American Journal of Education and Technology (AJET)

ISSN: 2832-9481 (ONLINE)

VOLUME 4 ISSUE 1 (2025)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Education and Technology (AJET)

Volume 4 Issue 1, Year 2025
ISSN: 2832-9481 (Online)
DOI: https://doi.org/10.54536/ajet.v4i1.3970
https://journals.e-palli.com/home/index.php/ajet

Innovations in Shredder: A Multi-Cutting Machine

Jimcel P. Pecaso[1*]

Article Information

Received: October 27, 2024
Accepted: November 29, 2024
Published: January 28, 2025

Keywords

Efficiency, Moisture Content, Performance, Pulley, Shredding Machine

ABSTRACT

This study focused on the design, fabrication, and performance evaluation of a shredding machine specifically developed for processing agricultural waste, including corn stalks and coconut covers. Powered by a 1440 rpm AC motor and utilizing a single-belt drive system, the machine was tested to measure its shredding efficiency and recovery rate under various material conditions. Shredding efficiency was defined as the percentage of material effectively shredded, while the recovery rate represented the proportion of useful shredded material collected. Trials conducted with corn stalks at 30% moisture content demonstrated an average shredding efficiency of 85.33% and a recovery rate of 70.33%, showcasing the machine's consistency and reliability. For coconut covers, the shredding efficiency varied based on maturity and moisture content, highlighting the machine's adaptability to different agricultural materials. The findings validate the shredding machine's potential as an efficient tool for managing agricultural waste. By enabling the conversion of residues into valuable materials for composting and other applications, the machine supports sustainable practices and reduces environmental impact, offering a practical and eco-friendly solution for waste processing.

INTRODUCTION

Advancements in technology have revolutionized various industries, and the shredding industry is no exception. The traditional manual-operated shredder machines have been plagued by issues such as time-consuming operations, excessive noise, and vibrations. Researchers have been exploring innovative solutions to address these challenges to create more efficient and user-friendly shredder machines (R *et al.*, 2023; Katiyar *et al.*, 2019).

Technology has become an essential part of everyday life, reshaping how we live and leaving a profound impact that integrates seamlessly into various aspects of society. Beyond providing access to knowledge, it fosters critical skills, equipping individuals to thrive in an ever-evolving world. This integration not only enhances learning but also opens new doors of opportunity, paving the way for a more connected and innovative future. (Quintos, 2024)

In today's environmentally conscious world, effective waste management is essential to sustainable agricultural development. Shredding machines are indispensable in this field through recycling, removing waste, or reusing materials easier. Still, current shredding technologies frequently fall short in terms of materials, efficiency and versatility. The fabrication of a multi-cutting shredding machine will assist in filling the current technological gaps in waste management and satisfy the changing demands of present-day society.

Nowadays existing shredding technologies exhibit significant limitations in terms of versatility, efficiency, and adaptability to a wide variety of materials. Modern waste management practices require the efficient processing of diverse materials, including plant stalks, grass, and coco coir. Traditional shredders often use a single cutting mechanism, which is not optimal for handling mixed-material waste streams.

By integrating multiple cutting mechanisms utilizing leaf springs and cylindrical shredder into one unit, the multi-cutting shredding machine will address common technological gaps. This innovation allows for the shredding of a wider variety of materials without compromising efficiency or speed. The machine will effectively handle mixed-material waste streams by incorporating adjustable cutting techniques

LITERATURE REVIEW

In the modern world, agricultural crops are vital to human sustenance as they provide essential nutrition. Accordingly, the fabrication of applicable machinery will be crucial to raising productivity and efficiency in the agricultural industry. It's vital to consider and prioritize shredding processes for certain plant stalks to achieve optimal yields while minimizing post-harvest losses.

Historically, shredding hasn't established the attention it deserves, often requiring different machines for various tasks in the field. However, innovative machine can be used. These days, recycling involves more than just shredding; it also involves expediting the process, cutting expenses, and advancing agriculture's overall sustainability.

