Multidisciplinary Applied Research and Innovation Vol. 3 No.1 (2022) 565-576

MARI

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN :2773-4773

Coconut Dehusking Machine

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DOI: https://doi.org/10.30880/mari.2022.03.01.069
Received 30 September 2021; Accepted 30 November 2021; Available online 15 February 2022

Abstract: In Malaysia, coconut dehusking is one of the most important jobs to do since the domestic use of the product varies, mainly to produce coconut milk. Currently, there are many designs of the coconut dehusking machine available in the market right now, ranging from simple, old-school peeling devices to electrical shredder machines. The problem with the current designs is the cost of operating it since it requires electricity, safety problems, and consumes high labour energy. In this study, the coconut dehusking machine is designed to solve these problems. To put it simply, the machine is split into three operations, piercing, peeling, and shearing operation. The piercing operation is when the ram is pushed the top moving blade, top static blade and bottom static blade pierces the coconut husk. In the peeling operation, the ram is depressed further until the top moving blade is pushed radially outwards. The bottom blade holder is then rotated using a bottom lever to apply shear force on the husk to remove it from the shell. This design is much more portable since there are wheels installed on the base of the machine. The blades also accommodate the type of coconut used in Malaysia. In this study, the model of the coconut dehusking machine was fabricated to demonstrate the working principle of the coconut dehusking machine. Suggestion: some changes such as altering the height of the blade might be applied to improve the peeling force applied to the husk.

Keywords: Coconut Dehusking, Coconut Dehusking Machine, Coir

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1. Introduction

Cocos nucifera, also popularly known as coconut, is a popular fruit that is widely planted and cultivated in Southeast Asia in countries like Malaysia, Indonesia, and Philippines [1]. However, the fruit is known and consumed worldwide and is popular for its usage in industrial and consuming purposes. The coconut fruit is consisting of an outer epicarp, a mesocarp, and an inner endocarp [2]. The epicarp, which is the husk of the fruit, will change its colour, which signifies its age. **Figure 1** shows the physical variation of coconut with varying maturity based on its shell colour. The tender coconut has been shown in **Figure 1(a)**, **Figure 1(b),** and **Figure 1(c)**. Meanwhile, **Figure 1(d)**, **Figure 1(e)** and **Figure 1(f)** show the mature coconut. Lastly, the copra coconut is shown in **Figure 1(g)**, **Figure 1(h),** and **Figure 1(i)**. The green-coloured shell shows that it is raw and fresh while the yellowish-brown colour indicates that the fruit is dried and aged for quite some time. The green coconut is mainly consumed for its juice and the white, fresh flesh inside the coir and dried coconut is mainly used for extracting its liquid, also known as coconut milk which will be used for cooking.

Figure 1: Type of coconut-based on its shell colour [3]

Coconut husk as shown in **Figure 2** has many benefits to the environment such as coconut husk can be used as a mosquito repellent. Preferably, in homes, coconut husk can be burnt in rooms before bedtime to repel mosquitoes. Coconut husk is natural, for this reason, the smoke produced from burning is harmless. Another environmentally friendly nature of coconut husk is its ability to be used as a growing medium. For instance, it can be used to grow flowers such as orchids and roses. These are essential nutrients for plant growth. Coconuts naturally possess a compound that encourages the development of beneficial bacteria, known as lignin. Coconut husk can also be used as biofuel which is a source of charcoal. When processed, coconut husks can be used to produce various household products such as carpets and others.

Figure 2: The coconut husk [4]

In the old days when technology was not yet advanced, the husk is peeled off using two different types of tools such as sharp-edged and point-edged iron rods. **Figure 2** shows the peeling coconut husk using the traditional way [5]. The artisan cautiously removes the husk very quickly. At this advanced time, there are so many machines for peeling coconut husk has been built such as roller-type blade mechanism. **Figure 3** shows the roller-type blade mechanism [6]. The roller type mechanism is such two rollers, each having an elongated configuration are disposed and spaced apart, substantially parallel to one another with respect to the base in a readily accessible position. The coconut is then placed in-between both rollers and then will be dehusked by the rotating force exerted by both of the roller-type blades mechanism.

