`

DESIGN AND FABRICATION OF CASHEW NUT SHELL BREAKING MACHINE

A PROJECT REPORT

Submitted by

GURUPRASAD M

In partial fulfilment of the degree

of

BACHELOR OF ENGINEERING

In

MECHANICAL ENGINEERING

K. RAMAKRISHNAN COLLEGE OF TECHNOLOGY

(An Autonomous Institution, affiliated to Anna University Chennai and Approved by AICTE, New Delhi)

SAMAYAPURAM – 621 112

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K. RAMAKRISHNAN COLLEGE OF TECHNOLOGY

(AUTONOMOUS)

SAMAYAPURAM-621112

BONAFIDE CERTIFICATE

Certified that this project report titled "**DESIGN AND FABRICATION OF CASHEW NUT SHELL BREAKING MACHINE"** is the Bonafide work **OF GURUPRASAD M(811722114304),** who carried out the project under my supervision. Certified further that to the best of my knowledge the work reported here in does not form part of any other project report or dissertation based on which a degree or award was inferred on an earlier occasion on this or any other candidate.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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DECLARATION

I jointly declare that the project report on **"DESIGN AND FABRICATION OF CASHEW NUT SHELL BREAKING MACHINE"** is the result of original work done by us and best of our knowledge, similar work has not been submitted to **"K RAMAKRISHNAN COLLEGE OF TECHNOLOGY"** for the requirement of Degree of **BACHELOR OF ENGINEERING**. This project report is submitted on the partial fulfilment of the requirement of the award of Degree of **BACHELOR OF ENGINEERING**.

SIGNATURE

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GURUPRASAD M

Place: Samayapuram

Date

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ABSTRACT

This paper presents the design and development of a cashew nut breaking machine aimed at improving the efficiency and precision of cashew nut shelling. Traditional manual shelling methods are labor- intensive and often result in a high percentage of damaged kernels. The proposed machine employs a mechanical shelling mechanism, incorporating rollers and blades to accommodate varying sizes of cashew nuts. The machine's design ensures minimal kernel damage and higher throughput compared to manual methods. Key include a user-friendly interface, adjustable settings for different nut sizes, and the machine significantly reduces processing time and increases the yield of whole kernels. This innovation holds potential for small to medium-scale cashew nut processing enterprises, promising to enhance productivity and profitability.

Keywords: Cashew nut shell-breaking machine, small-scale farmers, roller mechanism, hopper, heater, nut processing, shell crushing, agricultural machinery, cost-effective design, productivity enhancement.

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CHAPTER 1
INTRODUCTION

1.1BACKGROUND

Cashew nuts, known for their rich nutritional profile and versatility in culinary applications, are an essential agricultural product cultivated predominantly in tropical regions such as India, Vietnam, and parts of Africa. Their production is a significant source of livelihood for millions of small-scale farmers and contributes substantially to the economies of these regions. However, the processing of cashew nuts, particularly the extraction of the edible kernel from its hard shell, presents significant challenges that hinder efficiency and profitability.

FIG:1.1 RAW CASHEW NUT SHELL

The cashew nut is encased within a tough outer shell that contains a caustic liquid comprising anacardic acid and cardol. These substances can cause severe skin irritation and burns if proper precautions are not taken. Traditionally, the extraction process has been manual, requiring skilled laborers to crack the shell without damaging the delicate kernel inside. This method, while effective to an extent, is labor-intensive, time-consuming, and poses occupational hazards to workers. shown in fig 1.1 Moreover, the manual approach often results in inconsistencies in quality and a high rate of kernel breakage, which reduces the market value of the product.

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In recent years, the increasing global demand for cashews has highlighted the need for more efficient and sustainable processing methods. Automation has emerged as a promising solution to address these challenges. Mechanical and automated shell-breaking machines are being developed to enhance productivity while ensuring worker safety. These machines are designed to apply precise forces to crack the shell without compromising the integrity of the kernel. By replacing manual labor with automated systems, the industry aims to reduce processing time, minimize injuries, and improve overall yield.

FIG:1.2 CASHEW NUT SHELLING IN ODEN DAYS

The development of cashew nut shell-breaking machines is part of a broader trend towards mechanization in agriculture and food processing. These innovations are driven by the need to meet the growing consumer demand for high-quality cashews in the global market while addressing labor shortages and health risks in the industry. Additionally, such machines contribute to sustainability by reducing waste and optimizing resource utilization. show in fig :1.2 As the technology evolves, it is expected to transform the cashew processing industry, enhancing profitability and fostering economic growth in producing regions.

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1.2 PROBLEM STATEMENT

1.2.1 BENEFITS:

1. **Improved Productivity:**
    - The hopper heater could soften the cashew shells, making them easier to break open.
    - The two-roller system would help streamline the shelling process, reducing manual labor and increasing throughput compared to traditional hand methods.
2. **Cost Reduction:**
    - Small-scale farmers would likely benefit from reduced labor costs, as the automated system requires fewer people for operation.
    - The increased efficiency could result in higher output, helping farmers achieve better economies of scale.
3. **Quality Enhancement:**
    - With controlled heating and rolling, there's a lower risk of breakage compared to manual methods, leading to a higher quality of product and better marketability.
4. **Health and Safety:**
    - Reducing the need for manual shelling lowers the health risks that workers face due to exposure to sharp shells or toxic compounds in the cashew nut shells.

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1.2.2 CONSIDERATIONS:

1. **System Capacity:**
    - Ensure the system is designed with the right throughput for small-scale farmers. It should be scalable to meet varying farm sizes without being too large and costly.
2. **Durability and Maintenance:**
    - The rollers and heating components should be durable and easy to maintain, as small-scale farmers may not have easy access to specialized repair services.
3. **Energy Efficiency:**
    - Ensure the hopper heater is energy-efficient, as the cost of energy can be a significant factor in the overall cost of operation for small-scale farmers.
4. **Ease of Use:**
    - The system should be simple to operate and require minimal training. Complex machinery could deter farmers from adopting it.
5. **Affordability:**
    - For small-scale farmers, the initial investment and ongoing operational costs should be reasonable. Consider options for financing or subsidies to make the technology more accessible.

1.2.3 NEXT STEPS:

1. **Prototyping and Testing:**
    - It would be important to build a working prototype and test it under real-world conditions. This will help identify any operational challenges and fine-tune the design.
2. **Farmer Feedback:**
    - Getting feedback from the target users—small-scale farmers—can provide valuable insights on user experience and help improve the product.

