Design and Development of Coconut Dehusking Machine Using Raspberry Pi

Roland A. Calderon*, Edgardo E. Cedeno*, and Razel C. Tulod**

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* Corresponding Author: Roland A. Calderon, E-mail: rcalderon@slsu.edu.ph
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Abstract

This study aimed to design and develop the automated Coconut Dehusking Machine using Raspberry Pi as minicomputer due to its flexibility and credibility of powerful CPU that send notification via GSM to mobile phone that is essential for counting dehusked coconut without using other computer peripheral devices. In addition, the device is equipped with limit switch to count the coconuts that have been dehusked and 16 x 2 sized LCD for displaying number of dehusked coconut. Furthermore, the device is operated by 2 horse-powered Electric Motor in rotational speed of 1,800 rpm under 220 volts main power source. A gearbox, roller chain and sprocket with 60 x 3 in sizes are used extremely to decrease the speed and at the same time may increase torque of the motor. This study was conducted at SLSU Lucena determined to be of help not for individual farmers but for mass use thru cooperativism or other banking financial schemes which adhere to modern way of farming. The researchers followed the process of developmental research through planning, designing, testing, modifying and evaluating the acceptability of the machine by the technical experts as respondents chosen purposively. From the gathered data, analyzed and interpreted, the developed machine is highly acceptable. After the modification it has been proven that the existing coconut de-husking machine is more efficient in terms of saved time and energy, more productive, easy to operate, human and environmentally friendly. Moreover, the machine performed above 92% efficiency in all the tests cases which significantly revealed the efficiency performance of eighty-seven percent (87%) over-all efficiency performance out of one hundred fourteen (114) coconuts in ten series of actual testing.

Keywords: Dehusk, Machine, Agricultural Technology, Minicomputer.

1. Introduction

Agro-technology and engineering innovation are both priorities of the university in the line of developmental research to conduct, since it is making its identity as the Center of Technology in Quezon.

Quezon Province is known for its abundant place in raising coconut. Coconut is the primary agricultural product of Quezonian [1] since has many uses such as its therapeutic and nutritional benefits [2]. The outer shells of coconuts are used to make a variety of products; including coco peat, coco husk chips, coco crush, and coir fiber [3]. The traditional practice is that the owners of the crop harvest it manually with their assistant personnel and remove the husk from the coconut using traditional tool method. They used two sharp triangular blades that have been causing injury to staff because applying a piercing force from their hand while applying pressure on the surface of the nut causes him significant damage, and this the issues with this manual tool [4]. This skilled worker can produced only about 6 coconuts per minute which is not enough to handle a lot of dehusking. Being a skilled worker of a dehusker requires a long experience to perfect its use.

Basically, the dehusked coconut product is processed into copra whose pulp is sun-dried and smoke-dried for about

* Lucena Campus, Southern Luzon State University, Lucena City, Philippines.

6 to 8 days and taken to coconut oil mill factories where it is processed into oil [5].

The development of Automated Coconut Dehusking Machine using Raspberry Pi will be the campus way to show that Raspberry Pi as the main part of the device can make a difference in how to replace the traditional method of coconut dehusking with a better one as there are now few coconut farmers involved in this kind of work others are elderly and some young people are now enjoying the technology industry [6]. The researchers used a modern dehusking machine because it has a minicomputer on small single-board computer developed by the Raspberry Pi foundation to promote the teaching of computer science in schools and in developing countries [7].

This development is intended to benefit coconut farmers through cooperators since they were the end-users of this development. This indicates that the possibility of this device's use will be with the assistance of the cooperator who will fund the specific farmer. Additional to this, the researchers will use other features to notify the cooperator the number of dehusked coconut through SMS.

In the study of Pascua et al., the "Performance Characteristics of a Prototype Coconut Dehusking Machine", revealed that 80% of the farmer-respondents preferred a unit with cost 50,000 to 80,000 pesos [8]. The design and development of this device will be a manifestation that the updates in the advance technology will put into reality where coconut farmers in Quezon will benefit.

The main goal of the study is to design and develop a machine that can safely and effectively dehusk coconuts that has a modern technology while reducing the amount of time required for the process.

2. Theoretical Background and Related Researches

Fallen coconuts were collected from Brgy. Ibabang Talim, Lucena City, Quezon where a machine can be used to test the coconuts that go through the device and to know the functionality of LCDs and SMS messaging technology.

