Automated Coconut Dehusking and Cutting Machine

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Abstract: In order to reduce the time it takes to dehusk and cut a mature coconut, and ensure a safe process, an Automated Dehusking and Cutting Machine was conceptualized and made. The machine eliminated the risk of getting the worker injured during the process of dehusking and cutting a mature coconut. A distinct advantage of the machine is that it can dehusk and cut a mature coconut in 10 seconds compared to a skilled worker which will take an average of 13 seconds to do the same process. The process starts by dropping the coconut into the top funnel and activating the funnel switch. The clamp roller catches the coconut and pushes it towards the rotating spike rollers. Each spike roller rotates inwards at different speeds thus allowing the coconut to rotate in its place and initiate the dehusking process. The spikes slide against the shell of the coconut and focus its force to the coir. Afterwards the nut drops onto the cutting platform and activates the cutting clamp to push forward. The saw will cut the coconut into two parts and drops into the catchpan below. This machine as it is today is found to be competitive when safety is considered eliminating the risk of self-injury due to mishandling. All the machine needs the operator to do is to push the buttons. Overall, the machine has proven to safe and efficient.

Key Words: coconut, dehusking, automation

1. INTRODUCTION

The coconut tree is called the "Tree of Life" because of the endless list of products and by-products that can be derived from its various parts [1]. The coconut industry is a dominant sector of Philippine agriculture [1]. Out of the 12 million farmlands, 3.1 million hectares are devoted to coconut. 68 out of the 79 provinces of the Philippines are coconut areas. There around 3.5 million coconut farmers and 25 million Filipinos are directly or indirectly dependent on the industry [1]. Coconut farms are widely distributed nationwide, largely in regions of Southern Luzon in the North and Mindanao in the South. There are around 324 M coconut trees in the country, about 85% of which are considered productive [1]. The coconut industry provides an annual average of 5.97% contribution to the GVA and 1.14% to the GNP [1].

Based on the statistics, the coconut industry is a huge industry that contributes the country mainly through exports of coconut products [1]. Coconut oil is the highest exporting coconut product and is produced from copra processing [1].

Copra processing is done first by dehusking the coconut [2]. The dehusking of the coconut is done manually using a dehusking tool. The dehusking tool is made up of a sharp-pointed steel firmly placed vertically in the ground [2]. The dehusking process is done by manually impaling the coconut until the husk loosens [2]. The husk is usually removed in one piece [2]. Impaling requires accuracy and experience making it difficult to get dehuskers in countries that are still trying to set up coconut plantations [2]. Figure 1 shows the manual dehusking process.

Figure 1. Manual Dehusking Process

After dehusking, the shell of the coconut is exposed. It is split open by cutting using a knife or bolo [2]. The coconut water is thrown out and the coconut cups are then prepared for the next process [2]. The cups are dried using either a sun drying process, smoke-kiln method or hot air drying process [2]. The quality of the copra is influenced by the drying. Improper drying can give rise to harmful toxins through the growth of aflatoxin molds [2]. The growth of these molds can be prevented through proper drying of copra [2]. After the drying process, the copra meat is extracted and removed from the shell and additional drying processes are done before it is packed in a sack and shipped to coconut oil extracting factories.

The manual process of dehusking coconuts is hampered by poor productivity especially if it is done in a large scale industrial processing. The Mechanical system of dehusking technology uses spiked rollers to effectively dehusk the coconuts. The coconuts are to be fed one by one by the worker and 33 spikes on the rollers will dehusk the coconut. The machine can be operated by only one person and can provide faster work rate [10].

One available Coconut Dehusking Machine is designed to dehusk mature and young coconut by hydraulically controlling the needle and claws located above the coconut pit [9]. The coconut is strictly placed in a vertical position in the pit and follows a 5-phase dehusking steps. The 1st phase brings down the needle to the top of the coconut in order to hold it in place. In the 2nd phase, the claws around the needle spread out halfway to dehusk the topside of the coconut. The 3rd phase lifts the pit towards the extended claws then in the 4th phase, the claws fully extend outward to complete 90% of the dehusking process. The operator would then manually remove the nut from the husk which at times would take some effort. Approximately, it can cleanly dehusk a mature coconut in 8 seconds almost effortlessly but takes quite a while to do it. Furthermore, the nut is manually removed from the husk during the 5th phase. It still requires an important skill from the operator to control the machine in order to dehusk the coconut. When done in 8 hours, it can also lead to fatigue.

