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Development of Mini Tempeh Packaging Machine

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Abstract: Automatic process plays an important role in packaging food in industry because it can be produced in large quantity and shorter time taken. In this project, development of Mini Tempeh Packaging Machine is too designed and fabricated. The machine was designed by solidworks software, and the analysis of machine was simulated to determine the physical a mechanical property of the machine performances. Other than that, Arduino uno also use for creating system automatic to making mini model support by stepper motor and servo moto. For material to create mini model prototype will use plywood as a body for conveyor and rubber will be route conveyor. Besides that, mini gear needed to be connector between servo motor and route conveyor while metal plate has been molded for side part. In this study, the time taken too completed is 17 second for each folded. Besides that, the cost of the material is RM 150, and it must be suitable as to minimize the cost.

Keywords: Mini Packaging, Model, Tempeh, Servo Motor, Arduino

1. Introduction

Food grade wrapping paper and perforated polyethylene bags are the most suitable materials for tempeh. Tempeh is a traditional Indonesian food of high nutritional quality obtained by fungal fermentation of dehulled, soaked and cooked legumes. Appropriate packaging is important as it provides optimum oxygen supply and temperature for inoculation and fermentation packaging to occur during processing [1]

Tempeh is a perishable food and must be wrapped and placed into the refrigerator or freezer immediately after incubation or other processing steps such as blanching. Tempeh packaged in perforated polyethylene bags is usually repacked inside another labelled, non-perforated bag for distribution and sale, and for easier labelling. If the tempeh is only packaged in one perforated bag, the label must be directly attached to the perforated surface with the use of government food contact approved adhesive. Then, bulk packed in cartons and returned to the refrigerator or freezer to await shipment [2].

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There are many ways to packing tempeh using automated machine. Clamping and folded are the most used method in packaging system tempeh. Many materials are use in packing tempeh such as banana leave, paper and plastic but typically use is plastics for packaging tempeh. It also has much procedure in packaging such as clamping, wrapping, and folding. The process for clamping machine is tempeh will flow in the plastic bag with enough quantity then the machine clamp will be clamping the plastic to be melted. However, the plastic material is not environmentally friendly, because it is difficult to crumble and will become pollution [3].

2. Materials and Methods

2.1 Materials

This research study utilized the original design specification of machine from industries to produce large production in packaging by combination mechanism to produce mini prototype packaging machine tempeh [4]. Table 1 show list of material for create every part to develop mini prototype of mini packaging machine tempeh. For stainless steel plate that used for mold side folded part. Play wood to fabricate part of body for the mini prototype packaging machine tempeh. As illustrated in, Arduino uno is component receive coding to run the system of automated Mini Prototype packaging Machine Tempeh [5]. Servo motor is a device to folded front rear part for 138 ° after past through mold part [6]. Other than that, Stepper motor will be functioned to move conveyor to move station by station [7]. Tire rubber as material using for conveyor it has more friction an appropriate to be track.

Table 1: List of material

	
Stainless steel plate **(a)**	**Plywood** **(b)**
	
Arduino kit **(c)**	**Servo Motor** **(d)**

	
Stepper Motor	**Tire Rubber**
(e)	**(f)**

2.2 Research Design and System

Research design refers to an organized plan and scientific investigation into a specific problem, undertaken with the objective of finding solutions to it. The process of research design in this study involves five main phases as shown in Figure 1. The research begins with the initial phase, which focuses on defining problem and design solution. The second phase is design of a prototype model, which comprises conceptual design, material selection, and design evaluation. The third phase emphasizes on the development of a prototype model, including equipment selection and fabrication processes. Next phase is testing and analysis through functional testing. The final phase is conclusion, which embraces the discussion and conclusion of findings.

