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# Development of an Appropriate Clove Threshing Machine to Increase the Productivity of Clove Farmers in Munduk-Buleleng, Bali, Indonesia

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**Abstract:** Clove plants are one of the agricultural commodities with high economic value. Good as spices, clove cigarette mixtures, ingredients for making medicines and ingredients for making essential oils. In the process of harvesting cloves, the process of separating clove flowers from their stalks still has many obstacles. The process currently carried out by farmers is by the manual method, namely by swiping clove flowers that are still integrated with the stalk into the palm of the farmer's hand. This process is time-consuming and can hurt the hands. If the process of separating clove flowers with their stalks is done at a slow tempo, it will harm farmers because if not dried immediately after picking it will reduce the quality of the cloves. For this reason, it is necessary to develop an appropriate clove threshing machine to increase the productivity of clove farmers. This research uses experimental methods in the form of making tools which include the stages of observation of needs, tool design, prototyping, trials, measurement of workload, production results and productivity. Workload is calculated based on the worker's pulse, production output is measured based on the output of threshed clove flowers, and labor productivity is calculated based on the ratio between output (production output) and input (workload) multiplied by his working time. The conclusion of the study showed that the designed clove threshing machine can speed up the process of separating clove flowers from their stalks compared to separating clove flowers from their stalks by manual method. The use of this clove threshing machine was able to reduce the workload on clove farmers by 11.8%, increase the production yield of threshing clove flowers by 324.6%, and increase the work productivity of clove farmers by 3 425.0%. It is recommended that clove flower growers should use ergonomic threshing machines in order to reduce workload and increase production yield and work productivity.

**Keywords:** Clove Threshing Machine, Appropriate Technology, Clove Farmer Productivity

## 1. Introduction

Advances in household industry technology provide convenience for the community, especially farmers in processing agricultural and plantation products. Therefore, the government plans development in the plantation and agricultural sectors, one example of which is clove plants. Clove plants are one of the agricultural commodities with high economic value. Clove leaves are not only used as a kitchen spice, but can be used as a mixture for kretek cigarettes, as an ingredient for making medicines and as an ingredient for making essential oils [1].

Cloves are one of the most cultivated cash crops in Indonesia. Clove flowers are the expected result of the cultivation of clove plants. One of the important stages in the clove flower production process is the process of threshing clove flowers or separating the flower part from the stem. The process of threshing clove flowers is currently done by swiping clove flowers that still contain stalks by hand.

The process of processing clove flowers to get dried clove flowers goes through several stages, namely: harvesting, threshing (separation of stalks with flowers), and drying.

Clove flowers are harvested when several clove flowers in one flower arrangement are reddish. After harvesting, the separation of flowers with their stalks is usually done by hand. After that, the flowers and stalks are dried separately in the sun or using a clove dryer. The process that takes a lot of time and energy is the process of separating clove flowers from their stalks. If the process of separating the clove flowers and their stalks is carried out too late, it will be detrimental to farmers because if they are not dried immediately after picking, the quality of the cloves will be reduced [2].

Along with the development of technology, clove threshing tools have also developed. In designing a clove threshing device, several factors need to be considered, including efficiency, safety and operator comfort. An efficient clove threshing device can speed up the process of threshing clove flowers, so farmers can save time and effort. In addition, clove threshing equipment must also be safe to use so that farmers do not have accidents when threshing. A clove threshing device that is convenient to use can reduce fatigue in farmers' hands and arms when separating flowers and stalks. In addition to being safe and comfortable, this clove flower thresher must be able to increase the production and work productivity of clove farmers. The approach that can be taken for this is to create appropriate technological tools [3-6], namely by creating an ergonomic clove threshing machine.

## 2. Research Methods

### *2.1. Clove Flower Thresher Tool Design*

The design of this clove threshing device is designed to complete the threshing process and clove flowers quickly and easily operate. It is hoped that after the completion of this tool can speed up the time and ease the work of farmers in the process of separating clove flowers from their stalks. The design drawings to be made can be seen in Figure 1:

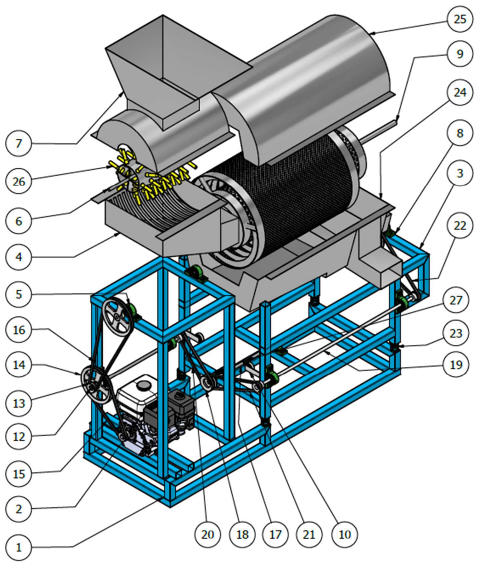


***Figure 1.*** *Design Clove thresher design.*

***Table 1.*** *Clove flower threshing machine design specifications. (Caption Figure 1).*

| No | Quan-tity | Name | Spesification |
|---|---|---|---|
| 1 | 1 | Skeleton | Hollow iron 40mm x 40mm |
| 2 | 1 | Burning motorbike | 1/2 hp petrol engine |
| 3 | 1 | Frame sorter | Hollow iron 40mm x 40mm |
| 4 | 1 | Thresher bottom cover plate | Stainless steel plate, 1.2mm thick |
| 5 | 8 | Pillow block UCP 202 | Type UCP 202, inner diameter 12 mm |
| 6 | 1 | clove thresher shaft | steel axle diameter 15 mm, stainless steel plate diameter 1.2 mm |
| 7 | 1 | Thresher top cover plate | Stainless steel plate, 1.2mm thick |
| 8 | 2 | Pillow block UCP 204 | Type UCP 202, inner diameter 20 mm |
| 9 | 1 | 9. Sorter | Steel axle diameter 20 mm, stainless steel plate diameter 1.2 mm |
| 10 | 2 | 10. Bearing mounting plate | Steel plate 2 mm thick |
| 11 | 2 | 11. Bearing | Type 6204 2RS, inner diameter 20 mm |
| 12 | 1 | 12. Dynamo-thresher-vibrator shaft | steel shaft, diameter 15 mm |
| 13 | 1 | 13. Pully A1 2 Inch | Type A1 2 Inch |
| 14 | 1 | 14. Pully A1 8 Inch | Type A1 8 Inch |
| 15 | 1 | 15. Center-dynamo belt | Rubber |
| 16 | 1 | 16. Center-threshing belt | Rubber |
| 17 | 1 | 17. Vibrating axles | steel shaft, diameter 15 mm |
| 18 | 1 | 18. Pully A2 2 Inch | Type A2 2 Inch |
| 19 | 1 | 19. Vibrating axle-rotary | steel shaft, diameter 15 mm |

| No | Quan-tity | Name | Spesification |
|---|---|---|---|
| 20 | 1 | 20. Vibrating belt – center | Rubber |
| 21 | 1 | 21. Vibrator belt – rotary connection | Rubber |
| 22 | 1 | 22. Belt rotary – rotary connection | Rubber |
| 23 | 4 | 23. Per frame sorter | Steel |
| 24 | 1 | 24. Rotary bottom cover plate | stainless steel plate, 1.2 mm thick |
| 25 | 1 | Rotary top cover plate | stainless steel plate, 1.2 mm thick |
| 26 | 66 | Rubber thresher | chicken feather thresher rubber |
| 27 | 1 | Vibrating pipe | Pipe diameter 15mm, steel axle diameter 10 mm |

This clove thresher uses a gasoline engine as its driving force. The way this clove thresher works is as follows.

1. When the combustion motor is turned on, the rotation of the motor is passed to the drive pulley attached to the combustion motor.
2. The rotation of the driving pulley of this rotation will be forwarded to the shaft that holds 3 pulleys, namely pulleys that continue the rotation of the combustion motor, pulleys that continue the rotation to the threshing shaft and pulleys that continue the rotation to the sorter or separator.
3. The rotation of the shaft holding 3 pulleys will continue the rotation to the threshing shaft, and at the same time continue the rotation to the vibrating and rotary shafts on the sorter or separator.
4. Cloves are inserted into a threshing device to knock clove flowers from their stalks with a threshing pipe containing threaded rubber that rubs against the clove flowers.
5. This clove thresher uses a gasoline engine as its driving force. The way this clove thresher works is as follows.
6. In the sorter or separator there are 2 levels, the first level will filter the stalks from the clove flowers, then the second level will filter the flowers from the dirt of the dirt left over from threshing.

The way the threshing machine works is as follows.

1. The rotation of the engine is connected to the drive pulley and belt (v-belt), the drive pulley will rotate the pulley connected to the main shaft.
2. The rotation of the main shaft will be passed on to the threshing shaft. In the threshing, the threshing shaft will rotate the threshing rubber which will produce an impact motion.
3. The rotation of the main shaft will be forwarded to the vibrating shaft, the vibrating shaft serves to vibrate the sorter and as a successor to the rotation to the sorter's connecting shaft.
4. The rotation of the vibrating shaft will be forwarded to the connecting shaft of the sorter.