Shirbhate *et al.* (2018) highlighted how human ingenuity has driven innovation in all aspects of production and safety within modern industrial settings. They emphasized that some existing tools are the result of thorough research and dedication, while others stand out for their exceptional performance. With this perspective in mind, the study introduced a new device and assessed its suitability, ease of use, operational efficiency, and how

[1] Partido State University, Philippines
[*] Corresponding author's e-mail: jimcel_psu@yahoo.com

effectively it functions for agricultural purposes.

Patil *et al.* (2016) observed that in India, certain crops play a vital role not only as human food and animal feed but also as sources of many industrial products. Traditionally, the process of dehusking these crops involved manual labor, using sticks, fingers, or sickles. Recognizing the challenges posed by this traditional method, the study introduced a sheller to address the issue of removing the outer sheath and dehusking the cobs more efficiently and found functional.

According to Sale's (2023) research, Nigeria is home to the largest livestock population in Sub-Saharan Africa. However, numerous challenges hinder the growth of agricultural industries across the continent, particularly in the animal agriculture sector because of accessibility, affordability, and quantity issues. Inefficient supply handling contributes to this challenge, especially when compared with more manageable crop residue. Inefficiency results in a labor-intensive, time-consuming, and costly process. In response to this pressing issue, a maize stalk shredder was developed with the aim of mitigating these challenges and providing a solution to the problem at hand.

Kedar *et al.* (2016) revealed in their study that corn, traditionally harvested with a sickle, requires manual plucking and dehusking by hand to remove its outer sheath. In the end, stalks are left unattended that can be recycled into pieces for other agricultural applications.

Furthermore, Azadbakht *et al.* (2019) asserted that machines stand out as the most effective option due to ease of construction, cost-effectiveness in repairs and maintenance, and capability to handle stalks of varying diameters. Consequently, developing a machine resistant to crop cutting during harvesting was deemed crucial, considering its significant impact on agricultural operations.

In the realm of agricultural innovation, the quest for efficient and labor-saving solutions is a continuous endeavor. Manual cutting of stalks, often done by hand, tends to add and incur high labor costs. Hence, the development of cutting-edge machinery becomes imperative to alleviate this burden.

In the local setting of Partido-Camarines Sur, the need and use of shredder machine is now considered eminent due to the vast agricultural lands where stalks and plant by-products required to be shred for animal use and organic fertilizer as way of recycling.

In an informal visit to farmers-friends in the localities of Goa, and Lagonoy, Camarines Sur, where agricultural products are prevalent, discussions arose about how plant stalks are cut into pieces for use as animal feed and fertilizer. It became apparent that traditionally, these stalks are typically cut into pieces using blades or sharp tools commonly employed for various agricultural tasks such as harvesting crops, clearing vegetation, or general fieldwork.

By considering technical creativity with a deep understanding of agricultural needs, this project proposes to create a stalk and grass-shredding machine that can meet different farmer needs at different operational scales like crop residue, vegetable and fruit waste and green waste.

In agricultural activities, the need to effectively dispose of plant residues such as stalks and plants or grass after harvesting is essential. These residues can be time-consuming and labor-intensive to remove manually, and improper disposal can lead to environmental pollution (Lei & Chen, 2020). Therefore, a plant and stalk shredding machine can be designed and fabricated to address this issue. This machine can efficiently cut and shred plant residues into smaller pieces, making it easier for disposal or further processing. The design of the plant and stalk shredding machine would incorporate blades or cutters to effectively break down the plant materials.

Additionally, the machine would be equipped with a transmission element, such as spur gears, to provide the necessary power for shredding. The machine would also be powered by an electric motor and have a robust body to withstand the forces involved in shredding.

By utilizing the principles and components used in plastic shredder machines and other existing shredders, an efficient and portable design can be developed for the plant and stalk shredding machine. Materials such as aluminum can be chosen for the machine's case, as it is lightweight and durable. The blades of the shredding machine can be made of stainless steel to maintain durability and effective cutting.