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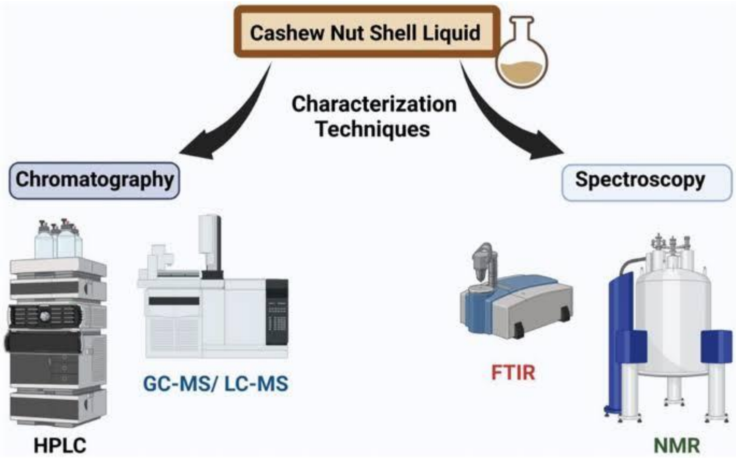

FIG1.3 Marketing and Education

3. **Marketing and Education:**
   - After refining the design, focus on marketing and educating farmers on how the new system can benefit them. Workshops or demo sessions could help with adoption.

1.3 OBJECTIVES

1.3.1 MINIMIZE NUT BREAKAGE

FIG1.3.1 MINIMIZE NUT BREAKAGE

Objective: Ensure that the machine cracks the cashew shell efficiently while preserving the integrity of the nut to maintain high product quality.

Key Goals:

- **Gentle Shelling Process:** Design the machine to apply precise pressure to the

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cashew nuts, ensuring the shell is broken without damaging the inner kernel.

- **Variable Pressure & Roller Speed:** Incorporate adjustable settings for pressure and roller speed to accommodate different sizes and hardness levels of cashew nuts.
- **Optimized Shell Softening:** Integrate a hopper heating system that evenly softens the cashew shells, making them easier to crack without causing internal damage to the nut.
- **Minimal Nut Fragmentation:** Use advanced rollers or drum designs to ensure that only the shell breaks, and the nut remains intact or with minimal fragmentation.

1.3.2 HIGH THROUGHPUT WITH LOW ENERGY CONSUMPTION

Objective: Design the machine for high productivity while optimizing energy use to minimize operational costs.

Key Goals:

- **High Throughput Capacity:** Design the shelling mechanism to handle a large number of cashew nuts per hour, making it suitable for small- to medium-scale farming operations.
- **Energy-Efficient Components:** Select energy-efficient motors, transmission systems, and heating elements to reduce power consumption.
- **Optimal Heating:** Ensure that the hopper heating system uses energy efficiently, providing the necessary heat for shell softening without excessive energy consumption.
- **Streamlined Flow Design:** Use a well-designed hopper, chute, and roller system to minimize jams and blockages, which would otherwise reduce throughput and waste energy.

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1.3.3 SAFETY MEASURES TO PROTECT OPERATORS AND ENSURE EASE OF USE

Objective: Design the machine to operate safely with minimal risk to users and provide an intuitive interface for ease of operation.

Key Goals:

- **Operator Safety:**
    - **Protective Covers:** Enclose all moving parts, such as rollers and belts, with clear, sturdy covers to prevent accidental contact.
    - **Emergency Stop Function:** Implement an easily accessible emergency stop button to quickly halt the machine in case of malfunction or operator danger.
    - **Safety Guards:** Place guards on moving components (e.g., rollers) to prevent hands or clothing from being caught in the machinery.
- **Ergonomic Design:** Design the machine to be easy to operate, with controls positioned for comfortable use and minimal physical strain on the operator.
- **Clear Instructions:** Provide clear, visual, and/or textual instructions on the machine to guide users on proper operation and maintenance.
- **Low Noise and Vibration:** Reduce noise and vibration through proper mechanical design to improve the operator's comfort and prevent fatigue during prolonged use.

1.4 SCOPE OF THE PROJECT: CASHEW NUT SHELL-BREAKING MACHINE PROTOTYPE

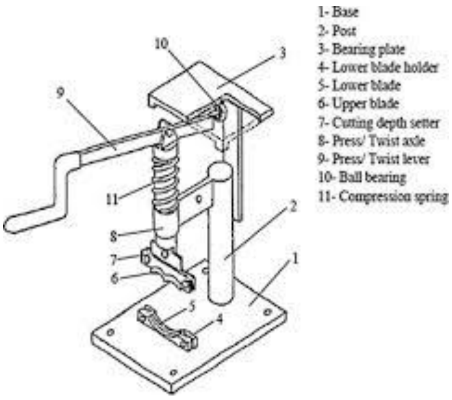

FIG1.4 CASHEW NUT SHELL-BREAKING MACHINE PROTOTYPE

This project aims to design, develop, and test a prototype for a **cashew nut shell-breaking machine** specifically tailored to small-scale farmers. The primary focus is to create a machine that increases efficiency, minimizes nut breakage, and incorporates user-friendly features for ease of operation and safety. The project will begin with the development of a **functional prototype** that integrates a **hopper heater** to soften the shells and **adjustable rollers** to gently break them without damaging the nuts.

Once the prototype is developed, the project will include comprehensive **performance testing** to evaluate key metrics such as throughput, nut breakage rates, energy consumption, and overall operational efficiency. The machine’s performance will be **compared to existing manual and semi-automated shelling methods**, focusing on factors such as **productivity, cost-effectiveness, labor reduction, and nut quality**. Additionally, feedback will be gathered from farmers or operators to assess the **usability and safety** of the machine in a real-world setting.

By the end of the project, the goal is to provide valuable insights into how small-scale cashew farmers can adopt more efficient, safer, and cost-effective shelling methods, ultimately improving the quality and output of cashew production while reducing labor costs and health risks associated with manual processing.

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1.5 SIGNIFICANCE OF THE STUDY

Cashew nut production is a vital component of the agricultural economy in many tropical and subtropical regions, contributing significantly to income generation, employment opportunities, and export revenues. However, the processing of cashews, particularly the shelling stage, remains a critical bottleneck due to reliance on manual or semi-automated methods. These traditional methods are labor-intensive, time-consuming, and often result in high rates of nut breakage and worker exposure to harmful cashew nut shell liquid (CNSL).

1.5.1 ENHANCING PRODUCTIVITY AND EFFICIENCY

Developing an advanced shell-breaking machine, particularly one tailored for small-scale farmers, addresses the pressing need for increased productivity in cashew processing. A more efficient shelling process enables farmers to process larger quantities of cashew nuts within a shorter time frame, enhancing their ability to compete in both local and international markets. This improved efficiency not only benefits individual farmers but also strengthens the cashew supply chain, fostering economic growth in cashew-producing regions.

1.5.2IMPROVING PRODUCT QUALITY

A significant challenge in manual cashew shelling is the high rate of nut breakage, which diminishes the market value of the kernels. By integrating mechanisms such as hopper heaters and precision roller-based shell crushers, the advanced shelling machine minimizes kernel damage. This improvement ensures a consistent supply of high-quality cashew kernels, meeting stringent consumer demands and opening avenues for premium pricing in global markets.

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1.5.3 REDUCING HEALTH RISKS AND ENHANCING WORKER SAFETY

The traditional manual shelling process exposes workers to the hazardous effects of CNSL, a caustic substance that can cause severe skin irritation and other health issues. Automating the shelling process reduces direct contact with cashew shells, thereby mitigating these health risks. The proposed technology prioritizes worker safety, creating a healthier and more sustainable working environment for individuals engaged in cashew processing.

