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Improvement on Prototype for Mechanism Binding Part in Tempeh Packaging Process

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Abstract

This project focuses on refining the design of binding parts through the implementation of an automated system, aiming to address packaging inefficiencies related to storage and binding mechanisms. The objectives include developing a miniature model of these parts for integration into automated packaging systems, and verifying the effectiveness and consistency of the binding mechanisms. The project flow encompasses preliminary research on packaging inefficiencies, identification of suitable machine-operated binding mechanisms, and the fabrication of a prototype using 3D printing and adhesive techniques. An Arduino-based system, equipped with ultrasonic sensors and motors, controls the binding process by detecting the tempeh's position and triggering the motor to bind it with a rubber band. The motor's speed and duration are adjustable for precise control. Efficiency testing involved ten trial runs and four design iterations, demonstrating that 70% of the trials resulted in perfect functionality. Time analysis revealed that the binding mechanism requires approximately 3-5 seconds to bind the rubber at the optimal middle position. The sensor's ideal height was determined to be 7-9 cm from the tempeh. The successful fabrication and automation of the binding mechanism represent a significant advancement in tempeh packaging. The Arduino-based system introduces a more efficient and eco-friendly approach, updating traditional methods, reducing costs, and increasing tempeh production. This innovative solution marks a substantial step towards enhancing the overall effectiveness, speed, and sustainability of tempeh-making processes.

1. Introduction

The tempeh industry is growing rapidly, and there is a growing demand for automated packaging systems that can improve efficiency and reduce labor costs [1]. However, many of the existing packaging systems are manual, which can lead to inconsistencies in the packaging process and increased labor costs [2]. One of the key challenges facing the tempeh industry is the need to develop an automated packaging system that can handle the specific requirements of the tempeh packaging process, including the size and weight of tempeh packages [3], the speed at which they need to be packaged, and any specific packaging requirements [4]. Another challenge is the need to incorporate binding parts into the packaging process [5]. Binding parts are used to hold the tempeh packages together and prevent them from falling apart during packaging and transport. However, incorporating binding parts into the packaging process can be difficult, particularly in an automated system. Furthermore, there is a need to ensure that the automated packaging system is reliable and consistent, with minimal downtime and maintenance requirements. This is particularly important in the tempeh industry, where consistency and reliability are critical to ensuring the quality of the final product. Therefore, the problem statement for the development of an automated tempeh packaging mechanism prototype for binding parts using an Arduino programmer is to create a reliable and efficient system that can handle the specific requirements of the tempeh packaging process [6], incorporate binding parts into the process, and ensure consistent results.

Objective

The main objective of developing an automated tempeh packaging mechanism prototype for binding parts using a system is to improve the efficiency and consistency of the tempeh packaging process [7]. There are three main goals for the project. Its primary goal is to improve binding component design by using an automated system. Second, it aims to build a small-scale replica of these parts so that they can be incorporated into packaging automation systems [8]. Finally, it makes sure that the binding mechanisms are more effectiveness and consistent in order to verify the efficacy of these improvements.

Product significance

Automated tempeh packaging equipment will undoubtedly benefit the industry in a number of ways. As the machine can replace manpower and expedite the production of large quantities of tempeh [9], the performance of that production will increase. In a short time, tempeh. The economy will undoubtedly benefit as tempeh production performs better and there is a greater demand for it in the nation. The original hand-packaging method can result in poor ergonomics because the worker's position is improper for extended periods of time [10]. Therefore, there won't be any issues with the health of the workers thanks to this automated packaging machine, which will also increase their productivity.

2. Materials and Methods

The methods outlined in this chapter are necessary to implement in order to successfully complete the project's automated mini tempeh packaging mechanism. It includes the project's work with the flowchart and the choice of framework for the project.

