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Development Of Betel Nut Splitting Machine

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Abstract

The areca nut separator machine is a tool to shorten the working time of farmers in splitting areca nuts. The purpose of this design is to obtain maximum and effective production results and reduce the risk of work accidents. The stages in making this areca nut separator machine consist of literature studies, designing tool drawings, preparing tools and materials, making and assembling tools, then testing and analysis stages. The specifications of the areca nut separator machine with a length of 800 mm, a width of 600 mm, a height of 1000 mm, rotors and splitting by blades are designed in such a way as to fulfill the splitting function. As a result, this machine is capable of producing up to 164.3 kg of areca nuts in 1.83 minutes with a work efficiency of 60% so that this tool is suitable for use in splitting areca nuts.

Keywords: Betel nut, areca nut, cutting machine, splitting machine

INTRODUCTION

Indonesia is one of the largest areca nut-producing countries in the world, with production reaching more than 200,000 tons per year. Areca nut has an important role in various industries, such as traditional medicine, leather tanning ingredients, and food product mixtures [1]. According to data from the Central Statistics Agency (BPS), betel nut production continues to increase every year, showing the great economic potential of this commodity. In some areas, such as Sumatra and Kalimantan, areca nuts are one of the mainstay commodities, which makes a significant contribution to the local economy [2].

Areca nut farmers in Indonesia still use traditional methods to process areca nuts, namely by splitting the fruit using a machete. This manual method has several disadvantages, such as taking a long time, requiring a lot of labor, and having a high risk of injury. Data shows that around 80% of areca nut farmers in Indonesia still use this traditional method, which causes the production process to be inefficient and prone to work accidents [3]. The high risk of injury due to the use of machetes, such as cuts and other injuries, is one of the main problems faced by areca nut farmers.

The manual splitting process with machetes not only limits production capacity but also increases the risk of work injuries for farmers. In the context of globalization and increasing market demand for areca nuts, efficiency and productivity are the main keys to increasing competitiveness [4]. According to reports from the Ministry of Agriculture, demand for areca nuts on the international market continues to increase, especially from Asian and Middle Eastern countries [5]. This requires farmers to increase their production in a more efficient and safer way. Therefore, technological innovation is needed that can help farmers increase areca nut production in a more effective and safe way.

By adopting modern technology such as areca nut splitting machines, farmers can increase their production capacity significantly. This machine not only speeds up the splitting process but also reduces the risk of work injury, so farmers can work more safely and comfortably. Using a betel nut splitting machine can also reduce labor costs because one machine can replace several workers who previously carried out the splitting process manually. Thus, this innovation not only provides economic benefits for farmers but also has the potential to improve their welfare by reducing their physical workload and risk of injury.

RESEARCH METHODS

This research will be carried out through several systematic stages to design and build a areca nut splitting machine. The following is a scientific research scheme compiled which can be seen in Figure 1.

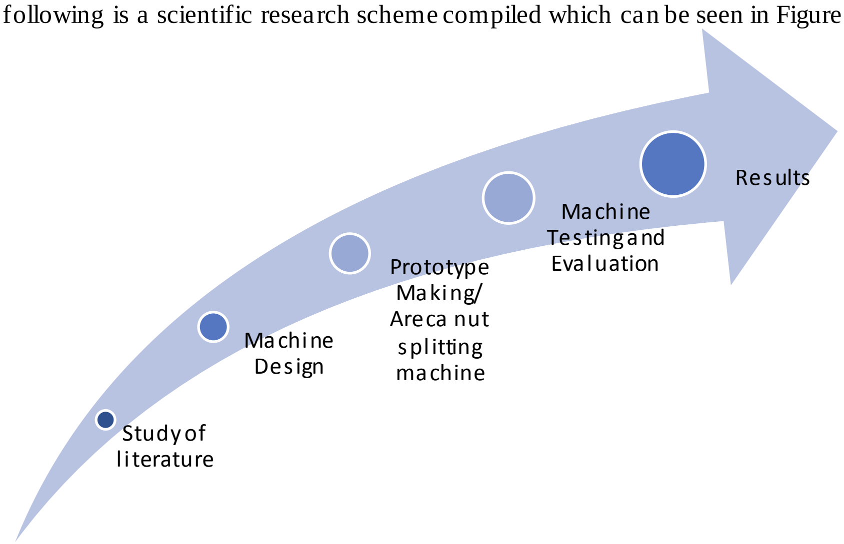

Fig. 1. Research Scheme

1. Literature Study
   A literature study was conducted to collect relevant information and data regarding existing fruit splitting machines, manual areca nut splitting techniques, as well as the needs and constraints faced by farmers. This information is collected from various sources, including journals, books, articles, and online sources. The goal is to understand the working principles of efficient and safe machines, as well as get initial design ideas that can be applied or modified for areca nut.

