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Design of Coconut De-husking Machine Using Quality Function Deployment Method

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ABSTRACT

The innovative design of a coconut machine can overcome the problems of manually process of a coconut de-husking. This paper objective is to design a coconut de-husking machine based coconut farming community needs. The design used method of the Quality Function Deployment (QFD) to develop a machine that suits to coconut farmers. The steps of the proposed method were to translate customer needs into coconut de-husking machine characteristics, parts of machine characteristics and development of coconut de-husking machine. The machine design for a coconut de-husking employed an electric motor, which it was connected to the roller. Then, the blades on the roller have been embedded and peeled the coconut husk. This research produced a design and development of a coconut de-husking machine based voice of customer approach and customer needs as a support in the design of the machine. Therefore, the development of machine may fulfill coconut farming community needs to overcome conventional process of coconut de-husking.

KEY WORDS: *Coconut de-husking machine, coconut farming, Customer need, Quality function deployment.*

1.0 INTRODUCTION

Indonesia is the second largest coconut producer in the world after the Philippines [1] that have potentially income generation for coconut farmers. The coconut husk is also potential downstream industries of the coconut fruit, which can support the community's economic of coconut farmers. Utilization of coconut husk can be a raw material in many products industry such as spring bed, mattress, car seat, seat of vehicle, pillow, rug, rope, net, doormat, carpet, vehicle dashboards, etc. [2]. However, the coconut processing in partially Indonesian industry is still using conventional system and with low value added [3].

Generally, the coconut farmers in Indonesia have used a conventional technology to de-husking coconut, using a crowbar-shaped tool of iron or wood that is mounted vertically with the tip of the above. That conventional technology have limited [4] such as: require great strength and specialized skills, the risk of blade crushed coconut that may be injure hand or foot, time consuming and uncomfortable de-husking position. The limitation of conventional coconut de-husking can to be addressed by making tools or machines. Some research such as Shansen *et al.* (2015) [5] conducted a study to design an automatic coconut peeling machine using the Program Logic Control (PLC). Furthermore, Nwankwojike *et al.* (2012) [6] designed and built the machine automatically opening the coconut husk by using two blades. Venkataramanan *et al.* (2014) [4] conducted research to develop a coconut automatic machine for stripping and the removal of coconut crown. But, that machines have a complicated operation, maintenance and very costly for the coconut farmers in Indonesia. Therefore, it is a challenge to design a machine that appropriate with Indonesian coconut farmers need and satisfaction.

The Quality Function Deployment (QFD) is one of method that widely used by many researchers to get the design of the machine or tool based-customer needs and satisfaction [7]. In this paper adopted the QFD method to determine the design of coconut de-husking machine. The main objective in implementing the QFD is [8]: accommodate the priorities; based costumer needs; ability to translate customer needs into the characteristics and technical specifications and design, finally build and test the results of these product whether or not to satisfy the customer or user. Therefore, this paper proposed to design a coconut de-husking machine based costumers needs. A case study

was conducted to the coconut farming communities in Indragiri Hilir, Riau Province, Indonesia.

2.0 LITERATURE REVIEW

2.1 Processing and Peeling Coconut Husks

The coconut fruit shaped elliptic and diameter's ranging from 150 mm to 200 mm [9]. The coconut fruit is composed outer layer, fibrous husk, seed coat, meat and water of coconut that can be seen in Figure 1. The coconut fruit has a high potential economic value and widely used for human needs such as coconut oil, coconut extraction pellet, desiccated coconut, coconut cream, coconut milk, shredded coconut dry (copra), and coconut water that can be used to make vinegar and nata de coco. The seed coat can be used to make charcoal, activated carbon and craft [10].

