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ORIGINAL ARTICLE

Development of Controllino Program to Integrate the Sensor Inputs for Motors Control

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ABSTRACT – The system fishcake machine available in the market cannot be controlled by its motor speed based on the desired speed. In addition, this machine uses PLC which causes the production cost of the machine to increase, cannot use components that have a small voltage such as 5V and indirectly makes the PLC a difficult component to integrate all types of components in one PLC only. So, in this paper, we will develop a program using MAXI Automation Controllino for motor speed control that can be changed according to the desired speed with PWM method. In addition, to analyse and validate the integration sensors and motors to control the entire system. Finally, in this study we use Controllino type Maxi Automation to replace the existing PLC in the market and this Controllino will relate to a sensor that is an ultrasonic sensor, infrared range sensor and a DC motor. To control this system, we use a software method that is Arduino IDE to write all the coding. This coding will be written based on all the programs or processes involved in the fishcake machine performed.

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Arduino IDE

INTRODUCTION

The existing fishcake machines in the Malaysian market mostly use Arduino or Programmable Logic Controller for the fishcake production process. The process of producing this fishcake will be programmed process of flour mixture that has been mixed until it becomes a fishcake shape that has been cut to the required shape and thickness. This fishcake machine uses a lot of input and output for the fishcake production process to run smoothly. The use of Arduino devices to be programmed in the production of fishcakes is very economical in the form of production because based on the information already known, price for Arduino components is very affordable. Even in terms of the use of Programmable Logic Controller tools, their use is safer and very suitable for industrial use. Often, fishcake machines produced by these large-scale products will use a Programmable Logic Controller because it is safer and easier to use.

To select the appropriate device to program the fishcake process is a very important factor so that this device can run the program smoothly based on the coding that has been written. The problem occurs when a fishcake machine requires a lot of input and output to be able to carry out the process. In addition, it requires a cheap device, but the quality of the device is comparable to the best devices on the market. In addition, requires a device that has high security features to protect the circuit or electronic components used. Based on the software used should be easily available and easy to use for a programmable.

To overcome this problem, we have chosen to use a Controllino device made in Austria. This device has many types, but we decided to use the Controllino Maxi Automation type. This Controllino Maxi Automation has many inputs and outputs to accommodate sensor integration as input and motor as output. This Controllino Maxi Automation product is also ready to come with a relay to facilitate the use of the motor. This Controllino is a Programmable Logic Controllers device that follows the industry grade and this Controllino is also fully compatible with the Arduino. Due to this, the Controllino is a very affordable device in terms of price to use compared to the existing Programmable Logic Controllers devices on the market. Furthermore, the Controllino has been designed to meet the most stringent industrial and electrical safety standards, guaranteeing that the final product is safe. This Controllino can also be programmed using various software. Usually programmed using Arduino IDE but can also use other software such as MATLAB software, Atmel Studio and others.

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CONTROLLINO MAXI AUTOMATION

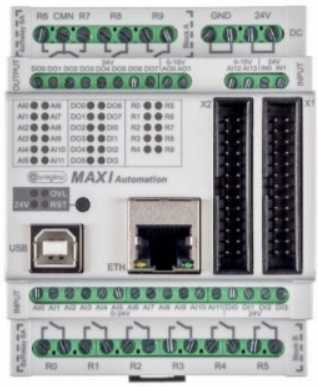

Figure 1. Controllino MAXI Automation

The MAXI Automation as shwon in Figure 1 is a version of Controllino IS designed especially for automation professionals. It is the ideal balance of small size and large input and output numbers. Following that, you may learn about the many kinds of implementations that these fantastic PLCs enable [1][2].

