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Design of a Corn Thresher and Corn Cob Chopper Using the Pahl & Beitz Method

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Abstract
The manual corn threshing process by farmers can slow down the processing and subsequent rotation of corn and affect the quality of the corn. In addition, waste from corn processing is not utilized correctly, so processing is needed. This study aims to design a corn threshing tool and corn cob shredder and to make the processing time more efficient so that the productivity and economy of farmers increase. The design method used is Pahl & Beitz, with four stages: planning and explaining tasks, designing product concepts, designing product shapes and details. The most recovered concept was produced based on the design method: concept variant 2. The corn threshing tool and corn cob shredder designed with a 240 kg/hour capacity can make the processing time more efficient. This is known from the results of testing. The tool can thresh 4 kg of corn in 1 minute, and corn cob waste is automatically chopped into powder that can be used as animal/poultry feed.

INTRODUCTION

As one of the largest agricultural countries in Asia, Indonesia has fertile soil that produces various types of commodities in the farming and plantation sectors, producing different kinds of biodiversity in the form of vegetables and fruits, including plant foods such as corn and rice. One of the agricultural commodities is corn, which can be a source of income for the community, increasing state income and reducing unemployment in Indonesia. Corn (Zea Mays L) is one of the plant commodities that plays a vital role in the food and feed sector. Corn can be used as a raw material for the food industry (for example cornstarch), animal feed, poultry, and fish. Therefore, post-harvest corn processing must be considered, so that the corn kernels' quality is genuinely high (Basuki et al., 2020).

According to Hudoyo and Nurmayasari (2020) quoted by (Cholilalah, Rois Arifin, 2023) Corn has many uses in the food industry, animal feed, industrial raw materials, and bioethanol fuel. Corn kernels can be ground into corn flour which is used to make bread, biscuits, noodles, and various other food products. In addition, corn is also used as animal feed which contains many nutrients for animals. Based on the structure and shape of the seeds, corn can be grouped into several types, namely horsetooth corn, pearl corn, pod corn, qpm corn and others (Djafar et al., 2021).

Talang Maur Village is one village that generally works as farmers, most of whom are corn farmers. This village is in Mungka District, Lima Puluh Kota Regency, West Sumatra Province. In general, it has a reasonably large corn plantation with various harvests ranging from 500 kg to 1500 kg. The process of threshing corn seeds by farmers can be seen in Figure 1 manual threshing.

Figure 1.*Manual Threshing*

Farmers do the threshing process by hand by cleaning the skin first and then threshing the corn kernels per row using their thumbs until they run out. So, the separation process can take a long time depending on the amount of corn. The threshing process can take 4 to 7 days to be processed to the next (drying stage) stage. In 1 hour, workers can thresh approximately 3 kg of corn from the cob.

In addition to using hands, the corn threshing process is also done with the help of a bicycle. The threshing process can be seen in Figure 2. Based on observations, the threshing process is done by cleaning the corn husks first and then placing the bicycle with the rear wheel hanging. Furthermore, the bike is pedalled using hands, and the corn that has been cleaned of its husk is attached to the edge of the bicycle wheel utilising the help of hands; occasionally, the corn is rotated so that all the corn kernels are separated from the cobs. After all the corn is separated from the cobs, workers must collect it again and then dry it until it is scorched so it does not get mouldy. In 1 hour, approximately 15 kg of corn can be threshed from the cobs.

Figure 2*. Corn Threshing Using Bicycle*

The result of corn processing is corn cob waste. Initially, the corn cobs were thrown away and sometimes burned because they were considered to have no economic value. Over time, it increased as a processed material into supports, fuel, and bioethanol after fermentation. Meanwhile, the use of corn cobs as animal feed has not been optimally developed. According to Fauziah., Y., A. (2020), quoted by (Hasrizart et al., 2023), stated that corn cobs are one of the wastes from corn cultivation, where these corn cobs are very potential if used as animal feed by giving a little treatment such as fermentation treatment. In addition, the availability of corn cobs is very abundant, easy to transport, rich in nutrients and easy to process as animal feed thanks to the help of microorganisms.