Next, the rotation of the connecting shaft will be forwarded to the sorting shaft.

### 2.2. Place, Time, and Research Sample

This research was conducted in Munduk village, Buleleng, Bali Province, Indonesia. Place for making clove flower threshing machines in the Mechanical Engineering laboratory, Bali State Polytechnic. Research time from May to August 2023. The clove flowers sampled in this threshing process are 5 kg, both on manual tools and on designed machines. while the number of workers who use manual tools is 15 people and those who use designed machines are 10 people. This research process was repeated up to 5 times.

### 2.3. Research Flow

The research flow can be explained by the following Figure 1 chart.

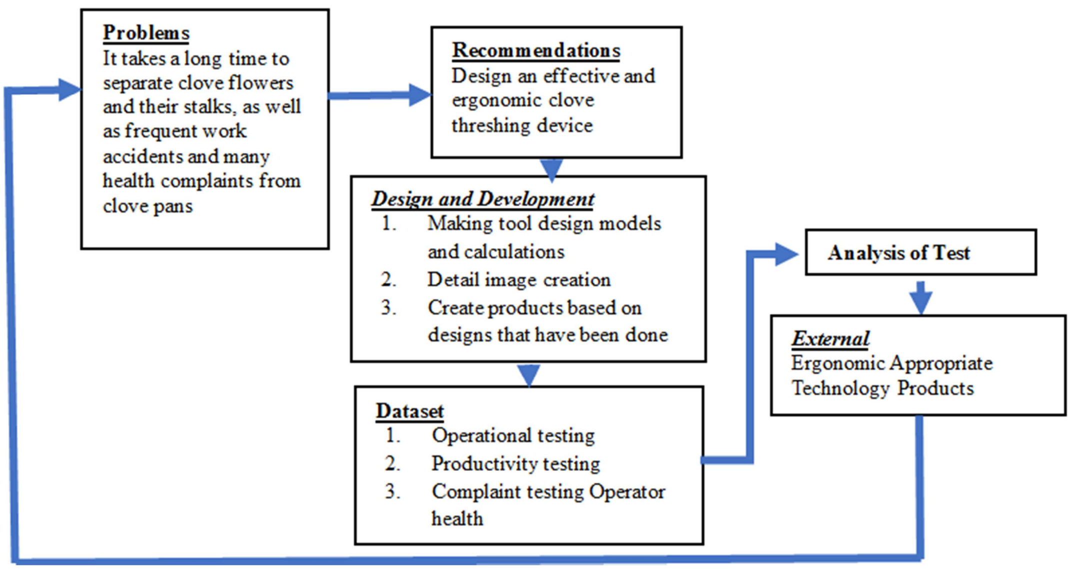


*Figure 2. Research Flow.*

### *2.4. Data Retrieval and Data Analysis Techniques*

The research data of this study is in the form of design data for appropriate technology tools for clove flower thresher using ergonomic rules. Production data is calculated based on the output of the clove threshing machine in one working hour. While the data on the work productivity of clove farmers is calculated based on the following formula: [7, 8].

$$P = \frac{Output}{Input\ x\ time} \quad (1)$$

P is the work productivity of clove thresher farmers in units of kilograms per hour bpm (beats per minute). Output is the amount of production produced from the clove flower thresher in kilograms. Input is the workload calculated based on the farmer's working pulse in units of bpm (beats per minute). Time is the farmer's working time which is calculated for each hour of work with the unit of time being hours.

The data obtained were analyzed using descriptive and inferential statistics. Differences in workload, production results and work productivity were calculated using independent t-test analysis between using manual tools and clove flower threshing machines at a significance level of 95% or an error rate of 5%.

## 3. Results and Discussion

### *3.1. Design Results*

From The design made, then realized in the form of a product in the form of a clove threshing machine, more details can be seen in figure 3.

***Figure 3.*** *Clove Flower Threshing Machine Design.*

The working principle of this clove threshing tool is to utilize the *engine speed which* is forwarded to the main shaft which functions to divide the rotation of the three components driven, namely the threshing, vibrating and sorting components.

Cloves are inserted into the threshing tube, inside the threshing tube the threshing rubber will hit or pound the clove flowers with the stalk until the clove flowers are separated from the stalk, the clove flowers that have separated from the stalk will come out through the lower funnel and go directly to the sorter, inside the clove flower sorter and the stalks will be sorted (separated) and out to different channels.