Figure 2: The traditional way of peeling coconut husk [5]

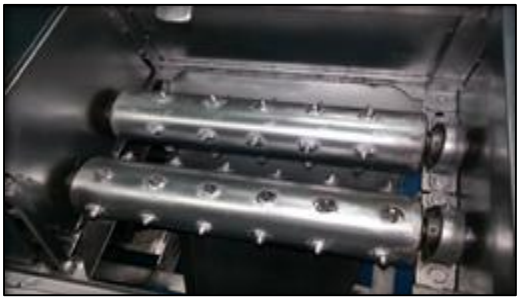


Figure 3: The roller type blade mechanism [6]

Multiple tools can be used to dehusk a coconut such as a machete, sickle, and crowbar. However, these utilities will expose the worker to the sharp end of those tools, risking them with hazards and possible injuries. In Malaysia, coconut dehusking so one of the most important jobs to do since the domestic use of the product varies, mainly to produce coconut milk. This with the addition of Malaysia being one of the countries that grow coconut trees. There are many designs of the coconut dehusking machine available in the market right now, ranging from simple, old-school peeling devices to electrical

shredder machines. In terms of effectiveness, the electrical shredder machines undeniably top the charts as they can shred many coconuts in seconds. Coconut dehusking machine uses vary from domestic use to commercial use. The main goal of the coconut dehusking machine is to dehusk coconuts at a fast rate and can dehusk coconuts cleanly so that they can split the coconut shell much easier. Thus, the quick dehusking rate and the precision in dehusking is the main concern in designing a coconut dehusking machine.

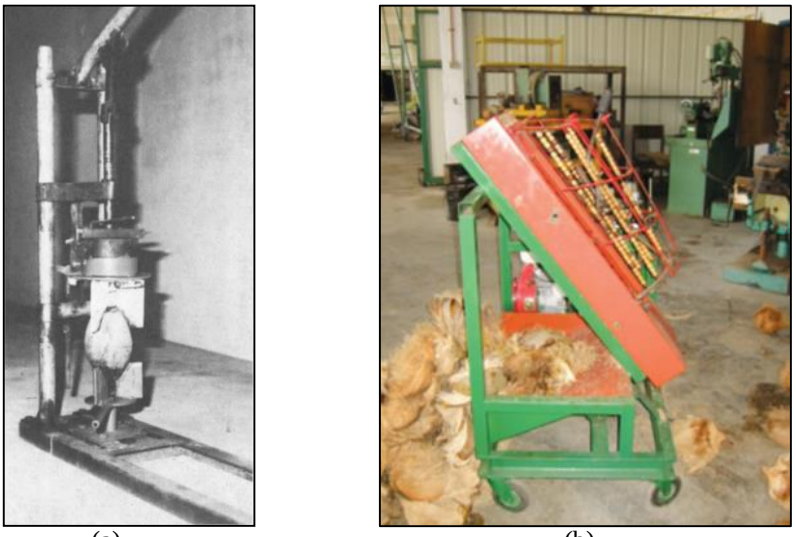
2. Literature Review

The coconut fruit is one of the most prominent fruits that is domestically farmed in Malaysia. It is intricately linked to the culture of the original people that lived in this part of the region since most food associated with that culture uses coconuts as its food ingredient. Thus, creating a machine to ease the process of coconut extraction is important so that the community will save some time to prepare the coconuts for their domestic needs.

Throughout the years, many attempts have been tried to mechanise the coconut dehusking process which is originally done by using sharp tools and physical effort. Nowadays, most machine available in the market is electrically generated machine which is intended for industrial purposes. Although it may seem beneficial due to its time-saving ability, it was not considered cost-friendly because it is expensive and generates a high electricity bill. Due to these reasons, a mechanically operated coconut dehusking machine is seen as favourable for domestic uses like household usage and small businesses.

One of the mechanical types of coconut dehusking machines is designed by Nijaguna [7] as shown in **Figure 4(a).** The machine is consisting of multiple blades to simulate the piercing and peeling motion of the manual coconut dehusking process which is operated by some levers. The machine requires two people to operate efficiently and some physical energy. However, it is suitable for small-scale usage which may need only a small amount of coconut to be dehusked. It is extremely favourable for users that aim for small-scale businesses or personal purposes.

The most available type of coconut dehusking machine which is electrically generated was designed by H. Md Akhir [8] as seen in **Figure 4(b)**, under the Malaysian Agricultural Research and Development Institute (MARDI) [8]. It is powered by an engine that needs fuel for operation. The machine uses two spike rollers as its peeling method by leaving space between them. The coconut is then placed between those spinning rollers and proceed to be dehusked. Although it fastens the process of dehusking a coconut, its overall cost of operation is calculated to be RM 211 per hour, which is expensive, especially for small-scale usage.