Furthermore, safety features such as emergency stop buttons and protective covers would be incorporated into the design to ensure the operator's safety while using the machine. The design and fabrication of the plant and stalk shredding machine would follow a systematic approach, starting with the design process. The design process would involve defining the job and product concept, followed by embodiment design and detailed design. The optimization of the shredder blade in this design would result in better grinding of the plant waste into fine particles, reducing the need for manual labor and skilled workers in the industry.

Besides, this project study focuses on innovations in shredding machinery, featuring a multi-purpose device that cuts plant stalks, giving farmers a versatile tool that expedites shredding and minimizes environmental waste. The introduction of the plant and stalk shredding machine would greatly improve the efficiency of plant residue disposal in agricultural activities, reducing labor and promoting environmental sustainability. For the mechanical assembly of the plant and stalk shredding machine, materials such as aluminum and stainless steel will be chosen (Olukunle, 2016).

Through interdisciplinary research and innovative application, the study will not just be fabricated as a machine but a resource to be valued and worth striving for.

With these key aspects in mind, this research proposal aimed to enhance innovation and sustainable farming practices within the agricultural sector by exploring the potentials of the shredding machine. The results of this study will benefit broader agricultural communities, which is why this study was conceptualized.

MATERIALS AND METHODS

The study utilizes the experimental and descriptive evaluative research design that ensures systematic approach to the development and evaluation of the multi-cutting shredding machine. Research and adoption form part of the undertaking since project were based on already existing machine with a little dash of innovation by the proponent.

This shredding machine required a multidisciplinary approach that combines engineering principles, agricultural expertise, and technology integration.

Manipulative intervention in the conceptual designs of the machine was based on the identified needs and feedback on factors such as the shredding mechanism, power source, and material selection.

RESULTS AND DISCUSSION

The machine to operate consist the following parts:

Base Frame

Sturdy rectangular base frame to support all components.

AC Motor

At one end of the frame is the mounting and a compact AC motor. The AC motor is the power source for the entire machine.

Power Transmission

The AC motor is connected to a belt system. The belt is secured to pulleys on both the motor and the main shaft that drives the shredder and cutter components.

Shredder Chamber

Next to the motor, illustrate a vertical shredder chamber designed for plant stalks. This chamber is equipped with sharp cross blades arranged for effective shredding. An opening at the top for feeding stalks in and a discharge outlet at the bottom for shredded material.

Coco Coir Decorticator

On the opposite side of the shredder, depict a separate cutter assembly designed specifically for coco coir extraction. This assembly include a cylindrical cutter with 16 toothed sharp edges for stripping the coir from the husk. A collection chute underneath is provided to gather the processed fiber/coir.

Main Shaft

A single horizontal 2.54centimeter shaft that connects both the shredder and the cutter. This shaft is driven by the belt from the AC motor, allowing both components to operate simultaneously.

Safety Guards

This include safety guards around the blades and openings for user protection.

Control Panel

Mounted on the frame, equipped with an ON/OFF switch and belt tension adjustment.

Technical Description of the Device

The fabrication of the prototype shredding machine was based on the finalized conceptual design. This involved engineering the mechanical components to suit the needs of the local farmers. Below is the actual shredding machine for agricultural use.

Shown in figure 1 is the innovative shredding machine anticipated to boost processing of grass, plant stalks and coco coir. The machine was operated efficiently by electrical-powered AC motor with option mounting for gas-fed engines to optimize energy efficiency.

Figure 1: The Multi Cutting-Shredding Machine

Table 1: Description of machine parts

Parts Number	Description
1	Stalk shredder chamber
2	Coco fiber shredder
3	Drive motor
4	NP bearing
5	Drive Pulley
6	Driven pulley
7	Drive belt
8	Base frame
9	Main shaft
10	wheel
11	Cross blades
12	Coco shell holder