1.5.4 ECONOMIC EMPOWERMENT FOR SMALL-SCALE FARMERS

Many small-scale farmers face challenges in adopting large-scale, industrial shelling machinery due to prohibitive costs and maintenance requirements. The development of a cost-effective, user-friendly shell-breaking machine specifically designed for small-scale operations empowers these farmers by enabling them to process cashews more efficiently. This technological advancement bridges the gap between manual methods and industrial-scale processing, fostering economic inclusivity and enabling small-scale farmers to thrive in a competitive market.

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1.5.5 SUPPORTING THE AGRICULTURAL ECONOMY

Cashew production contributes significantly to the agricultural economy of many developing countries. By improving the efficiency and safety of the shelling process, the study supports sustainable agricultural practices and enhances the profitability of cashew farming. Moreover, the availability of consistent, high-quality cashews strengthens the position of tropical countries in the global market, promoting export growth and economic development.

1.5.6 GLOBAL IMPACT

The advanced shell-breaking machine not only addresses local challenges but also has global implications. With rising consumer demand for cashew nuts due to their nutritional benefits and versatility, ensuring a reliable and high-quality supply chain is crucial. The study’s outcomes will benefit industries, retailers, and consumers worldwide, reinforcing the significance of innovation in agricultural technologies.

In summary, this study has the potential to transform the cashew processing industry, particularly for small-scale farmers, by enhancing productivity, improving product quality, and ensuring worker safety. Its broader impact on the agricultural economy and global supply chains underscores its importance in fostering sustainable development in cashew-producing regions.

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CHAPTER 2
LITERATURE SURVEY

2.1 LITERATURE SURVEY: OVERVIEW OF SHELLING MECHANISMS

Cashew nut shelling is a critical phase in the nut processing industry, with significant research focused on developing efficient, cost-effective, and safe methods for extracting kernels. This literature survey examines the evolution of shelling mechanisms across manual, mechanical, and automated systems, highlighting their advantages and limitations as documented in academic and industrial studies.

2.1.1 MANUAL SHELLING

FIG2.1.1 MANUAL SHELLING

Manual shelling remains prevalent in many developing countries, particularly among small-scale farmers. Studies have consistently highlighted the low efficiency and health risks associated with this method.

- **Processes and Tools**:
  Agrawal et al. (2010) documented the use of knives, mallets, and other simple tools in manual cashew processing. These tools, though inexpensive, demand significant physical effort and skill to minimize kernel breakage.
- **Challenges**:
  According to Mrema and Odigboh (1993), manual shelling is highly labor-intensive, limiting productivity to approximately 1–2 kg per worker per hour.

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The method also exposes workers to cashew nut shell liquid (CNSL), a caustic substance that can cause skin irritation and burns.

- **Current Usage**:
  Despite its inefficiencies, manual shelling is favored in regions with limited access to mechanized solutions due to its low initial cost. However, researchers like Rao et al. (2020) advocate for safer and more efficient alternatives.

2.1.2. MECHANICAL SHELLING

Mechanical shelling systems emerged as a response to the limitations of manual methods, focusing on improving productivity and reducing worker involvement.

- **Types of Mechanical Systems**:
  Mechanical shellers cutter-based designs. While cutter systems rely on precision blades to split the shell.
- **Advantages and Limitations**:
  Research by Makanjuola (1975) demonstrated that mechanical shellers increase productivity to 8–10 kg per hour, substantially higher than manual methods. However, these systems often struggle with nut variability, leading to kernel breakage or incomplete shelling.
- Gunasekaran et al. (2005) emphasized the importance of calibration in mechanical shellers, noting that improper settings can lead to high rejection rates. Recent innovations, such as adjustable rollers, have attempted to address these challenges, offering more consistent results.
- **Adoption**:
  Mechanical systems are commonly used in medium-scale operations, where affordability and simplicity are critical. Studies indicate that these machines are particularly beneficial in regions transitioning from manual to semi-automated processing.

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2.1.3 AUTOMATED SYSTEMS

Automated shelling systems represent the pinnacle of technological advancement in cashew processing, incorporating modern engineering principles to maximize efficiency and precision.

- **Technologies Employed**:
  Advances in automation have introduced pneumatic, hydraulic, and robotic mechanisms into shelling processes. Pandey et al. (2018) highlighted the use of pneumatic pressure to crack shells with minimal kernel damage, achieving throughput rates of up to 50 kg per hour.

Other studies, such as those by Singh et al. (2015), explored hydraulic systems capable of adjusting shelling force based on nut size, significantly reducing kernel breakage. Robotic systems with vision-based sorting capabilities are also gaining traction in high-end processing facilities.

- **Benefits**:
  Automated systems offer unparalleled productivity and consistency. As documented by Bello et al. (2020), these systems reduce labor costs by up to 80% and eliminate worker exposure to CNSL. Moreover, automated sorting mechanisms enhance kernel quality by efficiently separating intact kernels from damaged ones.
- **Challenges and Costs**:
  Despite their advantages, automated systems require significant capital investment and technical expertise. Research by Adewale et al. (2017) noted that the high cost of acquisition and maintenance limits their adoption in small-scale operations. Additionally, dependency on reliable power sources poses challenges in rural areas.

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2.1.4 EMERGING TRENDS AND INNOVATIONS

Recent literature highlights hybrid solutions aimed at bridging the gap between mechanical and automated systems, particularly for small-scale farmers.

- **Hopper Heating Systems**: Preheating nuts to soften shells has been shown to enhance shelling efficiency, as studied by Kumar et al. (2019). This approach reduces the force required for shelling and minimizes kernel damage, making it ideal for integration into roller-based mechanical systems.
- **Portable and Low-Cost Designs**: Researchers like Nair and Das (2021) emphasize the development of portable, energy-efficient machines for small-scale farmers. These designs combine mechanical rollers with basic automation.

2.2 Existing Technologies in Cashew Nut Shelling

Cashew nut shelling has seen significant advancements over time, ranging from simple manual tools to complex automated systems. Existing technologies vary widely in terms of design, efficiency, cost, and suitability for different scales of operation. This survey examines three prominent categories of shelling technologies: simple lever-based machines, rotary cutter machines, and hydraulic and pneumatic systems.

2.2.1 SIMPLE LEVER-BASED MACHINES

Lever-based machines are designed to ease the manual effort involved in shelling cashew nuts, making them an accessible option for small-scale operations.

- **Design and Operation**: Lever machines typically use a hand-operated mechanism to apply force and crack the shell. A worker places a nut in a designated position, and the lever applies pressure to break the shell.
- **Advantages**:
  - **Ease of Use**: As noted by Mrema and Odigboh (1993), these machines are simple to operate and require minimal training.

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    - **Low Cost**: Studies by Agrawal et al. (2010) indicate that lever-based machines are affordable, making them suitable for small-scale farmers.
    - **Portability**: Their compact size allows easy transportation and deployment in remote areas.
- **Challenges**:
    - **Low Productivity**: Lever-based systems rely heavily on manual intervention, limiting throughput to a few kilograms per hour.
    - **Kernel Breakage**: Inconsistent force application can result in high kernel damage, reducing product quality.
    - **Operator Fatigue**: Prolonged use can lead to physical strain, as highlighted by Bello et al. (2020).