MOTOR DRIVER MDDS30

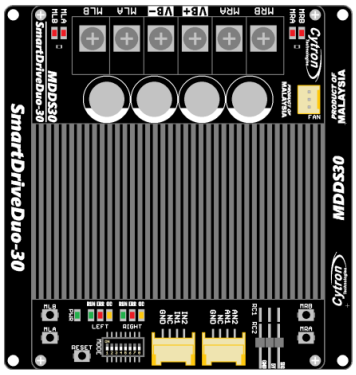

Figure 2. Motor driver type of MDDS30

The MDDS30 is an 18V DC source, and its output voltage is 18V. It can only operate two brushless DC motors, either clockwise or anti-clockwise. For this driver motor mode, utilize PWM mode with a microcontroller, with the mode value set to (10110100) [3]. Figure 2 shows the used motor driver.

ARDUINO IDE SOFTWARE

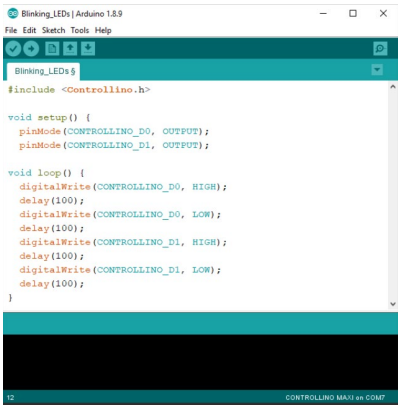

Figure 3. Arduino IDE

The Arduino platform, as well as the software that goes with it, is fully open source. The programming environment of the Arduino platform is simple to use and mastering it does not take much practice, even for beginners. The Arduino programming language is heavily influenced by C ++, and the C ++ library can be used to extend it [4].

An Arduino microcontroller delivers around 300,000 programme code lines per second and sufficient input and output for many applications. An integrated development environment (IDE) is provided for host computers running Linux, MacOS and Windows operating systems. The programming language is C/C++ and several libraries simplify basic applications such as printing on an alphanumeric LCD or serial connectivity [5].

BRUSHLESS DC MOTOR

Figure 4. High Power Planetary DC Geared Motor

Brushless DC motors (also known as BLDC motors or BL motors) are brushless DC motors that do not have brushes. The controller delivers current pulses to the motor windings, which power the speed and torque of the synchronous motor. The next Brushless DC Motor will be connected with the Motor Driver for acts as an interface between the motors and the control circuits. The controller circuit operates on low current signals, while the motor needs a large volume of current. The aim of motor drivers is to convert a low-current control signal into a higher-current signal capable of driving a motor [6]. Figure 4 shows the used DC geared motor.

IR SENSOR

Figure 5. (IR) Sensors type of E18-D80NK

In this project, we employ an infrared range sensor of type E18-D80NK as shown in Figure 5. This sensor detects if the 10KG of kneaded dough put on the conveyer has run out. This sensor will provide data to the Controllino Maxi Automation, causing both brushless DC motors to stop. This sensor has a usually open NPN configuration. This sensor simply has three wires: Out (Black), 5V (Brown), and GND (Blue). Below is a photo of the IR sensor E18-D80NK, as well as a table with further information about it. [7]

ULTRASONIC SENSOR

Figure 6. Ultrasonic Sensors type of HC-SR04

The ultrasonic sensor in Figure 6 is used to determine the gap between it and some object in its line of sight or vibration. For distance measurement, the object must be capable of reflecting audio signals. The difference between soft surfaces that absorb sound and hard surfaces that scatter sound signals causes an error in distance measuring readings. The HC-SR04 used in this experiment will measure distances ranging from 2 cm to 400 cm [8].

FLOWCHART SYSTEM FISHCAKE MACHINE

In this flow chart will be divided into three. The first will describe the success of this experiment. The process has seven processes that start with the design of a fishcake machine and end with proceed to experiment. While the second flow chart describes for control input and output in Fishcake Machine. Last flowchart about to produce fishcake.

