MALAYSIAN JOURNAL OF APPLIED SCIENCES 2022, VOL 7 (2): 83-92
E-ISSN:0127-9246 (ONLINE)
http://dx.doi.org/10.37231/myjas.2022.7.2.339
https://journal.unisza.edu.my/myjas

ORIGINAL ARTICLE

DESIGN MODIFICATION AND STRUCTURE SIMULATION ANALYSIS OF TAPIOCA PEELING MACHINE

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Received: 29/10/2022, Accepted: 30/10/2022, Published: 31/10/2022

Abstract

This project works on the design of a tapioca peeling machine for peeling freshly harvested tapioca tubers with the capacity of peeling tubers of different weight and diameter sizes. The need to mitigate the low output, drudgery, high labour costs and losses associated with manual peeling called for the design of the machine to improve the agricultural yield of the crop. The objectives of the research were to study the existing tapioca peeling technologies, to select and size the machine components, to develop the layout of the machine and to carry out the cost analysis of the tapioca peeling machine. To solve the problem, the innovation was designed to peel tapioca skin with two stage of peeling (the first layer and the second layer) to increase the productivity. From simulation analysis of the tapioca peeling machine, the design of machine can worked and functioned successfully, and introduced a great improvement to the current tapioca peeling machine.

Keywords: 2-layer skin, Peeling technologies, Structural analysis, Simulation analysis, Tapioca

Introduction

Tropical and subtropical plants of the family Euphorbiaceous are known as the main source of carbohydrates and their leaves as vegetables. Tapioca is importance in many developing tropical economies such as the tropical parts of Africa, West India, Brazil, Malagasy, Indonesia, Philippines, Malaysia, Thailand and China (Ajibola & Babarinde, 2016). Tapioca peeling has been practiced as far back as when tapioca came into existence, but the instrument for peeling has evolved from stone and wooden flight into simple household knifes. This makes the peeling of large quantity of tapioca drudgery. According to Isaac & Jude (2022), the tapioca peel has two layers; the outer layer called periderm and the inner layer called cortex.

The problems encountered in peeling tapioca root tuber arise from the fact that tapioca roots exhibit appreciable differences in weight, size and shape. There are also differences in the properties of the tapioca peel which varies in thickness, texture and strength of adhesion to the root flesh. Thus, it is difficult to design a tapioca peeling machine that is capable of efficiently peeling all roots due to the wide differences in properties of roots from various sources (Deepika et al., 2021). This present effort is the beginning of a process to design a machine capable of peeling different sizes of cut-to-size tapioca tubers. This research effort therefore seeks an uncomplicated design to make it cheap to produce and easy to use (ergonomic) for post-harvest workers just like the grinding machines are easy to operate for end user. Therefore, this effort is focused on planning and building a machine that can peel tapioca of various sizes tuber (Adeshina & Olusola, 2020; Oyedele et al., 2019; Oluwole & Adio, 2013).

Tapioca (Manihot esculenta Crantz) is a long starchy root, high in carbohydrates. The three regions of the tapioca tuber are (Nathan et al., 2018 & 2017):

i) Periderm: - This is the farthest layer of the tuber, the skin. It consists mainly of dead cells, which cover the surface of the tuber.

ii) Cortex: - It is located below the periderm, usually about 1.5 - 2.5 mm thick and not white.

iii) The middle part of the tuber: - This form most of the tapioca and consists of stored essence and is always white.

Peeling refers to the removal of the brown epidermal skin layer (outermost) layer and the cortex layer which lies beneath the epidermal layer leaving the central portion for human consumption or industrial applications. Ideally and especially in the food industry, the peel needs to be completely removed without removing the useful tuber flesh. In tapioca peeling operation both the periderm and the cortex are removed as waste, and the central portion of the tuber left as the desired output. There are several methods of peeling tapioca, which have been adopted. The four main method or procedures include manual, chemical, steaming and mechanical methods. Each has its own advantages and disadvantages (Kouteu et al., 2016; Mohan et al., 2013).

The manual method of peeling tapioca is primitive and cumbersome. It is performed by hand peeling of tapioca using sharp edged object like knife. Chemical method is often adopted in the industries, factories and food processing companies. It involves chemical actions and thermal shock, which leads to softening and loosening of the skin using caustic soda (NaOH). In the steaming method, the tubers are subjected to high steam pressure over a short period of time to avoid partial cooking (or eventual cooking). The disadvantage is that the tubers could be subjected beyond the time required, which will lead to cooking (Barati et al., 2020; Kalpana et al., 2016).

