Jurnal Dinamika Vokasional Teknik Mesin
Vol. 8, No. 2, October 2023, pp. 100-112
https://journal.uny.ac.id/index.php/dynamika/issue/view/66355
ISSN: 2548-7590, DOI: 10.21831/dinamika.v8i2.66355

Design and Build a Coconut Husk Chopper Machine Using an 8 HP Gasoline Engine

Muchlisinalahuddin[1] , Yudi Apriyadi[2], Zulfan Efendi[3] , , Rudi Kurniawan Arief[5]
[1,2,3,4] Program Studi Teknik Mesin, Universitas Muhammadiyah Sumatera Barat, Aur kuning,
Jl. By Pass, Tarok Dipo, Kec. Guguk Panjang, Kota Bukittinggi, Sumatera Barat, Indonesia
*Email: muchlisinalahuddin.umsumbar@gmail.com

Article Info

Article history:

Received October 02, 2023
Revised October 19, 2023
Accepted October 20, 2023
Published October 30, 2023

Keywords:

Chopper
Coconut Fronds
Manufacturing
Frame
Capacity

ABSTRACT

The coconut frond cutter or coconut frond shredder is a device used to transform coconut fronds into small pieces, even turning them into a finely textured material. This study examines the design and development of a coconut-chopping machine that uses an 8 HP combustion motor. Structural analysis was performed on the machine frame by considering the maximum and minimum Von Mises Stresses. The analysis results show that the maximum Von Mises Stress in the frame is 1.670e+06 N/mm², while the minimum stress is 2.338e+04 N/mm². The displacement of the frame was observed at 2.642e-02 mm to 1.000e-30 mm. The safety factor of the frame was found to be 1.366e+02, indicating an adequate level of safety. Next, this study analyzed the shredding capacity of the machine. The analysis showed that the largest shredding capacity was 3619.30 kg/hour, which occurred at a high rotation of young fronds, producing fine shreds. Meanwhile, the smallest shredding capacity of 612.66 kg/hour occurs at low rotation of old fronds and produces coarse shreds. These results provide essential insights into using coconut shredding machines based on the rotation level and the processed material. This research contributes to the development of efficient and effective coconut processing technology.

Corresponding Author:

Muchlisinalahuddin
Department of Mechanical Engineering
Universitas Muhammadiyah Sumatera Barat
Jl. By Pass, Tarok Dipo, Bukittinggi, Sumatera Barat, Indonesia
Email: muchlisinalahuddin.umsumbar@gmail.com

INTRODUCTION

The coconut plant holds significant economic value, as it is one of the plants that produce vegetable oil. Its presence is crucial for Indonesia, creating job opportunities for the community and serving as a source of foreign exchange income. There are extensive coconut plantations, especially in the Riau province, which is an ideal location for coconut cultivation.

Indonesia is the world's largest producer of coconut oil, and coconut plantations contribute substantially to the country's profits. Apart from being a source of vegetable oil, various parts of the coconut tree, such as its fronds, can be utilized as livestock feed and compost fertilizer. However, coconut fronds need processing to become finer for easier use in livestock feed and compost production, which is achieved through a coconut frond shredding machine (Pristiansyah, Hasdiansah, 2021).

The coconut frond cutting or shredding machine is a device used to transform coconut fronds into small pieces or even finely processed material (Dwianda et al., 2022). This machine is primarily employed for livestock feed and compost fertilizer production. The role of cattlemen and coconut plantation farmers is crucial in this industry, forming a beneficial and effective model of mutual symbiosis to reduce feed costs in the cattle farming industry and produce compost fertilizer for farmers (Hasbi Assiddiq S et al., 2022). In return, coconut frond waste from plantations does not cause environmental pollution. Using coconut frond cutting or shredding machines can transform this waste into more valuable products (Anwar & Nasution, 2021).