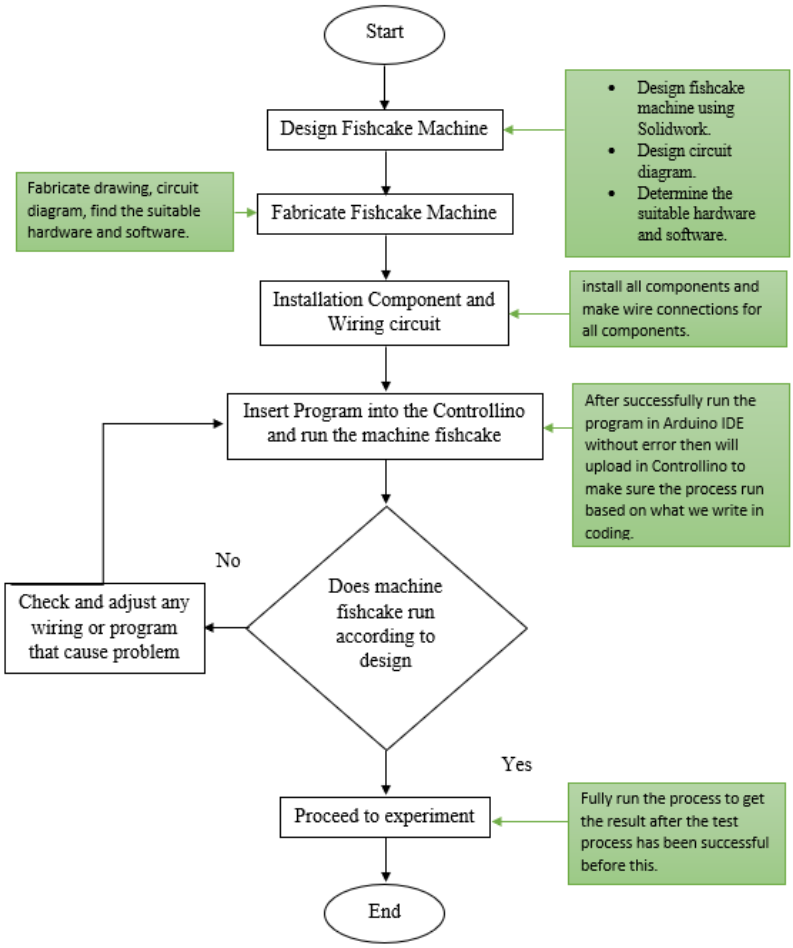

Figure 7. Flow chart for machine fishcake design

For the experimental project, flow chart in Figure 7 is very important because to show progress step by step from start until end of process. This project is developed to produce a fishcake machine and designed using Solid Work software. This design makes it easier to describe the overall project and simplify the process which is important for selection of the appropriate componenta depending on the size listed in the design. The next part is to manufact a fishcake machine based on the design that has been improved. This fishcake machine focuses more on the body fabrication beside the component and wiring circuit that will be installed and equipped in the project.

Moreover, Controllino hardware will be programmed as programmable logic controller to run the fishcake machine. Then will return to part of insert program into the Controllino and run the machine fishcake and will repeat the progress until success.

The proposed fishcake machine is the continuity of the previous shape detection and classification project [9][10] including the long range communication project [11][12] which is designed for the machine with several wireless capabilities.