Automating the dehusking and cutting process would help the coconut industry by providing a safer and efficient way of doing the first two processes of copra processing. In the current manual process using the dehusking tool [2], a single and experienced worker would dehusk an average of 300 coconuts an hour. This current manual process can be further improved using automation thereby eliminating the use of the manual dehusking tool, which can be unsafe to work with.

2. DESIGN & IMPLEMENTATION

2.1 Machine Design

The machine is composed of three major sections: the mechanical design, electrical design and the pneumatic system. The mechanical design served as the framework and body of the machine. The electronics serves as the control, hand and brain of the machine. The pneumatics served as the extending and retracting force for the automation to happen. The machine in its entirety is shown in Fig 2.

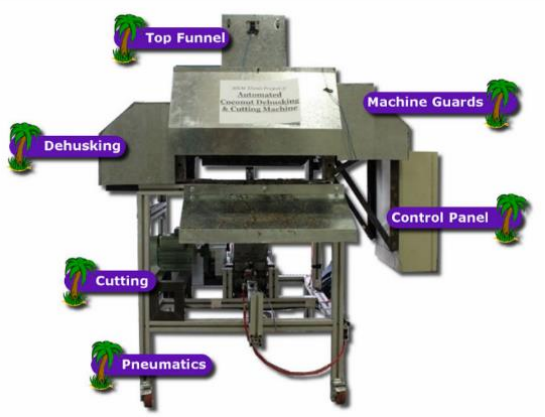

Figure 2. Automated Coconut Dehusking and Cutting Machine

The mechanical design of the machine involves two spike rollers rotating inward with opposite direction so that the husk will be taken out of the machine. Upon installing all these components, the Automated Coconut Dehusking and Cutting Machine was able to dehusk and cut the mature

coconut. We had also placed safety guards to protect the operator from getting cut, wound or even being dehusked.

The electronic system of the Automated Coconut Dehusking and Cutting Machine is composed of two electromagnetic relays that controls the dehusking and cutting motor, power supply which converts 220 V to 24 V, magnetic contactor which switch the motor on and off, circuit breaker which act as a safety parameter, A Mitsubishi PLC which serves as the brain of the machine and terminal block. Relay 1 controls the dehusking motors while Relay 2 controls the cutting motor. When the Relay is energized, the magnetic contactor will be switched on resulting to the switching on off the motors. PLC is incorporated here because of the compatibility of the components which is 24 V and we believe that it is more suitable for this application.

The pneumatic system is applied in order to give the Automated Dehusking and Cutting Machine an automated approach for the dehusking and cutting process. The pneumatic system consists of the pneumatic-controlled roller clamp assembly which holds the mature coconut in place while being dehusked, and the pneumatic-controlled cutting clamp which extends the cutting clamp to the saw. With all these features, the Automated Dehusking and Cutting Machine not only automates the dehusking and cutting process, but it also proves to be efficient and removes the risk of the operator from getting harmed. Figure 3 shows the actual machine.

Figure 2. Actual Automated Coconut Dehusking and Cutting Machine

2.1 How it works

The coconut will enter the machine via top funnel. Upon entering, it will trigger the pneumatic cylinder by the limit switch located at the top funnel. After triggering the pneumatic cylinder, the coconut will be clamped by the clamp roller assembly pushed by the pneumatic cylinder to the spike roller assembly. The coconut's position will be secured in the dehusking mechanism. Then the spike assembly will dehusk the coconut within seconds. The husked coconut will fall automatically after the dehusking process to the cutting mechanism via dehusking-cutting funnel. The husked coconut will trigger the pneumatic cylinder that will push the husked coconut to the circular saw after landing on the cutting base. The limit switch is located at the cutting base. Then the coconut will be pushed to the circular saw where the cutting process will occur. The husked coconut will be cut into two and it will fall automatically at the catchpan.

