International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 02 | Feb - 2025 SJIF Rating: 8.448 ISSN: 2582-3930

Design and Development of a Semi-Automatic Coconut Broom Stick Machine

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Abstract

This paper focuses on the design and development of a semi-automatic machine to separate individual dry coconut leaves into their stick (stem) and leaf portions, aimed at streamlining broomstick production. The machine is powered by a 1/4 HP direct-drive motor, which drives two rubber rollers via a shaft supported by Unit Cast Pedestal (UCP) bearings. As the coconut leaf is fed into the machine, the rollers pull it through, while a precisely positioned blade mechanism efficiently detaches the stick from the leaf. The structure of the machine is constructed using durable mild steel (MS) sheet metal, ensuring robustness and longevity while securely housing all components. Key design considerations include motor configuration, blade placement, and material selection for strength and weight optimization. The design process employs CAD modelling for precision and visualization, while testing and iterative refinements ensure optimal machine performance. This semi-automatic solution aims to enhance productivity, minimize manual labour, and improve efficiency in the broomstick manufacturing process. The paper serves as a significant step towards mechanizing traditional tasks in rural industries, offering a cost-effective and reliable alternative to manual leaf separation methods.

Keywords

Coconut Broom Stick, Semi-Automatic Machine, Leaf Stick Separation, Mechanization, Agricultural Equipment.

1. Introduction

In recent years, automation and mechanization have significantly transformed various industries, particularly in agriculture and small-scale manufacturing. One of the most labour-intensive processes in rural industries is the production of broomsticks, which involves manually separating dry coconut leaves into their stick (stem) and leaf portions. This traditional method is not only time-consuming but also physically demanding, resulting in low productivity and increased labour costs. To address these challenges, there is a growing need for innovative and automated solutions that can streamline this process effectively. This project introduces a semi-automatic coconut leaf separator to improve efficiency, reduce manual effort, and increase production rates. Coconut broomsticks are widely used in households and industries.

Uloh Emeka Victor et al. provides valuable insights into the challenges of designing machines for agricultural

applications, including issues like material variability, jamming prevention, and synchronization of components [1]. T. Logeswaran et al. focuses on automating the extraction of midribs to improve efficiency and reduce manual labour. The study proposes a mechanized system featuring rubber rollers, blades, and a motorized drive to ensure precise separation of leaflets and midribs [2]. The work by Nwankwojike et al. focuses on the palm frond broom peeling machine to automate the traditional manual process of broomstick production [3]. Salah-Adeen et al. presents a mechanized solution for broomstick production by automating the process of midrib extraction from coconut leaves [4]. S.J.K. Annamalai et al. emphasizes the efficient utilization of agricultural by-products generated from coconut, arecanut, and cocoa processing. It highlights the potential of value addition, waste management, and resource optimization to promote sustainability and economic benefits [5]. Neeraj Dubey and Geeta Agnihotri explores the use of natural fibres from coconut palm leaf midribs as reinforcement materials for polymer composites [6]. Keshav G and M Damodaran focuses on developing an affordable, manual machine to address challenges in incense-stick production. Traditional methods are labour-intensive, time-consuming, and often produce inconsistent quality due to manual paste application on bamboo sticks. To overcome these limitations, the proposed design incorporates a hand-crank mechanism and a compound gear-train system to reduce operator effort and enhance productivity [7].

1.1. Existing Method

In most of the villages, the villagers more rely on the coconut tree's product so they tend to do the midrib separation through the means of their own hands with the only help of knives, but it seems to be an unsafe method and also takes a longer time and which may happen to be damage to their hands. The figure 1 gives the glimpse of the work which are being carried out by people. Keeping this drawback and the safety of people in mind, this work brings in a new technology where a machine is designed and developed to peel of the coconut leaves without intervention of human efforts.

Figure 1: Existing method to remove midrib from coconut leaf

2. Objectives and Problem Statement

2.1 Problem Statement

The traditional method of coconut broomstick production involves manual separation of the coconut leaf midrib, which is labour-intensive, time-consuming, and inconsistent. This approach results in high production costs, physical strain on workers, and reduced efficiency. Furthermore, variations in leaf thickness and structure cause irregular separation, leading to wastage and non-uniform broomsticks. The need for a mechanized, cost-effective, and user-friendly solution is essential to enhance productivity and minimize manual labour.