On the other hand, besides corn farmers, some of the people of Talang Maur Village also have egg-laying chicken farms and fish farmers. So that corn farmers and chicken and fish farmers depend on each other. The harvest from corn farmers can be sold to the chicken farmers and corn cobs that have been separated from the seeds can be used as a mixture of fish feed after processing. Observing the potential conditions of the land availability aspect and the aspect of corn plant commodities that are developing in an area, of course, will increase corn production and also has the potential to increase the impact of waste from processing in the form of corn skin and corn cobs. This condition is caused because the technology that exists and is currently used is still focused on processing the results and does not have the efficiency to process the waste produced (Ilahude et al., 2021).

Pahl and Beitz proposed a way of designing products as described in their book, *Engineering Design: a systematic approach. Pahl & Beitz stated, "This phase involves the collection of information about the requirements to be embodied in the solution and also about the constraints",* which means that the design phase must involve gathering information about the requirements that must be realized in the solution as well as the constraints (Winata & Suryadi, 2020).

Pahl & Beitz's design proposes a way of designing a product, which consists of 4 activities or phases, and consists of several steps, (Sunyoto et al., 2023).:

a. Planning and explaining the task,
b. Designing the product concept,
c. Designing the product shape and
d. Designing the details

According to Kotler and Armstrong (2001) quoted by (Muniarty et al., 2022), a product is something that can be offered to the market to be noticed, owned, used, or consumed and can also be a tool to satisfy consumer desires and needs. Products include physical objects, services, people, places, organizations and ideas. In general, products are used as a tool to satisfy and fulfill needs by consumers.

Considering the above conditions, designing a corn threshing tool and corn cob shredder for corn farmers in Talang Maur Village is necessary. Therefore, researchers are interested in designing a corn threshing tool that can thresh corn kernels, shred the cobs and reduce processing time using the Pahl & Beitz method. The Pahl & Beitz method is designing an item in four stages: planning and explaining tasks, designing product concepts, designing product shapes and product details.

RESEARCH METHODS

This research was conducted in Talang Maur Village, Mungka District, Lima Puluh Kota Regency, West Sumatra Province. The initial research step was conducting a preliminary study to collect information about the problem. The preliminary research was in the form of observation and interviews with 2 corn farmers. Observations were conducted directly with corn farmers in Talang Maur Village to obtain data on the machines used to assist the corn threshing process. Farmers do it manually and use bicycles to thresh corn seeds. Interviews were conducted to get information about corn and other useful information to continue the research. Furthermore, a literature study was undertaken to find valuable references or theories in books, journals, and previous research. The next step is identifying the problems obtained during the preliminary study. After identifying the problem, a problem formulation is made to get the right solution to the problem. Furthermore, the research objectives are determined, which help determine the success or failure of the research.

The next step is to process the data using the Pahl & Beitz design method which consists of 4 phases, namely, first planning and explaining the task (explanation of product specifications), second product concept design composed of 3 steps (preparation of alternative concepts, sketches of concept variants, weighting of concept variants), third product shape design (design of selected concept variants), fourth detailed design (product manufacturing). After the design stage is complete, testing is carried out on the designed tool to determine whether the designed tool functions according to user needs. Furthermore, analysing the results of data processing that has been carried out in the form of a detailed description is used as consideration and evaluation

material adjusted to the problems identified previously. The last step is to draw conclusions and make suggestions.

The stages carried out in the research are made in the form of a flowchart to describe the flow of the research process from start to finish.

Figure 3. *Flow chart*

RESULTS AND DISCUSSION

1. Task Planning and Explanation

It is the first phase in designing using the Pahl & Beitz Method. This stage is carried out by collecting information on the desired and needed requirements to compile the specifications of the corn cob thresher and shredder to be designed. This tool is designed to have two functions: corn kernel thresher and corn cob shredder. To facilitate the preparation of specifications can be done by reviewing aspects of geometry, kinematics, force, energy and others. From these aspects, the relevant requirements can be described, and a list of specifications can be made

Table 1. *Specification Requirements*

No	Condition	Information
1	The Movers	Using a drive with a high rotational speed, uses small costs and is easy to operate.
2	Corn thresher	The thresher used can remove corn kernels attached to the corn cob, does not make noise, and does not damage the shape of the corn kernels.
3	Corn cob shredder	Using a shredding blade that can grind corn cobs into powder, made of solid and sturdy material so that it does not break easily.
4	*Hopper*	The materials used must be strong, sturdy, and easy to shape during construction.
5	Threshing and shredding tubes	Using solid materials, resistant to corn impacts, easy to shape because it functions as a machine house
6	Chopper sieve	The sieve used has a diameter that is appropriate to the level of fineness of the feed material.
7	*Output*corn kernels and shreds	Using solid and sturdy materials, easy to shape can produce the results of threshing and shredding well so they don't scatter.
8	Frame	The materials used must be robust, sturdy, lighter, easy to construct and able to withstand loads because they support the threshing and shredding tubes.
9	*Pulley*	Pulley material is lighter, easy to install and affordable. A pulley is useful as a motion transmission shaft connected to the belt.
10	*Belt*	The material is strong and not easily broken because it functions as a movement transmission.