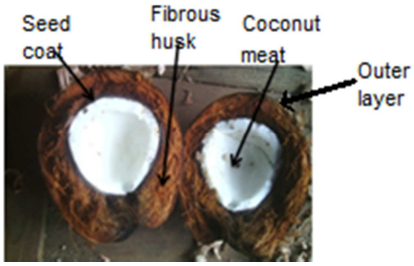


Figure 1: Parts of a coconut fruit

Process of splitting between the coconut husk and coconut shell has several stages of production, among which the stripping process of coconut fiber. According Suhardiyono [10], stripping coconut husks in Indonesia were still using traditional or manual equipment that can be seen in Figure 2. The de-husking coconut by manual or traditional equipment has the disadvantage such as requires a lot of energy from the worker, experienced worker, poses danger to the worker due to sharper edge may contacted, which injury the worker's hands [11]. In addition, the manual process of coconut de-husking is time consuming and low productivity.

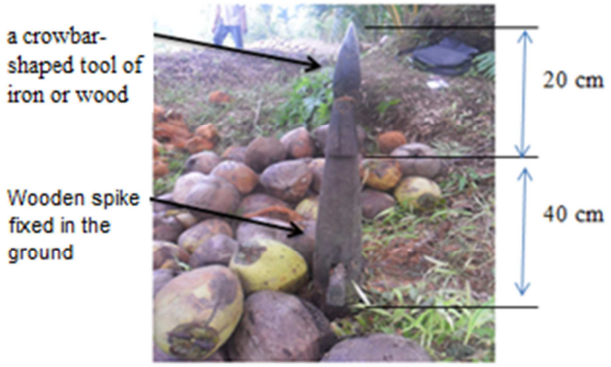


Figure 2: The conventional method to de-husking a coconut

2.2 Quality Function Deployment (QFD

The Quality Function Deployment (QFD) is a method to determine the priority needs and requirement of customers by collecting customer voices and customer needs. The QFD is very helpful in the process of designing a product to obtain a competitive product by creating a product in accordance with the requirement and needs of customers. This method identifies the target of the design with the needs of customers, product characteristics, technological barriers and product competitiveness [12]. The QFD takes into account of customer needs (whats), technical characteristics (hows), which followed by rating to make priority of the product design that is illustrated by house of quality as depicted in Figure 3 [13].

The QFD uses the principle of Concurrent Engineering, which all experts are involved in all stages of product development. The QFD process uses a matrix to translate the needs of customers from the initial planning stages through production control. Each phase or matrix is consisting of a more specific aspect of the product requirements. The relationship between the matrix elements then is evaluated for each stage. The most important aspects only for each phase are incorporated into the next matrix. According Chan & Wu [7], the QFD is a four-phase: (1) product planning: building a house of quality (an example in Figure 3), (2) product design: requires creativity and innovative ideas in the experts team, (3) process planning: flowcharted manufacturing process and process parameters or target value documented, and (4) process control: performance indicator was created to monitor the production process.

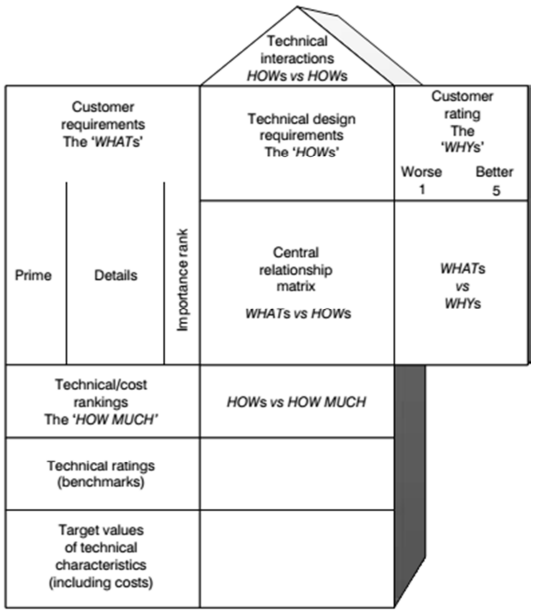


Figure 3: An example of House of Quality for QFD by Oakland (2004) [13].

3.0 METHODOLOGY

The methodology to design of coconut de-husking machine based on the quality function deployment (QFD) method, which the basis for determining the parameters needed to design accordance

with the coconut farmer's community needs. Figure 4 illustrated the methodology flowchart for the intended process to do survey collection of the data and development of House OF Quality (HOQ) for de-husking machine design. The survey design for capturing the coconut farmer's community requirements was consisted of identify population and sample, choose survey method, design questionnaire and carry out survey. The survey and distributing questionnaires were conducted in the Enok District, Indragiri Hilir, Riau Province, Indonesia.