Table 2: Supplies and Materials

QTY	Unit	Name & Description	Unit Cost	Total Cost
2	Pcs	Angle Bar, 1X1X1/4	350.00	700.00
1/2	Sheet	G.I. sheet # 18	1,525.00	1,2500.00
2	Ft	Axle shaft, 1", threaded end ¾"dia	135.00	337.50
2	Pcs	NP bearing, 1"dia	225.00	450.00
1	Unit	1.75hp Induction Motor, single phase, 220V with 3.5cm twin rail	4,600.00	4,600.00
3	Kilos	Welding Rod, E-6013	150.00	450.00
8	Pcs	Bolts, nuts, washer 3/8" X1"	20.00	160.00
2	Pcs	Pulley, 9cm dia, single rail	560.00	560.00
1	Pc	Square bar, 12mm	250.00	250.00
2	Pcs	B-47 Drive belt	250.00	500.00
1	Pc	On-off AC switch, heavy duty	250.00	250.00
2	Pair	Cartwheels, 4-inch diameter	250.00	500.00
1	Pair	Cutter/shredder blade 14"	500.00	500.00
Total				**9,507.00**

The table provides a detailed breakdown of the costs associated with fabricating the shredding machine. It lists the quantity, unit, description, and price of each item, including materials such as angle bars, GI sheets, an induction motor, welding rods, bearings, pulleys, and other essential components. Labor costs are not included, as the proponent personally fabricated the machine. The total cost of building the machine amounts to ₱9,507.00, offering a clear estimate for budgeting and resource planning.

Table 3: Technical Specification of the prototype multi-cutting machine

Specification	Details
Motor Type	AC Motor
Motor Power	1.5 HP
Voltage	220V
Speed	1440 RPM
Weight	10.5 kg
Drive System	Single Belt Drive with 3-inch Diameter Pulley, B-48
Main Shaft	24-inch length, 2-inch thickness, steel
Shredder Blade	14-inch length, 1/4-inch thickness, 2-inch width, steel
Cutter Drum	8-inch diameter cylindrical cutter, 20cm dia, 16 shredding teeth

Base Frame	Rectangular steel frame for stability, W-37cm X L-52cm X H-68cm
Safety Features	Blade guards, control panel with ON/OFF switch
Processing Capacity	Approx. 200–300 kg/hr (depending on material type)
Material Processed	Coconut husks, plant stalks, corn stalks
Moisture Content Range	Operates efficiently between 10% and 50% moisture content

Table 3 provides an overview of the shredding machine's technical specifications, detailing its key components and operational parameters. It includes information on the motor type and power, drive system, blade dimensions, cutter drum size, and base frame material. Additionally, the table highlights the machine's capacity, safety features, and recommended moisture content range, ensuring its efficiency in shredding materials like coconut husks, plant stalks, and corn stalks. This summary underscores the machine's robust design and reliable performance.

The Determination of Moisture Content

On materials selection, the proponent randomly selected samples from the following material type: 70% plant (corn) stalks, and 30% outer husk of a matured (brown) coconut that is firmer and can be shredded.

According to the American Society of Agricultural and Biological Engineers (ASAE) standards, the moisture content of agricultural products like corn stalks is generally measured and reported on a wet basis (wb).

The moisture content on a wet basis (MC_{wb}) is the percentage of the mass of water relative to the total mass of the sample. The formula to be followed is:

MC_{wb} = (Mass of water/ Total mass of the sample) X 100

Where:

Mass of Water

The difference between the wet mass (initial mass) and the dry mass (mass after drying).

Total Mass

The initial mass of the sample before drying.

The formula is:

MC_{wb} = (Wet mass−Dry mass/ Wet mass) X 100

The corn stalks moisture content depends on harvest conditions, drying practices, and storage. The moisture content for corn stalks was determined to be 15-70% based on drying and storage conditions.

Wet Mass (initial mass) of Corn Stalks

50 kg test sample

Dry Mass (mass after drying)

The dry mass after drying is 35 kg.

Mass of water = Wet mass - Dry mass

50 kg−35 kg =15 kg

MC_{wb} = (15 kg/ 50 kg) X100

MC_{wb} = 0.3×100 = 30%

The conduct of shredding tests for each identified sample followed the parameters to be measured:

Shred size, consistency, efficiency, speed, energy consumption, and noise level.