2. Machine Design
   Based on data and information obtained from literature studies, the next step is to design a areca nut splitting machine. This process involves creating initial sketches and designs, which are then developed into 3D models using design software such as AutoCAD or SolidWorks. Simulations and strength analysis are also carried out to ensure that the design is safe and efficient, and meets the required technical specifications.

3. Prototype Making/Areca Splitting Machine
   Once the design is complete, the next step is making a machine prototype. This process begins with selecting and purchasing the required materials and components. These components are then assembled according to the design that has been created. Initial testing is carried out to ensure that all machine parts function properly before proceeding to further testing stages.

4. Machine Testing and Evaluation
   The machine prototype that has been made is then tested to assess its performance. Tests were carried out on various types and sizes of areca nuts to measure the speed, efficiency and safety of machine work. Machine performance data, such as splitting time and number of fruits processed, are collected and evaluated. If deficiencies are found, design modifications are made and the machine is retested until it reaches optimal performance. Apart from that, calculations of important components such as shafts, splitting knives, bearings, pulleys, pins and motor power are also carried out. This calculation involves the following equations.
   a. Axis [6]: $T = \frac{P\ x\ 60}{2x\ \pi x\ N}$
      where T is torque (Nm), P is power (W), and N is rotation speed (rpm).
   b. Splitting Knife

$$F = \frac{T}{r}$$

where F is the force (N) and r is the radius of the shaft (m).

c. Bearings:

$$L_{10} = (\frac{C}{P})^3\ 10^6$$

where L10 is the bearing life (revolution), C is the dynamic capacity (N), and P is the equivalent load (N)

d. Pulleys [7].

$$D = \frac{V}{\pi\ X\ N}$$

inwhere D is the pulley diameter (m), V is the linear speed (m/s), and N is the rotational speed (rpm).

e. Peg [6]:

$$\tau = \frac{2\ X\ T}{d\ x\ l}$$

where τ\tauτ is the shear stress (Pa), ddd is the diameter of the post (m), and lll is the length of the post (m).

f. Motor Power [7]:

$$\mathrm{P} = \frac{F\ x\ v}{\eta}$$

where P is power (W), F is force (N), v is linear speed (m/s), and η is efficiency.

5. Results

The results of this research are fully documented, starting from the literature study process to machine testing and evaluation. Research reports are prepared including background, methods, results and conclusions. Machine use and maintenance guidelines are also provided for farmers. In addition, an analysis of machine components was carried out to increase the productivity produced by the machine, as well as recommendations for further development and possible commercialization of the machine.

With this systematic research method, it is hoped that the process of designing and building areca nut splitting machines can be carried out effectively and efficiently, and provide useful results for areca nut farmers.

RESULTS AND DISCUSSION

Areca nut splitting machines have an important role in the areca nut processing industry. The process of manually splitting areca nut often takes a lot of time and effort. Therefore, the development of efficient and effective areca nut splitting machines is very necessary to increase productivity and reduce dependence on human labor [8].

This research aims to design and develop a areca nut splitting machine that can automatically separate areca nut skin from fruit flesh [9]. This machine is designed to increase the efficiency of the areca nut splitting process, reduce damage to the areca nut, and increase user safety and comfort.

It is hoped that this research can contribute to the development of more modern and efficient areca nut splitting machine technology, as well as becoming a reference for further research and development in this field. The design of areca nut splitting machines has important significance in increasing production efficiency, reducing dependence on human labor, and improving the quality and safety of the areca nut processing industry. A well-designed machine not only speeds up the areca nut splitting process but also reduces the risk of injury to users, increases product quality consistency, and encourages technological development in the fields of mechanics and automation [10]. Thus, the design of areca nut splitting machines not only supports operational efficiency and reduces production costs, but also strengthens the industry's competitiveness in a competitive global market.