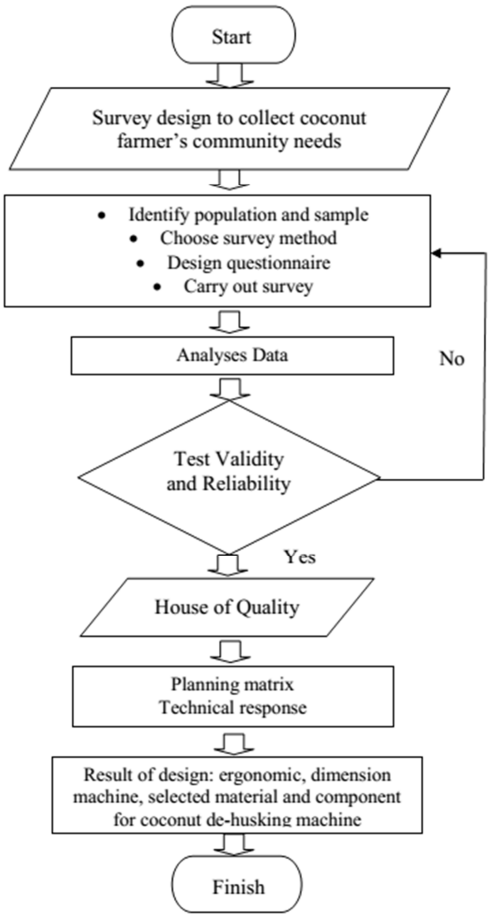


Figure 4: Flowchart of methodology for the QFD of coconut de-husking machine

4.0 RESULT AND DISCUSSION

4.1 Initial Survey Results

The population and sample for this survey was defined based on the coconut farmer's community in Enok District, Indragiri Hilir, Riau Province, Indonesia. There were 528 respondents of coconut farmer's community in that area. According to Arikunto [14], if the population was less than 100 respondents, then all of that population was taken for research sample. If a large number of population (more than 100), so it can be taken for research sample between 10% and 15%. Furthermore, in this research the population was more than 100 respondents, so then 10% of samples was taken for research sample. The determination of the number of samples was based on probability sampling technique of random sample used formula: n = 10% × N, where: n=sample size, N=the number of population. Therefore, n = 0.1 × 528, around 53 sample of respondents.

Test of Validity and Reliability

The validity and reliability tests performed using SPSS 17.0 software. The validity test was conducted to determine the value of "r" that can be seen from the corrected item-total correlation in SPSS data. Based on the value of r table for the number of respondents were 53 then (N-2). Therefore, it was resulted 51 samples of respondents, which a significant level of 1% was 0.357. The data of validity test results for coconut farmers community needs that can be seen in Table 1.

Table 1: Testing of data validity for coconut farmer's community needs

No	Attributes of Costumers Needs	Value of r	Information
1	Easy to use or user friendly	0,430	valid
2	Cheapest product	0,405	valid
3	Quickly in processing	0,415	valid
4	Safety product	0,406	valid
5	Portable product (easy to carry or moveable)	0,371	valid
6	Spare-part available on market	0,389	valid
7	Easy maintenance	0,400	valid
r Critical Table		**0,357**	

The test of reliability was used reliability analysis, model of *Alpha Cronbach*. The reliability test of value can be seen in the value of alpha coefficient. According to the test result that the measuring instrument with the item in questions was 7 items, then it has a value of alpha coefficient of 0.722, as was depicted in Figure 5. That was indicated the reliable measurement tool that can be used as a measurement tool for coconut farmer's community needs.