Basically, mechanical method includes mechanized means of peeling; aim at peeling a large number or a batch at a time. Many mechanisms have been devised for this purpose. This includes the continuous process, abrasive belt conveyors and batch abrasion types among others. These methods of peeling have not been yielded the desired results. Hence, the continued research in this area. An extensive literature research was conducted to determine the state of the art in tapioca processing. This project is intended to solve the problem of tapioca peeling and to serve as a base for the commercial production and utilization of tapioca peeling machines (Tobiloba et al., 2019).

Materials and Methods

In the development of the tapioca skin peeling machine, an AC motor with components shown in Figure 1 was used based on the specifications as stated in Table 1 and 2. This system is important to move the tapioca peeling machine to work successfully. This system can help to avoid damage

towards the electrical flow on the tapioca peeling machine during the process. Furthermore, this system will also reduce the processing time and cost and increase the production.

Table 1. Specification of the AC Motor Electric

No.	Parameters	Capability Values
1	AC Motor Type	200 w
2	Voltage	220 v
3	Three Thread cable	Connected with motor
4	High speed	2800 R.P.M

No.	Component
1	End bell
2	Wiring cover
3	Motor frame
4	Stator
5	Fan blades
6	Rotor
7	Bearing
8	Bell bearing

Figure 1. AC Motor Configuration and Component

Hence, Figure 2 indicated the system used to illustrate the tapioca peeling machine function and overall process flow. Before starts to develop the machine, the properties such as capacity of tapioca and the appropriate size to peel tapioca skin was identified and followed as shown in Table 2.

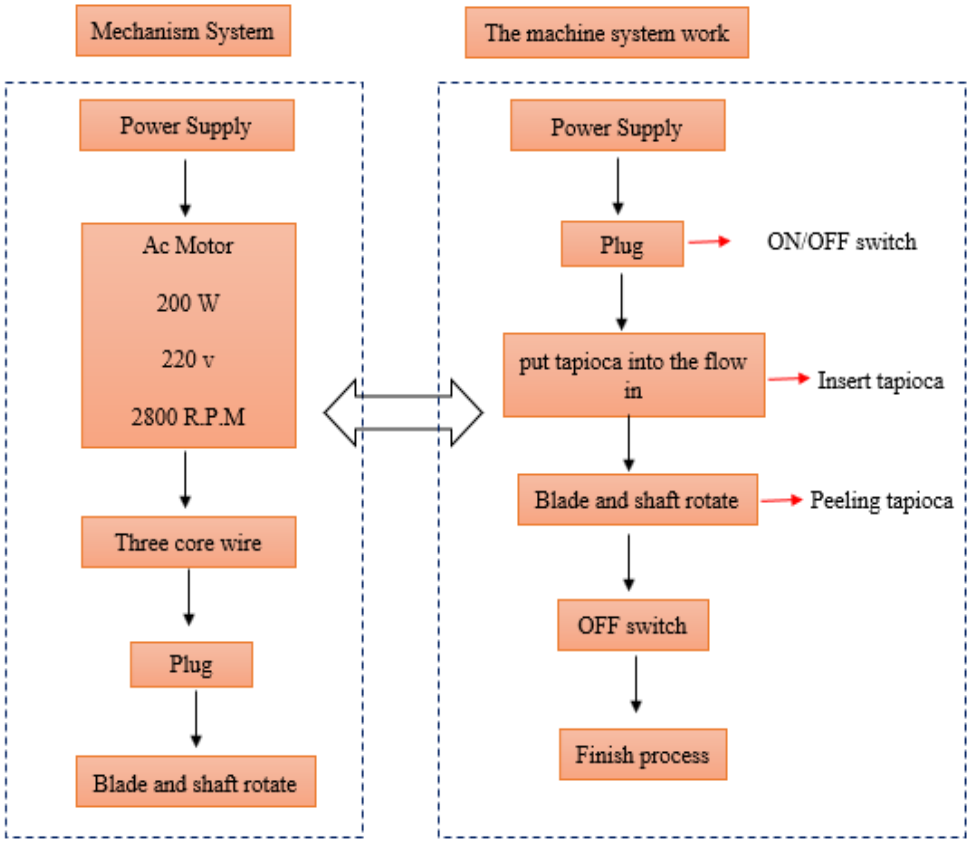


Figure 2. Flow for Machine Movement and Mechanism System

Table 2. Properties of Machine Model

Model	Eco-auto- tap
Capacity	120 kg/h
Weight	80 kg
Size model	450mm*450mm*650mm
Thick of cutting	5-20 mm
Diameter tapioca	6 cm-80cm

Material selection is of utmost importance to ensure that the components to be fabricated have the desired performance requirements. Since different components of the tapioca peeling machine would be subjected to varying forms and the degree of stresses strains, torque and frictional effect, the material with the appropriate engineering properties was chosen. Therefore, stainless steel with corrosion resistant was selected.