(a) (b)

Figure 4: Coconut dehusking machine (a) designed by Nijaguna [7] and (b) designed by H. Md Akhir [8]

3. Methodology

The fabrication of the coconut dehusking machine needs to follow the required process and fabrication for the project testing.

3.1 Project Design

There are a few important things that need to study to make sure the model will work efficiently. Among the elements that need to be studied are the types of materials and components used, the proper application process, objective analysis products, as well as the cost of each material and component used. Coconut dehusking machine in **Figure 5** consists of improvement on blades, lower lever and a height adjuster. The base is used to brace and accommodate all the force and weight that be imposed on it to make sure the stability and sturdiness of the machine. The base was made of steel because it was the second metal strongest. It will make sure the product is not easily damaged and can be used for a long time.

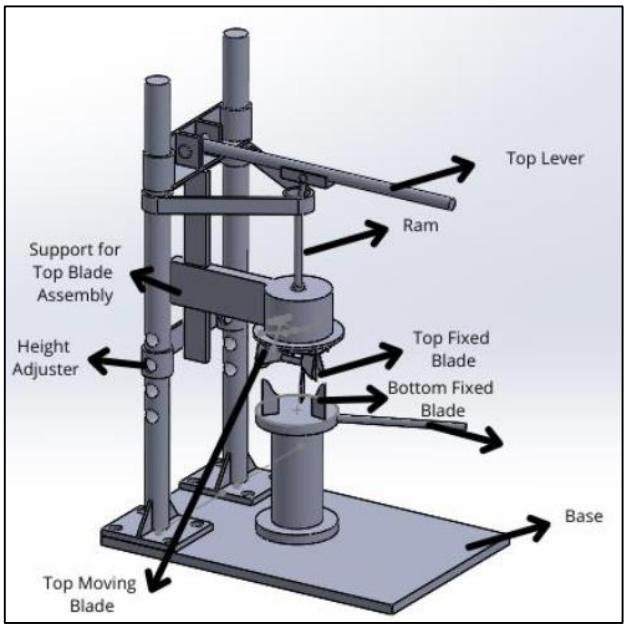


Figure 5: Coconut dehusking machine

The blade is shown in **Figure 6(a)** is made of mild steel material due to its high strength so that it does not deform when subjected to reaction force by the coconut husk. The function of the blade is to penetrate the husk of the coconut. It is the main component in performing the shearing, peeling, and piercing operation of the coconut. The placement of the blades according to its three types. The three top static blades are attached to the bottom of the center cylinder. The position between each of the blades is 120º from each other. The placement is placed on a 120º angle distance is so that it can conduct the piercing operation of the coconut effectively. The three bottom moving blades are attached to the bottom that has three fixed, 120º - spaced blades which can be rotated using the bottom blade lever. The reason for this placement is for effective shearing force on the bottom of the coconut after peeling and piercing operation.

The top fixed blade is shaped to accommodate the shape of the top half of the coconut for piercing operation. The top moving blade is shaped as V-trough, which is two sharp-edged blades parallel to the moving blades that are connected by an interconnecting piece. It is shaped in such a way as to ease the peeling operation when the blade touches the part of the coconut that has been pierced into during the piercing operation. The bottom fixed blade is shaped to fit the shape of the bottom half of the coconut shell. It will be shearing for the left husk after the piercing operation and peeling operation.

A Springed lever is used to operate the mechanism that is needed to dehusk a coconut as shown in **Figure 6(b)**. The lever is equipped with a spring that is positioned vertically with the help of support above the lever. The spring will help pull the lever upward when the lever is released, returning it to its initial position. The material for the lever is suggested to be made from mild steel due to its sturdiness and durability, as force will be applied to the lever. The lever will be medium-weighted, meaning not too light but also not too heavy. The main function of this component is to push the ram in a downward motion, which will go directly to the upper part of the coconut. The ram is assembled on the machine by pivoting its one end on the machine's column and is positioned facing upward to give it enough space to rotate downward when depressed. When given sufficient force to the lever, the blade that is connected to the bottom part of the coconut will produce enough piercing force to penetrate the fibers of the husk but not enough to cause damage to the precious coir inside of it.