Reliability Statistics

Cronbach's Alpha	N of Items
.722	7

Figure 5: Reliability test result

4.2 Development of the House Of Quality (HOQ)

The development process of the House of Quality (HOQ) consisted of several processes, such as by distributing questionnaires to coconut farmer's community who serve as the respondents. Then, collecting and analizing of data, sub-sequence that was performed the validity and reliability tests of the results of obtained questionnaires. The results of validity and reliability tests were incorporated into the matrix of the House Of Quality to obtain the required attributes for design of coconut de-husking machine based method of the Quality Function Deployment (QFD). The development processing of the matrix of the House Of Quality, it can be seen in Table 2.

Table 2: Development of House Of Quality (HOQ)

No	Technical response / Costumer Requirements	Weights of important	Supporting components of de-husking coconut	Dimension of the machine	Ergonomic design
1.	Easy to operate or user friendly	4,23		△	◎
2.	Cheapest product	4,24	◎	◎	○
3.	Quickly processing of de-husking coconut	3,92		△	◎
4.	Portable product (easy to carry or moveable)	4.15	△	◎	◎
5.	Spare-part available on market	3,98	◎		
6.	Easy maintenance	3,87		△	○
7.	Safety to use	4,11	○	○	◎
	Total	28,5	90,46	99,86	172,02
	Ranking		3	2	1

Symbol information:

Symbol	Value	Information
<empty>	0	No relationship
△	1	Slightly relationship
○	3	Moderate relationship
◎	9	Very strong relationship

4.3 Design Results based on the HOQ for Coconut De-husking Machine

The design result of priority ranking of the HOQ was determined by the highest value to lowest value of coconut farmer's requirements. The highest value of ranking would be a top priority in the design of coconut de-husking machine. Accordance the ranking result of the design of coconut de-husking machine was awarded by ergonomic design became the main priorities, followed by the dimensions of the machine, the materials and selection of components machine.

The ergonomic design of coconut de-husking machine was required a safety and comfortable to use, easy to operate or user friendly, a quicker in process and portable product (easy to carry or moveable).

The dimensions design of coconut de-husking machine used Anthropometric data of Indonesian people. Decision-size based on the position of the worker who adapted to the design of the machine dimensions. The Anthropometric data used in the design of coconut de-husking machine were: shoulder height = 138.96 cm, hip = 95.28 cm high and the length of the shoulder grip to forward = 64.81 cm. The design of ergonomic and dimensions of the coconut de-husking machine results were illustrated in Figure 6-8.

The materials and components selection of the coconut de-husking machine were as following:

- Steel plate
- L profile of steel for the machine frame
- Cutting knife
- Connecting shaft for transmission
- Connecting shaft as the gear sprocket
- Selection of pipe of machine knife
- Selection of bearing
- Selection of gear
- Selection of motor
- Selection of reducer
- Selection of sprocket and chains.
- Selection of coupling