2.1 Materials

Table 1 *list of material*

No.	Component	Quantity	Price (RM)
1	Dc Motor 3-6V	3	2.90
2	Battery 12V 1.2AH	1	38.00
3	Plastic Gear for Dc Motors	1	11.50
4	Band sealer Timing Belt	2	10.00
5	Wood Ceiling 2.5 cm x 0.5 cm (2Feet)	3	7.50
6	DIY Wood (Diameter 2cm)	7	17.50
7	Box	1	0.00
8	Arduino UNO	1	39.90
9	L293D DC Motor Driver	1	7.40
10	IR Infrared Obstacle Avoidance Sensor	1	1.90
11	Wire (2feet)	1	2.50

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2.2 Methods

A mechanism is a grouping of moving parts that performs an appropriate motion. To control the motion of the automated tempeh packaging machine in this project, several mechanisms are required [11]. Without a mechanism system to regulate its movement, whether it is moving in a linear, rotary, or reciprocating fashion, the machine will not move on its own. The tempeh will enter the binding mechanism through the conveyor after leaving the folding process, stop when it hits the sensor, and then be bound by rubber [12]. The dc motor's speed and direction of rotation have been set by the Arduino coding, and the motor stops when the sensor is touched. Following Figure 1 is the flow process of automated tempeh packaging machine mechanism.

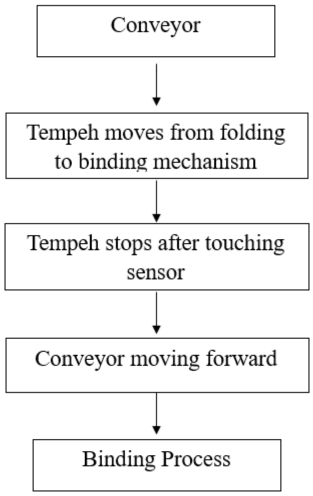


Fig. 1 *Mechanism Flow process*

3. Results and Discussion

An automated packaging system boosted efficiency by streamlining tasks and reducing manual work. It keeps a steady pace and accuracy, managing repetitive jobs effortlessly. Adding binding parts to this system made packaging more secure, decreasing the chance of damage or contamination during transport and storage. Rigorous testing showed a significant drop in packaging errors compared to manual methods. The automated system reduced mistakes like misaligned bindings and improper seals, improving product quality, reducing waste, and ensuring better-packaged tempeh.

3.1 Real diagram and Schematic diagram

The ultrasonic sensor was gathering data when the tempeh reaches the binding portion and use that data to trigger the motor. The mechanism must experiment with adjustable speed, which also serves to control the motor's speed in order to ascertain how long the motor turns. Adjustable time also controls the motor's movement. In the center of the tempeh, place the rubber band. Upon completion of the tempeh tie, the motor will shut down at the predetermined time. Below is Figure for electronic parts.