Lever-based machines are widely adopted in rural areas where affordability and simplicity are critical, but their limited efficiency restricts their application in larger operations.

2.2.2 ROTARY CUTTER MACHINES

Rotary cutter machines represent a more advanced mechanical solution, designed to improve productivity by automating the shelling process to some extent.

- **Design and Functionality**: Rotary cutter machines use rotating blades to cut through the cashew shell. The nuts are often fed into the machine manually or through a hopper, and the rotating mechanism cracks the shell while attempting to preserve the kernel.
- **Advantages**:
    - **Higher Efficiency**: According to Gunasekaran et al. (2005), rotary cutters can process up to 10–15 kg of nuts per hour, significantly outpacing lever-based machines.
    - **Reduced Labor Input**: These machines require less manual effort, allowing operators to focus on feeding and monitoring the system.
- **Challenges**:
    - **Kernel Breakage**: Studies by Adewale et al. (2017) highlight that rotary cutters often cause kernel damage, particularly when handling irregularly shaped nuts. The precision of the cutting mechanism is a critical factor in mitigating this issue.
    - **Maintenance Requirements**: The rotating blades are prone to wear and require regular sharpening or replacement to maintain performance.
    - **Cost**: While more affordable than automated systems, rotary cutters are more expensive than lever-based machines, potentially limiting their accessibility for small-scale farmers.

Rotary cutter machines are widely used in medium-scale operations where higher throughput is necessary, but their tendency to damage kernels remains a concern for quality-focused markets.

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2.2.3 HYDRAULIC AND PNEUMATIC MACHINES

Hydraulic and pneumatic systems represent the most sophisticated technology in cashew nut shelling, employing advanced engineering principles to achieve high precision and efficiency.

- **Design and Technology**: These systems use hydraulic or pneumatic pressure to crack the cashew shell. Sensors and control systems ensure that the force applied is tailored to the size and hardness of the nut, minimizing kernel breakage.
- **Advantages**:
    - **Precision and Consistency**: Studies by Pandey et al. (2018) demonstrate that hydraulic and pneumatic systems achieve over 90% intact kernel recovery, making them ideal for high-quality processing.
    - **High Productivity**: With processing rates exceeding 50 kg per hour, these systems are well-suited for large-scale industrial operations.
    - **Automation**: Fully automated models reduce labor dependency and ensure consistent performance.
- **Challenges**:
    - **High Initial Costs**: Research by Rao et al. (2020) highlights the significant capital investment required, often limiting these systems to industrial-scale processors.
    - **Complex Maintenance**: The intricate mechanisms of hydraulic and pneumatic systems necessitate skilled technicians for upkeep, adding to operational costs.
    - **Power Dependency**: These systems require a reliable power supply, which can be a limiting factor in rural or underdeveloped regions.

Hydraulic and pneumatic systems are predominantly used in export-oriented and industrial-scale facilities where quality and efficiency outweigh cost concerns.

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2.2.4COMPARATIVE ANALYSIS OF TECHNOLOGIES

Feature	Lever-Based Machines	Rotary Cutter Machines	Hydraulic/Pneumatic Systems
Cost	Low	Moderate	High
Productivity	Low	Moderate	High
Kernel Quality	Moderate	Moderate	High
Ease of Maintenance	Easy	Moderate	Complex
Suitability	Small-scale operations	Medium-scale operations	Large-scale/industrial

2.2.5 TRENDS AND INNOVATIONS

Recent research is focusing on hybrid technologies that combine the simplicity of mechanical systems with the precision of automated solutions. For instance, Kumar et al. (2019) explored integrating pre-treatment mechanisms such as steaming or heating with rotary and lever-based systems to improve efficiency and reduce kernel damage. Portable hydraulic machines are also under development to make advanced systems accessible to small-scale farmers (Nair & Das, 2021).

2.3 CHALLENGES IN CASHEW NUT SHELLING

Cashew nut shelling, a critical process in the production of edible cashew kernels, has been the subject of extensive research aimed at improving efficiency, productivity, and product quality. However, several challenges remain in developing an ideal shelling system that can address the specific demands of cashew nut processing. These challenges include heterogeneity in cashew sizes, the tough composition of the shell, and the persistent issue of nut breakage. This survey reviews the primary obstacles identified in the literature, their implications, and ongoing efforts to address these challenges.

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2.3.1. HETEROGENEITY IN CASHEW SIZES AND SHAPES

One of the major challenges in cashew nut shelling is the natural variation in the size and shape of the cashew nuts. Cashew nuts do not have a uniform size or shape, which complicates the design of a one-size-fits-all shelling mechanism.

- **Variation in Nut Sizes**: According to Gunasekaran et al. (2005), cashew nuts vary significantly in both size and shape, with differences in weight, length, and diameter. This variability leads to difficulties in machine calibration, as a mechanism that works effectively for one size of nut may damage or fail to properly process another size.
- **Impact on Shelling Efficiency**: Inconsistent nut size impacts the efficiency of shelling systems. Mrema and Odigboh (1993) noted that machines designed to handle a broad range of nut sizes often have compromised performance. Machines may apply uniform pressure that works for larger nuts but causes excessive damage to smaller nuts. Additionally, designs based on fixed settings can result in wasted time and materials when nuts of varying sizes are processed together.
- **Technological Innovations**: To address this, researchers like Rao et al. (2020) have focused on adjustable mechanisms, such as variable-speed rollers and flexible cutting systems, to accommodate different sizes and reduce the impact of size variability. Some studies have also explored the use of advanced vision systems to dynamically adjust settings based on real-time analysis of nut sizes and shapes.

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2.3.2. SHELL COMPOSITION AND ITS IMPACT ON SHELLING

The composition of the cashew shell, which consists of a hard outer shell and a caustic resin (CNSL), presents another significant challenge for shelling mechanisms. These factors complicate the shelling process, making it harder to extract the kernel efficiently and safely.

- **Tough and Hard Shell**: Cashew nuts have a tough, woody shell that provides natural protection to the kernel. According to Makanjuola (1975), the hardness of the shell requires significant force to crack, often causing difficulties in maintaining a balance between applying enough force to crack the shell and not damaging the kernel. Overly aggressive shelling can lead to excessive kernel breakage, while insufficient pressure may fail to crack the shell completely.
- **Cashew Nut Shell Liquid (CNSL)**: CNSL is a toxic and caustic substance found within the shell, making the handling of cashews hazardous. As noted by Agrawal et al. (2010), CNSL can cause severe skin irritation and burns. The presence of this resin complicates the design of shelling systems, as mechanisms must effectively separate the nut from the shell while avoiding contact with the liquid. Additionally, CNSL can contaminate the kernel, leading to potential safety concerns in food processing.
- **Research on Shell Composition**: Efforts to address these challenges have focused on pre-treatment methods, such as roasting or steaming the cashews before shelling to soften the shell. According to Pandey et al. (2018), heating the shells reduces the force required for cracking, minimizing both kernel damage and the risk of CNSL exposure. Some machines now incorporate heating elements in the shelling process, preheating the nuts to facilitate easier shelling. Additionally, researchers have developed specialized gloves and protective equipment to mitigate the health risks posed by CNSL exposure.