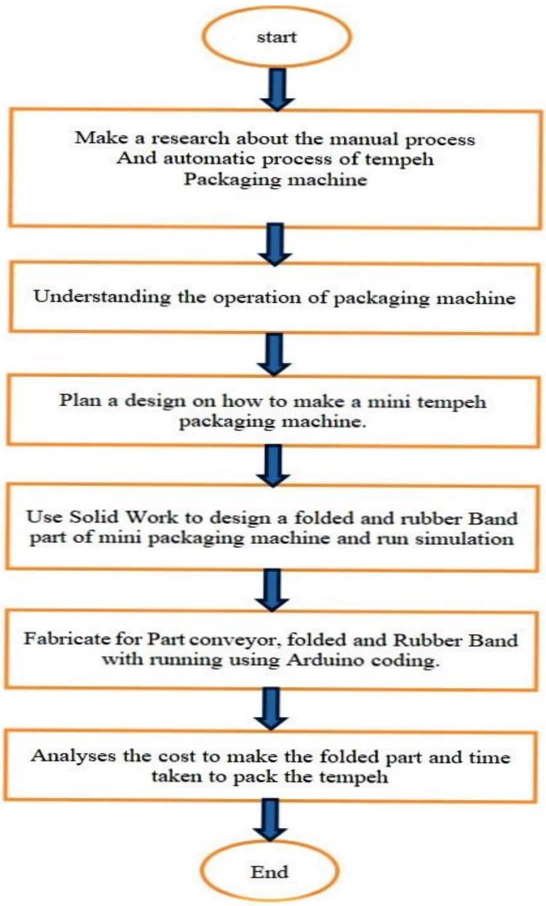


Figure 1: Research design process flow chart

2.3 Design of prototype model

The design of a mini prototype model of mini automated packaging machine tempeh is focus on small scales industries to reduce cost, time and human. The design processes in this study involved the activity of brainstorming session and conceptual design. In the design processes, brainstorming is often used as a method for generating ideas to solve a design problem. In this study, brainstorming has been conducted to obtain idea and consensus on mini packaging machine tempeh. The conceptual design of side stand is mainly generated from the brainstorming session. The design is further drawn in 3D modelling using SolidWorks software as illustrated in Figure 2 and Figure 3, respectively.

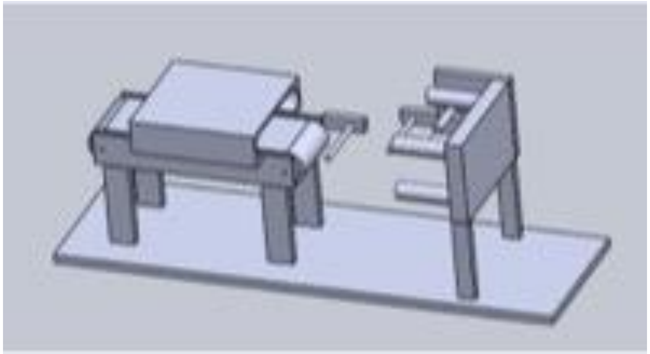


Figure 2: Isometric view

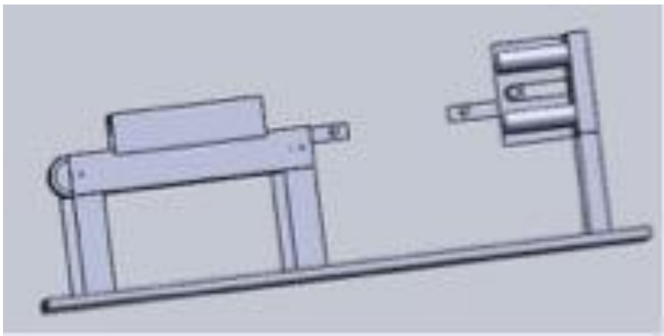


Figure 3: Side view

As for design evaluation, finite element analysis (FEA) is used in this study. It is a method of using virtual simulation technology to evaluate a product design. This includes the design reacts to physical effects force impact. In this study, FEA method is specifically adopted to determine the stress, displacement and strain using computer software of SolidWorks.