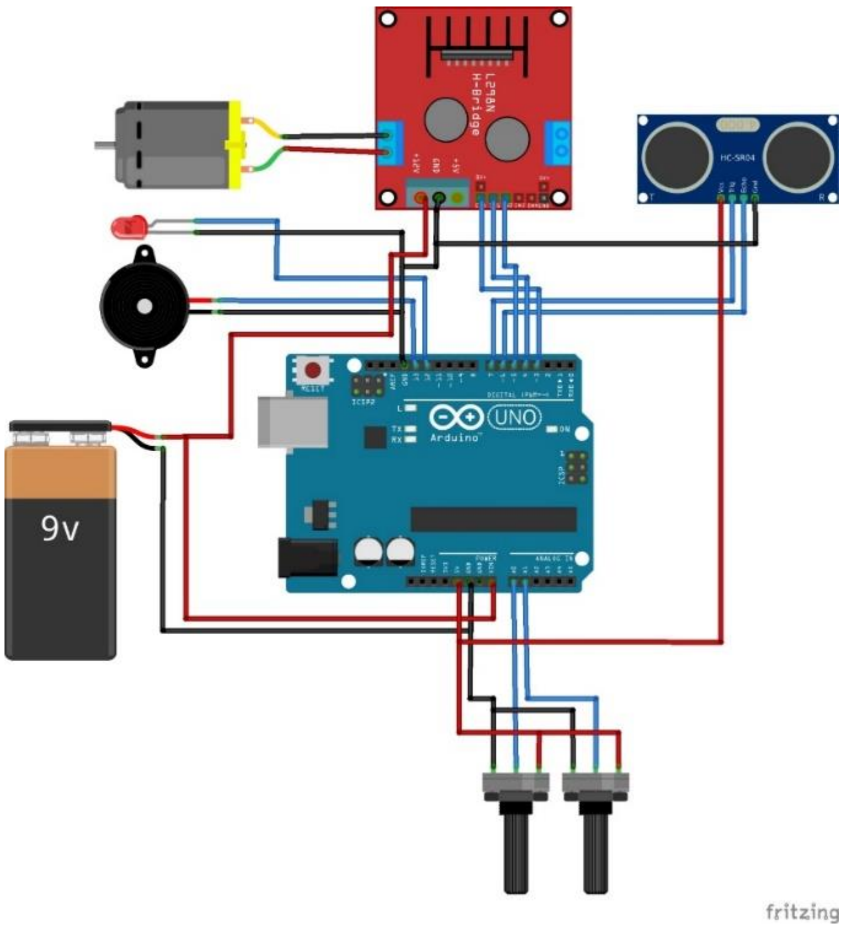


Fig. 2 *Real Diagram*

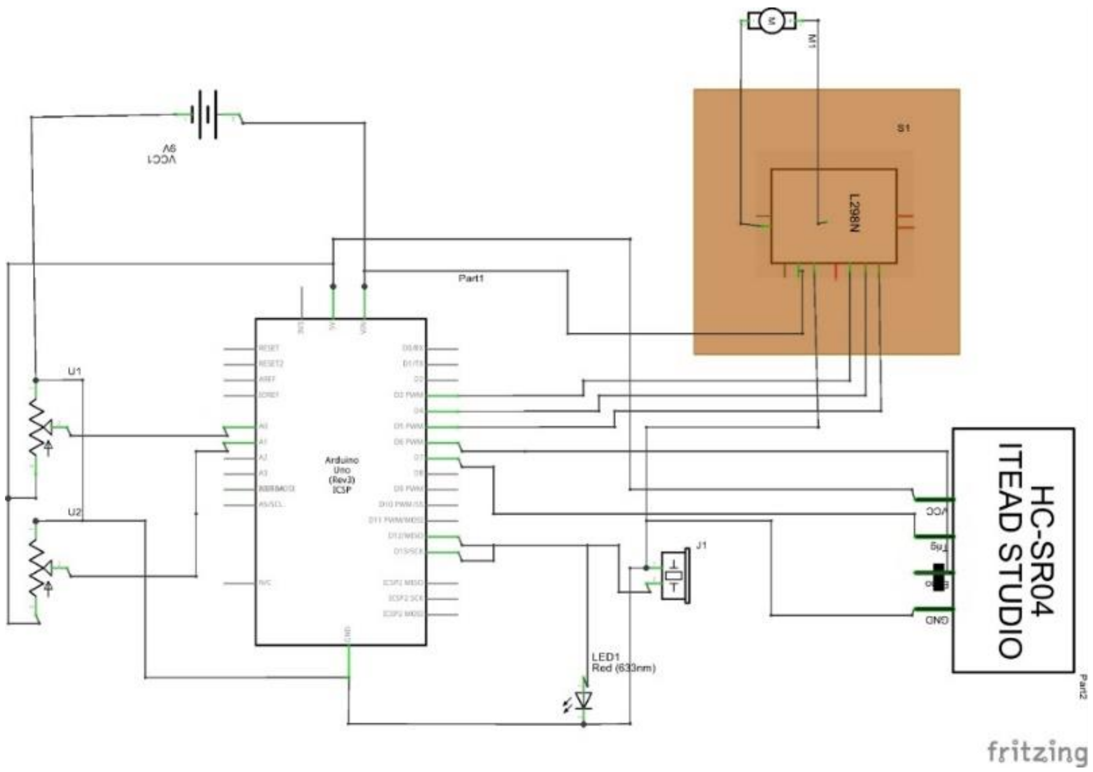
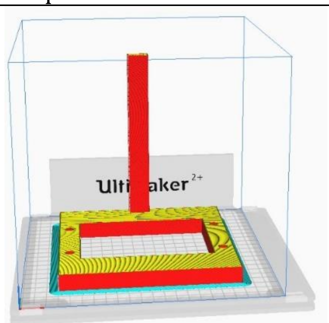
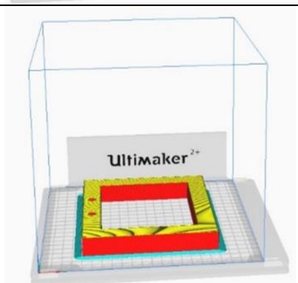
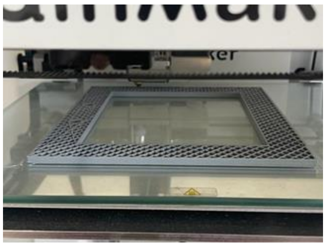
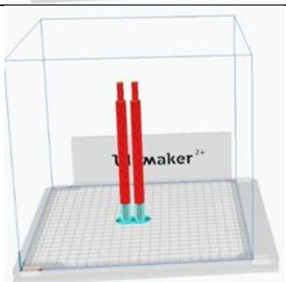
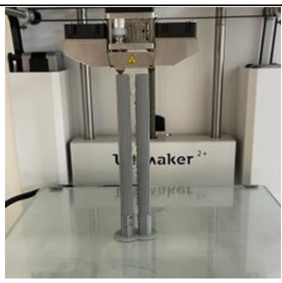
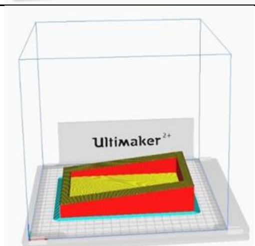
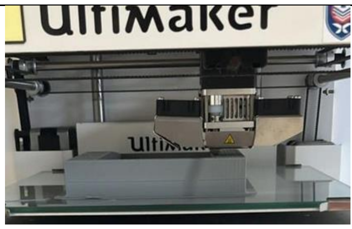