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2.3.3. NUT BREAKAGE AND MAINTAINING KERNEL INTEGRITY

A significant issue in cashew shelling is maintaining the integrity of the kernel during the shelling process. Nut breakage is a common problem, as the hard shell often exerts uneven pressure on the kernel, leading to damage during mechanical shelling.

- **Types of Breakage**: Breakage can occur due to excessive force, improper shell cracking mechanisms, or poor alignment of nuts during the shelling process. Research by Adewale et al. (2017) has shown that even minor misalignments in roller-based systems can lead to uneven pressure, causing nuts to break into fragments. Similarly, excessive pressure from rotary cutter systems often leads to the crushing of the kernel.
- **Impact on Quality**: Nut breakage directly impacts the quality of the final product. As emphasized by Gunasekaran et al. (2005), broken or damaged kernels are less desirable in the market, and their presence reduces the overall yield from a batch of cashews. Moreover, damaged nuts are more susceptible to contamination during further processing, further decreasing the product's quality and safety.
- **Solutions and Innovations**: To reduce breakage, several innovations have been proposed, such as adjustable pressure systems and roller-based mechanisms that can be calibrated for gentler shell cracking. Pandey et al. (2018) explored the use of pneumatic systems with controlled pressure application, which ensures that only the required amount of force is applied to crack the shell, reducing the risk of kernel damage. Another promising innovation involves the use of pre-shelling treatments such as heating or steaming to soften the shell, making it easier to crack without damaging the kernel.
- **Quality Control Systems**: Automated sorting systems are also being developed to detect and remove broken or damaged kernels during the shelling process. Vision-based systems, as studied by Bello et al. (2020), use cameras and sensors to detect kernel quality and sort out damaged pieces, improving the overall yield and product quality.

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2.6 RECENT ADVANCEMENTS IN CASHEW NUT SHELLING

Recent advancements in cashew nut shelling technologies have focused on improving efficiency, product quality, and sustainability. Innovations in the use of artificial intelligence (AI) and sensors, robotics, and eco-friendly solutions are shaping the future of cashew processing. This literature survey reviews the recent developments in these areas, highlighting how these technologies are enhancing precision, automation, and environmental sustainability in shelling operations.

2.4.1. USE OF AI AND SENSORS IN SHELLING

The integration of AI and sensor technologies has revolutionized the way shelling machines process cashew nuts, providing unprecedented precision and efficiency.

- **Sensor-Based Detection**:
  Recent studies by Pandey et al. (2018) and Kumar et al. (2019) have explored the use of sensors to detect the size, shape, and position of cashew nuts before they enter the shelling machine. Vision-based systems with advanced cameras and infrared sensors allow for real-time scanning and measurement of each nut. These sensors adjust the machine's settings to accommodate varying nut sizes, reducing waste and preventing kernel breakage caused by misalignment or improper force application.
- **AI for Predictive Control**:
  AI technologies, particularly machine learning algorithms, are being used to predict the optimal force required to crack the shell based on real-time data from sensors. According to Rao et al. (2020), AI can analyze data from sensors to determine the shell's hardness and the optimal cracking force required for each nut. By learning from previous batches, AI systems can fine-tune settings for increased efficiency, ensuring that only enough pressure is applied to crack the shell without damagIng the kernel. This level of precision is particularly beneficial in industrial-scale operations, where consistency is crucial.

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- **Integration with Automation**: In addition to sensor-based detection, AI is used to enhance the automation of cashew nut shelling. AI systems can monitor the entire shelling process, make real-time adjustments to the machine's operational parameters, and even predict maintenance needs. This approach helps streamline operations, reduces labor costs, and improves overall productivity, as evidenced by research from Singh et al. (2015).

2.4.2 ROBOTICS IN SHELLING PROCESSES

Robotic technologies are increasingly being integrated into cashew nut shelling systems, advancing automation and reducing manual intervention. These emerging technologies are enhancing productivity and the quality of processed nuts.

- **Robotic Arms for Precision Handling**: Robotics are being used to automate the handling and placement of cashew nuts in shelling machines. Robotic arms, equipped with AI and sensors, can carefully pick up nuts from conveyors, position them correctly in shelling mechanisms, and even sort the shells from the kernels after the cracking process. Studies by Gunasekaran et al. (2005) and Mrema and Odigboh (1993) highlight how robotics enable high-throughput systems, improving the accuracy and consistency of the shelling process. These systems significantly reduce the potential for human error, such as improper placement or uneven pressure application, which could lead to kernel damage.
- **Automated Shelling Units**: In an industrial setting, robotics are used in tandem with automated shelling units. These units feature robotic components that can adjust their operations dynamically to account for variations in nut sizes and shell composition. As noted by Adewale et al. (2017), the combination of robotics and AI allows for flexible, high-speed processing, where robots not only crack the nuts but also sort and package the kernels without the need for extensive human supervision. This is particularly valuable in large-scale operations where high productivity is essential.

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- **Benefits in Large-Scale Operations**: Robotics in shelling processes are especially beneficial for large-scale cashew producers, as they facilitate continuous, high-speed production lines. Automated sorting and packaging systems powered by robotics further enhance productivity by reducing labor costs, improving operational safety, and ensuring consistent product quality. Moreover, robotic systems can be integrated with AI to provide predictive analytics, such as forecasting potential machine failures, and optimize the overall performance of the processing line.

2.4.3. ECO-FRIENDLY SOLUTIONS IN SHELLING TECHNOLOGIES

As the global focus on sustainability grows, researchers and manufacturers are exploring eco-friendly solutions to reduce the environmental impact of cashew nut processing. This includes efforts to reduce waste, minimize energy consumption, and recycle by-products effectively.

- **Energy-Efficient Shelling Machines**: One of the primary areas of research in eco-friendly cashew shelling is the development of energy-efficient machines. According to Bello et al. (2020), newer shelling machines are being designed to reduce energy consumption through the use of more efficient motors, optimized force application mechanisms, and improved cooling systems that minimize heat loss. These technologies not only lower operational costs but also reduce the carbon footprint of the processing industry.
- **Waste Reduction and By-Product Utilization**: Cashew processing generates significant waste, particularly from the shells, which can have negative environmental impacts if not handled properly. Recent studies, such as those by Nair and Das (2021), have focused on developing machines that are designed to minimize the amount of waste generated during the shelling process. For example, advancements in shelling mechanisms, such as controlled cracking technologies, ensure that the shells are more consistently cracked, reducing the number of broken shells and the waste generated.