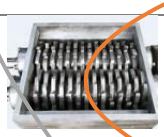
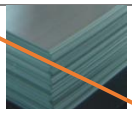
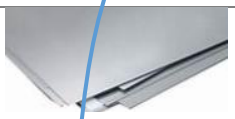
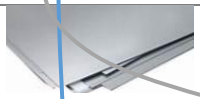
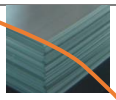
(Source: Data Processing, 2024)

According to (Iqbal R Pamungkas et al., 2019), when making a list of requirements, it is important to distinguish a requirement, whether it is a demand or a desire. Requirements that must be met in every condition or other words, if the requirements are not met, then the design is not considered correct and the desired requirements, if possible. for example, if a requirement requires a reasonably high cost without providing a significant technical influence, then the requirement can be ignored. For example, I made a design for a corn cob thresher and shredder by covering the entire machine with iron plates to make it look neater. Adding this design does not significantly affect the performance and functionality of the tool, but only provides aesthetic value and additional production costs.

2. Product Concept Design

The product concept design is based on the specification requirements explained in the first stage. The product concept design consists of several steps, namely the preparation of alternative concepts in morphological tables, sketching concept variants and weighting or assessing concept variants to determine the selected variant design.

Table 2. *Tool Morphology*

No	Specification	Variants		
		A	B	C
1	The Movers	 6 hp petrol engine	 Hp Dynamo	 Crank
2	Corn thresher	 Threaded iron	 Shock absorber	 Iron coated tires
3	Corn cob shredder	 Double	 Single	
4	Hopper	 2 mm iron plate	 Aluminum iron	
5	Sheller and shredder tube	 2 mm iron plate	 Used drums	 Aluminum iron
6	Chopper sieve	 8mm		
7	Output of corn kernels and shreds	 2 mm iron plate	 Aluminum iron	
8	Frame	 Iron elbow	 Hollow iron	 Wood
9	Pulley			
10	Belt	 Flat belt	 Rope	

(Source: Data Processing, 2024)

The morphology table shows the materials that will be used to make the product. The selection of materials is very important because it can affect the product to be made. One of them is in the transmission of motion, According to Handoyo, et al., (2019) quoted by (Diharja et all., 2022) Determining the selection of pulleys must be done carefully because the size of the pulley can affect the resulting rotation. If the pulley has a large diameter, it will produce a slow rpm rotation, conversely if the diameter is smaller it will produce a fast rpm rotation. From the table 2, there are 3 alternative concept solutions resulting from a combination of concept variants. The concept variants are made into sketches to display the shape of the 3 alternative concept variants that will be selected. The following is a picture of the concept variants.

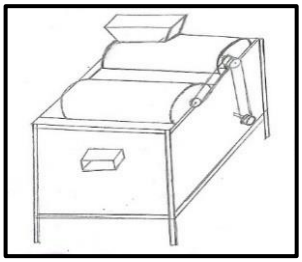


Figure 4. *Concept Variant I*

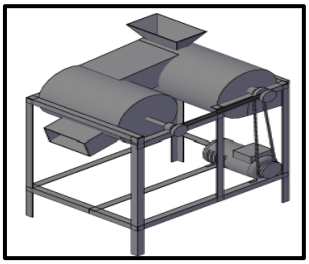


Figure 5*. Concept Variant II*

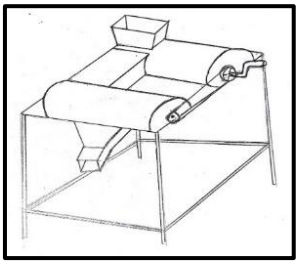


Figure 6. *Concept Variant III*

Next, a concept assessment will be conducted to obtain an optimal concept design by evaluating and assessing all concept variants. The results of the concept variant assessment are the initial Solution concept which will be re-evaluated for its suitability with the evaluation criteria given by the expert.

