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The Development of Tempeh Packaging Mechanism Prototype: Slicer Folded and Binding Part to Pack Tempeh by using Kraft Paper.

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Abstract: The development of Automated tempeh packaging mechanism was carried out due to the manual process taken by the small industry especially IKS. In the industry, tempeh packaging process that using paper is done manually as it required more work. Packaging process manually needs longer time and require more worker. Therefore, this project carried out the design the mechanism, fabricated and automated the folded and binding part for the automated tempeh packaging process. The scope of this project is focusing on the packaging process by using kraft paper. Solidworks software was used to design the paper folding and binding part and the fabrication process applied to complete the parts are as follows; welding, drilling, cutting, bending, rapid prototyping process and others. This prototype mechanism consists of mechanical and electronic parts. The mechanisms that control the movement of the machine are DC motor, servo motor and Arduino. Once all the mechanical and electrical parts was assembled, the function test was run. Function test for folding part was about 80% function and binding part was 70% succeed.

Keywords: Tempeh, Prototype, Packaging, Kraft Paper, Soybean, Fabrication, Design, Solidworks, Arduino.

1. Introduction

Tempeh is a food that is originally from Indonesia and is a plant-based protein source. It is made from fermented soybean. As it is rich with nutrients that can give many health benefits, tempeh is becoming popular all over the world. Consuming tempeh as part of a well-balanced diet can help in getting more important nutrients like protein and iron, as well as provide other health benefits, such as lowering your risk of developing chronic diseases [1].

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There are few types of tempeh packaging such as banana leaves, plastics and paper. Each type of this packaging can affect the quality of the tempeh differently. When used as tempeh packaging, banana leaf packaging can overcome a deficiency in tempeh acid and wrapping with this banana leaf can avoided the sour taste that results from an improper fermentation process [2]. Tempeh wrapped in plastic is very common on the market. The ease with which plastic may be obtained leads to a huge of plastic packaging for tempeh. Tempeh wrapped with paper is the least type of packaging on the market. It is because the packaging process is manual.

In this project, the research is focusing more on the packaging process that uses kraft paper. Mostly in the industry, the packaging process that using paper is done manually as it required more work, and the process done is more detailed. Moreover, wrapping manually can give more satisfactory results. Therefore, the original packaging process takes a longer time and require more worker. As the result, longer time for workers to pack tempeh in large quantities can lead to poor ergonomics as the worker needs to sit for a long time. Working in a seated position for an extended period of time can cause back pain, muscle soreness, and pains. Other than that, hiring more workers made the price of tempeh higher due to the increase in the labor force. Currently, there are no existing machine that pack tempeh by using kraft paper. Therefore, the objectives that need to be achieved in this project are to design, fabricate and automate the mechanism of folded and binding part for the automated tempeh packaging machine by using kraft paper.

The purpose of this project is to develop a prototype of tempeh packaging mechanism that can help and solve problems of some small traders which is an automated tempeh packaging machine. The research of this project is focusing on small industries (IKS) as it can be used for a better performance on their production. The development of this packaging mechanism consists of folded and binding part that was designed using Solidworks software. This prototype was fabricated by using mild steels, zinc and aluminium. In order to build this prototype, there will be different process conducted such as cutting, welding, machining and others. Furthermore, the fabricated prototype will be controlled with the help of Arduino. For this project, the target company that will be benefit of using this machine is a small company that produce tempeh. This prototype will proceed with complete fabrication by the manufacturer to come out with the actual product

2. Methodology

Methodology of this project contains the materials used, design of the mechanism, control system and the testing procedure that was done in order to achieve the objectives of the project. The material selection for this prototype fabrication is based on the size, strength and the availability of the material. For this prototype fabrication, there are a few processes that need to be done in order to complete this project. Table 1 shows a list of material and process of each part of this machine's prototype.

Table 1: List of Material and Processes

Component	Material	Process
Slicer	1. 2mm Aluminium Plate 2. PLA Filament	1. Rapid Prototyping 2. Cutting 3. Drilling 4. Riveting
Rubber Band Supplier	1. 3mm Aluminium Plate 2. Square Hollow Mild Steel 3. Mild Steel Plate	1. Cutting 2. Bending 3. Drilling 4. Filing 5. Welding
Rubber Band Gripper	1. 1mm Zinc Plate	1. Cutting

	2. 2mm Aluminium Plate	2. Drilling

2.2 Concept of Mechanism

Mechanism is an arrangement of moving parts performing a properly functioning motion. In this project, there are several mechanisms needed to control the movement of the automated tempeh packaging machine. This machine cannot move by itself without the mechanism system to control the movement whether to move it linearly, rotary or reciprocating. This machine was designed with a conveyor to move folded tempeh from the folding part to the binding part, a rail to move hook frame, a motor to move the gripper so it can grab and release the rubber band. Following Figure 1 is the flow process of automated tempeh packaging machine mechanism.