The main objective of this research is to integrate the structural strength aspects of the frame with performance and capacity analysis in the coconut frond shredding process. The research aims to ensure that the machine's frame structure has sufficient strength to handle operational loads while considering safety factors. Additionally, performance analysis of the machine will provide insights into its functioning at various rotation levels and coconut frond processing conditions. By combining these aspects, the research seeks to optimize the efficiency and effectiveness of the coconut shredding machine, resulting in efficient processing aligned with the needs of the coconut processing industry.

METHODS

Flow Chart

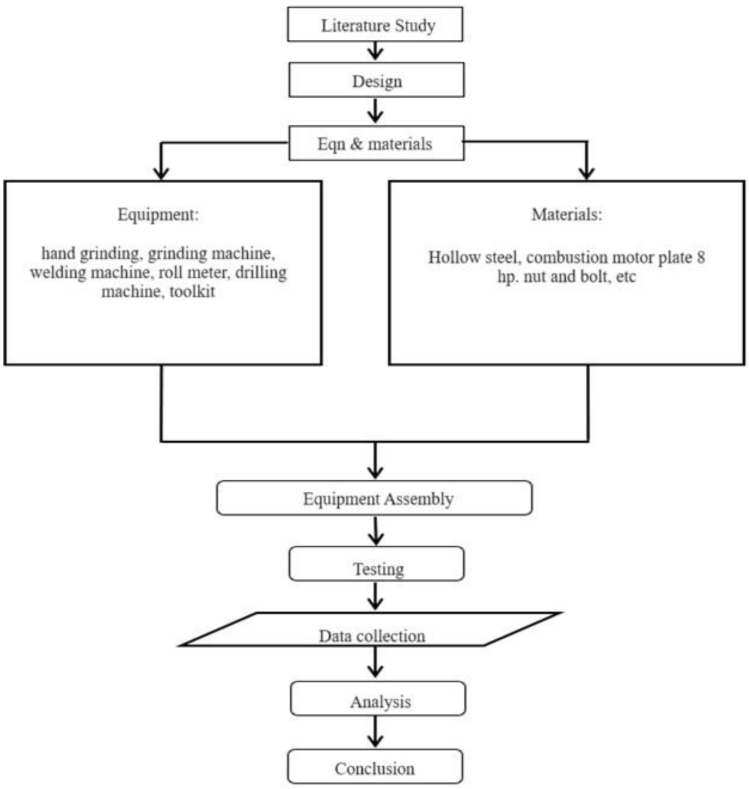

Figure 1. Research flow diagram

Design

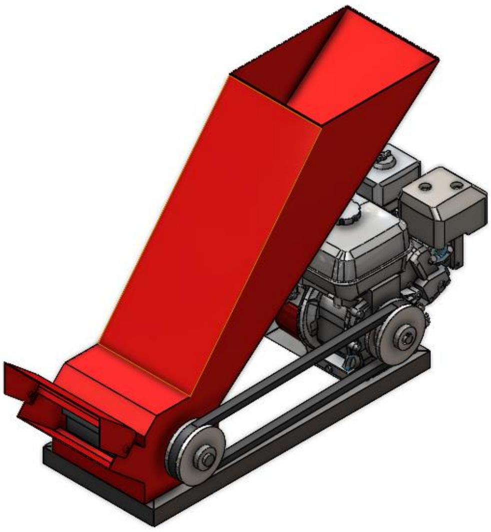

Figure 2. Design of coconut chopping machine

The machine's components include a cover, knife shaft, knife blade, two 3-inch pulleys, a V-belt, and an 8 HP petrol motor.

Tools and materials

The tools used in the design and construction of this machine include a cut-off grinder, an angle grinder, a tape measure, a manual arc welding machine, a hammer, and wrenches. The material for the cover is a thick 2-mm iron plate, and the frame is constructed from a 30 x 30 mm hollow steel frame with a thickness of 2 mm. Meanwhile, the knife blades are made from 8-mm thick car leaf springs.