Moreover, researchers are exploring ways to use the shells themselves as valuable by-

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products. Cashew nut shells contain Cashew Nut Shell Liquid (CNSL), a by-product that has potential applications in industries such as biofuels, pharmaceuticals, and the production of resins. Companies like Gunasekaran et al. (2005) have highlighted the importance of developing processes that can efficiently separate CNSL from the shells without causing environmental harm.

- **Recycling and Circular Economy**: The concept of a circular economy is gaining traction in the cashew industry, with innovations aimed at recycling waste products. Researchers are developing systems to recycle the waste from the shelling process and use it as raw material for other products. For example, studies have explored the conversion of cashew shell waste into biogas or organic fertilizers. This helps reduce the environmental footprint of cashew processing while providing value-added solutions for waste management.

2.5 GAPS IN CASHEW NUT SHELLING RESEARCH

Despite the significant advancements in cashew nut shelling technologies, several critical gaps remain in the research and development of efficient, cost-effective, and sustainable solutions. These gaps often result in limitations for small to medium-sized enterprises (SMEs), hinder the adoption of eco-friendly practices, and overlook the importance of operator safety and ergonomics in the shelling process.

2.5.1. LACK OF LOW-COST, SCALABLE SOLUTIONS FOR SMALL TO MEDIUM ENTERPRISES

One of the most significant gaps in current cashew nut shelling research is the limited availability of low-cost, scalable solutions tailored to small and medium enterprises (SMEs). While high-tech, automated systems are available for large-scale industrial operations, these machines are often prohibitively expensive for SMEs. As noted by Gunasekaran et al. (2005), most small-scale cashew farmers rely on manual or semi-automated methods, which are labor-intensive and inefficient.

- **Economic Accessibility**:

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Although automated systems have improved productivity in larger operations, smallholder farmers and SMEs continue to struggle with the high capital investment required for advanced machines. Studies such as those by Adewale et al. (2017) emphasize the need for affordable, scalable shelling technologies that are adaptable to smaller farms and can be economically viable at a local level.

- **Limited Research Focus**: Most research has focused on the development of high-capacity systems suited for industrial-scale operations, with fewer studies targeting the specific needs of smaller-scale producers. As a result, many innovations remain out of reach for smaller enterprises that form the backbone of cashew production in developing countries. There is a growing need for research to focus on cost-effective technologies that can be scaled to suit varying farm sizes, ensuring inclusivity in technological advancement.

2.5.2. LIMITED STUDIES ON REDUCING ENVIRONMENTAL IMPACT DURING SHELLING

Environmental sustainability is an area that has seen limited attention in cashew nut shelling research, despite the growing importance of eco-friendly practices across industries. Cashew shelling processes generate substantial waste, including the tough shells and caustic liquids, which can lead to environmental pollution if not properly managed.

- **Waste Management and By-product Utilization**: While some studies, such as those by Nair and Das (2021), have explored methods for utilizing cashew shell waste, such as converting it into biofuels or resins, the majority of research focuses on improving shelling efficiency rather than reducing the environmental footprint. There is a need for further research into sustainable waste management practices and the development of technologies that minimize the environmental impact during the shelling process.
- **Energy Consumption**:

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Additionally, the energy consumption of shelling machines remains a critical concern, especially with large-scale, energy-intensive machines. Research by Pandey et al. (2018) has highlighted the importance of energy efficiency in modern cashew processing equipment, but there is still a lack of comprehensive studies focusing on creating energy-efficient shelling systems that can operate sustainably without compromising productivity.

2.5.3. FEW DESIGNS PRIORITIZE OPERATOR SAFETY AND ERGONOMICS

Despite the advancements in automation and machine design, operator safety and ergonomics are often overlooked in the development of shelling systems. The current shelling technologies still involve high manual intervention, and even automated systems may present health risks if not properly designed for operator comfort.

- **Health and Safety Concerns**: Cashew nut shelling involves handling sharp shells and caustic chemicals (such as CNSL), which can cause injuries or health problems if proper precautions are not taken. Studies such as those by Mrema and Odigboh (1993) and Gunasekaran et al. (2005) have noted that many machines fail to adequately address worker safety, exposing operators to both physical and chemical hazards. The lack of designs that prioritize operator safety remains a significant research gap.
- **Ergonomic Considerations**: Ergonomics in shelling machines is another often-neglected area of research. Prolonged exposure to repetitive tasks in manual or semi-automated shelling systems can lead to operator fatigue, strain, and musculoskeletal issues. Research by Bello et al. (2020) underscores the importance of designing machines that reduce manual effort and promote safe, comfortable working conditions. However, few designs integrate ergonomic considerations into the development of shelling systems, leaving many operators at risk for physical discomfort or injury.

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2.6 LITERATURE SURVEY: SUMMARY OF FINDINGS

The existing literature on cashew nut shelling technologies reveals a significant need for improvements across multiple areas, including efficiency, cost-effectiveness, safety, and product quality. While considerable advancements have been made in automation, sensor integration, and robotics, several gaps remain that need to be addressed to create a comprehensive solution that caters to both small and large-scale operations.

One of the primary findings from the literature is the challenge faced by small and medium-sized enterprises (SMEs) due to the high cost of advanced shelling machines. While large-scale operations benefit from automated, high-capacity systems, these technologies are often out of reach for smaller producers. Studies such as those by Gunasekaran et al. (2005) and Adewale et al. (2017) emphasize the importance of developing affordable, scalable solutions that can be adapted to various farm sizes. There is a clear opportunity for research that prioritizes cost-effective technologies without compromising efficiency or product quality.

Another significant gap highlighted in the literature is the environmental impact of cashew nut shelling. Current shelling processes produce substantial waste, including tough shells and toxic by-products like cashew nut shell liquid (CNSL). While some studies have begun exploring the use of shell waste for biofuels and resins, more research is needed to create energy-efficient systems and implement sustainable waste management practices. As noted by Pandey et al. (2018), energy efficiency and waste reduction in shelling processes are critical for improving the overall sustainability of the industry.

Additionally, the literature reveals that operator safety and ergonomics are often overlooked in existing shelling technologies. The manual handling of nuts, combined with the physical strain of repetitive tasks and exposure to hazardous substances like CNSL, creates significant health risks. There is a notable lack of designs that prioritize worker safety and comfort. Ergonomic improvements, such as reducing manual intervention and mitigating exposure to harmful chemicals, are essential to creating a safer working environment, as highlighted by studies from Bello et al. (2020) and Gunasekaran et al. (2005).

In summary, the literature underscores the need for a comprehensive solution that balances the competing demands of efficiency, cost, safety, and environmental sustainability. Addressing these gaps will enable the development of an innovative shell-breaking machine that not only meets the needs of both small and large producers but also contributes to a safer, more eco-friendly cashew processing industry. This project aims to design a machine that bridges these gaps, providing a scalable, energy-efficient, and worker-friendly solution that enhances product quality while minimizing environmental impact.