Fig. 3 *Schematic Diagram*

3.2 3D printer properties front, side, gear on side and bottom parts.

Some elements of this project need 3D printers to be completed. parts for the front, side, and bottom, as well as one for the equipment on the rear. To complete the print, each part takes two to nine hours to complete as shown in Table 2. Because using more than 20 percent density would take too long, the average density is set at 20 percent.

Table 2 *Properties, result and description part*

Parts	Properties	Result	Description
Front			-Layer Thickness: 0.15 mm. -Infill Density: 20 -Print Time: 7 hours 53 minutes -Material Used:13.44 meters -Final Product: 103 grams.
Side			-Layer Thickness:0.15 mm -Infill Density: 20% -Print Time: 8hours 28 minutes -Material Used: 16.21 -Final Object: 128 grams.
Gear on side			-Layer Thickness: 0.15 mm, -Infill Density: 20% -Print Time: 2 hours 58 minutes. -Material Used: 3.18 -Final Object: 15 grams.
Bottom			-Layer Thickness: 0.15 mm, -Infill Density: 20% -Print Time: 8 hours15 minutes. -Material Used: 14.91 -Final Object: 118 grams.

3.3 Results for binding tempeh mechanism

The functionality test cases were designed to assess the efficiency of the tempeh packing technique. The prototype functions flawlessly in every way, including the giving mechanism. The Arduino programming and mechanical mechanism always function perfectly. The sensor that detects the movement of the tempeh and the DC motor rotate and move the rubber for the binding process in order to guarantee that the tempeh that has finished folding paper may be provided and processed through the binding machine.