2.3 Development of Prototype Model

This study utilized the tools, equipment, and machines for the purpose of fabrication and assembly operations. The selected equipment is based on the type of operations needed for fabrication and assembly of side stand. The equipment used in this study are inclusive of measuring equipment, cutting machine and joint with hot glue gun.

The measurement process includes linear measurement and marking as shown in Figure 4 (a). The measurement of length is done by leaving a gap on the work piece to spare some tolerance for the next cutting process. The work piece was also highlighted with marking to avoid cutting mistakes as shown in Figure 4 (b).

Figure 4: (a) Dimensional measurement; (b) Marking process; (c) Hand-held jig saw cutting; (d) Cutting into desired shape

This studied employed glue as main assembly operation. Glue was a process of joining by part to assemble. The processes of glue used of extreme heat and stick glue to melt structure to joined. This studied used the hot glue gun method for joining process as shown in Figure 4 (d). Eventually, finishing process was done to removed waste from hot glue gun; uneven glue part was not tough to stick between parts in Figure 5 (a).

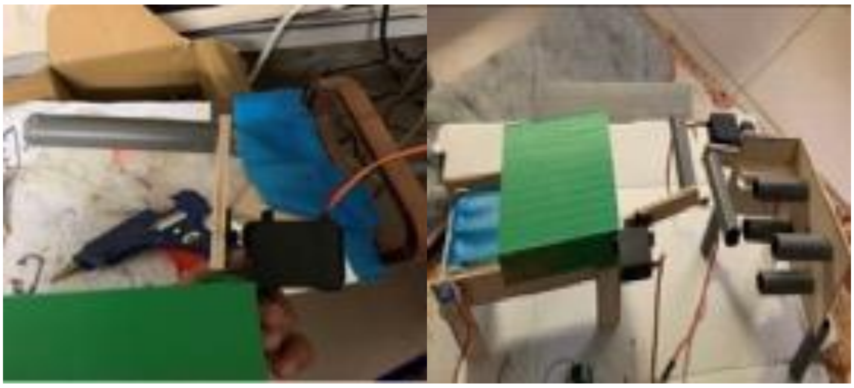


Figure 5: (a) Welding Process; (b) Finishing process

2.4 Functional Testing

In this studied, functional test had been run for mini model from design was created from solidwork as Figure 6 to apply in real prototype as shown in Figure 7. Other than that, programming from c++ also running completed without any error founded to run prototype by automated. Specifically, mechanism from every part that stepper motor and servo motor done successful to folded and rubber band that packaging process as shows.