The technical efficiency of the shredding machine identified physical parameters delimited to the following:

Design of Pulley

The selection of the drive is dependent on the metrics such as power rating, belt utilized and size of the pulley. This was guided by given data and equation below:

Given:

N_2 is the speed of the shredding blade

N_1 is the speed of driving motor =1440rpm

d_1 is the diameter of the driving motor pulley =80mm

d_2 is the diameter of the shredder pulley =80mm

Speed of the Shredder Blade

$N_1/N_2 = d_2/d_1$

$N_2 = (N_1\ d_1)/\ d_2$ = 1440 X 80/ 80 = 1440rpm

Belt Design

Belt length was calculated by considering the distance from driving pulley center to driven pulley center. The V-belt standard size B48 with 7mm belt thickness was utilized.

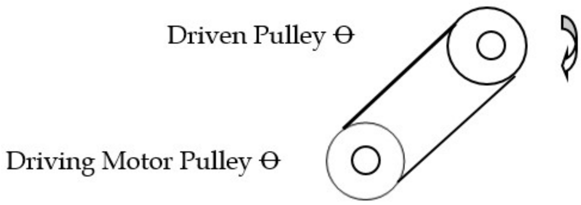

Figure 2: Driving Motor Pulley

Figure 2. The mechanical drawing of the pulley system showing the driving motor pulley (with speed N_1 and diameter d_1) connected to the shredder pulley (with speed N_2 and diameter d_2). The belts and rotational directions are also indicated.

Power transmitted by the belt

The concept comes from classical mechanical engineering principles derived from Newton's laws of motion and energy transfer theories and according to Euler-Eytelwein and Coulomb's formula.

The belt and power transmitted by the belt (N) is required. Below is the equation that highlights the importance of maintaining a proper tension difference in the belt for efficient power transmission.

Given

P: is the power transmitted by the belt (watts (W) or horsepower (hp).

T_1: is the tension in the tight side of the belt =100N
T_2: is the tension in the slack side of the belt =200N
V: is the velocity of the belt (in meters per second (m/s) =2.64m/s
$P=(T_1-T_2)\ V$
$P=(1000\,N-200\,N)\times 2.64\,m/s$
$P=800\,N\times 2.64\,m/s$
P = 2112W
The power transmitted by the belt is 2112 watts (W), or 2.112 kilowatts (kW). This is the power being transferred from the AC motor to the shredding mechanism via the twin belt. This power enables the shredding blades to efficiently cut the dried corn stalks with ease.

Evaluation of Force
The force required for a shredding machine depend on various factors such as the material being shredded, the design of the shredding blades, and the desired particle size. A simplified equation to estimate the force required for shredding can be derived from the basic principles of mechanics, specifically the force required to cut or tear the material.
And, one commonly used equation to estimate cutting force is the specific energy consumption equation:
$F = E/d$
where:
F is the force required for shredding (in newtons, N)
E is the specific energy consumption = $10^6 J/m^3$ (applicable to plant stalks as the given sample).
d is the thickness of the material being shredded = 0.005m (5 mm). Therefore:
$F = (10^6 J/m^3)/\ 0.005m$
F= 200,000 N
The computation estimates the force required for shredding using the specific energy consumption equation. With a specific energy consumption of $10^6 J/m^3$ (value for plant stalks) and a material thickness of 0.005 m (5 mm).
The result indicates that a force of 200,000 N is necessary to shred the material effectively, offering a clear understanding of the machine's mechanical requirements.

