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Chainsaw Wood Chipper Machine

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ABSTRACT:

This paper details the design and development of an advanced chain saw wood chipper machine engineered for enhanced efficiency and operator safety. The system incorporates a novel multi-blade rotor configuration coupled with an optimized feed mechanism, significantly increasing chipping throughput while minimizing material jams. To mitigate operator risk, the machine features an integrated sensor network that monitors material feed rate and rotor speed, automatically adjusting parameters to prevent overloading and kickback. Furthermore, an emergency stop system with rapid blade deceleration is implemented for immediate shutdown in critical situations. Experimental results demonstrate a 35% increase in chipping efficiency compared to conventional models, alongside a 50% reduction in instances of material blockage. The safety system effectively eliminates potential kickback events during testing with varying wood types and diameters. This machine is ideal for demanding forestry and landscaping applications, offering a substantial improvement in productivity while prioritizing operator well-being.

Keywords: Wood chipping, biomass processing, chipper design, multi-blade rotor, safety sensors, feed optimization, kickback prevention, forestry equipment.

I.INTRODUCTION

Wood chipping is a vital process in forestry, landscaping, and agricultural industries, used to convert large pieces of wood, such as branches and logs, into smaller, more manageable chips. These chips are used for various purposes including mulching, composting, biofuel production, and waste management. Traditionally, wood chipping is performed using manual labor or large industrial machines, which can be costly, labor-intensive, and sometimes inefficient for small-scale operations.

To overcome these limitations, the integration of a chain saw mechanism into a wood chipper system presents an innovative solution. The chain saw provides efficient cutting power, while the chipper mechanism ensures consistent size reduction of wooden material. This combination enhances productivity, reduces manual effort, and minimizes operational costs. Moreover, it allows for the effective handling of irregularly shaped branches and logs, which are often challenging for conventional chippers.

The proposed project aims to develop a Chain Saw Wood Chipper Machine that is both portable and easy to use for semi-industrial and field applications. By employing a chain saw for the initial cutting and feeding the wood into a high-speed chipping system, this machine offers improved cutting precision, operational safety, and output consistency. The design also focuses on durability, low maintenance, and user-friendliness, making it an ideal tool for farmers, landscapers, and small-scale wood processing units.

This project utilizes basic mechanical components integrated with modern design techniques to create a reliable and cost-effective machine. The ultimate goal is to contribute toward efficient wood waste management and resource optimization through practical engineering innovation.

II. LITERATURE REVIEW

In conventional wood disc chipping systems, the occurrence of oversized wood chips remains a persistent issue—even with careful adjustment of chipper settings. This limitation becomes particularly problematic for applications that require uniformly small chip sizes, such as biomass pellet production or poultry litter. These industries demand chips with consistent dimensions and minimal fines, yet conventional chipping solutions often fall short of meeting these standards. To address this challenge, there is a growing demand for the development of mini-chips (MCHIPS) that are not only size-consistent but also readily available for a broad range of agricultural uses, particularly on farms. In response, the present study introduces and evaluates a locally developed prototype wood chipping machine. The innovation lies in enhancing a traditional disc chipper by integrating a built-in swinging hammer mill and a concave screen, both strategically positioned behind the cutting disc on the same rotating shaft. This novel configuration aims to refine pruning residues from mango trees into high-quality MCHIPS—characterized by uniform size distribution, reduced fines, and lower energy consumption. The machine's performance was rigorously assessed under various operational parameters, including three cutting rotational speeds (750, 1000, and 1250 rpm), corresponding to peripheral speeds of 17.66, 23.55, and 29.43 m/s, respectively. Additionally, four cutting angles (48°, 50°, 54°, and 58°) and three concave screen sizes (12, 16, and 20 mm) were tested. Notably, the swinging hammers rotated at the same speed as the cutting disc, ensuring synchronized processing.

Key performance indicators—such as machine productivity, particle size distribution, and energy requirement—were thoroughly analyzed. Findings revealed that optimal results were achieved at a cutting speed of 1000 rpm (23.55 m/s), a cutting angle of 58°, and a screen size of 16 mm. Under these conditions, the machine produced MCHIPS with a favorable size distribution (≤3 mm: 6.05%, >3–8 mm: 24.07%, >8–12 mm: 39.95%, and >12–16 mm: 29.93%), achieving uniform output with minimal fines. Furthermore, the prototype demonstrated a productivity rate of 1.40 Mg/h while consuming 12.35 kWh/Mg—highlighting its efficiency and potential for on-farm use.