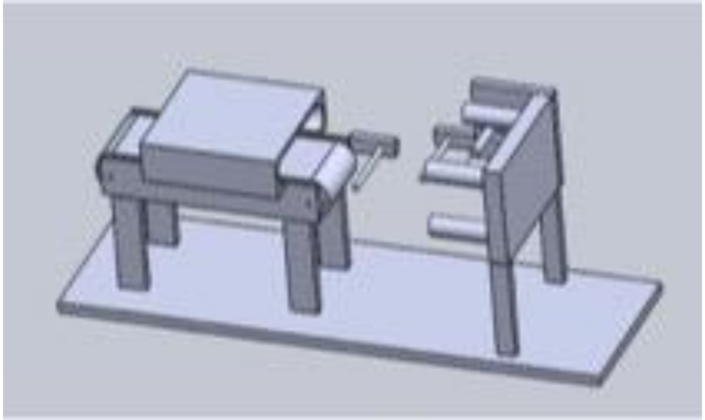


Figure 6: Solidwork Design

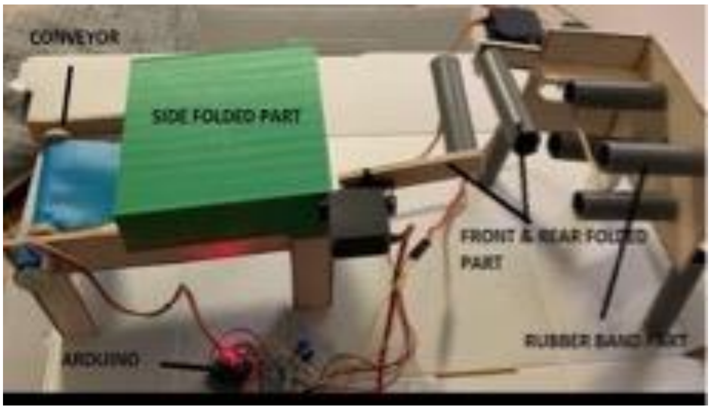


Figure 7: Real Prototype

3. Results and Discussion

3.1 Simulation Results

The material selection was one of the main phases of product design process that had great impact on the manufacturing of sustainable products [8]. Besides, the objectives of this project were to minimize the cost, so in ordered to minimize the cost; the material selection should be select correctly. In this simulation test, the material selection was Aisi 316 stainless steel and alloy steel. In this simulation, there were some tests that will be applied on this design

I. Running the simulation test on the selection material which is AISI 316 stainless steel and alloy steel

Table 2: Mass Properties of AISI 316 Stainless steel For Folded Part

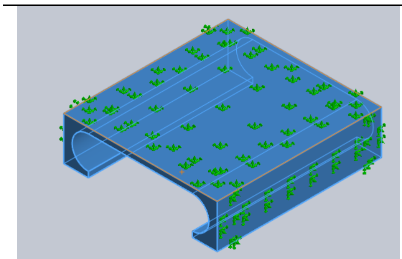
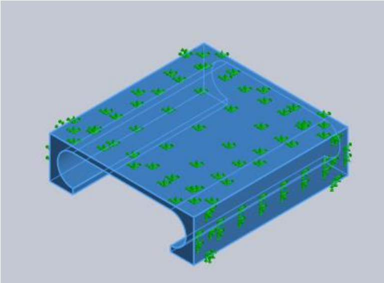
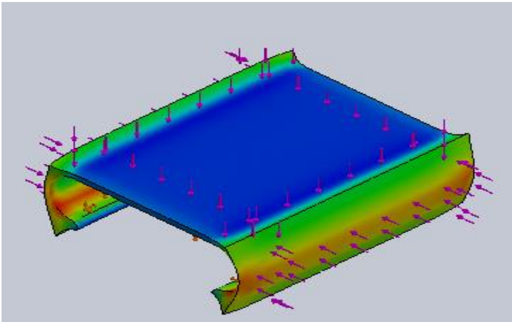
	Folded part	Mass properties of "folded" Mass = 1.88 kg Volume = 0.00 m^3 Surface Area = 0.07 m^2 Center of mass: (m) X = 0.00 Y = 0.01 Z = 0.07 Principal axes of inertia and principal moments of inertia: (kg.m^2) Taken at the center of mass. Ix = (1.00, 0.00, 0.00) Px = 0.00 Iy = (0.00, 0.00, -1.00) Py = 0.00 Iz = (0.00, 1.00, 0.00) Pz = 0.00

Table 3: Properties of AISI 316 Stainless Steel

Model Reference	Properties	Components
	see properties below	Folded part
Force-4		Entities:3 Type: Normal force Value:10 N Phase Angle:0 Units: deg

Properties:

Study name	folded (-Default-)
Material name	AISI 316 Stainless Steel Sheet (SS)
Material source	Simulation library
Model type	Linear Elastic Isotropic
EX	1.93E+011 N/m^2
NUXY	0.27
DENS	8000 kg/m^3
SIGXT	5.8E+008 N/m^2
SIGYLD	1.7237E+008 N/m^2
ALPX	1.6E-005 /Kelvin
KX	16.3 W/(m.K)
C	500 J/(kg.K)

From the Table 2 and 3 above it shows that mass of side folded part is 1.88 kg which is not too heavy to handle. The purpose for this first simulation test is to observe whether the material used is suitable and must be easy to handle. The force 10 N are applied to that material for test strain and get the result for yield strength is 1.724e+008 N/m².