The design of this machine was based on the review of the previous research using rotating cutting method with more feeder's cavities to achieve higher production rate. This new machine concept was designed using Solidworks design software (**Fig. 2**) with 14 carriage cavities to hold the betel nut to be cut **(Fig.3)**. Based on previous research, this machine is expected to increase production rate by 2 times. This machine deploys an electrical motor that could be replaced with small combustion engine if needed.

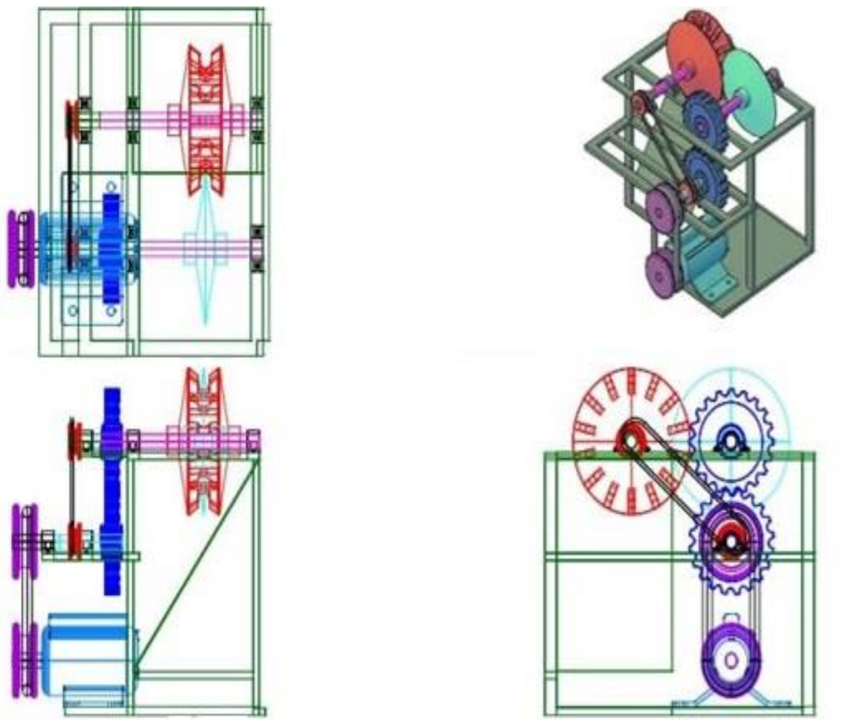

Fig 2. Machine design

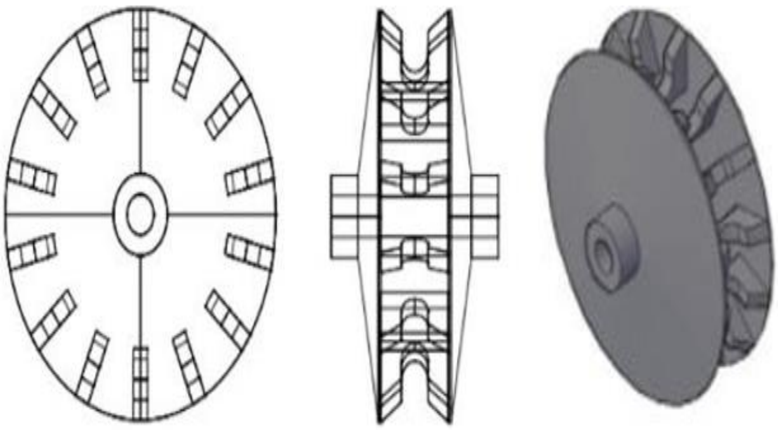

Fig 3. Nut carriage with 14 cavities

After the machine design has been completed, the next step is the process of making the machine for the areca nut splitting machine until the assembly process occurs with high precision and accuracy. This process involves collecting the main components that have been selected based on the technical specifications of the design, as well as installing the components systematically according to a predetermined order. The assembly of this machine is carried out by paying attention to mechanical and engineering principles, and ensuring that each part is properly connected to achieve optimal performance in accordance with the objectives and functions planned in making this areca nut splitting machine.