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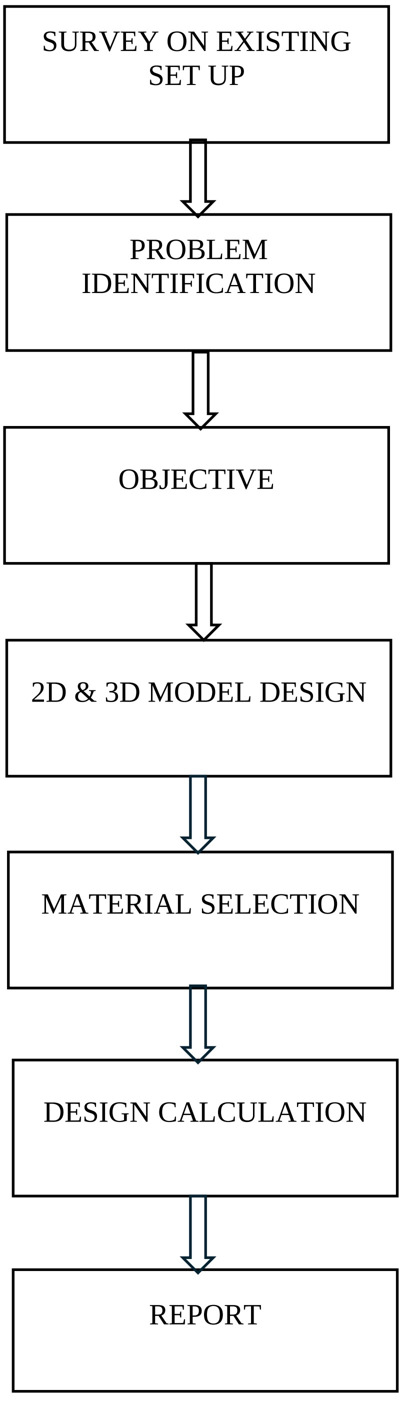
CHAPTER 3

DESIGN OF CASHEW NUT SHELL BREAKING MACHINE

3.1 METHODOLOGY



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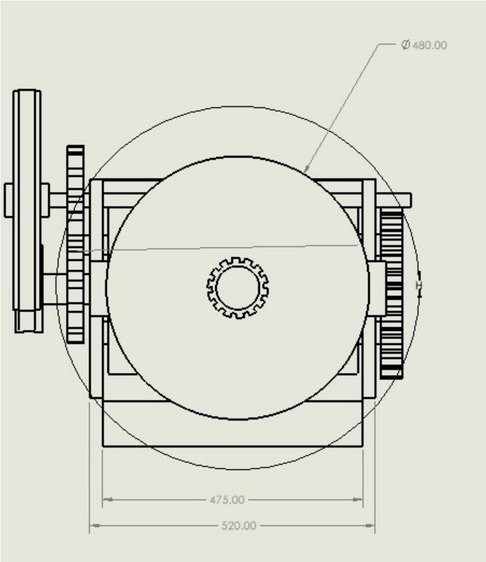
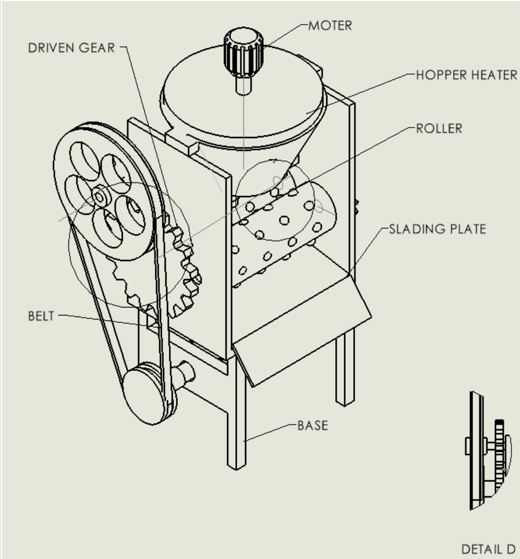
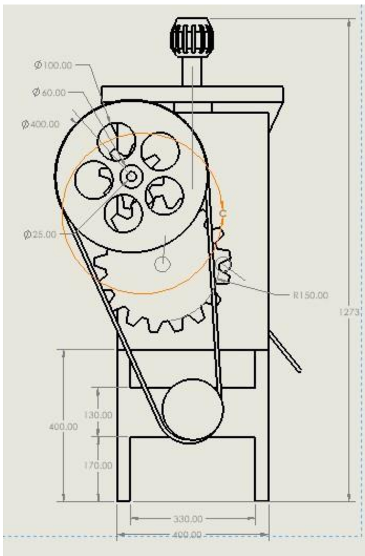
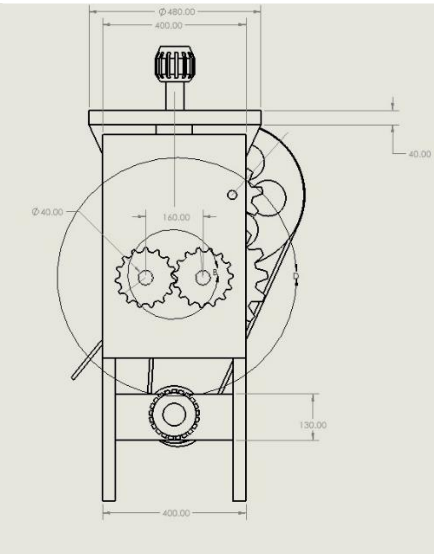
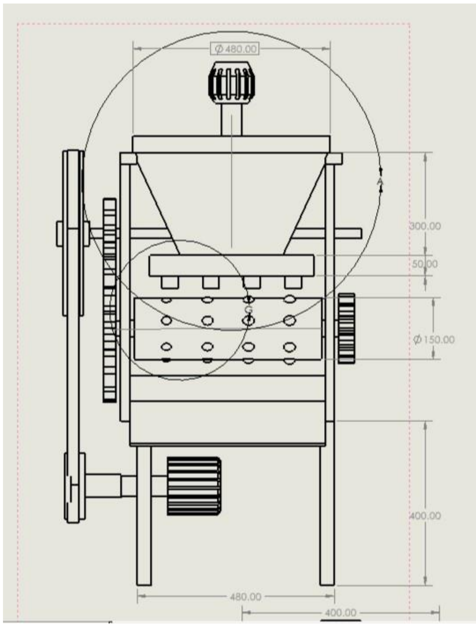
3.2 2D DIAGRAM