For the first simulation test 2, it shows that the static test is being applied on this design. The material used for this test is AISI 316 Stainless steel. The purpose of this simulation test is to confirm that the selected material must be compatible to make the rubber band part. The concurrent technical evolution in stainless steel and increasing volatility of raw material prices has made it more important for the engineers and designers who use stainless steel to make sound technical judgments about which stainless steels.

Table 4: Mass Properties of AISI 316 Stainless steel For Rubber Band Part

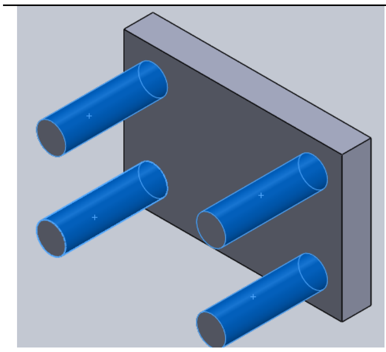
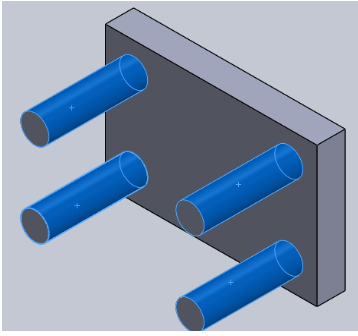
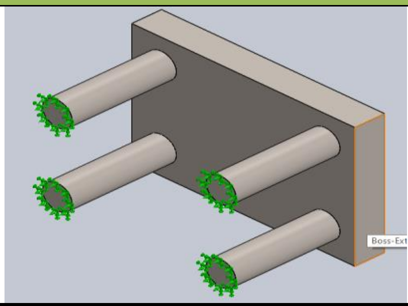
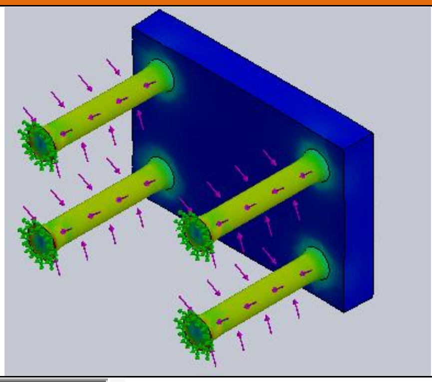
	Rubber Band part	Mass properties of "Static 1" Mass = 3.10 kg Volume = 0.00 m^3 Surface Area = 0.06 m^2 Center of mass: (m) X = 0.00 Y = 0.00 Z = 0.02 Principal axes of inertia and principal moments of inertia: (kg.m^2) Taken at the center of mass. Ix = (1.00, 0.00, 0.00) Px = 0.00 Iy = (0.00, 1.00, 0.00) Py = 0.00 Iz = (0.00, 0.00, 1.00) Pz = 0.00

Table 5: Properties of AISI 316 Stainless Steel

<table>
<tr><th>Model Reference</th><th>Properties</th><th>Components</th></tr>
<tr><td></td><td>
<table>
<tr><td>Study name</td><td>Static 1 (-Default-)</td></tr>
<tr><td>Analysis type</td><td>Static</td></tr>
<tr><td>Mesh type</td><td>Solid Mesh</td></tr>
<tr><td>Thermal Effect</td><td>Include temperature loads</td></tr>
<tr><td>Zero strain temperature</td><td>298Kelvin</td></tr>
<tr><td>Solver Type</td><td>FFEPlus</td></tr>
<tr><td>Inplane Effect</td><td>Off</td></tr>
<tr><td>Soft Spring</td><td>Off</td></tr>
<tr><td>Inertial Relief</td><td>Off</td></tr>
<tr><td>Friction</td><td>Off</td></tr>
<tr><td>Use Adaptive Method</td><td>Off</td></tr>
</table>
</td><td>Rubber Band part</td></tr>
</table>