The prototype is a semi-finished machine that can already be run for observation. Upon successful result of the prototype, this machine continues to the finishing process and final trial conducted. The manufacturing process of this machine consists of fabrication and assembly. Fabrication processes such as grinding, cutting, drilling, turning, and welding (Figure 4). A used motorcycle disc brake is used for splitting blade by sharpening its edge using a hand grinder (Figure 5). Final step is to install the components to complete the machine and set for trial.

Fig 4. Fabrication process of betel nut splitting machine

Fig 5. Sharpening of disc brake's edges to be used as betel nut cutter

The machine testing conducted to examine machine capability if processing the betel nut. This testing uses a stopwatch to record processing time and tachometer to observe the engine speed. The testing was conducted by observing 3 different stages of cutting speed and time consumed to process 1 kg of betel nut. machine's processing capability will be calculated based on this testing result.

The discussion of the components of the areca nut splitting machine resulted in calculations using the following equation:

To obtain power on the areca nut splitting machine, the force on the areca nut splitting shaft is measured.

Force on the shaft

$$F_s = K_s . A_s$$

$$K_s = 0,86$$

Su = *620 Mpa*

1Mpa = 1N/mm^2

Su = *620 N/mm2*

Ks = 0.86 (620N/mm2)=533.3 N/mm2

Cross-sectional area of the blade

A1 = $\frac{1}{2}.a.t$ A2 = $\frac{1}{2}.\left(\frac{1}{2}a.t\right).t$

= $\frac{1}{2}.4,5.2$ = $\frac{1}{2}.\left(\frac{1}{2}.4,5.1,5\right).1,5$

$= 3,5cm$ = 2.53cm

Atotal = A1 + A2

= 3.5 + 2.5

Knife shear resistance

Fs =*Ks. As*

=*533.3N/mm^2.6 cm2*

=*533.3N/mm2 .60 mm2*

=31,998 N

Torque on rotary blade

Q =Fs . r

= 31.998 N 0.00762 m

=243.82 Nm

Inertia in the shaft blade

$Iporos = \frac{1}{2}\, m.r^2$

$= \frac{1}{2}\ .\ 1,2\ .\ (0,00381)^2$

$= \frac{1}{2}\ .\ 1,2\ .\ 1,45$

$= 0.87\ kg/m^2$

$W = \frac{2\ .3,14\ .140}{60}$

= 14 .65 rad/ sec

t =assumed to reach 140 rpm in 5 seconds.

a $= \frac{w}{t}$

$= \frac{14,65\ rad/s}{5\ s}$

$= 2.93\ rad/s^2$

Power

P =T . W

= 243.82 Nm . 14.65 rad/sec

= 3571.9 watts

$= \frac{3571,9\ watt}{746}$

=4.7 hp

The shaft is the link between the gear wheel and the knife holder cylinder. If P is the nominal output power of the driving motor, then a safety factor is usually taken in planning, so that the first correction can be taken Fc : 1.0

Then the design power Pd(kW)

P_d =Fc . P (kW)

= 1.0 .143 (kW)

= 143 (kW)

1. Torsion moment

$$T_{va} = 9,74.10^{-5}.\frac{Pd}{n_1}$$

$$= 9,74.10^{-5}.\frac{143}{2800}$$

$$= 4,9743\ \text{kg/mm}$$

Where :

Pd = design power

N1 = engine speed

2. The shaft material is taken from ST 37 carbon steel with specifications:

-Permissible stress of material (σ_b) =37 kg/mm2

-$Sf1$= 2.0 (for SC material)

-Sf2 = 2.0 (for material hardness factor)

3. Shaft shear stress (τ_a)

$$\tau_{a} = \frac{\sigma b}{Sf_1.Sf_2}$$

$$\tau_{a} = \frac{37}{2,0.2,0}$$

$$= 9,25 kg / mm^2$$

When testing the betel nut splitting machine, it is divided into 3 speeds, namely low, medium and fast speeds.