### *3.2. Drive Motor Calculation*

To be able to determine the power on the motor must first determine the force that occurs on the shaft. The magnitude of the force that occurs in this design uses the following equation formula:

***Table 2.*** *Loading Shaft.*

| Component | Mass (kg) | Shaft Rotation (rpm) |
|---|---|---|
| 1. Threshing Shaft | 12.4 kg | 360 rpm |
| 2. Vibrating Shaft | 35 kg | 360 rpm |
| 3. Sorting shaft | 21 kg | 32 rpm |

Determining the amount of load (F) received by the threshing shaft (Component 1) is as follows [10].

$$F = m.g \quad (2)$$

$$F = 12.4\ kg\ x\ 9.81\ m/s^2$$

$$F = 121.64\ N$$

Then the required torque is [10]:

$$T = F\ x\ r \quad (3)$$

$$T = 121.64\ N\ x\ 0.09\ m$$

$$T = 11.19\ N.m$$

After knowing the required torque, it can be calculated the motor power using the formula [10]:

$$P = \frac{2\ x\ \pi\ x\ n\ x\ T}{60} \quad (4)$$

$$P = \frac{2 \text{ x } 3.14 \text{ x } 360 \text{ rpm x } 11.19 \text{ N.m}}{60}$$

$$P = 421.72 \text{ Watt}$$

$$P \approx 0.42 \text{ kW}$$

Determining the amount of load (F) received by the vibrating shaft (component 2) is as follows:

$$F = m \text{ x } g$$

$$F = 35 \text{ kg x } 9.81 \text{ m}/s^2$$

$$F = 343.35 \text{ N}$$

Then the required torque is:

$$T = F \text{ x } r$$

$$T = 343.35 \text{ N x } 0{,}04 \text{ m}$$

$$T = 13.74 \text{ N.m}$$

After knowing the required torque, it can be calculated the motor power using the formula:

$$P = \frac{2 \text{ x } \pi \text{ x } n \text{ x } T}{60}$$

$$P = \frac{2 \text{ x } 3.14 \text{ x } 360 \text{ rpm x } 13.74 \text{ N.m}}{60}$$

$$P = 517.72 \text{ Watt}$$

$$P \approx 0.52 \text{ kW}$$

Determining the amount of load (F) received by the shaft sorter (component 3) is as follows.

$$F = m \text{ x } g$$

$$F = 21 \text{ kg x } 9.81 \text{ m}/s^2$$

$$F = 206.01 \text{ N}$$

Then the required torque is:

$$T = F \text{ x } r$$

$$T = 206.01 \text{ N x } 0.225 \text{ m}$$

$$T = 46.36 \text{ N.m}$$

After knowing the required torque, it can be calculated the motor power using the formula:

$$P = \frac{2 \text{ x } \pi \text{ x } n \text{ x } T}{60}$$

$$P = \frac{2 \text{ x } 3.14 \text{ x } 32 \text{ rpm x } 46.36 \text{ N.m}}{60}$$

$$P = 155.28 \text{ Watt}$$

$$P = 0.16 \text{ kW}$$

So the machine power obtained from the three shafts is:
P (machine) = 0.42 + 0.52 + 0.16
= 1.1 kW ≈ 1.48 HP

### *3.3. Calculation of the Reject Shaft*

*Power shaft plan*
the power received by the vibrating shaft is 0.1214 kW, the selected correction factor is 2.

$$P_d = f_c . P \text{ (kW)} \quad (5)$$

$$= 2 \text{ x } 0.16 \text{ kW}$$

$$= 0.31 \text{ kW}$$

*Twisting Moment*
The torsion moment can be determined using the following equation: The planned main shaft speed is 32 rpm.$(n^1)$ with the following formula [10].

$$T = 9.74 \, x \, 10^5 \frac{Pd}{n^1} \, (kg.mm) \quad (6)$$

$$= 9.74 \, x \, 10^5 \frac{0.31 \, kW}{32 \, Rpm}$$

$$= 974{,}000 \text{ x } 0.01$$

$$= 9{,}740 \text{ kg.mm}$$

*Shear Stress*
Determining the shear stress can use the following equation where the type of shaft material used is St 42 steel, where St 42 steel has a tensile strength of 42 with a safety factor of S = 6.0 and S = 1.3. $\frac{kg}{mm^2} f_1 f_2$ with the following formula [10].