2.2 Objectives

The paper aims at designing and developing a semi-automatic coconut leaf separation machine for efficient broomstick production and automating the separation process using a motorized roller and blade mechanism. Enhancing precision in cutting the midrib without damaging the leaf portion is one among the concern by considering the reduction in labour effort and physical strain by eliminating manual separation. Optimization of material selection for durability, stability, and efficiency is another parameter ensuring cost-effectiveness by making the machine affordable for small-scale manufacturers. This work also highlights the importance of minimizing wastage by improving accuracy and consistency in separation.

3. Materials and Components

3.1 Machine Components

- **Power System: 1/4 HP direct-drive motor**- The motor is the central electrical component responsible for driving the rollers and powering the entire system.
- **Transmission System: Shaft with UCP bearings**- UCP (Universal Combination Pillow) bearings are used to support the rotating shaft and rollers.
- **Cutting Mechanism: Blade positioned near rollers**- The blade is designed to cut or detach the midrib (the stick portion) of the coconut leaf from the leaf blades.
- **Rollers:** Rubber-coated rollers for gripping and pulling the leaf
- **Frame:** MS sheet metal for durability and stability.

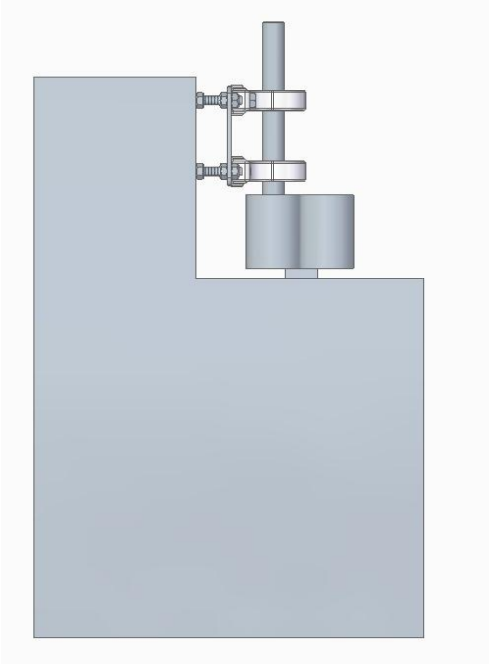

Figure 2: Side View of Assembly

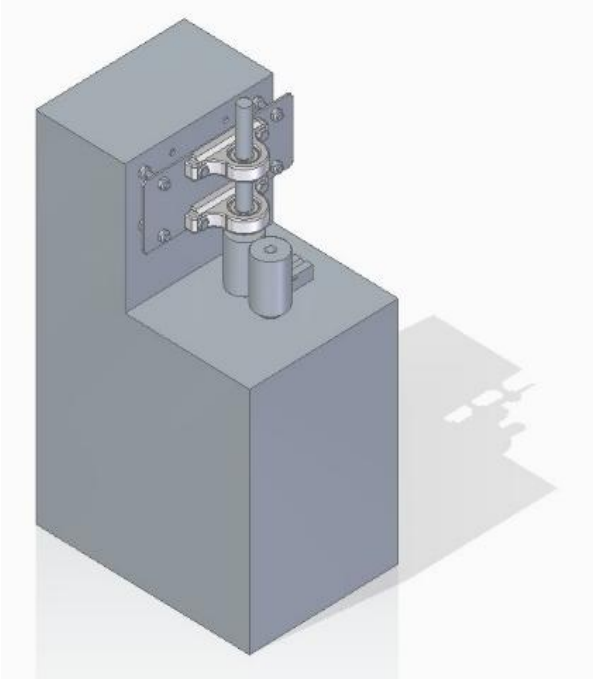

Figure 3: Side View of Assembly

Figure 2 and 3 shows the 3D model of the machine which is fully assembled by the rollers, shafts, bearing and frame.