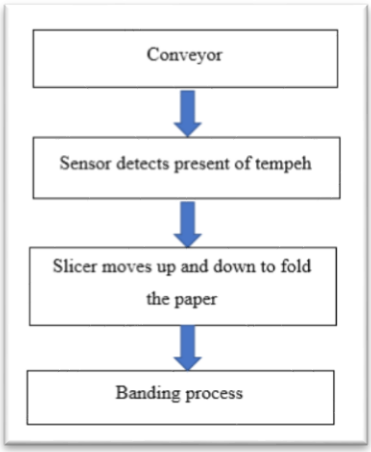
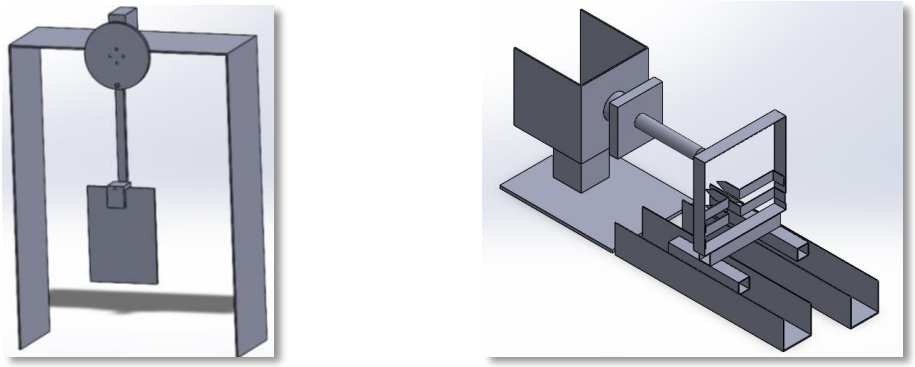


Figure 1: Mechanism Flow Chart

The design of this prototype consists of three part which is slicer folded, rubber band supply and rubber band gripper. Design was made by using Solidworks software. The design was finalized with the combination of several parts and mechanism. Figure 2 shows the design of slicer and the design of rubber banding.



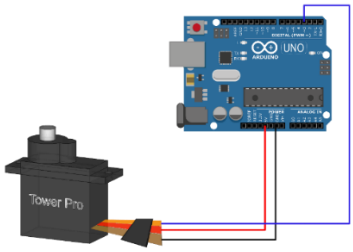
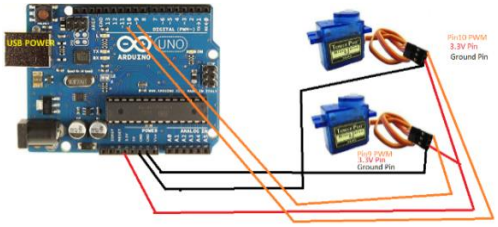
(a) (b)

Figure 2: (a) Design of Slicer (b) Design of Rubber Banding on the right

2.3 Control System

After all part has been fabricated, the next process was to set up the control system. DC motor and Servo motor are the devices use to move the mechanism in this project. Both motors need to be set up to their own circuit. DC motor were controlled by using power supply while servo motors were controlled by using Arduino. Table 2 shows the components and the control circuit for each mechanism. Electric circuit diagram shows the connection between each component. Different components need different type of circuit for it to function correctly. Wrong circuit connection will make the components do not function.

Table 2 Control Circuit for Each Mechanism

Mechanism	Component	Circuit
Slicer Folded	• MG90S Servo Motor • Arduino Uno • Wire Jumper	
Rubber Band Supply	• Power Supply • DC Motor • Wire	
Rubber Band Gripper	• SG90 Servo Motor • Arduino Uno • Wire Jumper	

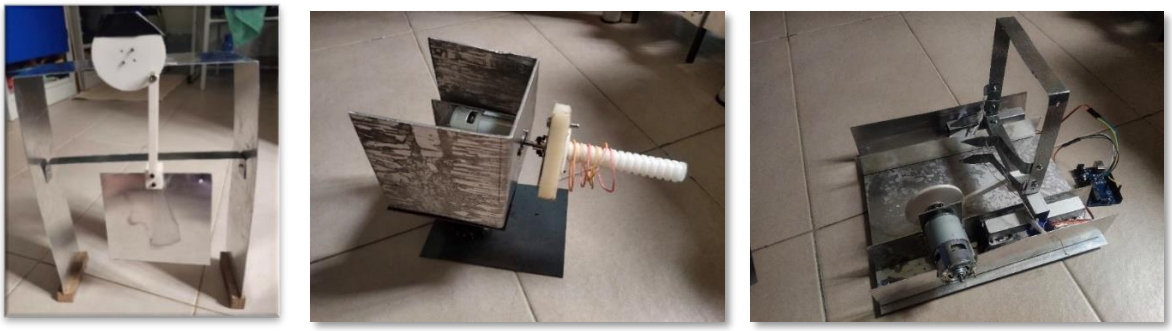
2.4 Testing Procedure

The testing procedure consists of four type of test which is feasibility test, functionality test, efficiency test and the programming test. All test was conducted to make sure that the mechanism will run smoothly. For the first test, feasibility test was conducted to determine whether the process chosen or the design made for the mechanism were accurate so the mechanism can operate successfully. Then, functionality test was done to analyse whether each mechanism that was fabricated were function as its required. Next, Efficiency test was done to analyse the performance of the mechanism to function as it required. The efficiency of the mechanism was tested by conducting 10 attempts of test and record the performance of the mechanism whether it was successful or not