The top lever is connected to a top fixed blade and a moveable blade, so when the piercing operation is done, the lever is applied, and the blades connected to the ram that is connected to the lever pierce the husk. The lower lever is shown in **Figure 6(c)** works as a component to make an inner spin. After the inner is spin, the bottom blade unit will spin and according to how much force that supply. The bottom lever functions to apply a shear force to the husk by rotating the bottom fixed blade. It is rotated about 30º. When the top lever hits the ram, it will apply force on the top blade then the top fixed blade will pierce the coconut. **Figure 6(d)** shows the force that is put into the lever will turn the wheel, then it will be inner with multiply force and make bottom blade unit spinning and peeling the coconut.

The height adjuster is assembled on the lower part of the machine by screwing it to the base to make it stand vertically. Then, the sliding support that is linked to the ram will slide through the height adjuster and then be locked to the desired hole according to the height required. The height adjuster as shown in **Figure 6(e)** will be made of mild steel to give it a sturdy and stable characteristic, as it will hold the weight of the ram, support ring, and the blades simultaneously. It functions as a limiter that prevents the top blade unit to go below a certain level of depth. This is to prevent the top blade unit from hitting the bottom blades.

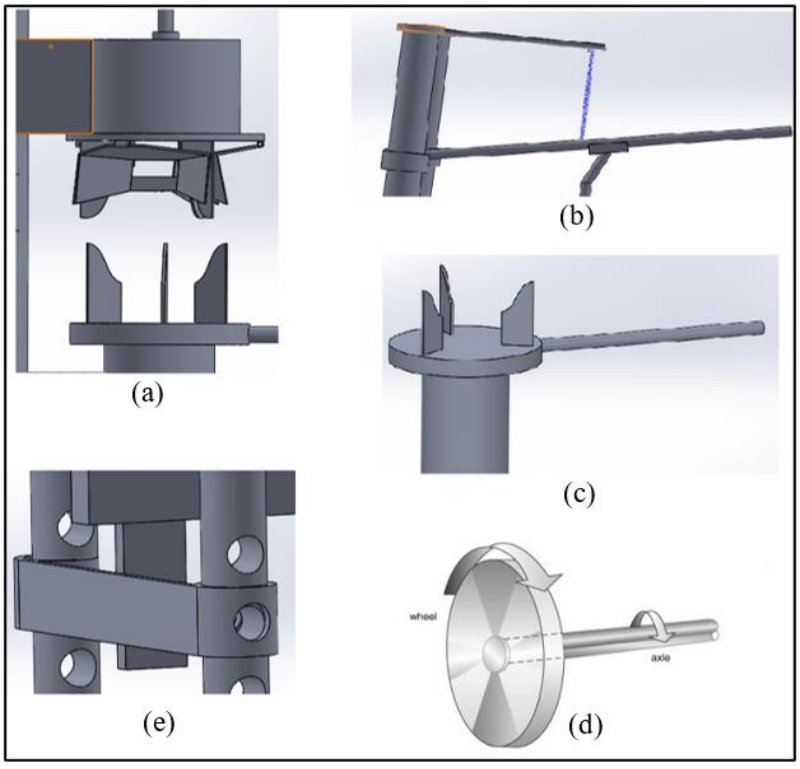


Figure 6: (a) Blade, (b) spring dehusking lever, (c) lower lever platform, (d) movement of the lower lever platform, and (e) Height adjuster

3.2 Evaluation of the Coconut Dehusking Machine

The objective of fabricating this machine is to prove that whether this type of design is possible to dehusk a copra coconut mechanically. The machine has three operations which are piercing, peeling, and shearing operations. However, due to the blades of the model being made of wood, it is impossible to dehusk it by using the fabricated model. Because of that, the coconut will be dehusked by using other equipment to demonstrate the operation of the machine. If the fabricated model is proven that it can dehusk a coconut by using these three operations, then the objective has already been achieved.

To operate the machine, the levers, top, and bottom, are made sure to be in a default position. Then, the old coconut will be loaded onto the coconut holder, which is the bottom fixed blade. Make sure that the coconut can be stabilized and fixed in the coconut holder before starting the procedure. Next, the lever will be depressed until it reaches its limits while the coconut is made sure to be pierced and peeled in the process. Finally, the bottom lever is then rotated in either clockwise or anti-clockwise direction until the remaining husk is fully removed. The top lever will be released, and the coconut is then unloaded. For the evaluation, a coconut that has already been husked will be used to demonstrate the concept of operation of the coconut dehusking machine.