FIXTURE NAME	FIXTURE IMAGE	FIXTURE DETAILS
fixed -1		entities: 4 face(s) type: fixed geometry

Load Name	Load Image	Load Details
Force-4		Entities:4 Type: Normal force Value:10 N Phase Angle:0 Units: deg

Component	Selection	Entire Moc
Sum X:	0.	-6.2725E-
Sum Y:	0.	3.1106E-
Sum Z:	0.	1.0239E-
Resultant:	0.	1.2404E-

From the table 4 and 5 above it shows that mass of side folded part was 1.88 kg was not too heavy to handle, and an important benchmark simulation is that of a point mass and restrictions take the form of a minimum mass that can be simulated passively [9]. The purpose for this first simulation test was to observe hat material was appropriate or not to be part for producing in real prototype in same time mass and sustainability also will take as important. The forced 10 n were applied to that material for test strain and get the result for yield strength was 1. 724e+008 n/m². In those cases, in which the testing requirements for certain products are unique or at variance.

3.2 Schematic and Coding Arduino

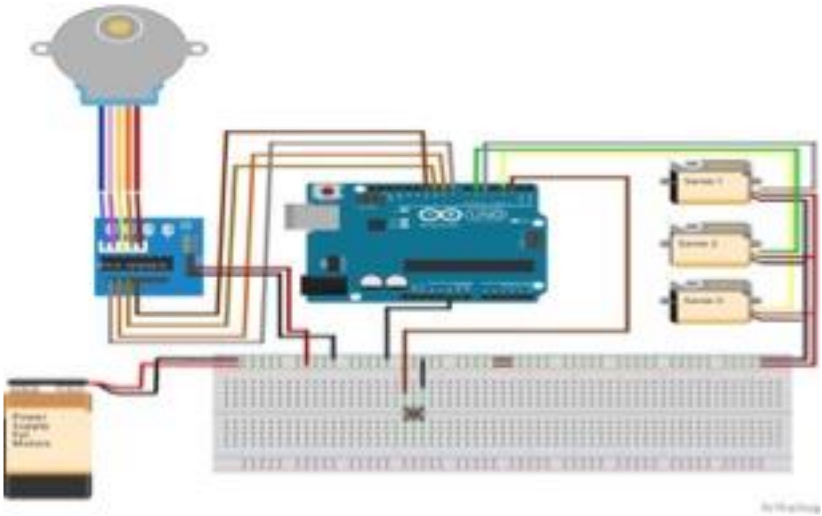


Figure 8: Schematic diagram

Figure 8 shows that, from power supply 5 v connect to positive and negative at broke board to active arduino. The number of inputs and outputs (how many sensors, leds, and buttons you could use on a single board), speed, operating voltage, and form factor were just a few of the variables. Some boards were designed to be embedded and had no programming interface (hardware) which you would need to buy separately. Some could run directly from a 3. 7 v battery, others need at least 5 v [11]. Then, stepper motor will command for speed 2048 stapa per revolution and connect to connect to pinned 8, 9, 10 and 11 to active.