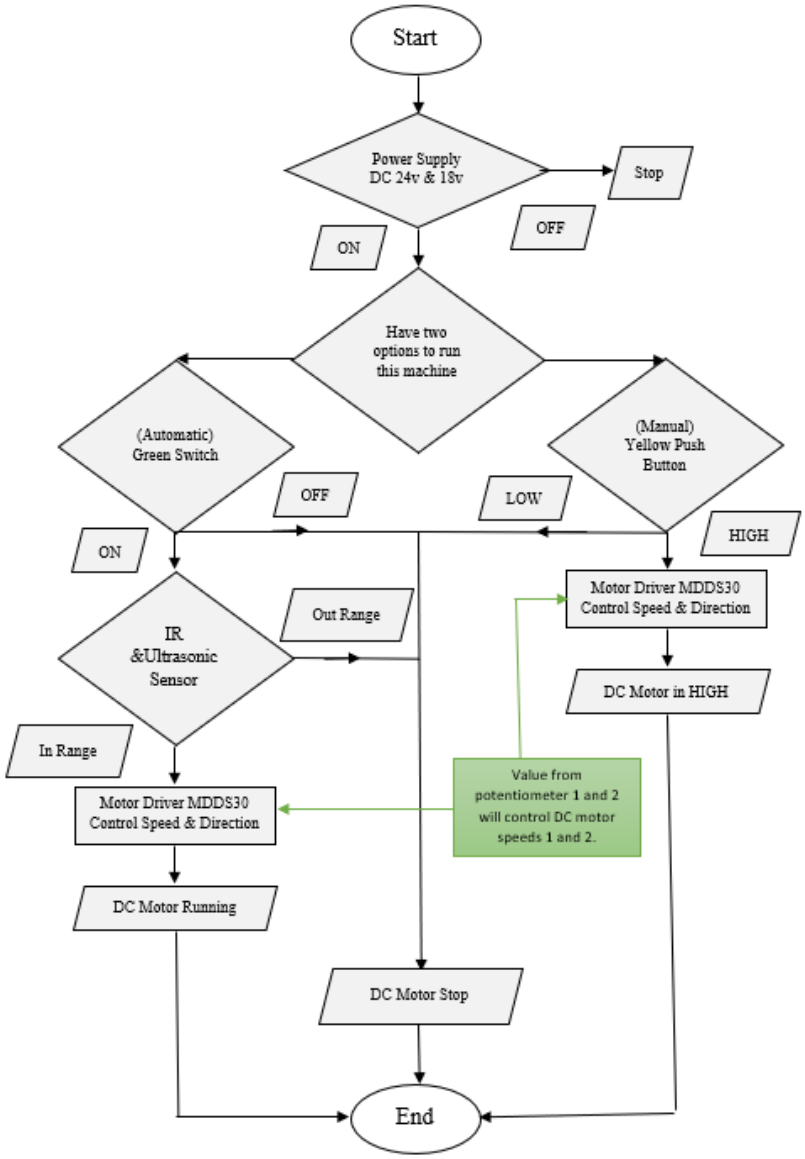

Figure 8. Flow chart for control input and output in Fishcake Machine

The use of power supply in this Fishcake Machine project uses two power supplies, namely Alternating Current (AC) and Direct Current (DC) power. For DC power used for components such as Controllino Maxi Automation, Indicator Light, and Potentiometer. The voltage for this DC power is 24V. The next component that uses AC power is the MDDS30 type driver motor from Cytron. After the power supply is switched ON, it is necessary to determine which mode you want to use either automatic or manual. If manual, need to push the yellow button and hold. Currently the Controllino gets a quality yellow button input and drives the DC motor using the driver motor. But if the yellow push button is released then the input becomes low and the Controllino will stop the DC motor through the motor driver.

Finally, if the switch is ON to automatic mode. IR sensors and Ultrasonic sensors need to detect the dough within a predetermined distance. Once the input requirements are met, the Controllino will drive the DC motor through the driver motor. But if one of the sensors does not follow the set conditions, then the Controllino will stop the DC motor through the driver motor. Same with the automatic switch function, if the switch is off, all process will stop. To control the speed of the two DC motors used, it is controlled using a motor driver, but the speed value is programmed to be read through potentiometers 1 and 2. For a clearer journey to control inputs and outputs in this Fishcake Machine project can refer to Figure 9 below.