$$\tau_a = \frac{\sigma_B}{(Sf_1 x Sf_2)} \, (\text{kg}/mm^2) \quad (7)$$

$$= \frac{42 \frac{kg}{mm^2}}{(6.0x1.3)}$$

$$= 5.39 \frac{kg}{mm^2}$$

*Shaft Diameter*
The diameter of the shaft can be determined using the following equation. This factor is expressed by being selected at l.0 if the load is worn smoothly, 1.0-l.5 if there is a slight shock or collision, and 1.5-3.0 if the load is subjected with a large shock or impact. If it is expected that there will be use with bending loads, it can be considered the use of factors whose prices are between 1.2 to 2.3. $K_t \, C_b$ with the following formula [10].

$$d_s = [\frac{5.1}{\tau_a} K_t . C_b . T]^{1/3} \, (mm) \quad (8)$$

$$= [\frac{5.1}{5.39} 1.2 \, x \, 1.5 \, x \, 9{,}740 \,]^{1/3}$$

$$= 25.26 \, mm$$

So for the minimum diameter size of the shaft obtained by 25.26 mm. For this reason, a shaft with a diameter of 30 mm is used to get better strength and is easily available in the market.

### *3.4. Workload, Production Output, and Work Productivity*

Workload is calculated based on the workers' heart rate in beats per minute (bpm) before work and after work [6, 9, 10]. The result of the calculation is as follows.

***Table 3.*** *The pulse of clove thresher farmers.*

| Variable | Using old way | | Using machine tools | | t | p |
|---|---|---|---|---|---|---|
| | Mean (bpm) | SD | Mean (bpm) | SD | | |
| Resting pulse | 69.08 | 1.75 | 70.08 | 2.44 | 1.076 | 0.296 |
| Work pulse | 12.96 | 2.97 | 108.41 | 3.12 | 23.097 | 0.001 |

Description: bpm = beats per minute

Table 3 shows that no significant difference was obtained in the resting pulse rate of farmers (p>0.05). This shows that the pulse condition of the farmers before work is the same. Meanwhile, the work pulse of clove farmers obtained a significant difference ($p < 0.05$). This shows that there is a significant difference in the work pulse of farmers between working using the old clove threshing method and using the new clove threshing machine.

Judging from the average work pulse, when using the old tool, a workload of 122.96 beats per minute was obtained, including a moderate workload [6, 9, 11]. Meanwhile, when using the new tool, a working pulse of 108.41 beats per minute was obtained. Based on these results, it can be stated that there was a decrease in the workload of clove farmers by 11.8%.

Machine productivity is the ratio of the output of clove threshing products during the normal period of time to the input of clove flower products separated from the stem in the period of time required to shed clove flowers, the amount of output of threshing clove flowers. Clove flowers used as samples are 5 Kg. Separating clove flowers with stalks with a capacity of 5 kg using manual tools takes an average of 58 minutes. Meanwhile, threshing clove flowers using a 5 kg capacity machine takes 13.67 minutes. It can also be stated that the capacity for threshing clove flowers using manual tools is 5.17 kg/hour while using a designed machine is 21.95 kg/hour.

So that the results of the calculation of production and work productivity of clove farmers are as follows.

***Table 4.*** *Production Results and Work Productivity of Clove Farmers.*

| Variable | Using old tools | | Using new tools (multifunctional contractors) | | t | p |
|---|---|---|---|---|---|---|
| | Average | SD | Average | SD | | |
| Total Production (kg/hour) | 5.17 | 1.06 | 21.95 | 3.27 | -38.343 | 0.001 |
| Work productivity | 0.04 | 0.01 | 0.21 | 0.03 | -14.826 | 0.001 |

Based on the results of the above calculations, it is obtained that the results of production and work productivity Clove farmers experienced a significant increase (P<0.05). Production increased from 5.17 kg/hour to 521.95 kg/hour or an increase of 324.6%. Meanwhile, the work productivity of artisans increased from 0.04 to 0.21 or an increase of 425.0%.

Ergonomic interventions need to be carried out to improve work productivity and work welfare of farmers [3, 12, 13]. In this study, the use of clove threshing machines was proven to reduce workload, increase production yields and work productivity of clove farmers. Work productivity is something that needs to be improved continuously [4, 8, 14, 15], And this labor productivity will indirectly improve the welfare of farmers and farmers' income [5, 16-18].

# 4. Conclusion

Based on the results and discussion above, the following can be concluded.

1. A clove threshing machine designed to speed up the process of separating clove flowers from their stalks compared to separating clove flowers from their stalks by manual method.
2. The use of this clove threshing machine is able to reduce the workload on clove farmers by 11.8%.
3. The use of this clove threshing machine is able to increase the production yield of threshing clove flowers by 324.6%.
4. The use of this clove flower threshing machine is able to increase the work productivity of clove farmers by 3 425.0%.

It is recommended that clove flower growers should use ergonomic threshing machines in order to reduce workload and increase production yield and work productivity.

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