2.1 Raspberry Pi 3 module B

The Raspberry Pi 3 module B+ employed in the system served as the minicomputer used to control the machine operations and analyze the quality of the product due to its flexibility and credibility of a powerful CPU. It is Single-Board Computer (SBC) with 1GB SRAM size and an integrated Wi-Fi and Bluetooth connectivity making it the ideal solution for robust linked design. The specification features ARM cortex A53 quad core processors with 64-bit processor clocked at 1.4GHz CPU speed and their Ethernet speed has been boosted from 100Mbps to 300Mbps. One feature included is a wireless dual-band LAN that comes with modular compliance certification which gives lower interference issues when integrating into other products. Moreover, the open source tool python language under the Linux operating system was used to process the received signal from the sensor [9]. This is show in figure 1.

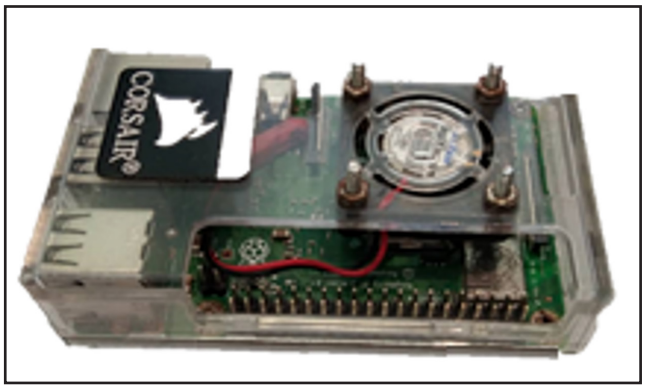

Figure 1. *Raspberry Pi 3.*

2.2 Limit Switch Mechanical Sensor

The researchers also made use of limit switch in order to correctly count the passing dehusked coconuts as shown in figure 2. The limit switch is a widely used mechanical sensor and robotics and factory automation operated by a physical force applied to it by an object. When the operation of the controlled device has reached its physical limit, it serves to open or stop an electric circuit [10].

2.3 LCD Screen

The system used an LCD with 16 x 2 intelligent alphanumeric dot matrix in size that displays the number of

dehusked coconuts. It has a built in HD44780 interface module with 8 data bits (DB0~DB7) and 3 control pins (RS, R/W*, E). The module has 16 designated pins with various functions compatible with the microcomputer. Additionally, the LCD used adapted to the Python programming language since it has an internal controller that can accept some commands and can change the display accordingly. [11].

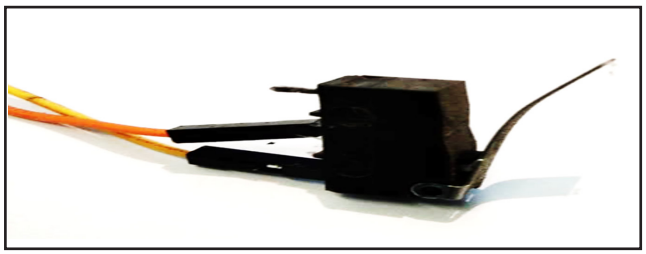

Figure 2. *Limit Switch Sensor.*

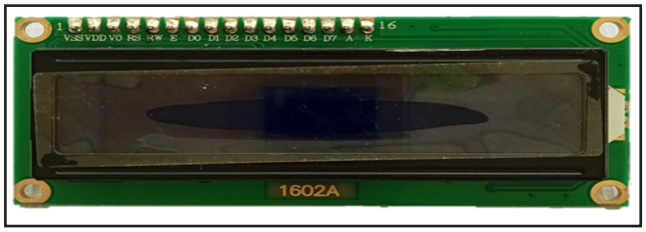

Figure 3. *LCD Screen.*

2.4 AC Motor

The most remarkable feature of this machine is the use of an AC motor. It makes use of an alternating current-powered electric motor (AC). An electric motor with 2 Horsepower transfers the timing belt to the gearbox. Using various sprockets, the same mechanism is also employed to lower the speed of the cylinders. [12] It features a speed of 1800 rpm as it features a single phase type motor. It also has 1.5KW of power that can be consumed and 13.0 Ampere that can flow safely through the device. This motor is prepared for hazardous duty applications and passed all necessary tests to receive their explosion proof certification. [13].

2.5 Gear Box

In this study, a gear box is employed to decrease the revolution rate from 1800 rpm down to 52 rpm [13]. When the load is changed to an abnormal state, its mechanism is employed to ensure that a high torque is delivered to the load without overloading the motor [9]. Additional to this, it can alter also the direction of power and torque rate since it used a gear ratio that almost always varies revolutions and giving it a mechanical advantage [12].