3. EXPERIMENTS

Three main experiments wer done to test the efficiency of the machine. First experiment is for the dehusking process since it is the main process of the machine. Dehusking time needs to be determined in order to set the proper time of clamping and releasing of coconuts during dehusking process. The average time will also determine if the machine's rate would match the desired output of coconuts per minute.

The cutting process is the next important process in the machine. It produces the final output which is a dehusked coconut cut in two. In order to meet the objectives, an efficient cutting time is necessary.

Lastly, to be able to fully measure if the machine is able to meet the objectives, a final test, wherein the two processes combined is conducted. Using the data from the previous experiments, the necessary settings are applied to the machine. This time the machine ran for a set amount of time and the output was recorded in order to determine if the rate of coconuts produced meets the objectives.

4. RESULTS AND DISCUSSION

Ten trials were conducted in order to determine the average dehusking time of each coconut. The average time was determined by averaging each of the times of the successful trials conducted. The resulting average time computed is 5.58 seconds. This average time is the time that will be used for clamping before release of the coconut during dehusking process. Based on the trials conducted, the experiment yielded 70% success rate for the dehusking process. Results shown in Table 1.

Table 1. Results of Dehusking Process

Trial	Time (in sec)	Machine Malfunction	Successfully Dehusked
1	4.01	No	No
2	5.35	No	Yes
3	7.83	No	Yes
4	6.61	No	Yes
5	4.60	No	No
6	3.94	No	Yes
7	5.16	No	No
8	5.27	No	Yes
9	5.24	No	Yes
10	4.83	No	Yes

*NOTE: unsuccessful coconuts are determined through failure in dehusking wherein the coconut is totally crushed instead of dehusked

For the cutting experiment, the approximate cutting time to be used is to be determined. This is achieved by adjusting the feed rate of the cutting mechanism through the air intake of the solenoid valve. Various cutting times were used in this experiment starting from 7 second cutting time to 2 second cutting time. At 2 second cutting time, the cutting mechanism fails due to a high feed rate and machine jam occurs. Approximately 3 second cutting time is the fastest successful time for cutting but for safety and to give tolerance, a setting of approximately 4 to 5 second cutting time will be used all throughout. Results shown in Table 2.

Table 2. Results of cutting process

	Trial					
	1	2	3	4	5	6
Approx.Cutting Time	7"	6"	5"	4"	3"	2"
Cutting Problem	No	No	No	No	No	Yes
Result	Good	Good	Good	Good	Good	Bad

*NOTE: Cutting problem and bad result pertains to the cutting mechanism getting stuck due to a high feed rate.

For the last experiment, the group was able to generate a success rate of 89%. Through the group's observation it was determined that the dehusking process was the factor that lowered the success rate of the machine due to the failure in dehusking sometimes resulting to crushed coconuts. Further study can be conducted in order to reduce the occurrence of crushed coconuts. As for the average rate for the whole experiment, the group was able to yield 15.4 coconuts every 3 minutes or an equivalent rate of 5.13 coconuts per minute.. Results shown in Table 3.

Table 3. No. of husked and cut coconuts in 3 mins

	Trial (t = 3 min)				
	1	2	3	4	5
Dehusking Problem	No	No	No	No	No
Cutting Problem	No	No	No	No	No
# of good coconuts	19	17	21	14	18
#of bad coconuts	1	3	1	5	1
Total Output	20	20	22	19	19

*NOTE: Good coconuts pertain to coconuts that were successfully dehusked and cut in two. Bad coconuts pertain to coconuts that were crushed during the dehusking process.

5. CONCLUSIONS

The Automated Coconut Dehusking and Cutting Machine present an automated process of the dehusking and chopping process done in the coconut industry. The rate at which it can dehusk and cut coconuts are slightly better than an experienced worker at around 5 coconuts per minute. The experienced worker is only able to do dehusking (without cutting) at the same rate. Plus it allows a safer way of doing the process eliminating the risk of injuries which can occur when doing the manual process. Aside from this, it also eliminates the need to train skilled workers in doing the manual process

and combines two processes into one machine. The automation improves the efficiency while at the same time addresses the safety issues in the manual process.

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