Evaluation of Power Output
To evaluate the efficiency of a shredding machine is to calculate the total power input, which is the electrical power consumed by the motor. This calculation will involve determining the electrical power provided to the motor and considering the motor's electrical efficiency. Below will be the applicable computation
$P_{input} = V \times I \times \eta_{electrical}$
V is the voltage supplied to the motor = 220V
I is the current drawn by the motor = 10Amp
η electrical efficiency of the motor = 0.85 or 85%
$P_{input} = 220\,V\times 10\,A\times 0.85$
$P_{input} = 1870W$
The electrical efficiency value of 0.85 (or 85%) used in is a typical motor efficiency used in the machine considering the type, design, and load of the motor under normal operating conditions.
So, the input power to the motor is 1,870 watts (W) or 1.87 kilowatts (kW).
The useful output can be determined basing on the work done in shredding of the stalks. the calculation of the Useful Power Output was guided by the formula below:
$P_{useful} = (F \text{ x } v)/\ \eta_{mechanical}$
Where:
F force required to shred the material = 400N
v is the velocity of the shredding blades = 26.8m/s
η the mechanical efficiency =0.85 (mechanical efficiency, or 85%)
The machine motor in this study operates at 1440 RPM (rotations per minute), and the blades utilized are 14 inches long. The radius is half the length of the blades: radius=14/2=7 inches ≈0.1778 meters, So, the velocity was calculated:
$v = (2\pi r\times RPM)/\ 60$
$V = 2\pi\times 0.1778\times 1440/\ 60 = 2\pi\times 0.1778\times 24 \approx 26.8\,m/s$
$P_{useful} = (F \text{ x } v)/\ \eta_{mechanical}$
$P_{useful} = (400\,N\times 26.8\,m/s)/0.85$
$P_{useful} = 10{,}720\,W/\ 0.85$
$P_{useful} = 12{,}612\,W$
The useful power output of the machine when shredding dried corn stalks is approximately 12,612 watts (W) or 12.61 kilowatts (kW). This value represents the effective power being utilized for the shredding process, considering the force, velocity of the blades, and the mechanical efficiency of the system.

Evaluation of Noise Level
In this stage, results of noise test were compared to the required noise levels of industry standards or regulatory limits for workplace noise exposure as mandated by the Occupational Safety and Health Administration (OSHA)- that sets permissible exposure limits (PEL) for noise
A compact and handheld level meter was utilized by the proponent to provide dB readings with a range from 40 to 130 dB suitable for industrial noise assessments.
As to the Permissible Exposure Limit (PEL)-90 decibels (dB) over an 8-hour workday: OSHA's general industry standard (29 CFR 1910.95) sets a PEL of 90 dB for an 8-hour time-weighted average (TWA). This means that workers can be exposed to noise levels of up to 90 dB over a typical 8-hour shift.

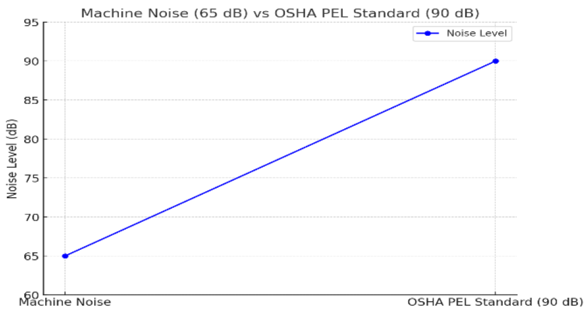

Figure 3: Machine Noise Level VS OSHA

Figure 3. Result comparing the machine noise level at 65 dB to the OSHA Permissible Exposure Limit (PEL) standard of 90 dB. The graph visually highlights how the prototype machine's noise level falls below OSHA's maximum permissible exposure limit.

The noise levels on user comfort and safety remained considered in the prototyping of the machine since lower noise levels minimize hearing damage and create a more comfortable working environment.

On materials selection, the proponent randomly selected samples from the following material type: 70% plant stalks, and 30% outer husk of a matured (brown) coconut that is firmer and can be shredded.

Measurement of Average Plant Stalks Dimension

The proponent randomly takes at least ten (10) pieces of samples from the representative samples of the material. For each sample, largest dimensions (e.g., diameter, length, width, thickness) was measured using a caliper. Measurement was recorded to the nearest 0.01 mm.

Average Dimension

$$\bar{x} = \frac{\sum xj}{n}$$

where:

xj is the dimension (length, width, thickness, diameter) of individual, sample (mm)

n is the total number of samples

$\bar{x}$ is the average size or dimension (mm)

The technical operability of the enhanced shredding device was the subject to in-depth testing using crop residue, coco coir, and plant stalks- green waste. This real-world assessment was used to gauge the device's performance under authentic conditions, ensuring its efficacy in practical applications.