Table 1. Results of testing time for splitting betel nuts with a machine

No	Test material	Low revs 525 Rpm	Medium spin 1740 Rpm	High revs 2742 Rpm
1	1 kg areca nut	0	32.72	21.72
2	1 kg areca nut	0	33.06	22.06
3	1 kg areca nut	0	33.14	22.14
4	1 kg areca nut	0	32.41	21.41
5	1 kg areca nut	0	32.25	22.25

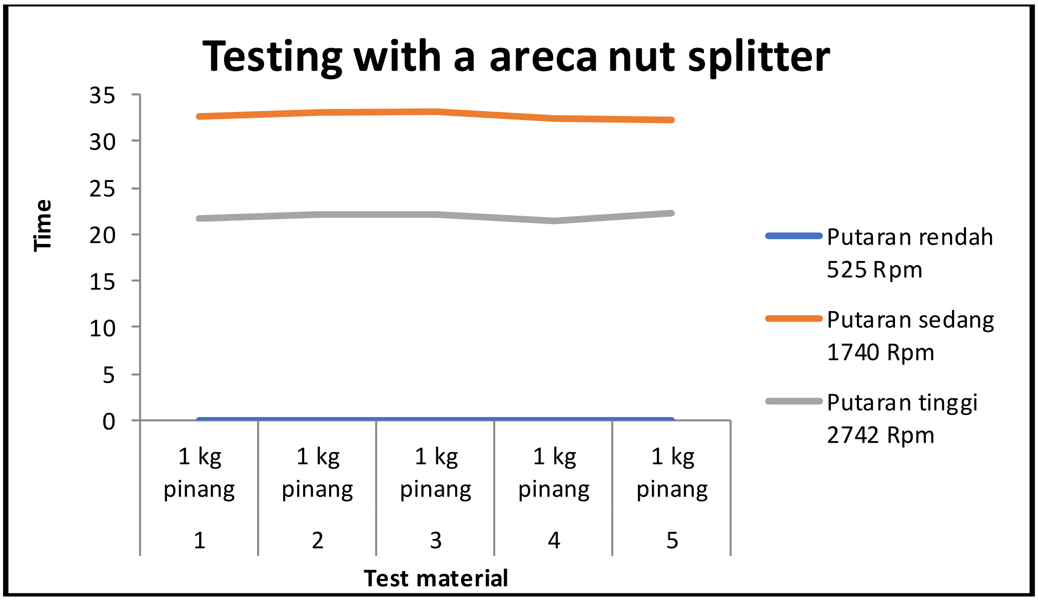

Fig. 6. Testing for splitting areca nut using a machine

1. Low revs

At low speed the machine cannot split the areca nuts because the engine power is not able to rotate the load of betel nuts, that's why in the test results table the number is 0 or there are no results that can be split. The results in the table can be seen in the table above.

2. Medium spin

Medium rotation is the most ideal rotation for splitting betel nuts because the rotation is not too fast. In the medium rotation, the time required to split the areca nut is 106.97 kg/hour.

Total time : 163.58seconds =2.72 minutes

$$kapasitas\ alat\,/jam\ =\frac{jumlah\ terbelah\ (kg)}{waktu\ total\ \ (menit)}$$

$$kapasitas\ alat\,/jam\ =\frac{5\ kg}{2{,}72\ menit}$$

= 111.11kg/hour

3. High revs

In the fast rotation, the time required to split the betel nut is an average of 1.83 minutes or around 109.58 seconds.

Total time : 109.58 seconds = 1.82 minutes

$$kapasitas\ alat\ =\frac{jumlah\ terbelah\ (kg)}{waktu\ total\ (jam)}$$

$$kapasitas\ alat\ =\frac{5\ kg}{1.82\ menit}$$

= 166 kg/hour

Comparison of manual cutting of areca nut with tools.

Table 2. Shows the comparison results of cutting areca nut manually and using a machine at three different rotation speeds: low rotation (525 rpm), medium rotation (1740 rpm), and high rotation (2742 rpm). The data in this table includes cutting time (in seconds) for 1 kg of areca nut in each experiment carried out five times for each speed.

Table 2. Comparison of cutting areca nut manually with tools.