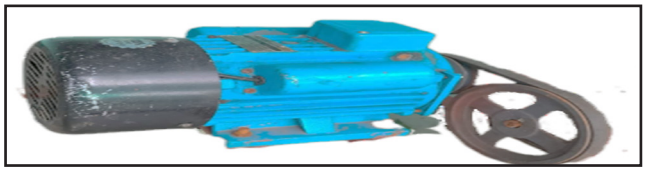

Figure 4. *AC Motor.*

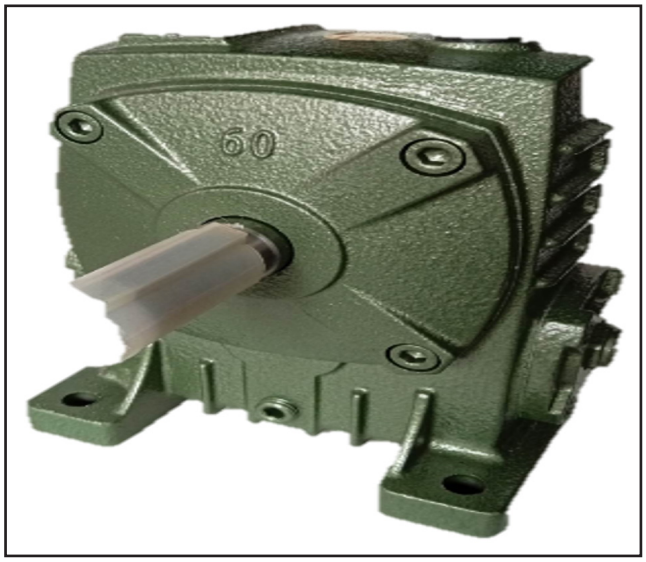

Figure 5. *Gear Box.*

2.6 Pillow Block

The study used a pillow block to serve as a gearbox aid throughout the cycle. It uses corresponding bearings to support the shaft's rotation during operation. It features housing materials usually made of cast iron or steel and has an anti-friction bearing. One or more types of rolling elements, such as a ball, cylindrical roller, spherical roller, tapered roller, or metallic or synthetic bushing, may be found inside a pillow block bearing. [12]

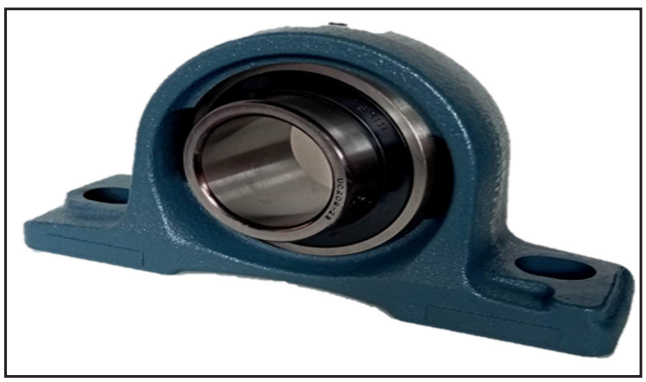

Figure 6. *Pillow Block.*

2.7 Coconut Dehusking Machine

The Coconut Dehusking Machine is composed of the following materials: two rollers, one with spikes, gear box, sprockets, chain, electric motor, body frame and raspberry pi single-board computer. The machine is designed based on the principle of a traditional device with four legs using a ¼ x 2 angle bar. Square bars, angle bars, flat bars and GI sheets are welded to specific lengths and sizes. The first pair of legs has a height of 81cm and the other pair has a height of 71 cm so that the coconut tends to go down into the catch bin. It has two shafts with 79 cm long and 11 cm in diameter with shaft spikes 14 cm apart. A spike with a height of 1.5 cm and a length of 2 cm angle was used to remove coconut husks as shown in Figure 7a and Figure 7b.