Table 3*. Solution Variant Assessment*

Solution variants	**Functional suitability** According to the wish list In principle it can be realized Within the limits of production costs Meet security requirements As per your wish Adequate information								**Decision**
	A	B	C	D	E	F	G	Explanation	
V1	+	-	+	-	+	-	-	Higher costs	-
V2	+	+	+	+	+	+	+	Selected variants	+
V3	-	-	+	+	-	-	-	Complicated processing process	-

(Source: Data Processing, 2024)

Based on the table 3, the most optimal concept variant is variant 2 (V2). So the assessment with the scoring concept is not carried out because only variant 2 is following the 7 specification lists.

3. Product Form Design

This phase is the result of the previous stage that meets the specification requirements according to the criteria in the product concept phase. The design of the product shape of the corn thresher and corn cob shredder is

made using AutoCAD software. At this stage, the form of the tool from the selected concept variant design is displayed in 3D.

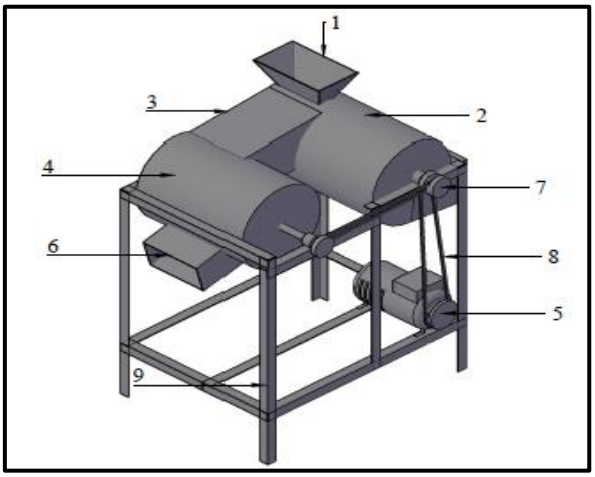


Figure 7. *Selected Concept Design*

Caption:

1. *Hopper*(place to put corn)
2. Corn threshing tube
3. Connecting channel
4. Corn cob shredder tube
5. The Movers
6. *Output*shredded
7. *Pulley*
8. *Bealting*
9. Frame

The corn threshing and corn cob shredder are designed with a simple shape. The main components of this tool are made of iron. The frame of the tool is made of 3 x 3 cm angle iron and the tube is made of 2 mm thick plate iron. The drive used is a 6 hp gasoline motor because it is more efficient in energy use.

4. Detail Design

This phase is the final stage, where the tool's shape, dimensions, components, specifications, and production costs are produced. The corn seed thresher and corn cob shredder are made by adjusting the user's height to be 57 x 82 x 114 cm. The frame is made of 3 x 3 cm angle iron because it is a sturdy and robust material that can withstand the load. The tube part is made of 2 mm thick plate iron because it has a strong material and is easy to shape. The drive is a gasoline motor because it has a high rotational speed and trim operating costs.

Figure 8. *Corn Thresher and Corn Cob Shredder*

Tool Testing

After the corn threshing tool and corn cob shredder are designed, the next step is to test the tool to apply it according to its function. Testing is carried out from the corn threshing process to the corn cob shredding process.

The equipment used in the testing process of the corn thresher and corn cob shredder is:

a. Corn kernel thresher and corn cob chopper
b. Corn
c. Stopwatch

The variables observed in this study are:

a. Time used to remove corn kernels
b. Fuel used in the process of threshing and shredding corn cobs

The steps taken to test the tool are to check the machine's condition, the fuel, prepare the dry corn to be threshed, and prepare a container to hold the corn kernels and the chopped results. After everything is ready, turn on the machine and put the corn to be threshed into the hopper then turn on the stopwatch to calculate the threshing process time. After the threshing process is complete, turn off the machine and stopwatch, then check the inside of the machine to make sure the corn is left inside.

Based on the test results conducted using a corn thresher and corn cob shredder, in 1 minute it can thresh approximately 4 kg of corn and shred corn cobs into powder that can be used as feed. While threshing corn seeds by hand takes 60 minutes to produce 3 kg of corn, and threshing using a bicycle takes 60 minutes to produce 15 kg of corn. With the presence of this corn thresher and corn cob shredder, farmers' productivity and economy have increased. When comparing work using machines and not using machines, the same number of working hours can produce much more corn seeds than those not using machines.