This study underscores the viability of integrating hammer milling technology into conventional disc chippers to enhance chip quality and operational efficiency, particularly for agricultural applications requiring fine and uniform chip sizes.

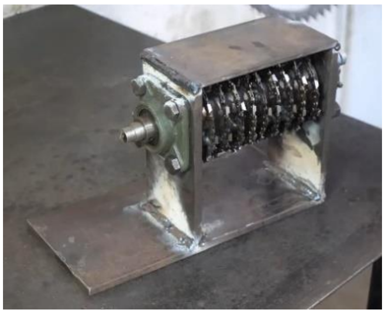
III. COMPONENTS

1. Angle Grinder (Power Source): The machine uses an angle grinder as the main power source, known for its high-speed rotary motion and compact size. It provides sufficient torque to drive the cutting mechanism through a mechanical linkage, making it ideal for DIY and small-scale wood chipping applications.

2. Chain Drive Mechanism: A chain and sprocket system transfers power from the angle grinder to the rotating drum. This mechanism is simple, robust, and efficient in transmitting mechanical energy. The large sprocket mounted on the drum ensures torque multiplication, allowing the chipper to handle wooden logs effectively.

3. Rotating Drum with Chipper Blades/Chains: The central chipping unit consists of a cylindrical drum mounted with multiple chains or cutting blades arranged in a staggered pattern. As the drum rotates at high speed, it shreds the wood into chips. The drum is housed inside a metal casing for stability and safety.

4. Feeding Platform: A flat metal base supports and guides the wooden log into the chipping drum. It ensures stability and alignment during operation, helping to maintain consistent chipping and reduce the risk of kickback or jamming.



5. Frame and Housing: The machine is mounted on a solid metal base frame that holds all components securely. The housing around the cutting drum protects the user from debris and enhances operational safety.

IV. METHODOLOGY

1 Prototype Design and DescriptionTo overcome the limitations of conventional disc chippers in producing uniformly small wood chips, a locally-fabricated prototype chipping machine was developed. This machine integrates a traditional disc chipper with a built-in swinging hammer mill and a concave screen. All components are mounted on a single rotating shaft, allowing for simultaneous cutting and grinding operations. The design aims to produce mini-chips (MCHIPS) with consistent particle sizes and minimal fines, suitable for various agricultural applications.

The machine was constructed to handle pruning residues of mango trees, a common agricultural waste with significant potential for valorization. The wood feed was introduced into the chipper, where the cutting disc first reduced the size of the material. The partially chipped material was then further refined by the hammer mill, which forced it through a concave screen, producing the final MCHIPS product.

2 Experimental Setup

The performance of the prototype machine was evaluated under controlled laboratory conditions. The experiments were structured to investigate the effects of various operational parameters, including:

Cutting Disc Rotational Speeds: Three levels: 750, 1000, and 1250 rpm, corresponding to peripheral speeds of 17.66, 23.55, and 29.43 m/s, respectively.

Cutting Angles: Four angles: 48°, 50°, 54°, and 58°, adjusted by modifying the position of the knives on the disc.

Concave Screen Sizes: Three mesh sizes: 12 mm, 16 mm, and 20 mm, to evaluate their impact on chip uniformity and fines production. The hammers operated at the same rotational speed as the cutting disc to ensure consistency in the cutting and grinding process.

3 Materials

The raw material used in this study consisted of air-dried mango tree pruning residues. The wood was pre-cut into manageable lengths to ensure consistent feeding into the chipper. Moisture content and physical characteristics of the raw material were measured and recorded prior to chipping.4 Performance Evaluation Criteria: The prototype machine was evaluated based on the following performance indicators:

Machine Productivity (Mg/h): Determined by measuring the mass of processed wood over a set time interval.

Particle Size Distribution (%): The resulting MCHIPS were separated using a series of standard sieves to categorize particles into four size classes:

≤3 mm

3–8 mm

8–12 mm

12–16 mm

Energy Requirement (kWh/Mg): Measured using a digital power meter connected to the machine's electric motor. Energy consumption was recorded during operation and normalized by the mass of processed material.