Assembly and Tool Manufacturing

Here are the stages of assembling and manufacturing the coconut shredder machine:

1. Frame fabrication
2. Engine cover fabrication
3. Blade creation
4. Tool assembly

Testing Equipment

The following are the stages of testing for the coconut frond shredder machine:

1. Preparing the coconut frond shredder machine.

   Checking the components of the shredder machine to avoid component failure issues.
2. Material preparation.

   Preparing coconut fronds, both young and old.
3. Starting the machine and checking the engine rotation.

Checking the engine rotation before testing and adjusting the rotation speed according to the data collection.

4. Feeding fronds into the shredder machine.
   Inserting coconut fronds into the shredder space and checking the rotation during shredding.
5. Checking the shredded results.
   Inspecting the results of shredded coconut fronds.

Data retrieval

In this data collection process, counting was carried out for young, semi-mature, and mature coconut fronds. The engine rotation was set to 3 levels: high, medium, and low. Subsequently, the engine rotation speed and the time of counting were measured. The weight of each frond in this test was 2 kg.

RESULTS AND DISCUSSION

Specification

Table 1. Specifications of coconut frond chopping machine

Component	Dimensions (mm)	Weight (kg)	Material
Frame	450x350x1000	15	Hollow Steel 30x30x2 mm
Cover	450x350x450	15	Plate Steel 2 mm
Blade	80x3x400	5	8 mm Car Leaf
8 HP Gasoline Engine	312x362x335	18	-

The Calculation of Coconut Frond Shredder Machine

1. Power of Movement

Rotation of the blade's eye

$$\frac{n1}{n2} = \frac{Dp}{dp}$$

$$\frac{2500\ rpm}{n2} = \frac{19\ mm}{19\ mm}$$

$$n2 = 2500\ rpm$$

Forces on the blade's edge:

$$F = m \times g$$

$$F = 5\ kg \times 10\ m/s^2$$

$$F = 50\ N$$

Torque on the blade of the Coconut Frond Shredder machine with a cutting force of 50 N, and a blade distance from the center of the shaft of 180 mm, is:

$$T = F \times r$$

$$T = 50\,N \times 0{,}18\,m$$

$$T = 9\,Nm$$

The power required to move the blade:

$$P = \frac{2\pi nT}{60}$$

$$P = \frac{2 \times 3{,}14 \times 2500\,rpm \times 9\,Nm}{60}$$

$$P = 2355\,watt$$

$$HP = \frac{2355\,watt}{747} = 3{,}15\,HP$$

2. *Calculating the length of a V-belt.*

   The length of the V-belt can be calculated by determining the distance between the two pulleys from the center point, where the distance is 540 mm, and the diameter of each pulley, namely pulley 1 (d1) with a diameter of 127 mm and pulley 2 (d2) with a diameter of 127 mm. The pulley length can be calculated using the following equation:

$$L = 2C + \left[\frac{(d_2 + d_1)\pi}{2}\right] + \left[\frac{(d_2 - d_1)^2}{4 \times C}\right]$$

$$L = 2 \times 540\,mm + \left[\frac{(127 + 127)mm \times 3{,}14}{2}\right] + \left[\frac{(127 - 127)^2 mm^2}{4 \times 540\,mm}\right]$$

$$L = 2 \times 540\,mm + \left[\frac{(127 + 127)mm \times 3{,}14}{2}\right] + \left[\frac{(127 - 127)^2 mm^2}{4 \times 540\,mm}\right]$$

$$L = 1080\,mm + 398{,}78\,mm$$

$$L = 1478{,}78\,mm$$

Simulation of the Strength of the Frame of Coconut Frond Shredder Machine

This static simulation aims to determine whether the frame can withstand the production process. The simulation utilizes Solidworks 2019 software, including von Mises stress, displacement, and safety factor simulation. The total load on the frame is known to be 160 N, including a gasoline engine with a weight of 18 kg (180 N), a blade with a weight of 5 kg (50 N), and a cover with a weight of 15 kg (150 N). The material used in the simulation is ASTM A36 Steel, with a yield strength of 250 MPa.