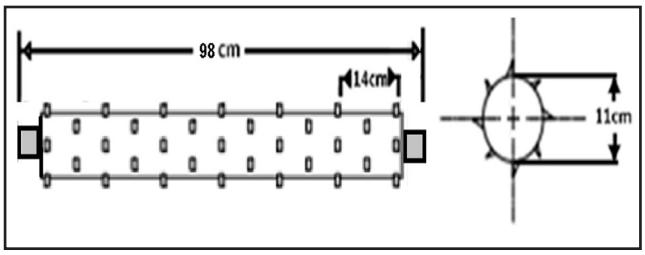

Figure 7a. *Shaft Front View and Side View.*

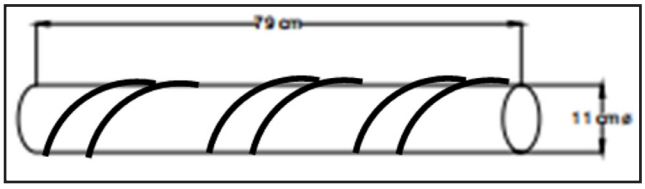

Figure 7b. *Shaft with spiral roller.*

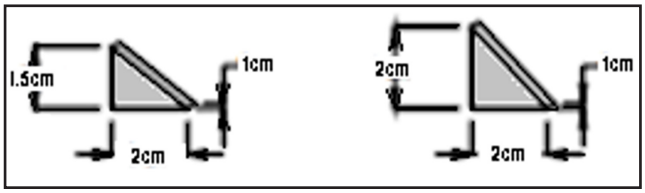

Figure 7c. *Shaft Spikes.*

The machine has a round metal cover that pushes the pressure down directly towards both the roller blade and the spiral roller. The three sprockets used in the device are 7" with 48 rpm for Sprocket A, 4" with 29 rpm for Sprocket B, and finally 3" with 70 rpm to reduce the speed of the motor. It works with a 2 horsepower electric motor at a rotation speed of 1800 rpm under a 220 volts main power source having a 60 hertz frequency. The limit switch mechanical sensor is located on the side of the catch tray with an angle of 40 degrees. Next to the limit switch, there is a blocking flat bar where it will be hit by a dehusked coconut and then its count will be connected to the raspberry pi. [8], [12], [14].

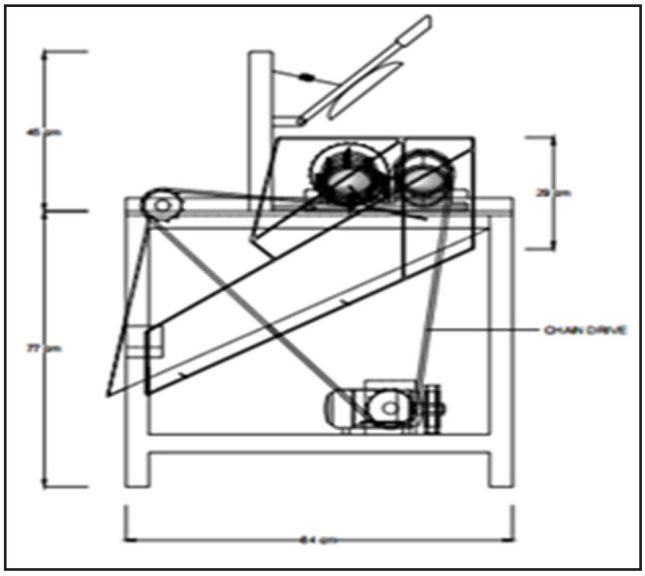

Figure 8. *Left Side View.*

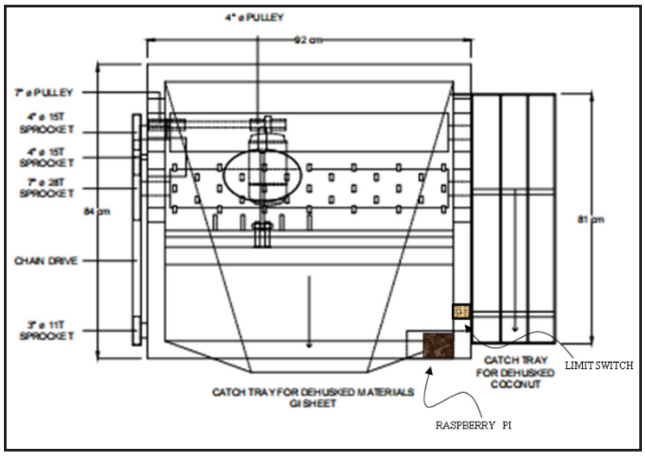

Figure 9. *Top View.*

3. Research Methodology

3.1 Coconut Dehusking System

The coconut fruits are placed at the middle of the dehusking machine that is being reinforced by a circle metal lid and go down directly towards both the roller blade and spiraled roller. The two (2) rollers are the main dehusking mechanism running through opposite directions. The device operates with 2 horsepower electric motor in a rotational speed of 1800 rpm under 220 volts main power source and 60 Hertz [15].