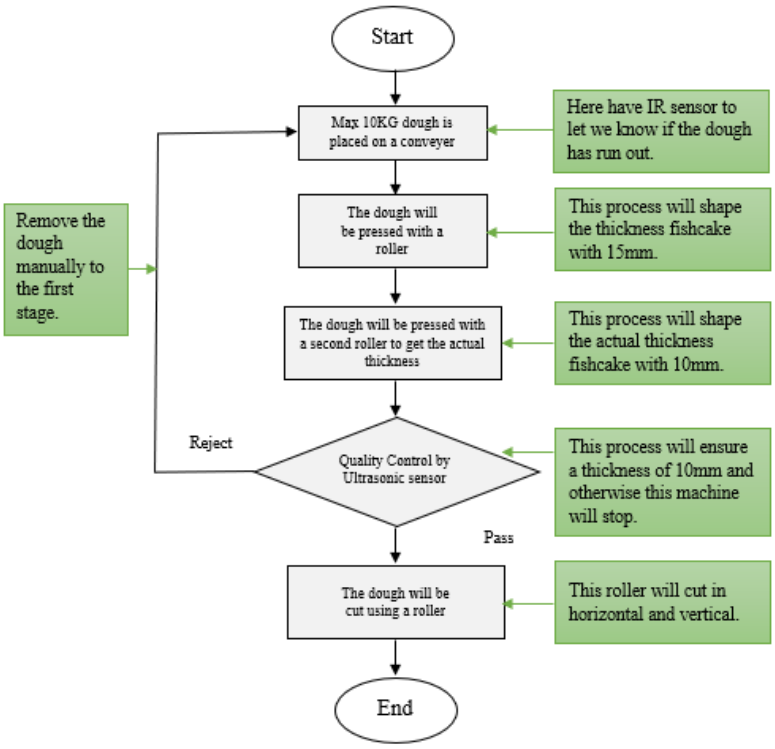

Figure 9. Flowchart to produce fishcake

The process to produce this fishcake is only five steps because this fishcake machine project is only new in the initial phase. So, the fifth step starts with placing the dough on the conveyer. After that, the dough will be run manually through the first and second rollers until it gets the same thickness from the left of the conveyer to the right of the conveyer. Next, it is run automatically until the 10kg dough that is placed is used up but if the dough thickness is less or more at 10mm it will stop. In this process we need to remove the dough that rejects to the first stage where the place 10kg dough that has been kneaded and the process will be repeated. Finally, if the dough exceeds the desired thickness, this dough will go to the last process, which is the process of cutting according to the shape of the fishcake. The figure below will illustrate in the form of a flowchart.

EXPERIMENTAL RESULTS

In this experimental results will be shown how to get the result after doing the experiment. Among the tests performed for the fishcake machine system using this Controllino Maxi Automation device are action time IR sensor and ultrasonic sensor to stop both brushless DC motors. In addition, the result performance for the motor used to obtain characteristics such as current, voltage, power and speed. Finally, make a calculation for power consumption in order to identify whether the circuit produced is not include as overload. From the results of power consumption can be continued to find energy efficiency.

Electrical Analysis

The results of the electrical study will prompt further investigation into electrical calculations so that it is possible to determine whether or not the circuit used to power the fishcake machine is overloaded. If the result shows that the power in is more than the power out, the circuit that was found does not have an overload problem. Aside from that, it will improve energy efficiency based on the power in and power out values that we use. This survey is designed to determine whether or not the use of electricity is beneficial.

Electrical Calculation

To make sure that the power supplied to the Fishcake Machine is sufficient and to ensure that there will be no overload of the combined power consumption of the components towards the power supply. Tables 1 and 2 show the details of power drained.

Power calculation is calculated based on formula:

$$\text{Power} = \text{Current (I)} * \text{Voltage (V)} \quad (1)$$

or

$$\text{Power} = (\text{Voltage (V\^2)}) / \text{Resistance, R} \quad (2)$$

Table 1. Power supply 24V with power drained

No	Components	Power Supply(W)	Power Drained(W)
1	Power Supply 24V	120	-
2	Controllino Maxi Automation	-	3.12
3	Infrared Range Sensor	-	0.5
4	Ultrasonic Sensor (HC-SR04)	-	0.075
5	SKK Tower Light 3 Layer	-	0.36
6	Yellow MKS Push Button	-	0.0151
7	ATOMS 2WAY ON/OFF Selector Switch	-	0.0151