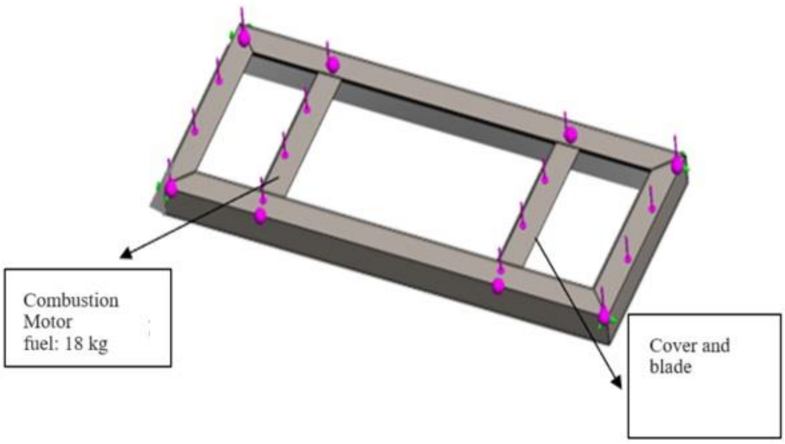

Figure 3. The position of the load point on the frame.

1. Von Misses Stress Simulastion

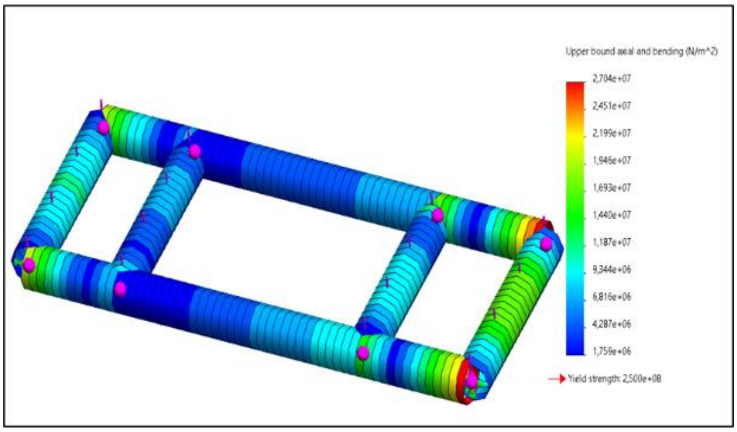

Figure 4. Results of von Mises stress simulation.

In Figure 4, the maximum Von Mises stress value is 1,670e+06 N/mm2 and its minimum value is 2,338e+04 N/mm2

2. Displacement Simulation

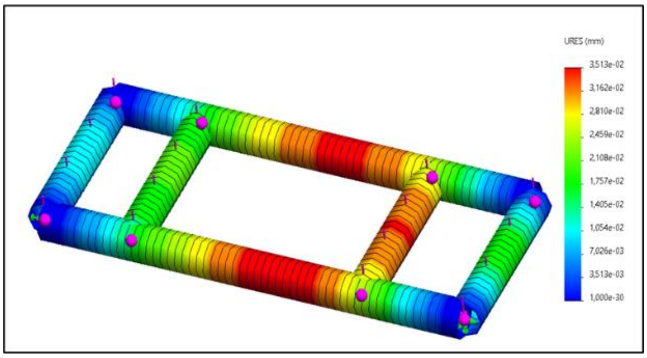

Figure 5. Displacement results

In Figure 5, the maximum displacement value obtained is 2.642e-02 mm (0.02642 mm), and the minimum value is 1.000e-30 mm.