4. Fabrication of The Coconut Dehusking Machine Model

The production of this coconut dehusking machine model is in line with the objectives as shown in **Figure 7**. The material that used in this product is pinewood. Coconut dehusking machine has the advantage of functioning without the use of electricity. As a result, the daily electricity cost will be saved because the coconut dehusking machine only required manpower for its operations.

Figure 7: Model of Coconut Dehusking Machine

4.1 Working principle of The Coconut Dehusking Machine

Based on **Figure 8**, these are the process of dehusking a coconut, which consists of three operations, which is piercing, peeling, and shearing operation. The first operation of the machine is the piercing operation. The piercing operation begins by placing the coconut on the bladed coconut holder as shown in **Figure 8(a)**. The lever as shown in **Figure 8(b)**, will be depressed downward and all the blades that were placed on the machine will pierce and make cracks at the outer surface of the coconut. The second operation of the machine is the peeling operation. When the movement of the static blade is being limited by the hardness of the coconut as the lever is depressed further, the moving blade as shown in **Figure 8(c)**, will be pushed radially outward thus the husk is peeled away from the husk. The final operation for dehusking the coconut is the shearing operation. After the husks have been peeled, the lever that was placed on the bottom, which is at the coconut holder, will be rotated about 30° to remove

the lower part of the husks, thus eliminating the whole husks of the coconut as shown in **Figure 8(d)**. The machine is then will be returned to the original position.

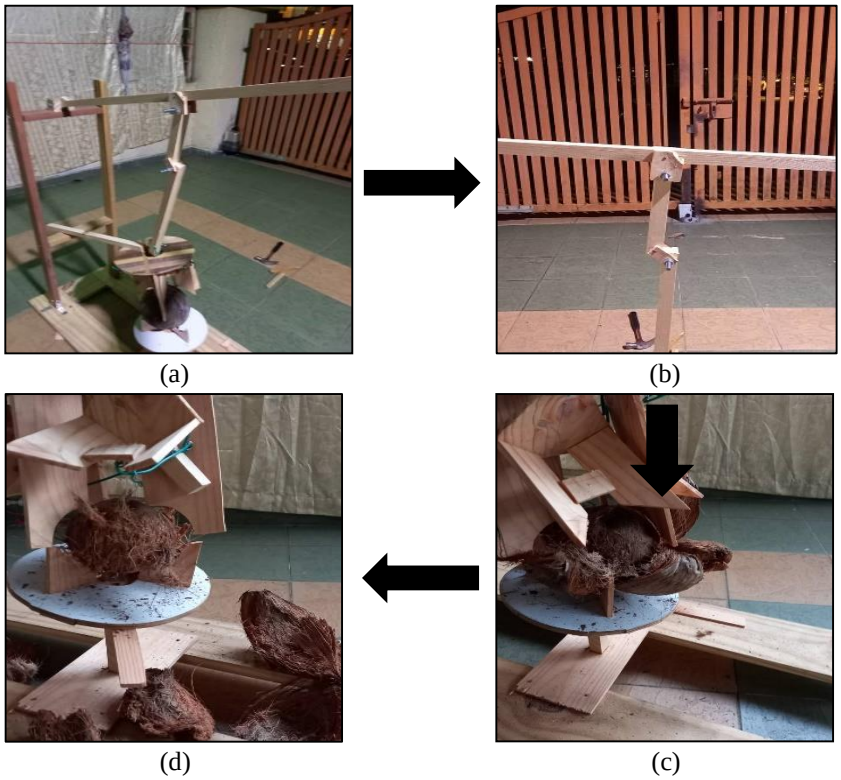


Figure 8: Coconut dehusking process

4.2 Additional Features and Changes

Some additional features and changes were also added to the model to make it more convenient for the users and make it suitable to dehusk copra coconut, which is smaller compared to coconuts produced in other countries and got finer and thinner husks. The feature that was added to the model is four wheels located on the bottom of the model, as seen in **Figure 9**. This feature enables easier portability and makes it effortless in moving the model from one place to another, especially when the real prototype is made from mild steel, which is heavier by weight.