Component that drained the power from power supply:
W consumption = 0.5 W + 0.075 W + 0.36 W + 3.12 W + (0.288 x 10 ^ -3) W + 0.0151 W +
+ 0.0151 W + 1.0584 W
= 4.0855 W
W in = 120W
Win – W consumption = 120 W – 4.0855 W
= 115.9145 W
Due Win > W consumption, therefore no overload

Table 2. Power supply 18V with power drained

No	Components	Power Supply(W)	Power Drained(W)
1	DC Power supply 12V7AH	84	-
2	DC Power supply 6V7AH	42	-
3	Motor driver type of MDDS30	-	3.4146
4	Brushless DC Motor	-	48.6
5	Stop button (latching turn release)	-	1.0584

Component that drained the power from power supply:
W consumption = (48.6 W x 2) + 3.4146 W + 1.0584 W
= 101.673 W
W in = 84 W + 42 W
= 126 W
Win – W consumption = 126 W – 101.673 W
= 24.327 W
Due Win > W consumption, therefore no overload

Energy Efficiency for 24V and 18V Power Supply
Calculation Energy Efficiency for 24V power supply.

$$n = \frac{W_{out}}{W_{in}} \times 100\%$$

$$= \frac{4.0855\ W}{120\ W} \times 100$$

$$= 3.40\ \%$$

If 5 stars equals 100 percent. While 1 star represents 20 percent. So, it can be said that the energy efficiency of this supply is not very good. Need to find a 24V power supply with a lower current (A).
Calculation Energy Efficiency for 18V Power Supply

$$n = \frac{W_{out}}{W_{in}} \times 100\%$$

$$= \frac{101.673\ W}{126\ W} \times 100$$

$$= 80.69\ \%$$

If 5 stars equals 100 percent. While 1 star represents 20 percent. So, the stars for energy efficiency of this project belong to 5 stars. For the use of 18V power supply is very good for its energy efficiency compared to the use of 24V power supply.

Action Time IR Sensor

In the use of IR sensor in this fishcake project will be tried by looking at the reaction of this IR sensor to stop if the detected item is suddenly finished. The unit for delay in Arduino is (ms). For example, you want to delay this sensor for 5 seconds and need to put a delay in the code of 5000ms. But in this project, we need this IR sensor to act quickly. So, in this result will show the time taken to stop by changing the value delay start from 0ms until 1000ms in the program. Figure 10 shows the action time of infrared sensor.

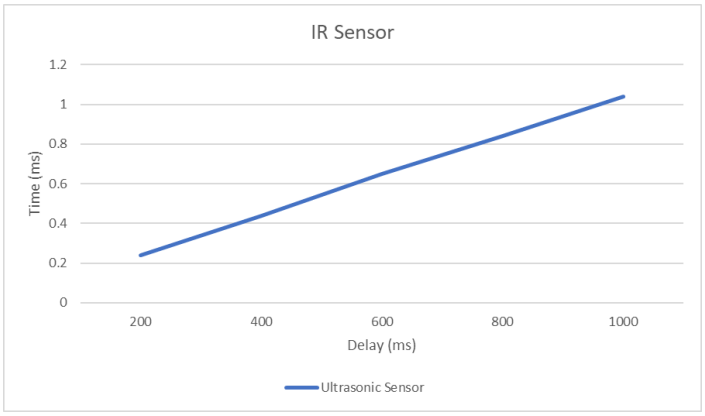

Figure 10. Graph for Action Time of IR Sensor.

In the table is a method of calculation to get the exact time by means of each delay recorded time three times. After that, just do the average calculation. From this figure it is shown that the higher the delay value placed the higher the time taken to stop the Brushless DC Motor.