3. Safety Factor Simulation

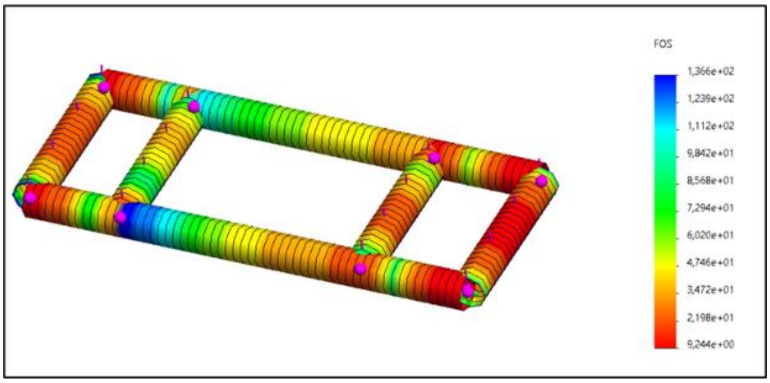

Figure 6. Safety factor simulation results

Figure 6 above shows that the safety factor on the frame of the chopper machine has a maximum value of 136.6 and a minimum of 9.44. According to Dobrovolsky, these values exceed the frame's safety factor, which should ideally fall within the range of 2.0 - 3.0 for static loads. Therefore, the ASTM A36 steel material can be replaced with another material that meets the specified criteria.

Testing Data for Coconut Frond Chopping Machine

1. Leaf sheath

Table 2. Testing of young frond counting

No	Round	Initial engine rotation (rpm)	Final engine rotation (rpm)	Time (s)	Result
1.	Low	1510,4	1198	7,01	Rough
2.	Medium	2209,8	2078,4	5,21	Moderate
3.	High	3736,4	3675,8	2,98	Fine

Figure 7. The results of rough chopping of young coconut fronds at low speed.

Figure 8. Results of rough chopping of young coconut fronds in the medium setting.

Figure 9. Results of rough chopping of young coconut fronds at high speed.

2. Medium fronds

Table 3. Testing of medium frond counting

No	Round	Initial engine rotation (rpm)	Final engine rotation (rpm	Time	No
1.	Low	1514,3	1234,8	9,11	Rough
2.	Medium	2258,7	2144,6	6,97	Moderate
3.	High	3777,2	3745,5	3,01	Fine

Figure 10. Coarse results of coconut midribs shredding at low speed.

Figure 11. Coarse results of medium-sized coconut frond chipping at medium speed.

Figure 12. Results of coarse chopping of medium-sized coconut fronds at high speed.

3. Old fronds

Table 4. Testing the counting of old fronds

No	Round	Initial engine rotation (rpm)	Final engine rotation (rpm	Time	No
1.	Low	1509,6	1290,2	11,75	Rough
2.	Medium	2497,4	2222,4	9,24	Moderate
3.	High	3842,8	3788	3,26	Fine

Figure 13. Results of the rough chopping of old coconut fronds at low speed.

Figure 14. Results of shredding coarse old coconut fronds at medium speed.

Figure 15. Results of the rough chopping of old coconut fronds at high speed.

Capacity Enumeration Analysis

Based on the test data results obtained, it is known that the higher the engine rotation, the finer the chopping results and the shorter the chopping time. This is very useful when we need chopped results according to our preferences. If coarse chopping is desired, the machine rotation is set to low, and conversely, if fine chopping is desired, the machine rotation must be set to high.

The frond type also affects the chopping results, where young fronds have more water content than half-aged or old fronds, making them easier to chop. This is indicated by a generally shorter chopping time compared to others.