No	Test material	Low revs 525 Rpm	Medium spin 1740 Rpm	High revs 2742 Rpm
1	1 kg areca nut	0	32.72	21.72
2	1 kg areca nut	0	33.06	22.06
3	1 kg areca nut	0	33.14	22.14
4	1 kg areca nut	0	32.41	21.41
5	1 kg areca nut	0	32.25	22.25

In **Table 2**, it can be concluded that the machine rotation speed has a significant effect on the efficiency of cutting areca nut. The machine at low speed is not able to cut, while at medium and high speeds, the machine can cut areca nut more quickly. High speed (2742 rpm) provides the most efficient cutting results with the shortest cutting time compared to medium speed (1740 rpm). Thus, to increase production efficiency and speed, it is recommended to use a machine with high rotation in the areca nut cutting process

Research on the design of areca nut splitting machines shows significant results in increasing cutting efficiency. Compared with previous research such as by Kiran et al [11], who developed a areca nut peeling machine, the cutting efficiency at high speed (2742 rpm) in this study was superior with faster cutting times. Research by Ramappa [12] on areca nut collecting machines showed good collection efficiency, but did not address the cutting aspect as effectively as this study. Additionally, research by Kumar et al. [13] who focused on micronutrient management of areca nut orchards, relevant to ensuring fruit quality before mechanical processing.

CONCLUSIONS

This research can be concluded that the manual cutting method produces 51.6 kg of areca nut per hour. However, the use of areca nut splitting machines shows a significant increase in production efficiency. At low speed (525 rpm), the machine is ineffective and cannot cut areca nut (0 kg/hour). At medium speed (1740 rpm), the machine is capable of cutting 111.11 kg of areca nut per hour. Meanwhile, at high speed (2742 rpm), the machine reaches the highest efficiency with 166 kg of areca nut per hour. This shows that the use of high-speed machines greatly increases cutting efficiency compared to manual methods..

REFERENCES

[1]. Sukadi, S., & Kurniawan, A. (2020). Rancang Bangun Mesin Pembelah Pinang. *Teknika: Jurnal Teknik*, *7*(2), 168-174.

[2]. Bangun, R. H. B. (2017). Kajian Potensi Perkebunan Rakyat di Provinsi Sumatera Utara Menggunakan Location Quetiont dan Shift Share. *Jurnal Agrica*, *10*(2), 103-111.

[3]. Maumura, Z. (2022). *Dampak Penambangan Pasir Terhadap Kehidupan Ekonomi Dan Lingkungan Masyarakat Di Gampong Pasi Pinang Kecamatan Meureubo Kabupaten aceh Barat* (Doctoral dissertation, UIN Ar-Raniry Fakultas Dakwah dan Komunikasi).

[4]. Zulgani, Z. (2023). *analisis hubungan daya saing sektor basis dan ketimpangan pembangunan terhadap pertumbuhan ekonomi provinsi jambi* (Doctoral dissertation, universitas batanghari).

[5]. Najah Hanifah, P. (2023). ANALISIS DAYA SAING LADA PROVINSI LAMPUNG DI PASAR INTERNASIONAL.

[6]. Leni, D., Bahar, Z., & Selviyanty, V. (2018). Rancang bangun mesin perajang pelepah sawit untuk pakan ternak. *Jurnal Teknik Mesin*, *11*(2), 51-57.

[7]. Putra, F. K., Safril, S., Leni, D., & YH, V. S. (2019). Rancang Bangun Mesin Pengiris Singkong. *Jurnal Teknik Mesin*, *12*(1), 19-23

[8]. Alqodri, F., Sumiati, R., Rakiman, R., Yetri, Y., & Leni, D. (2021). Modifikasi mesin pengupas kulit pinang kering. *Jurnal Teknik Mesin*, *14*(2), 59-63.

[9]. Usman, R. (2019, June). Angle Setting Between Two Cutters' Blades of Dried Areca Nut Peeling Machines Due to Increase Its Production. In *IOP Conference Series: Materials Science and Engineering* (Vol. 536, No. 1, p. 012091). IOP Publishing.

[10]. Kuthe, N. V., Ingle, P. B., & Gore, V. G. (2021). Biomass briquettes as an alternative energy source compare to wood charcoal in boilers. *Int. J. Sci. Res. Mech. Mater. Eng*, *5*(4), 16-40.

[11]. Kiran et al. (2014). "Development and Performance Evaluation of Arecanut Dehusking Machine." Journal of Agricultural Engineering.

[12]. Ramappa (2013). "Modelling and Analysis of Areca nut Collecting Machine." Current Agriculture Research Journal.

[13]. Kumar et al. (2015). "Micronutrient Management in Arecanut Plantations for Enhancing Yield." Journal of Plant Nutrition.