The process of dehusking starts when the coconut fruit is placed in the roller blades, the coconut will be dehusked due to the opposite rotational direction of the rollers. When the coconut is completely dehusked it will roll down into the catch-bin and it will pass through the limit switch to be able to count the coconut that has been dehusked. Consequently, the raspberry pi computer will send notification via GSM every after five completely dehusked ripe coconut stored in bin [12].

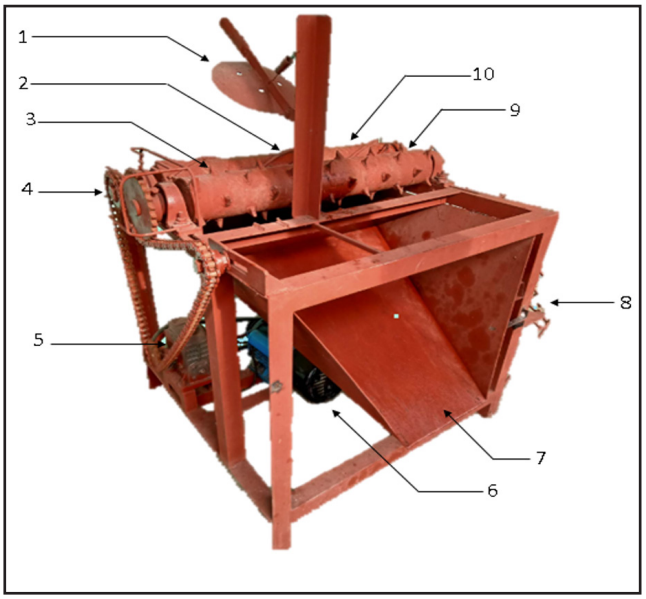

Figure 10. *Actual dehusking (1) Metal lid (2) Spiral roller (3) Spike (4) Sprocket (5) Gear motor (6) AC Motor (7) Output Tray (8) Catch Tray (9) Roller with spike (10) Shaft/Roller.*

3.2 Dehusked Coconut Counting System

The device's counting system used a small metal plate placed in the path of the dehusked coconut. When it is triggered, it will tap the sensor lever which will trigger the raspberry pi to send the notification signal to the mobile phone. The limit switch is connected to the raspberry pi programmed for the counting system. Raspberry pi computer sends a signal to the mobile phone to notify that an actual number of coconuts had been dehusked and being displayed through a pop-up message in the notification panel of the device [16].

3.3 Electronics Diagram of the Prototype

This diagram is used by researchers to show the stream of devices and how they work. It shows the connections of the materials and how the Raspberry pi computer processes the movement of the limit switch actuator from the moving coconuts where its data is received by the mobile phone [17].

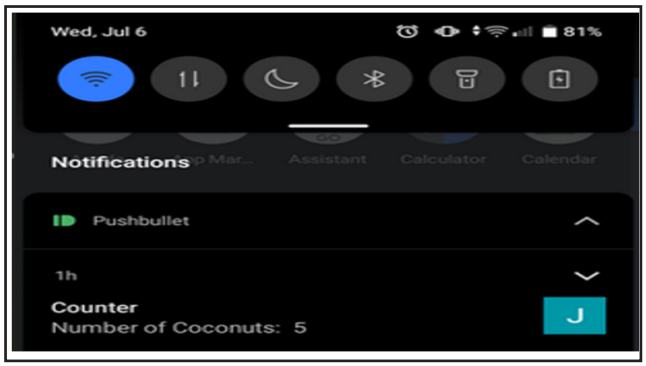

Figure 11. *Notification of dehushed coconut sent by Raspberry Pi computer to mobile phone.*

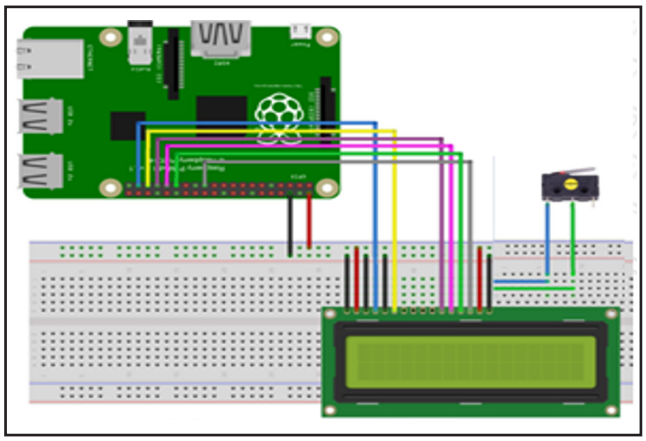

Figure 12. *Electronics Diagram of the Device.*

3.4 Design Calculation

There are numerous issues with the hand dehusking of coconuts as it now stands. Accidents may happen, there would be a reduction in output, work would be needed for long hours, and expert labour would be needed [12]. Therefore, the device we created has enough power to run it smoothly using a two-shaft motor. The machine uses torque forces to rotate the motor, sending 2 HP at 1800 RPM to the shaft. These are the requirements of the design calculation of the machines. The average torque forces transmitted to shaft is determined using Equation 1:

$$P = 2\pi TN$$

$$T = \frac{\mathrm{P}}{2\pi N}$$

Where:

P = rated power of motor (2HP)

N = rated speed 1800rpm

T = torque transmitted to the shaft

F = Force on shafting

To get the right amount of torque to turn the motor. This is the calculation we used:

$$T = \frac{2HP * 33{,}000}{2\pi(1800)} = 5.839\ ft - lb$$

The average forces on shafting are determined using Equation 2:

$$T = (F)(r)\ (lb - in)$$

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

To get the right shafting forces, we used this:

$$F = \frac{5.839\ ft - lb}{0.5m\ \frac{1"}{12"}}$$

$$= 140.138\ lbf$$

For the Speed and Gear ratio, we used the following Equation 3-4:

$$Speed\ ratio = \frac{N1}{N2} = \frac{52}{49} = 1.1$$

T1 = number of Teeth of the driver (pinion)

T2 = number of Teeth of the driven gear

$$Speed\ ratio = \frac{T_2}{T_1} = \frac{16}{16} = 1$$

For the sprocket and chain, we used the Equation 5:

Diameter of the sprocket,

$$D = \frac{P}{\sin\frac{180}{T}}$$

$$P = D \sin\frac{180}{T}$$

$$= 4in\ sin\ \frac{180}{16}$$

$$= 0.78\ (Main\ shaft\ to\ speed\ reduces)$$

$$P = 4\ in\ \sin\frac{180}{15}$$

$$= 0.83\ (speed\ reducer\ to\ motor)$$

4. Performance Evaluation

To evaluate the performance of the device, the researchers consulted IT experts and Engineers related to the design device and modified the system design. A test was conducted to find out whether the device will perform based on the design. Adjustments and some corrections were taken before finalizing and setting the developed device. After all the adjustments, these were finalized. The device was valuated in order to determine its acceptability [4]. This study followed the developmental research design and this was conducted at SLSU Lucena Campus.

Figure 13. *Actual Coconut Dehusking and Counting Prototype.*

Table 1. *Results of Dehusking Coconut.*

Test	# of Coconut Dehusked	# of well Dehusked Coconut	# of Coconut of Not Dehusked Well	Efficiency	Time (sec)
1	10	9	1	90.00	90
2	12	10	2	83.33	108
3	11	9	2	81.82	99
4	13	12	1	92.31	117
5	10	8	2	80.00	90
6	9	8	1	88.89	81
7	13	11	2	84.62	117
8	11	9	2	81.82	99
9	13	12	1	92.31	117
10	12	11	1	91.67	108

The results of the performance test show that the machine performed above 92% efficiency in all the tests cases. It is also significantly revealed based on the series of dehusking tests that efficiency performance garnered eighty-seven percent (87%) over-all efficiency performance out of one hundred fourteen (114) coconuts in ten series of actual testing. The roller has been fabricated with narrow-wide spikes to avoid breakages of the coconuts as the sizes of these nuts were not properly considered before designing the machine. Opposite the roller with spikes is another roller with circular metal employed spirally to guide the dehusked coconuts directly towards the catch bin. The modification has led to the following advantages over the existing coconut dehusking machine; more efficient, saved time and energy, more productive, easy to operate, human and environmentally friendly.

5. Conclusions

The modification and improvement of existing coconut dehusking machines for farmers was carried out and tested. The performance evaluation reveals that the average efficiency of the machine was 90 percent while the average capacity was 195 coconuts per hour. Based on the data gathered distorted and broken coconuts were 6 percent and 3 percent respectively, however these figures are infinitesimal or extremely small compare to the existing dehusking machines, thus, it is highly recommended for use by farmers.

Future Research Direction

The design and development of this machine needs enhancements by adding updated features of technology significance. Additional sensor device and programming algorithm will be considered in order to increase the accuracy of counting and mobile notification. In terms of design modification, additional shaft spikes and spiral roller in the shaft will be incorporated in the next version of the prototype to refine the coconut dehusking production.

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