3. Results and Discussion

3.1 Prototype Result

After all parts has been fabricated, it needs to be assembled to equip all the components. Figure 3 shows the slicer part, rubber band supply and rubber band gripper that has been assembled. Folded slicer consists of slicer plate, the mechanism to move the slicer plate and the stand that will hold the slicer. Next, the rubber band supply consists of three part which are the threaded rod that will hold rubber bands, a frame that hold DC motor and the stand that support the rubber band supply. Lastly, Rubber band gripper consist of five components which are DC motor, moving mechanism, wheels, rails, and frame with gripper.



(a) (b) (c)

Figure 3: (a) Folded Slicer, (b) Rubber Band Supply (c) Rubber Band Gripper

Although all the mechanism was functioning but the efficiency of the mechanism needs more improvement. The efficiency of the mechanism was shown in Table 3. After conducting 10 attempts of testing of the mechanism, the efficiency was calculated. The efficiency of folded slicer was 60% as its only successfully fold the paper downward six time from 10 attempts. Next, the efficiency of rubber band supply was 100% as it had no problem to supply the rubber band and success in each testing attempt. Lastly, the efficiency of rubber band gripper was 50% which half of the attempts was unsuccessful as the rubber bands keep sliding out from the gripper.

Table 3 Efficiency of Mechanism

Number of Test	Mechanism Testing Result		
	Folded Slicer	Rubber Band Supply	Rubber Band Gripper
1	Unsuccessful	Successful	Unsuccessful
2	Successful	Successful	Unsuccessful
3	Successful	Successful	Successful
4	Unsuccessful	Successful	Unsuccessful
5	Unsuccessful	Successful	Successful
6	Successful	Successful	Unsuccessful
7	Unsuccessful	Successful	Unsuccessful
8	Successful	Successful	Successful
9	Successful	Successful	Successful
10	Successful	Successful	Successful
Efficiency	60%	100%	50%

3.2 Discussions

The overall performance of this automated tempeh packaging machine prototype is based on the ability of the prototype to function as it requires. It is a really difficult task to be able creating a full functioning machine without a proper planning in a short time. This prototype was successfully fabricated and was able to functioning.

For the first part in this project which is the slicer part that function as a folded mechanism to fold front and back part of the tempeh packaging. The slicer required to move up and down between two conveyors to fold the paper. As the result of fabrication and technical process, the slicer was able to move up and down. The movement of the slicer depends on the diameter of the slider mechanism that hold the slicer plate. Therefore, the distance of the slicer movement depends on it. Even so, the slicer needs to be improved so that the distance for the slicer to move up and down is longer. Other than that, improvement must be made to make the movement the slicer to be more precise. Instead of the mechanism, reciprocating movement much better for the slicer.

Next, for the second part which is the rubber band supply. This part was required to rotate 360 degrees to supply rubber bands to the rubber band gripper. The rubber band supply was 100% successful. The rubber band supply was able to supply the rubber band with the rotating threaded rod that was controlled by DC motor. The only improvement that can be made for the rubber band supply is that the speed of the DC motor needs to be controlled and it also need a timer.

Moreover, for the rubber band gripper which is the hardest part in this project that required to grab a piece of rubber band and needs to move back and forth. The rubber band gripper was easily able to move back and forth as required. Other that than, the gripper also was able to grab a rubber band and move it to the folded tempeh. Although the part has the ability to move but it need more improvement for it to function smoothly.

Lastly, testing process was conducted to test the functionality of the components used which is the servo motors. It is also to test whether the programing coding is correct. After the testing process was done there were some motors were found not functioning. Other than that, the programming coding

also need to be edited after the testing process were done. After testing the testing of servo motor were done, the motor then was tested to the slicer folded and binding part. As the result, the mechanism was functioning well but some motors were not functioning as in the programming.

4. Conclusion

As conclusion, the objectives of this project were successfully achieved. By using Solidworks 2021 software, the design of the fully automated tempeh packaging machine slicer folded and binding part are easily created. The prototype of tempeh packaging mechanism was also being fabricated and automated successfully. Furthermore, the material and components selected for this project need to be chose properly because of some parts are not functioning as it required. Moreover, more knowledge about Arduino programming is needed to run this project as most of the programming are totally different and need to be edited so that the components will move properly.

Next, for the overall performance of this project are functioning but it needs more improvement for it to move smoothly without any external error. Each part of the prototype has its own criteria that need to be improved that will be discussed in the recommendation. Although the time taken to pack tempeh by using this automated tempeh packaging machine is more than the manual process, this machine at least can help the small traders to produce more pieces of tempeh in a range of time.

Lastly, for this type of project, time management is really important in order to complete all the process in this project from designing process to the testing process. All planning needs to be properly scheduled so that every process can be conducted properly.

Acknowledgement

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