Fabrication is the process of constructing product from the raw materials towards the processes that involved measurement, cutting, assembling and finishing. There are two product divisions, namely original equipment manufacturer (OEM) part and fabrication parts as shown in Table 3 and Table 4. Both the OEM and fabrication part were involved in each process that has been carried out in the workshop. Further the development of the fabrication process was proceeding with simulation approach using Fusion360 software.

Table 3. Original Equipment Manufacturing (OEM) Part

Item	Part Name	Material	Quantity
1	Ac Motor	OEM	1
2	Conveyor Belts (Belting)	OEM	2
3	Bearing Set	OEM	4
4	Drawer Slide	Steel	2
5	Handle	Plastic	2

Table 4. Fabrication Part

Item	Part Name	Material
1	Body Frame	Mild Steel Square Hollow 1x1
2	Cover The Body Frame	Aluminum Shape Plate 1mm
3	Roof Tapioca	Perspex (490mm X 640mm)
4	Transmission	
5	Drawer	Aluminum 1mm And Perspex Plastic
6	Tapioca Blade 15mm	Mild Steel Round Bar
7	Shaft 6mm	Mild Steel Round Rod
8	Flow In	Round Aluminum Shape 100mm
9	Round Tapioca Blade	Round Aluminum 90mm
10	Finishing	Painting

Results and Discussion

The system developed on the tapioca skin peeling machine is a system that cares about the safety and time of the user. It can be seen that the tapioca input is inserted into the machine without the user being hit by the shaft as the whole machine is closed. Once the first process is completed the user does not need to use hands to take the tapioca input as this machine has placed a movement on the shaft to move the tapioca input as a ready -peeled tapioca pusher to the end of the machine so that the tapioca input is at the output hole and falls into 1 container provided at the machine. Users also do not have to waste time to clean the remains of tapioca skin that has been peeled because in the machine there is a container drawer that stores the remains of the skin. This can also prevent the occurrence of injuries during cleaning the machine. To clean the shaft part of the tapioca machine it is only necessary to add water to the hollow blade of the tapioca to clean the remnants of the tapioca skin attached. Inside the machine, there is a motor that serves

as the main function of the machine. The plate part is covered with 1 box on the motor plate to prevent the motor from being exposed to water or falling tapioca skin residues. Next, the end result of this machine will produce a tapioca filling that is ready to undergo any food processing or production.

In addition, the time taken by the tapioca peeling machine to complete the process of removing the tapioca peel from the contents is faster than the available products in the market. With 50 horse power supplied by the motor, the machine moves the engine faster and more powerful to process the tapioca input faster. Two tapiocas can be peeled in 30 seconds to get the final result compared to the existing product that needs 1 to 5 minutes to peel the tapioca skin. This machine is capable of processing a large quantity of around 160 tapiocas in one hour and working in a long duration of time. If compared with the existing peelers that use a lot of manpower will cause the working time will be shorter. This user friendly machine is also easy to operate and can be operated by the unskilled people with no experience in operating the machine due to the safety and ergonomics features for the user. In addition, using this machine can also guarantee the cleanliness of the end result due to the separation of the skin from the tapioca content that is ready to be processed and not exposed to contamination before being processed into the next product. This will increase the value of peeled tapioca that will be purchased by chips tapioca entrepreneurs and suppliers in Malaysia.

This quality machine will beneficial and able to help all users, especially entrepreneurs of tapioca chips, tapioca flour and small and medium industrial operators (Edeh et al. 2020). This machine will produce greater yields and at the same time reduce the manpower with less/minimum workers. This will save cost, human energy and make the investment of buying a tapioca peeling machine a profitable investment to the users and small medium enterprise company.

Structure Analysis for The Shaft and Blade

The diagram in Figure 3 shows the safety factor analysis for the tapioca skin peeling machine shaft. The analysis shows in blue that the shaft used is safe and the placed load is suitable for the peeling tapioca skin processing. Tapioca skin peeling machine is made using mild steel that gives a superior and neat finish, will not rust, the use of mild steel is more economical and lighter than other steels. This material was chosen to make it easier for users to make the tapioca peeling process. Further the machine development and structure analysis was studied using simulation techniques. Fusion 360 software is used to create analytical simulations to test the durability of the shaft and the load on the bearing so that the product works for use by the user (Gana et al., 2020).