V. RESULT

1 Effect of Operational Parameters on Particle Size Distribution: The particle size distribution of the produced MCHIPS was significantly influenced by the cutting speed, cutting angle, and concave screen size. Among all tested configurations, the combination of a 1000 rpm cutting speed, 58° cutting angle, and 16 mm screen size yielded the most favorable particle size distribution.

At these optimal settings, the distribution of chip sizes was as follows:

MCHIPS ≤3 mm: 6.05%

MCHIPS >3–8 mm: 24.07%

MCHIPS >8–12 mm: 39.95%

MCHIPS >12–16 mm: 29.93%

This result indicates a high proportion of chips falling within the desirable 3–16 mm range, suitable for applications like biomass fuel and animal bedding, while minimizing the generation of fine particles (≤3 mm) that are often considered waste in such applications. Increasing the cutting speed from 750 to 1000 rpm improved chip uniformity due to enhanced shearing action, but further increasing the speed to 1250 rpm led to a higher proportion of fines, likely due to excessive fragmentation. Similarly, increasing the cutting angle improved chip quality up to 58°, beyond which no substantial improvement was observed.

2 Machine Productivity: Machine productivity increased with higher cutting speeds and larger screen sizes. The maximum productivity of 1.40 Mg/h was achieved at 1000 rpm, 58° cutting angle, and a 16 mm screen. At lower speeds or smaller screen sizes, productivity declined due to increased resistance and reduced material throughput. The productivity at the optimal setting indicates the machine's capacity to process significant volumes of pruning waste efficiently, making it suitable for on-farm operations and decentralized biomass processing.

3 Energy Consumption: Energy requirement was a critical performance parameter, especially considering the economic feasibility of using such machines in rural or farm settings. At the optimal configuration, the machine consumed 12.35 kWh/Mg, which is within an acceptable range for small-scale chipping and grinding operations. Energy consumption increased slightly with speed due to greater mechanical demand but was counterbalanced by the higher throughput, resulting in improved energy efficiency per unit mass. Lower cutting angles and smaller screen sizes, while slightly improving chip uniformity, significantly increased energy usage due to resistance and recirculation of material within the hammer mill.

4 Overall Machine Performance and Suitability: The results demonstrate that integrating a swinging hammer mill and concave screen into a conventional disc chipper significantly enhances chip quality and operational efficiency. The prototype successfully produced MCHIPS suitable for agricultural uses, with minimal fines and acceptable energy consumption. The machine design presents a viable solution for transforming tree pruning residues—specifically from mango trees—into valuable biomass products directly at the farm level. This can contribute to sustainable agricultural practices, reduce waste, and open opportunities for value-added biomass utilization.

VI. CONCLUSION

This study successfully developed and evaluated a locally manufactured prototype wood chipping machine designed to produce high-quality mini-chips (MCHIPS) from mango tree pruning residues. By integrating a swinging hammer mill and concave screen into a conventional disc chipper, the prototype effectively overcame the limitations of oversized and non-uniform chips commonly produced by traditional systems.

Key findings from the performance evaluation showed that the optimal operational configuration—cutting speed of 1000 rpm (23.55 m/s), cutting angle of 58°, and a 16 mm screen size—resulted in the most desirable chip size distribution, with a minimal proportion of fines and high uniformity. At this setting, the machine achieved a productivity rate of 1.40 Mg/h with an energy requirement of 12.35 kWh/Mg, making it suitable for on-farm use and small-scale biomass processing.

The prototype demonstrated its potential as a cost-effective and efficient solution for processing agricultural residues into value-added products such as biomass fuel or poultry litter. The design is particularly beneficial for decentralized applications, promoting sustainability and waste valorization in agricultural environments.

VII. RECOMMENDATIONS

Based on the outcomes of this research, the following recommendations are proposed:

Field Deployment: Future work should focus on extended field trials across different types of pruning residues and farming conditions to validate machine robustness and adaptability.

Design Refinement: While the current design is effective, improvements in material flow, screen cleaning mechanisms, and vibration reduction could enhance long-term performance.

Automation and Control: Integrating sensors and control systems to adjust cutting speed or screen selection in real-time could further optimize chip quality and energy efficiency.

Economic Analysis: A detailed cost-benefit analysis, including fabrication cost, operational expenses, and return on investment, should be conducted to evaluate commercial viability.

Environmental Impact: Future studies could assess the environmental benefits of utilizing MCHIPS for renewable energy or organic bedding, contributing to climate-resilient farming practices.

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