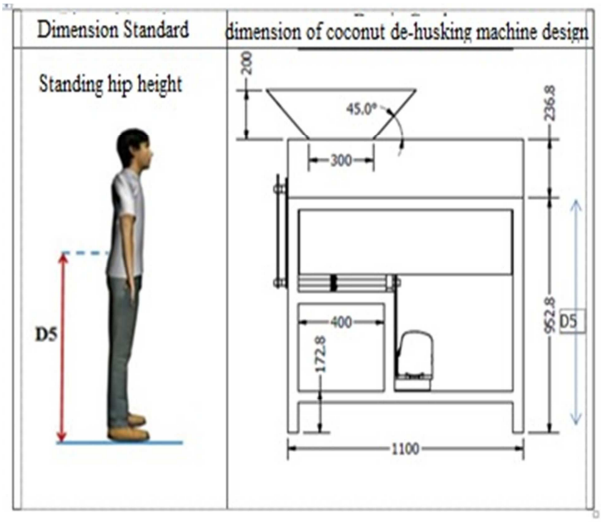


Figure 6: Dimension of standing hip height for ergonomic consideration

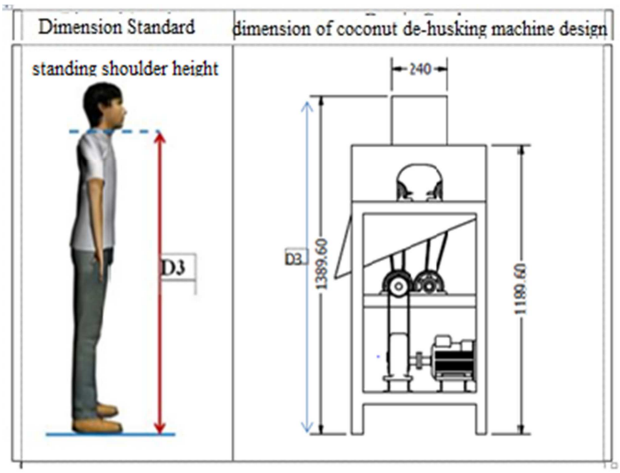
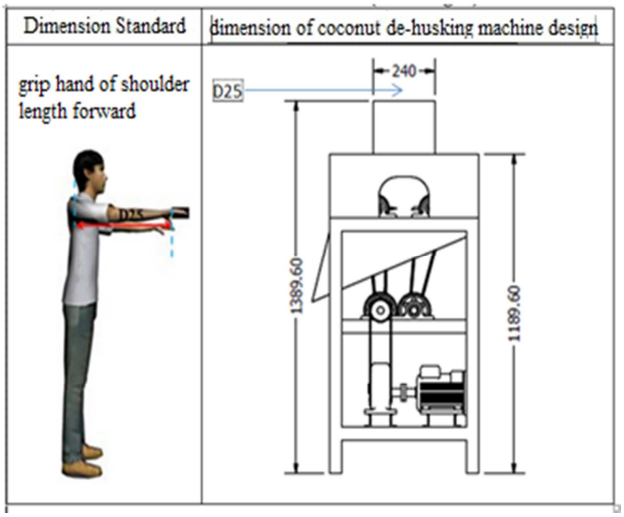


Figure 7: Dimension of standing shoulder height for ergonomic consideration



Gambar 8: Dimension of grip hand of shoulder length forward for ergonomic consideration

Finally, based on ergonomic design using Anthropometric dimensions and availability components or parts in market were revealed a coconut de-husking machine design, as shown in Figure 9.

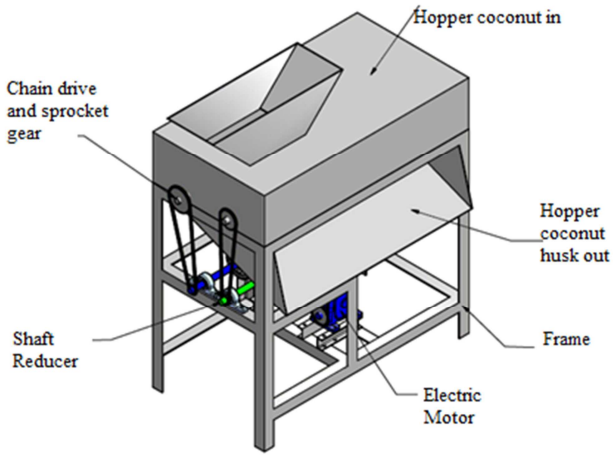


Figure 9: The design of coconut de-husking machine

5.0 CONCLUSION

This paper proposed to design a coconut de-husking machine using Quality Function Deployment (QFD) approach, which based on coconut farmer's community requirements to determine the parameters of design. A survey to identify population and sample, choosing survey method, design questionnaire and distribute the questioner were done to collect coconut farmer's community needs. A case study was conducted to the coconut farmer's community in Indragiri Hilir, Riau Province, Indonesia. Based survey result, the machine parameters should be easy to operate, cheapest price, quickly in process de-husking, safe to use, easily carried or moved, part easily obtainable in the market and easy maintenance. The top priority ranking in the design machine was an ergonomic design, with a total value weighted of 172.02. Secondly, the dimensions of machine that was 99.86 of a total value weight. Thirdly, selection of materials and components machine was 90.46 of a total value weight. The data specification of the coconut de-husking machine design was obtained: a cutting knife selection of conical helical on roller, a 3Hp of electric motor and the speed of 2700 rpm, the reducer ratio of 1:50.

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