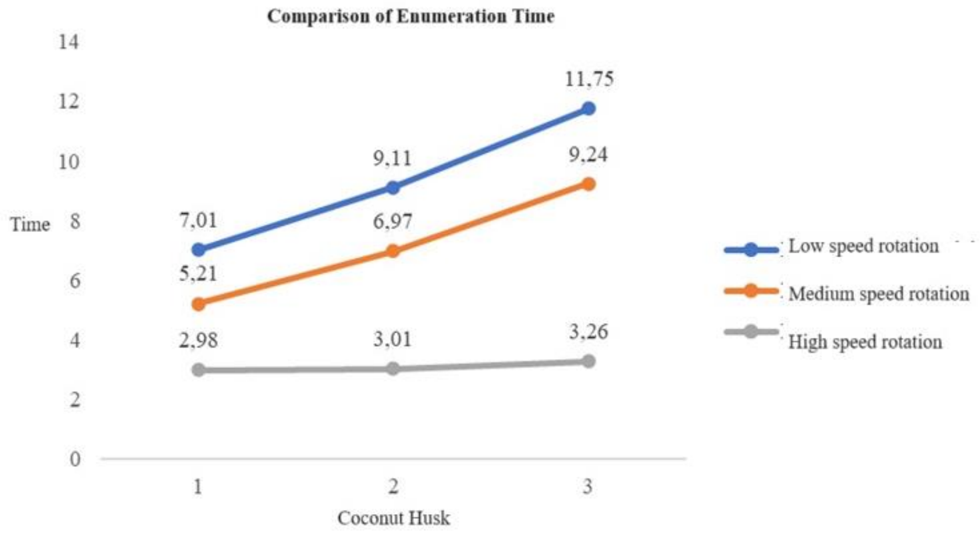

Figure 16. Comparison of enumeration time.

The counting capacity can be calculated using the equation below.

$$\text{Capacity} \left(\frac{\text{kg}}{\text{hour}}\right) = \frac{\text{weight of the frond(kg)}}{\text{enumeration time (Hour)}}$$

weight of the frond = 2 kg

enumeration time = 7,01 s = 0,0019472 hour

$$\text{Capacity} \left(\frac{\text{kg}}{\text{hour}}\right) = \frac{\text{weight of the frond(kg)}}{\text{enumeration time (Hour)}}$$

$$\text{Capacity} \left(\frac{\text{kg}}{\text{hour}}\right) = \frac{2\text{ kg}}{0{,}0019472\text{ hour}}$$

$$\text{Capacity} \left(\frac{\text{kg}}{\text{jamhour}}\right) = 1.027{,}115\text{ kg/hour}$$

The results of other counting capacity calculations can be seen in table 5 below.

Table 5. Counting capacity result

No	Engine Rotation	Types of fronds	Counting capacity (Kg/h)	Enumeration results
1.	Low RPM	Young frond	1.027,10	Rough
		Half-aged frond	790,34	Rough
		Old frond	612,77	Rough
2.	Medium RPM	Young frond	1.381,96	Medium
		Half-aged frond	1.033,00	Medium
		Old frond	779,22	Medium
3.	High RPM	Young frond	2.416,11	Fine
		Half-aged frond	2.392,03	Fine
		Old frond	2.208,59	Fine

The data in Table 5 above shows that the highest counting capacity is derived from calculating high-speed data on young fronds, amounting to 2,416.11 kg/hour, with fine counting results. Meanwhile, the smallest counting capacity is obtained from calculating low-speed data on old fronds, totaling 612.77 kg/hour, with coarse counting results.

CONCLUSION

Based on the design and analysis above, the conclusions are:

1. The coconut frond shredder functions well.
2. The frame analysis conducted using SolidWorks 2019 software through static simulation indicates that this shredder's frame has a robust structure and can support the machine's performance during usage. This is marked by the safety factor values for the large frame, with a maximum value of 1.366e+02 (136.6) and a minimum value of 9.44.
3. The maximum von Mises stress value is 1.670e+06 N/mm2 (1,670,000 N/mm2), and the minimum is 2.338e+04 N/mm2 (23,380 N/mm2). These values are lower than the allowable material stress of 2.500e+08 N/mm2 (250,000,000 N/mm2).
4. The maximum displacement value is 2.642e-02 mm (0.02642 mm), and the minimum is 1.000e-30 mm (1.000 x 10-30 mm).
5. The engine rotation significantly influences the shredding results. The higher the rotation, the finer the shredding, and vice versa. Higher rotation narrows the distance between the blade and the base.
6. Shredding young fronds tends to be faster than shredding old ones. This is due to the texture of the fronds, where young fronds are generally softer than the hard old fronds.
7. The highest shredding capacity is obtained from calculating the high-speed rotation of young fronds, amounting to 3619.30 kg/hour, with fine shredding results. Meanwhile, the smallest shredding capacity is obtained from the calculation of low-speed rotation of old fronds, totaling 612.66 kg/hour with coarse shredding results.

