance to corrosion.

Through testing, the machine demonstrated effective shelling performance, maintaining consistent speed and power delivery. The integration of an electric motor and battery charging system ensures continuous operation, making the melon sheller suitable for both domestic and commercial applications. The machine also proved to be cost-effective, energy-efficient, and easy to operate, offering a significant improvement over manual shelling methods.

The average efficiency of the machine was tested to be 71.8%, while the average seed damage was 15.6%. In comparison, the manual shelling efficiency was 15.3% for the same time interval. The moisture content of the melon seeds was found to significantly affect the efficiency and feeding rate of the machine. Optimal performance was achieved when the moisture content was within a specific range.

The overall cost of the project was ₦485,400. Considering the benefits of the machine, including increased efficiency, reduced labor costs, and improved product quality, the project is deemed economically viable.

5.2 CHALLENGES ENCOUNTERED

During the fabrication and testing phases, several challenges were identified, including:

• Material Sourcing Issues: Some components, such as bearings and the blower, were difficult to procure.

• Fabrication Constraints: Precise cutting and welding required additional refinements to ensure accuracy. Besides, inconsistent power supply to operate machines such as the lathe, angle grinder, welding machine, (etc) for the various fabrication operations was another challenge.

• Power Management: The efficiency of the battery charging system needed optimization to sustain prolonged operation.

• Shelling Efficiency Variations: Adjustments were required to improve the separation of shells from the melon seeds.

Despite these challenges, the project successfully achieved its primary objective of developing a functional, efficient, and durable melon shelling machine.

5.3 RECOMMENDATIONS

Based on the results and challenges encountered during this project, the following recommendations are made for future improvements:

- Optimization of Power Management System: Enhancing the charging system with a solar panel or an improved alternator can ensure better energy efficiency and sustainability.
- Improved Shelling Mechanism: Modifying the shelling chamber and introducing adjustable clearance settings can improve seed-shell separation efficiency.
- Automation Enhancements: Implementing programmable controls for speed variation and shelling adjustments can improve overall machine performance.
- Further Testing and Calibration: Conducting additional tests with different melon seed varieties will help refine performance and adaptability.
- Further research should be conducted to optimize the machine's design and performance, particularly in relation to the moisture content of the melon seeds.

- The machine should be tested with different types of melon seeds to determine its versatility and adaptability.
- The project should be scaled up for commercial production, with a focus on marketing and distribution strategies to make the machine accessible to farmers and processors.
- Training programs should be established to educate users on the proper operation and maintenance of the machine.
- Future studies should investigate the potential for integrating the melon sheller with other processing machines to create a comprehensive melon processing system.

5.4 FUTURE WORK

To advance the design and improve functionality, future projects can focus on:

- Developing a fully automated shelling and separation unit.
- Integrating a user-friendly control panel with speed and efficiency monitoring.
- Designing a larger-capacity model for commercial-scale operations.
- Exploring alternative energy sources such as hybrid solar and battery power.

5.5 SAFETY REQUIREMENTS AND MAINTENANCE

The DC powered Egusi melon seed shelling machine is designed with safety features to prevent accidents and injuries. The machine has a protective cover to prevent accidental contact with moving parts. The user is required to wear protective wear, such as gloves and safety glasses, while operating the machine.

Regular maintenance is necessary to ensure the machine's optimal performance and longevity. The machine's moving parts should be lubricated regularly, and the electrical components should be checked for damage or wear. The machine should also be cleaned regularly to prevent dust and debris accumulation, especially in the shelling unit.

5.6 FINAL REMARKS

The DC-powered melon sheller designed and fabricated in this project is a significant contribution to mechanized agriculture. By improving efficiency and reducing manual labor, this machine provides an effective solution to the challenges associated with traditional melon seed shelling methods. Further refinements and innovations in this area can lead to even more advanced and efficient shelling technologies, benefiting farmers and agro-industrial businesses alike.

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APPENDIX


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