On Shredding Efficiency

Moisture Content (%) for Matured Dry Coconut Cover:

- Dry basis (d.b.) ~ 15% - 20% (much lower than a young cover)

Moisture Content (%) for Young Coconut Cover:

- Dry basis (d.b.) ~ 100% - 200% (higher moisture content)

Table 4: Shredding Efficiency of the prototype (%)

Machine Speed (rpm)	Moisture Content (Matured Dry)	Shredding Efficiency (Matured Dry)	Moisture Content (Young)	Shredding Efficiency (Young)
1440	15%	60%	100%	75%

The table highlights how the shredding machine performs at a constant speed of 1440 RPM when processing matured dry and young coconut covers. For matured dry materials with a moisture content of 15%, the machine achieves a shredding efficiency of 60%. In contrast, young coconut covers with 100% moisture content have a higher shredding efficiency of 75%. This comparison shows that the machine is more effective at shredding young materials due to their higher moisture content, which makes them easier to process.

Shown is the shredding efficiency at 1440 rpm given speed at 30 min continues machine work, the following were considered:

1. Mass of material before shredding (Initial Mass): Minitial
2. Mass of material after shredding (Final Mass): Mfinal
3. Time taken for the shredding process

The formula for shredding efficiency is typically:

$$\eta_{shredding} = (M_{final} / M_{initial}) \text{ X } 100\%$$

Where:

Mfinal is the weight of the coconut cover that has been effectively shredded into the desired particle size. The Shredding Efficiency is at 1440 rpm given speed.

The following data was limited on the test sample for young coconut cover and matured dry coconut cover at 500 g:

Young Coconut Cover

- Initial Mass, Minitial = sample of 500 g
- Final Mass after shredding, Mfinal=450 g

$$\eta_{shredding,\ young} = (450/\ 500) \text{ X } 100 = 90\%$$

Matured Dry Coconut Cover

- Initial Mass, Minitial= sample of 500 g
- Final Mass after shredding, Mfinal=400 g

$$\eta_{shredding,\ matured} = (400/500) \text{ X } 100 = 80\%$$

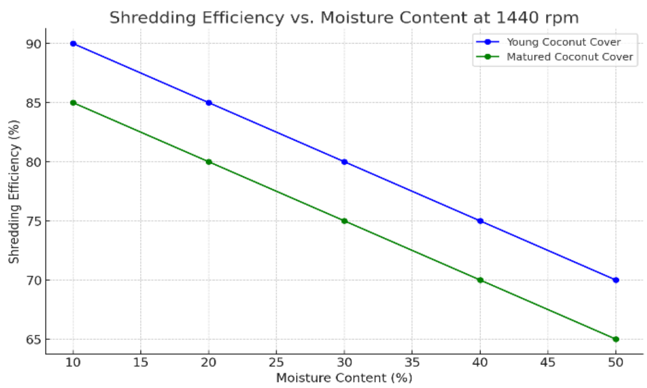

Figure 4: Shredding Efficiency vs. Moisture Content at 1440 rpm

Figure 4 above showed the shredding efficiency for young and matured coconut covers across different moisture content levels at a constant speed of 1440 rpm. This demonstrates how increasing moisture content tends to lower shredding efficiency for both young and matured coconut covers, with matured covers showing slightly lower efficiency across all moisture levels.

Test on Corn Stalks

The calculation of the mean shredding efficiency and recovery rate of the machine, specific values were based on multiple trials (3) conducted using a corn stalk at 30% moisture content, driven by an AC motor running at 1440 rpm:

Trial

The specific test run (1, 2, and 3).

Shredding Efficiency (%)

The efficiency of the machine during each trial, based on the amount shredded versus the total initial mass.

Recovery Rate (%)

The percentage of useful shredded material collected after each trial.