4 Methodology

4.1 Flow Chart

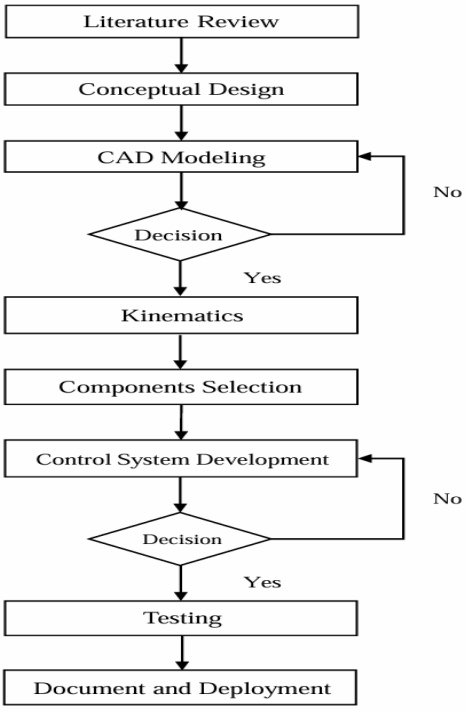

Figure 4: Flowchart

Figure 4 shows the process of our work which is carried by us for the model completion of work step by step.

4.2 Working Principle

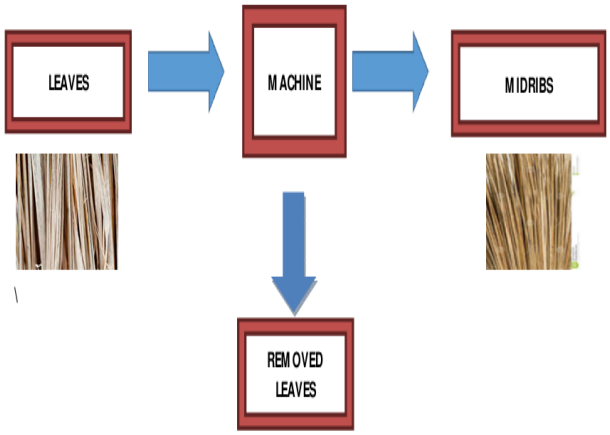

Figure 5: Block diagram of the proposed method

Figure 5 shows the work flow to get the output from the machine

- **Leaf Insertion**: The dry coconut leaf is manually fed into the rollers.
- **Separation Process**: The rollers pull the leaf, guiding it through the blade mechanism, which separates the stick from the leaf.
- **Output Collection**: The separated sticks are collected, while the remaining leaf is discarded.

4.3 Fabrication and Assembly

- **Frame Construction**: MS sheet metal for structure
- **Alignment & Fitting**: Motor, bearings, and rollers securely mounted
- **Testing & Calibration**: Adjustments made to blade positioning and roller pressure for optimal performance.

Figure 6: Actual Model Isometric View

Figure 7: Actual Model Front View

Figure 6 and 7 shows actual model of the machine which is fully integrated by rubber rollers, shaft, UCP bearing, blade, motor and body frame.

5. Results and Discussion

5.1 Machine Performance

Performance evaluation was conducted using multiple dry coconut leaves, and the results recorded are shown in Table 1. We can extract around 800 to 900 broom sticks per hour. For 8 hours a day, we can extract 6800 to 7200 sticks a day. We can operate machine continuously for 6 hours without a break. Then we can provide a break of 30 to 40 minutes and we can start to operate the machine.

Table 1: Machine Performance

Parameter	**Value**
Processing Time per Leaf	**5 seconds**
Stick Extraction Rate	**95%**
Motor Power Consumption	**250W**
Operator Effort	**Low**

5. Conclusion

The semi-automatic coconut leaf separator for broom production represents a significant advancement in the automation of traditional processes. By efficiently separating the midrib (stick) from the leaf portion of coconut leaves, the machine enhances the productivity of broomstick production

while reducing manual labour, with a processing time of 5 seconds per leaf, a 95% stick extraction rate, and an optimized motor speed of 1400 RPM, the machine demonstrates high efficiency. The low operator effort and reduced power consumption (250W), making it an energy-efficient and user-friendly solution for broomstick manufacturing. The integration of durable mechanical components, motor-driven rollers, and efficient blade mechanisms ensures smooth operation and high-quality output.

Acknowledgments

We extend our gratitude to Head of the Department of Mechanical Engineering and all teaching and non-teaching staff of Acharya Institute of Technology for their constant support.

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