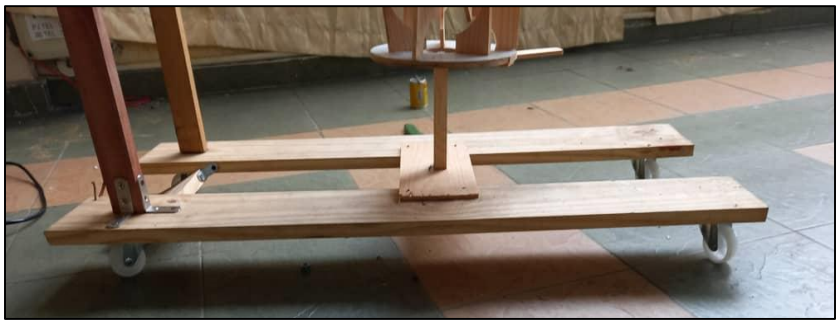


Figure 9: Wheels on the Coconut Dehusking Machine Model

The changes that were made to the fabricated model are on the blades on the top and the coconut holder. The size and the distance of the blade from one another are changed to make sure that it fits and accentuates the shape of the country's locally grown coconut. This will ensure that the coconut can be stabilized and be fixed on the coconut holder to dehusk the coconut without damaging the coir inside the fruit.

Finally, the coconut holder is equipped with a simple wheel and axle machine to operate the shearing operation, as seen in **Figure 10**. This will further reduce the cost of the prototype that will be fabricated in the future while making it possible to remove the lower part of the husks completely.

Figure 10: Wheel and axle on the coconut holder

5. Coconut Dehusking Machine Operation Test

The coconut dehusking machine to dehusk a coconut consists of three operations, which is piercing, peeling, and shearing operation.

5.1 Piercing Operation

For the piercing operation, two sets of static blades are positioned on the top and the coconut holder, respectively. Each set consists of three, custom-made blades which will pierce through the coconut husks, while at the same time, avoid any damage on the surface of the coir inside the husk. In **Figure 11**, each static blade is placed 120° away from the other to give an equal force distribution on the coconut husk when pierced. The piercing force is transmitted from the lever to the ram, the top blade support ring, and the top fixed and hinged blades when the ram is lowered. Through this motion, the place where the husk is pierced by both the top fixed blades and the top-hinged blade is on the same three lines. Because one component of the moving blade is linked to two independent blades, it pierces two different areas at once, resulting in even larger slits on the three slits. **Figure 12** shows the coconut before it was pierced and the coconut after it was pierced.

Figure 11: Top Blades

Figure 12: Before and after the Coconut was pierced

5.2 Peeling Operation

After the piercing operation, the lever is depressed further to activate the moving blade. The moving blade is pushed radially outward causing the husk to peel away from the shell as shown in **Figure 13**. This is achieved by the interconnecting strips on each moving blade is collided against the husk and pushing it radially outwards when the force from the ram is being applied. The stability of the coconut is preserved during the operation because the fixed blades also function to hold the coconut shell together. The link that connects the ram and the interconnecting piece helps the force from the ram to be transferred to the interconnecting piece. However, this model cannot perform the peeling operation since the material is made from wood. The exact material of the blade, which is mild steel, needs to be used to make this operation functional.

Figure 13: Before and after peeling operation

5.3 Shearing Operation

For the shearing operation, there is three-blade static at the coconut holder. In **Figure 14**, the three blades will shear for the bottom of the coconut. After the peeling and piercing operation is done, the bottom blade is rotated about 30° using a lever in the direction of clockwise or anticlockwise. The holder will remain by holding the coconut. The shearing operation will make sure that the husk left on the coconut especially on the lower part is removed. The levers (top and below) are then moved back to their original position. **Figure 15** shows the after coconut was sheared.

Figure 14: Three-blade at coconut holder

Figure 15: After the coconut was sheared

5. Conclusion and Recommendation

The focus of our project is to fabricate the model of portable coconut dehusking machine that is suitable for the copra coconut and to test the model of a coconut dehusking machine to prove that it can perform the piercing, peeling, and shearing operation. The modification is designed to make the machine more efficient and user-friendly. This machine can be really useful for unskilled workers using the coconut dehusking machine. Besides, the coconut dehusking machine can work effectively and can peel a coconut husk in a short time by a single worker. In this project, the model of the coconut dehusking machine is fabricated instead of the actual prototype. Thus, only the demonstration of machines operation can be shown instead of it dehusking the coconuts since the material used for the model is wood. The material is simply not strong enough to penetrate the husk of the coconut. As the recommendation, the fabrication of the prototype of the machine must be made using the exact material that is mild steel so that we can evaluate the effectiveness of the coconut dehusking machine.

Acknowledgment

The authors would like to thank you Universiti Tun Hussein Onn Malaysia (UTHM) for their financial support and facilitation in this project.

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