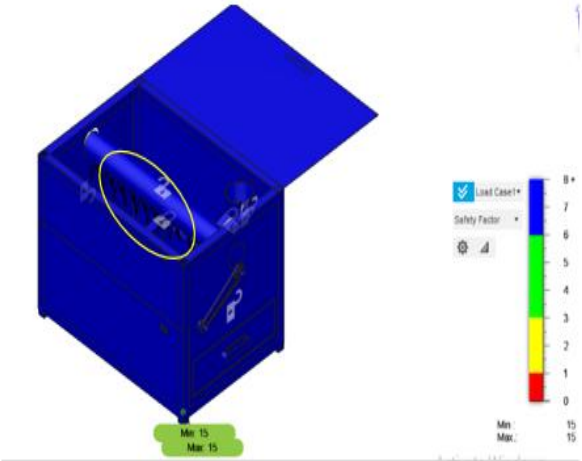


Figure 3. Safety Factor Analyses

Based on Figures 4a and 4b, the analysis found that some parts of the machine were exposed to failure and some part had successful analysis. Green colour indicate successful rate of analysis while the red colour indicate failed analysis. This is because the load insert is not suitable where the height does not match the size of the shaft and the design is too small. When the size and load had been changed on the shaft used, the result turned to a successful analysis on the shaft. Analysis was also done on the shaft to obtain the maximum and minimum load of the tapioca that are suitable and can be connect during the process. The machine structural analysis was tested by changing the size shaft used and the load. Changing the size shaft and the load used had given a positive outcome/result as compared to the previous design shown in Table 5.

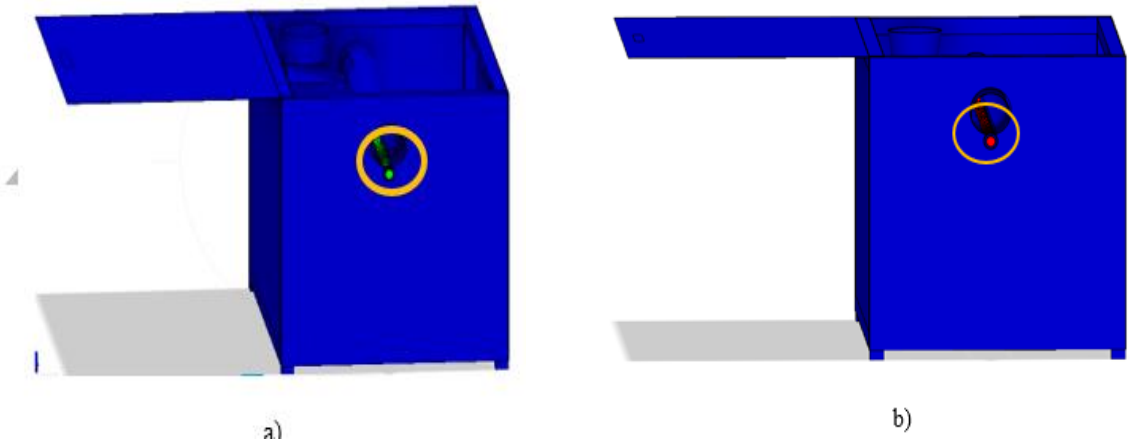
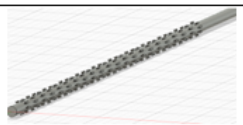
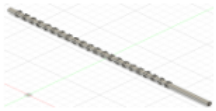


Figure 4. Simulation Analysis by Colour Indication; a) Successful Analysis b) Failure Analysis

Table 5. The Different Between Size and Load Changes

Size / Load	Previous	New
Size	 Size diameter balde 20mm And size shaft 2.5mm	 Size diameter balde 15mm And size shaft 3mm
Load	100 N	200 N

Structure Analysis for The Bearing Load

Based on Figure 5, the analysis for bearing load was done to observe the degree of rotation of the bearing together with the speed of the motor used. The result indicated a successful rate when the same load of 200 N was placed on the shaft and blade of the tapioca peeling machine. Therefore the strength and the functional of the blade and shaft rotate can also be identified from the bearing load structural analysis of the tapioca peeling machine similar to the study done by Edeh (2022).