REFERENCES

Anwar, P., & Nasution, M. Y. (2021). Perancangan Mesin Pencacah Pelepah Sawit Untuk Pakan Ternak Dengan Menggunakan Metode Dfma (Design for Manufacture Andassembly). *Aptek*, *13*(1), 14–20. https://doi.org/10.30606/aptek.v13i1.498

Dwianda, Y., Febrianton, A., & Irwan, P. (2022). *Perancangan dan Pembuatan Mesin Pencacah Rumput Gajah dan Pelepah Kelapa Sawit Untuk Pakan Ternak Design and Manufacture of Elephant Grass and Palm Frond Chopping Machines*. *12*(2), 2089–4880. https://jtm.itp.ac.id/index.php/jtm/index

Elita Rahmarestia W, A. Asari, Yanyan A. Hoesen, D. A. S., & Balai. (2020). *PENGEMBANGAN MESIN PENCACAH TANDAN SAWIT TIPE PISAU SIRKULAR*. *1645*, 1–76.

Hanafi, I., & Nurrohkayati, A. S. (2023). Analysis of the Design of the Palm Frond Chopping Machine as a Basic Ingredient for Animal Feed. *Procedia of Engineering and Life Science*, *3*(December), 3–7. https://doi.org/10.21070/pels.v3i0.1325

Hanafie, A., Fadhli, F., & Syahruddin, I. (2016). Rancang Bangun Mesin Pencacah Rumput Untuk Pakan Ternak. *ILTEK : Jurnal Teknologi*, *11*(01), 1484–1487. https://doi.org/10.47398/iltek.v11i01.403

Hasbi Assiddiq S, Asrul, & Pratama Hermanto. (2022). Rancang Bangun Mesin Pencacah Rumput dan Pelepah Kelapa Sawit dengan Penggerak Motor Bensin Sebagai Pakan Ternak. *Infotekmesin*, *13*(2), 212–218. https://doi.org/10.35970/infotekmesin.v13i2.1530

Pencacah Sampah Organik Tipe Piringan Dengan Kemiringan Sudut Hopper Input, M., Saparin, D., Sari Wijianti, E., & Santoso Wibowo, B. (2022). 40 Saparin., dkk; Mesin Pencacah Sampah Organik Tipe Piringan Dengan Kemiringan Sudut Hopper Input 60 Derajat. *Jurnal Teknik Mesin*, *8*(2).

Pristiansyah, Hasdiansah, S. (2021). *IPTEK BAGI MASYARAKAT MESIN PENCACAH PELEPAH DAN DAUN KELAPA SAWIT UNTUK PAKAN SAPI DI DESA SEMPAN*. *1*(1), 41–45.

Rahmarestia, E., Asari, A., Hoesen, Y. A., Anggit, D., Balai Besar, S., Mekanisasi, P., & Serpong, P. (n.d.). *PENGEMBANGAN MESIN PENCACAH TANDAN SAWIT TIPE PISAU SIRKULAR (Development of Circular Saw Type of Empty Fruit Bunch Oil Palm Shredder)*.

Robiansyah. (2019). Perancangan Mesin Pencacah Pelepah Sawit Untuk Pakan Ternak Sapi. *Jurnal Teknik Mesin*, *1*(1), 1–10.