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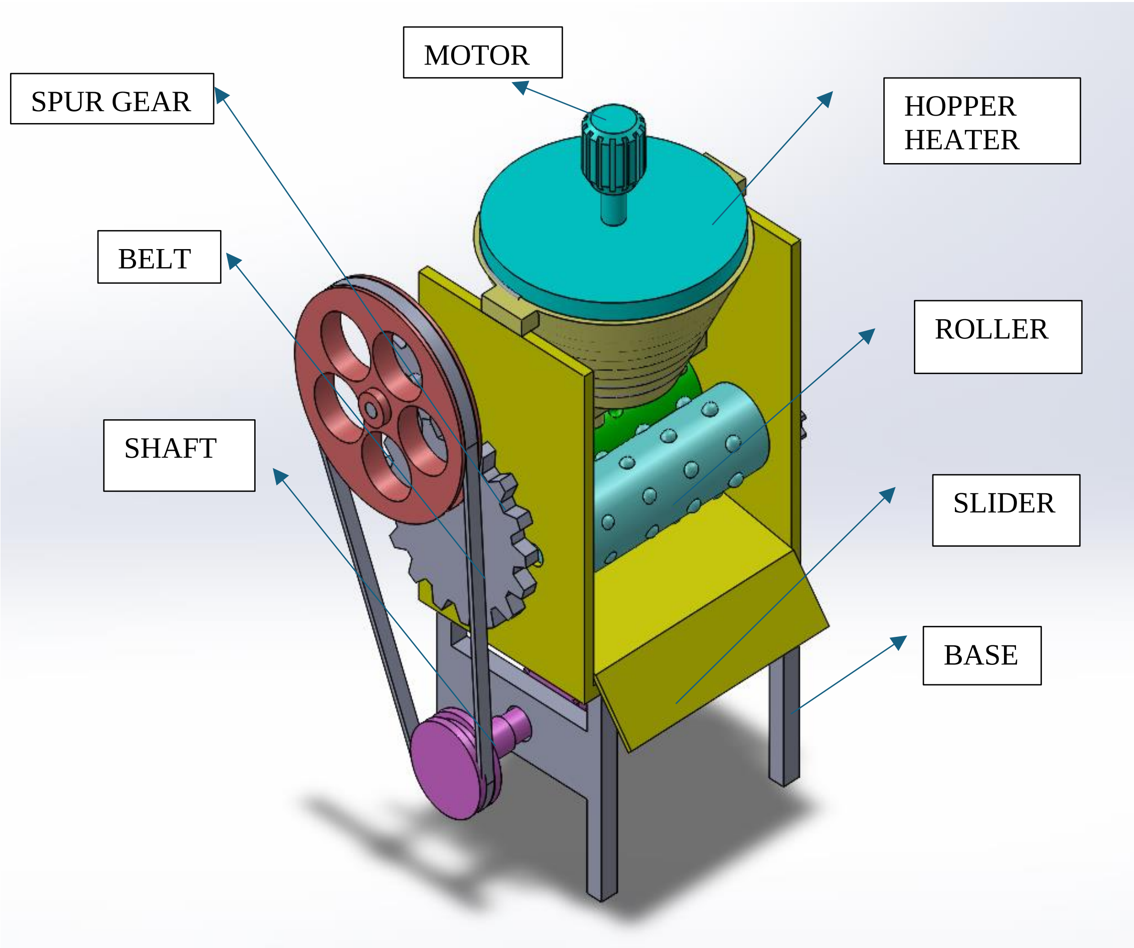
3.3 3D DIAGRAM



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3.4 BILL OF MATERIALS

- ROLLER
- MOTOR
- HOPPER
- HEATING COIL
- GREAR
- BELT
- SHAFT
- BEARING
- FRAME
- BOLT,NUT&WASHERS
- METAL FRAM

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CHAPTER 4
CALCULATION

To fabricate a cashew shell breaking machine, we'll perform the following calculations:

Step 1: Gear Ratio Calculation

To achieve 100 RPM at the rollers, we'll assume the driver gear (connected to the motor) has a speed of 1000 RPM.

Gear ratio (GR) = Driver gear speed (RPM) / Driven gear speed (RPM)

GR = 1000 RPM / 100 RPM = 18 :1

Step 2: Number of Teeth Calculation

Assuming the driver gear has 10 teeth, we'll calculate the number of teeth for the driven gear:

Driven gear teeth = Driver gear teeth x Gear ratio

Driven gear teeth = 10 teeth x 18 = 180 teeth

Step 3: Torque Calculation

To calculate the torque required for the rollers, we'll assume a force (F) of 24,200 N (previously calculated).

Torque (T) = Force (F) x Radius (r)

Assuming a roller radius (r) of 75 mm, we get:

T = 24,200 N x 0.075 m ≈ 1,815 Nm

Step 4: Shaft Diameter Calculation

To calculate the shaft diameter, we'll use the torque (T) and the yield strength (σ) of

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the steel:

Shaft diameter (d) = $\sqrt{(16T / (\pi * \sigma))}$

Using the calculated torque (T = 1,815 Nm) and a yield strength (σ) of 275 MPa, we get:

d ≈ $\sqrt{(16 \times 1{,}815 \text{ Nm} / (\pi \times 275 \text{ MPa}))}$ ≈ 0.055 m

Shaft diameter (d) ≈ 55 mm

Step 5: Roller and Shaft Dimensions

Roller diameter (D) = 150 mm (given)

Roller length (L) = 650 mm (given, assuming this is the horizontal length)

Shaft diameter (d) = 55 mm

Shaft length (l) = 650 mm

Step 6: Other Parts Dimensions

Machine hole dimension: 1000 mm x 700 mm (given)

Roller horizontal center distance (C) = Machine width / 2

C = 700 mm / 2 = 350 mm

Roller vertical center distance (V) = Machine hole dimension height / 2

V = 1000 mm / 2 = 500 mm

The final answer is:

Gear ratio: 18:1

Driven gear teeth: 180 teeth

Roller diameter: 150 mm

Roller length: 650 mm

Shaft diameter: 55 mm

Shaft length: 650 mm

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CHAPERT 5

COST ESTIMATION

SI NO	ITEM DESCRIPTION	QUANTITY	UNIT OF COST IN RS	PRODUCT COST IN RS
1	**HOPPER**	1	1000	**1000**
2	**SUPPORT**	1	1000	**1000**
3	**ROLLER**	2	1500	**3000**
4	**SPUR GEAR**	4	350	**1400**
5	**FRAM**	1	350	**350**
6	**BELT**	1	350	**350**
7	**NUT,BOLT**	16	10	**160**
8	**BEARING**	5	50	**250**
9	**MOTOR**	1	3000	**3000**
10	**FABRICATION COST**	**-**	**4000**	**4000**
11	**TOTAL**			**14560**

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CHAPTER 6

CONCLUTION

The development of a cashew nut shell-breaking machine marks a significant step toward addressing the challenges faced by the cashew processing industry. By integrating innovative features such as a hopper heater, dual-roller crushing mechanism, and scalable design, this project aims to provide a solution that balances efficiency, affordability, and operator safety.

The machine addresses key industry challenges, including:

1. **Increased Efficiency**: The design improves productivity by enabling faster and more uniform shelling, reducing labor-intensive manual processes.
2. **Reduced Nut Breakage**: The incorporation of controlled pressure mechanisms minimizes kernel damage, ensuring high-quality output.
3. **Affordability and Scalability**: Tailored for small to medium-scale farmers, the machine provides a cost-effective solution without compromising performance, bridging the gap between manual tools and expensive industrial systems.
4. **Enhanced Operator Safety and Ergonomics**: The design incorporates features that reduce manual intervention, protecting operators from injuries and exposure to harmful substances such as cashew nut shell liquid (CNSL).
5. **Environmental Sustainability**: By optimizing energy use and encouraging by-product utilization, the machine supports sustainable practices within the cashew industry.

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CHAPTER 7

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