CONCLUSION

Based on the study's objectives, it can be concluded that the corn kernel thresher and corn cob shredder designed have dimensions of 57 x 82 x 114 cm. The corn kernel thresher and corn cob shredder can work according to their function with a 240 kg/hour capacity. With the new corn kernel thresher and corn cob shredder, the corn kernel threshing process time is faster than that of the manual. Corn cobs that were initially only burned and had no economic value can be utilized properly. The advantages of this tool are that it not only shreds corn cobs but can also shred corn kernels to be used as poultry feed and is energy efficient. The designed tool is still not optimal because some corn enters the corn cob shredder tube channel, causing some corn to be destroyed along with the corn cob. This is due to the size of the design and the placement of components that are not right,

Suggestions that can be shown for further research improvement are to improve the factors causing corn to enter the connecting channel so that it is not chopped together with the corn cobs. Improvements can be made by adjusting the size of the components in the threshing tube, namely the distance between the sieve and the corn threshing knife.

REFERENCES

Basuki, M., Aprilyanti, S., Azhari, A., & Erwin, E. (2020). Perancangan Ulang Alat Perontok Biji Jagung dengan Metode Quality Function Deployment. *Jurnal INTECH Teknik Industri Universitas Serang Raya*, *6*(1), 23–30. https://doi.org/10.30656/intech.v6i1.2196

Cholilalah, Rois Arifin, A. I. H. (2023). Eco-Friendly Biodegradable Plastic From Corn Cob Waste. In Angewandte Chemie International Edition, 6(11), 951–952.

Diharja, F. P., Irfa'i, M. A., & Rosadi, M. M. (2022). Analysis of the Effect of Variation in Driven Pulley Diameter on Output Rotational Speed and Final Torque on Toyota Kijang Innova E 2.0 M/T Transmission Trainer. Engineering Journal: Media for the Development of Science and Engineering Applications, 21(1), 32-41.

Djafar, M. F. Y., Astika, L., Hendrawan, W., Hasan, F., & Yunus, F. M. (2021). Analisis faktor-faktor yang mempengaruhi produksi jagung kelompok tani bangkit bersama di desa Ambara. *AGRINESIA: Agribusiness Scientific Journal, 5*(2), 155-161. https://doi.org/10.37046/agr.v5i2.11953

Hasrizart, I., Nasution, A. S., Ginting, N., Kartika, K., & Juliana, J. (2023). Pemanfaatan tongkol jagung sebagai pakan ternak Koptan Rudang Mayang Desa Balai Kasih. *Jurnal Derma Pengabdian Dosen Perguruan Tinggi (Jurnal DEPUTI), 3*(1), 140–147. https://doi.org/10.54123/deputi.v3i1.237

Ilahude, Z., Liputo, B., Djamalu, Y., & Antu, E. S. (2021). Desain mesin multi proses pengupas, pemipil dan pengolah limbah jagung untuk pakan ternak. *Jurnal Vokasi Sains dan Teknologi, 1*(1), 8-11. https://doi.org/10.56190/jvst.v1i1.3

Iqbal R Pamungkas, Sulaksono, B., Munandar, M., Suwandi, A., & Fajar, M. F. (2019). Perancangan mesin tube notcher menggunakan metode G. Pahl dan W. Beitz. *Teknobiz: Jurnal Ilmiah Program Studi Magister Teknik Mesin*, *9*(2), 20-32. https://doi.org/10.35814/teknobiz.v9i2.536

Muniarty, P., Marthiana, W., Sudirjo, F., Fauzan, R., & Sanusi. (2022). Product design and development. Padang: PT. Global Executive Technology.

Sunyoto, S., Supriyono, S., & Kuncoro, H. (2023). Desain mesin pemarut dan pemeras kelapa terpadu dengan metode Pahl dan Beitz. *Presisi, 25*(2), 52-59. https://ejournal.istn.ac.id/index.php/presisi/article/view/1639

Winata, E. K., & Suryadi, A. (2020). Perancangan kursi tunggu yang ergonomis untuk lansia dengan metode Pahl and Beitz pada Klinik XYZ Sidoarjo. *JUMINTEN*, *1*(6), 61–72. https://doi.org/10.33005/juminten.v1i6.130.