Fig. 4 *Efficiency of the binding mechanism*

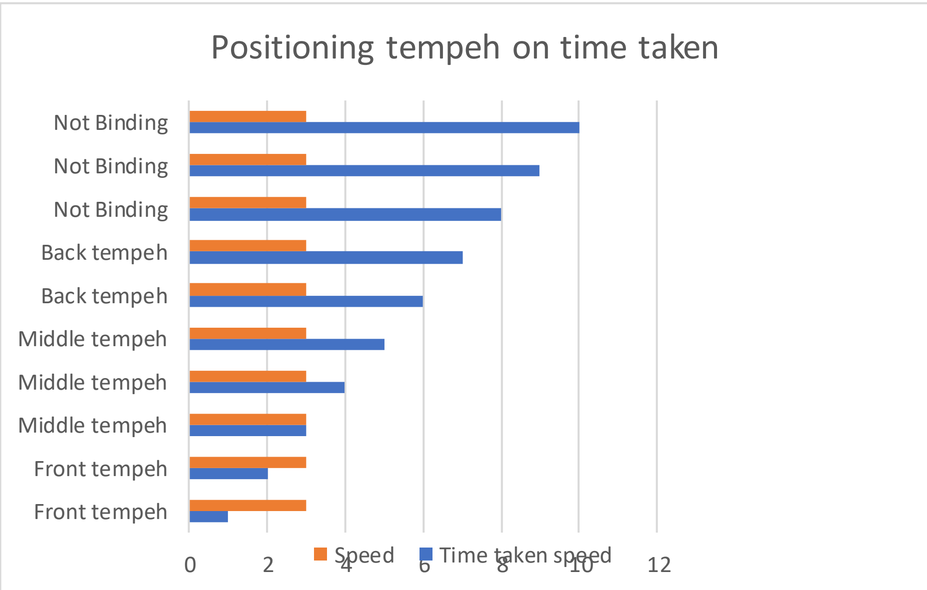


Fig. 5 *Positioning rubber bind the tempeh*

Following the completion of ten tests on Figure 4, the data above were gathered. The first through fourth tests' results, which are displayed above, are faulty due to coding errors at Arduino and structural errors in the mechanism. After rebuilding the code and creating a new structure out of plastic that was printed using a 3D printer, the issue was resolved. To make the building stronger and keep it from rotting, plastic has replaced all of the wood. The tests from 5 to 10 run well once the issue has been resolved [13]
The data gathered above on Figure 5 indicates that rubber will bind perfectly in three to five seconds. The rubber's position in front of the tempeh was recorded from 1 to 2 seconds. If the rubber is in front of the tempeh, the tempeh will not perfect bond. The rubber is behind the tempeh in the data collected from 6 to 7 seconds. It is also not appropriate to bind tempeh in this position. Finally, the rubber does not bond directly at tempeh between 8 and 10 seconds [14].

Table 3 *The height of sensor and Efficiency of mechanism*

Parts	Height (cm)	Functionality
Sensor	1	Malfunction
	2	Malfunction
	3	Malfunction
	4	Malfunction
	5	Malfunction
	6	Malfunction
	7	Function
	8	Function
	9	Function
	10	Malfunction

Table 4 *Type of rubber band*

No of test	Rubber band 1 	Rubber band 2 
1	Malfunction	Function
2	Malfunction	Malfunction
3	Malfunction	Function
4	Function	Function
5	Malfunction	Function
6	Function	Function
7	Malfunction	Function
8	Malfunction	Function
9	Malfunction	Function
10	Function	Function

The system malfunctions between 1 and 6 and 10 cm; when the height is inappropriate, the sensor's distance from the object prevents it from functioning correctly. Additionally, it does not operate properly if the height is more than 10 cm since the sensor is too far from the mechanism's Centre. A sensor needs to be between 7 and 9 cm in order to function effectively [15].

There are two types of rubber bands: the first is made entirely of rubber, while the second is made of both rubber and fabric. According to the data gathered above, a rubber band with fabric is the most appropriate since it lowers track friction compared to wood-based materials. Rubber band 2 has a higher function test score—9 on 3—than rubber band 1.

4. Conclusion

The tempeh binding machine project has made big strides in revolutionizing tempeh production. The prototype automates soybean binding, reducing the labor needed compared to traditional methods. It's proven to be accurate and efficient, promising faster tempeh production without compromising quality. Early tests suggest it's ready for wider use, adaptable to different soybeans and production sizes, potentially impacting tempeh producers globally. This innovation highlights the need to modernize traditional tempeh-making techniques, offering producers a way to improve efficiency, cut costs, and ramp up production. However, more testing and adjustments are necessary to ensure the machine's reliability and suitability for various conditions [16]. Overcoming production hurdles and ensuring cost-effectiveness are crucial for its successful introduction into the market.

In essence, the tempeh binding machine project marks a significant step forward in tempeh production technology. With further refinements and strategic planning, it could revolutionize the industry, providing a more sustainable, cost-efficient, and scalable way to make top-notch tempeh.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: study conception and design: Asnawi Radzuan, Dalila Harun; data collection: Asnawi Radzuan; analysis and interpretation of results: Asnawi Radzuan, Dalila Harun; draft manuscript preparation: Asnawi Radzuan, Dalila Harun. All authors reviewed the results and approved the final version of the manuscript.

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