The motors rotation had several direct relationships to these applied input pulses. The sequence of the applied pulses was directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation was directly related to the frequency of the input pulses and the length of rotation was directly related to the number of input pulses applied [12].Moreover, if a motor was replaced by another typed, users would need to modify the software [13].Lastly, servo motor will commanded to rotated 135º and connect to break board to terminal negative and positive while in arduino will connect to pin 5, 6 and 7 to active.

```
#include <Stepper.h>
#include <Servo.h>

int T1 = 5000;    //Time for stepper to rotate after button is pressed in milliseconds (1 sec = 1000 milliseconds)
int T2 = 1000;    //Time to wait after stepper stops
int T3 = 5000;    //Time for stepper to move for second time after servo number 1 goes to 180 and return to 0 degree
int T4 = 1000;    //Time to wait after stepper stops
int T5 = 2000;    // Time to wait after 2nd servo move to 180 and then back to 0
int T6 = 5000;    // Time to move stepper motor
int T7 = 1000;    //Time to wait after stepper stops
int button = 2;
const int stepsPerRevolution = 2048;  // change this to fit the number of steps per revolution for your motor

// initialize the stepper library on pins 8 through 11:
Stepper myStepper(stepsPerRevolution, 8, 10, 9, 11);
Servo Servo1;
Servo Servo2;
Servo Servo3;

unsigned long pre;
unsigned long post;

void setup() {
  pinMode (button,INPUT_PULLUP);
  // set the speed at 60 rpm:
  myStepper.setSpeed(10);
  Servo1.attach (5);
  Servo2.attach (6);
  Servo3.attach (3);
  Servo1.write(0);   //move both servo to zero degree initially
  Servo2.write(0);
```

```
void loop() {
 if (digitalRead(button)==LOW){   //when button is pressed
  pre = millis();
  delay (150);
 post = millis();

 while (post-pre <= T1){    //move stepper for time T1
  post = millis();
  myStepper.step(4);
 }

 delay (T2);                //wait for T2

 Servo1.write(135);         //move servo 1 to 180 and back
 delay (1000);
 Servo1.write(0);

 pre = millis();
  delay (10);
 post = millis();

 while (post-pre <= T3){        //move stepper for time T3
  post = millis();
  myStepper.step(4);
 }

delay (T4);


delay(T5);

pre = millis();
 delay (10);
post = millis();

while (post-pre <= T6){        //move stepper for time T3
 post = millis();
 myStepper.step(4);
}

delay (T7);

Servo3.write(180);
delay(1000);
Servo3.write(0);
}
```

Figure 9: Codding for Mini Model of Automated Packaging tempeh

This studied from Figure 9 shows that component in using for this codding was three servo motor and one stepper motor. Techniques and references to handy resources for ubiquitous computing projects Supplementary material includes a circuit schematic reference, introductions to a range of electronic engineering principles and general hints & tips [14]. For the first commanded was to identify time taken and speed for each to run and stop when pushed button started. Then first commanded will commanded stepper motor to started for 5 second with enough speed to past through molded for side part and delay 1 second to let first servo motor to rotate 135 ° for front side part. Next, stepper started rotating after delay 1 second to next station second servo motor that rotate 135 ° to folded rear part. Lastly, after delay 1 second conveyor rotate for 5 second going to third servo motor a might be rotate 180 ° to pushed rubber band to tie that folded from opened and it will reset for all part.

4. Conclusion

As conclusion, it was possible to design and create a mini packaging machine model for folded and rubber band component objectives that could design the mini packaging machine system mechanism. Other than that, automated manufacturing for folded and rubber parts was also efficient and could evaluate the mini model's output by using the arduino system to make it run automatically from the conveyor to another component. The average time taken for labor and automatic machine is not much difference. Besides, labor has many idle times because too much activity is done while packing the tempeh. The average time taken is roughly calculated by using 5 samples worker with 5 different times taken. Accordingly, to the analysis, the time taken for a worker to pack the tempeh is shorter than using automatic machine to pack the tempeh. Besides, using labor to pack the tempeh will not get constant time as what an automatic machine can do because labor cannot pack the tempeh is constant time as what machine can do because has been programmed and the time taken is constant.

The Arduino coding is successfully transferred to stepper motor to move conveyor smoothly and it will past through mold for side folded. Then after that Arduino will order to servo motor to rotate 135 ° to folded front part and it will continue to rear part also using servo motor with 135 °. Moreover, for rubber band part will use servo motor by rotating 180 ° by horizontal position to move that rubber to hold fold. One of the strengths of Arduinos is the possibility they afford to load the experimental script on the board's memory and let it run without interfacing with computers or external software, thus granting complete independence, portability, and accuracy [15].

In a nutshell, the uses of automatic machine in tempeh packaging process much better than using labor to pack the tempeh. This is because, from automatic machine, it can be estimating how much the number of tempeh will be pack in one day and time taken to pack the tempeh can also be estimated.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

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