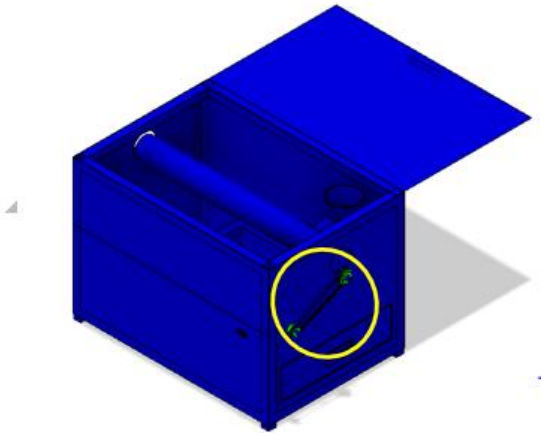


Figure 5. Successful Analysis Bearing Load

Advantange of The Functioned Tapioca Peeling Machine

The previous work on tapioca peeling machines has seen evolution in terms of sharp shaft and the safety of using the machine (Ojolo et al., 2017). The tapioca peeling machine also moved away from fuel turn on the internal combustion engine to a more environmentally friendly electric cutting machine (Oyedele et al., 2019; Olayanju et al., 2019; Sk Tyagi et al., 2018). Even so, this tapioca peeling machine is not uncommon due to the extension cables available characteristics of them. For this reason, this new design of functioned tapioca peeling machine in Figure 6 is seen as a perfect solution as it does not contribute to fuel to operate and electricity bills.

In addition, this tapioca peeling machine can also solve the problem in terms of time, which is no need to repeat two times for the same processing for tapioca peel peeler. This machine is able to peel two layers of tapioca skin which is quite thick about in 1-2 mm thickness compared to the existing machine. Furthermore, this machine can also prevent pollution around the workplace because every skin residue that has been peeled is directly put into the skin container provided in this machine.

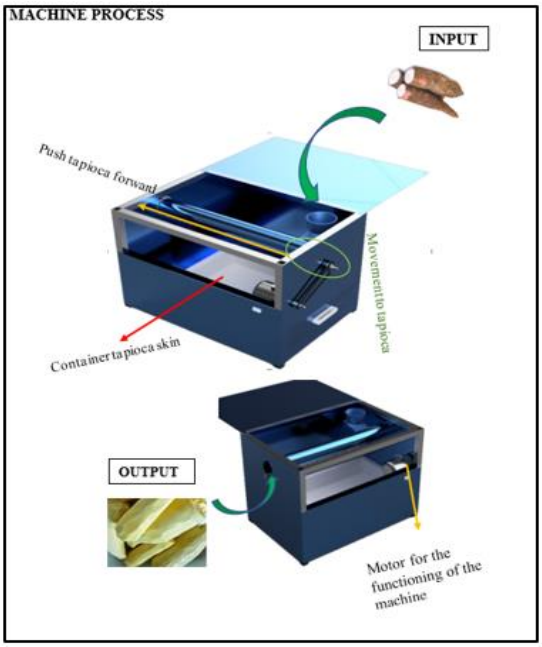


Figure 6. Functioned Tapioca Peeling Machine Process

Conclusion

The tapioca peeling machine involved simple mechanism and can operate easily. The unit is equipped with a sturdy frame when the shaft rotates as the strength of its support. Tapioca has different sizes and shapes, so this machine can only actualize the size between 6 cm to 80 cm in diameter of the tapioca. On the shaft part of this machine can peeling the tapioca skin beautifully and evenly compared to the existing machine only a handful of the skin is peeled, the rest is left on the tapioca. There are many ways to reduce production costs must be investigated to make the study more interesting to small and medium entrepreneurs in rural areas.

The implementation of automatic and improvement tapioca peeling machine culture practice which will increase for a reduction in tooling cost and employee time. The tapioca peeling machine had undergo testing and evaluation using software such as simulation or analysis found in Fusion 360 and Solidwork. From the structure analysis, it indicated that the strength of the new design is better as compared to other previous designs. This analysis that had been done involved the stress and strains design that drawn in the software.

Acknowledgments

The authors fully acknowledged the Universiti Sultan Zainal Abidin for providing the equipment and facilities that make this research possible, viable and effective.

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How to cite this paper:
Ireana Yusra Abdul Fatah, Nor Izzah Hazirah Abdul Hadi, Razwan Rohimi. (2022). Design Modification And Structure Simulation Analysis Of Tapioca Peeling Machine. *Malaysian Journal of Applied Sciences, 7*(2), 83-92.