Table 5: Data in three (3) Trials

Trial	Shredding Efficiency (%)	Recovery Rate (%)
1	85	70
2	87	72
3	84	69

Mean Shredding Efficiency

Mean Shredding Efficiency = (85+87+84)/3 = 256/3 = 85.33%

Mean Recovery Rate

Mean Recovery Rate = (70+72+69)/3 = 211/3 =70.33%

Table 6: Summary Table with Means

Trial	Shredding Efficiency (%)	Recovery Rate (%)
1	85	70
2	87	72
3	84	69
	Mean 85.33	Mean 70.33

Table 6 displays the individual trial results and the calculated mean values for both shredding efficiency and recovery rate.

The shredding machine's performance was tested in three trials using corn stalks with a 30% moisture content, powered by an AC motor running at 1440 rpm. Two key metrics were evaluated: shredding efficiency, which represents the percentage of material successfully shredded compared to the total initial mass, and recovery rate, which reflects the proportion of useful shredded material collected. The average results across the trials showed a mean shredding efficiency of 85.33% and a mean recovery rate of 70.33%, demonstrating the machine's reliability and effectiveness in both shredding and material recovery.

Table 7: Use of the Multi-Cutting and Shredding Unit

Operator	Time Consumed (minutes)		
	Actual Test 1	Actual Test 2	Actual Test 3
Beginner	20	17	17
Trained	5	5	5

The shredding unit was used to make cut and shred stalks and coco coir respectively was operated by a neophyte and a trained worker during the test run. The beginner and the trained worker both conducted three trials. The average time it took the beginner to finish a shredding was 18 minutes, whereas the trained worker took only 5 minutes specific for stalks and 1 coco cover as test materials.

CONCLUSION

The machine was typically designed with a single cutting mechanism, which limits ability to process materials like plant stalks and coco husk efficiently. By combining different cutting mechanisms, such as those from steel blades, into a single unit, this innovative machine was able to process a wider variety of materials. Its adjustable cutting techniques enhance its ability to shred diverse waste and maintain speed and efficiency, making it an option and effective solution for today's waste management needs.

The shredding machine developed in this study demonstrated reliable performance and efficiency in processing agricultural waste. Powered by a 1440 rpm AC motor, the machine consistently achieved an average shredding efficiency of 85.33% and a recovery rate of 70.33% when tested with corn stalks at 30% moisture content. Its adaptability to materials with varying moisture levels and maturity, such as coconut covers, highlights its versatility. These results confirm the machine's capability to transform agricultural residues into valuable resources, contributing to sustainable waste management and resource recovery.

REFERENCES

Azadbakht, M., Rezaei Asl, A., & Tamaskani Zahedi, K. (2014). Energy requirement for cutting corn stalks (Single Cross 704 Var.). *International Journal of Agricultural and Biosystems Engineering, 8*(5), 479–482. Retrieved from https://publications.waset.org/9998237/energy-requirement-for-cutting-corn-stalks-single-cross-704-var

Kilanko, O., Oko, A. I., Leramo, R. O., & Ilori, T. A. (2019). Development and performance evaluation of melon shelling and separating machine. *International Journal of Mechanical Engineering and Technology, 10*(2), 440–450.

Luckyardi, S., Mega, R. U., Kevin, R., Naufal, A. N., & Hanifah, A. P. (2022). Corn sheller machine technology to improve farmers' productivity. *International Journal of Agricultural and Biosystems Engineering, 17*(2).

Patil, K. K., Pandit, S., Pol, G., Kadam, S., & Jadhav, A. (2016). Design and fabrication of corn shelling and threshing machine. *International Journal of Innovative Research in Science, Engineering and Technology, 5*(7). https://doi.org/10.15680/IJIRSET.2016.0507234

Quintos, S. B. (2024). Assessment of the impact of technology integration: Basis for intervention framework. *American Journal of Education and Technology, 3*(3). https://doi.org/10.54536/ajet.v3i3.3439

Shirbhate, S. S., Pande, H. H., Raj, N., Raut, J. J., & Taral, A. V. (2018). Design and manufacturing of corn shelling machine. *International Journal of Innovations in Engineering Research and Technology, 5*(7).