Action Time Ultrasonic Sensor

For the ultrasonic result will be the same as the IR sensor result because want to know if this sensor can function well when controlled using Controllino Maxi Automation. This ultrasonic sensor is the most important input in the system using Controllino Maxi Automation because this input is used to control the thickness of the Fishcake. If this sensor does not respond well to Controllino Maxi Automation will cause the thickness of the fishcake produced is not uniform. Next, the table below is the result recorded for the action time of ultrasonic sensor with the variable being the delay value. Figure 11 illustrates the action time required for the ultrasonic sensor.

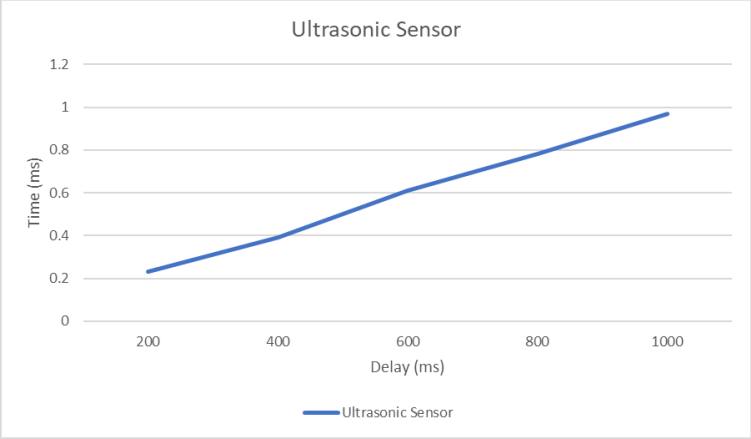

Figure 11. Graph action time for the ultrasonic sensor

For a change of delay value this is the same delay as the IR sensor because the instructions of these two sensors sit once under the same if in the code. To get the result action for this ultrasonic use the same method as the IR sensor by recording three values of time taken for each delay value. After having the three times, continue to calculate the average to be included in the line graph.

So, based on the value shown through the graph, found that each time the delay value increases in the code it will make the time taken to stop the brushless DC motor also increases.

Performance Brushless DC Motor

For brushless DC results, this motor will emphasize on 4 factors, namely power, current, voltage and speed. If we go back to the first objective, where for this fishcake machine system it is necessary to control the speed of the brushless DC motor by being able to change different speeds. If the speed is change then the values of power, current and voltage also change. So below is a table and graph for the performance of brushless DC motors with increase the value of voltage from 2V until 18V. Table 3 shows the detail performance of brushless DC motor.

Table 3. Performance Brushless DC Motor

No.	Current (mA)	Voltage (V)	Power (W)	Speed (rpm)
1	70.1mA	2.15	0.1507	45.1
2	74.2mA	4.05	0.3005	104.8
3	92.8mA	6.02	0.5587	223.9
4	103.5mA	8.11	0.8394	312.2
5	121.2mA	10.32	1.2508	406.2
6	135.1mA	12.13	1.6388	462.4
7	143.5mA	14.15	2.0305	535.3
8	158.3mA	16.30	2.5803	660.1
9	166.2mA	17.62	2.9228	761.5

Based on this result number 4 in Table 3 is suitable with system fishcake machine because need their speed not to fast for later can install camera to capture defect fishcake.

CONCLUSION

In this paper, an overall conclusion will be made for this fishcake machine system based on the objectives stated previously. In addition, to inform the shortcomings of this project to be improved again in the future so that this fishcake system project becomes one of the best fishcake machine systems in the food automation industry.

The system produced using Controllino Maxi Automation is successful because it can control the speed of both brushless DC motors and also the Controllino Maxi Automation can control the input as sensor and output as brushless DC motor well according to the program that has been made. So, from this result, the desired objective is achieved. But to improve this system using Controllino Maxi Automation is to change the Ultrasonic Sensor, to use a sensor that is more accurate to the change in value. For example, the Ultrasonic Sensor HC-SR04 used this is accurate with the change in value in (CM) units. For fishcake thickness requires a sensor that is very sensitive to changes in the (MM) unit.

ACKNOWLEDGEMENT

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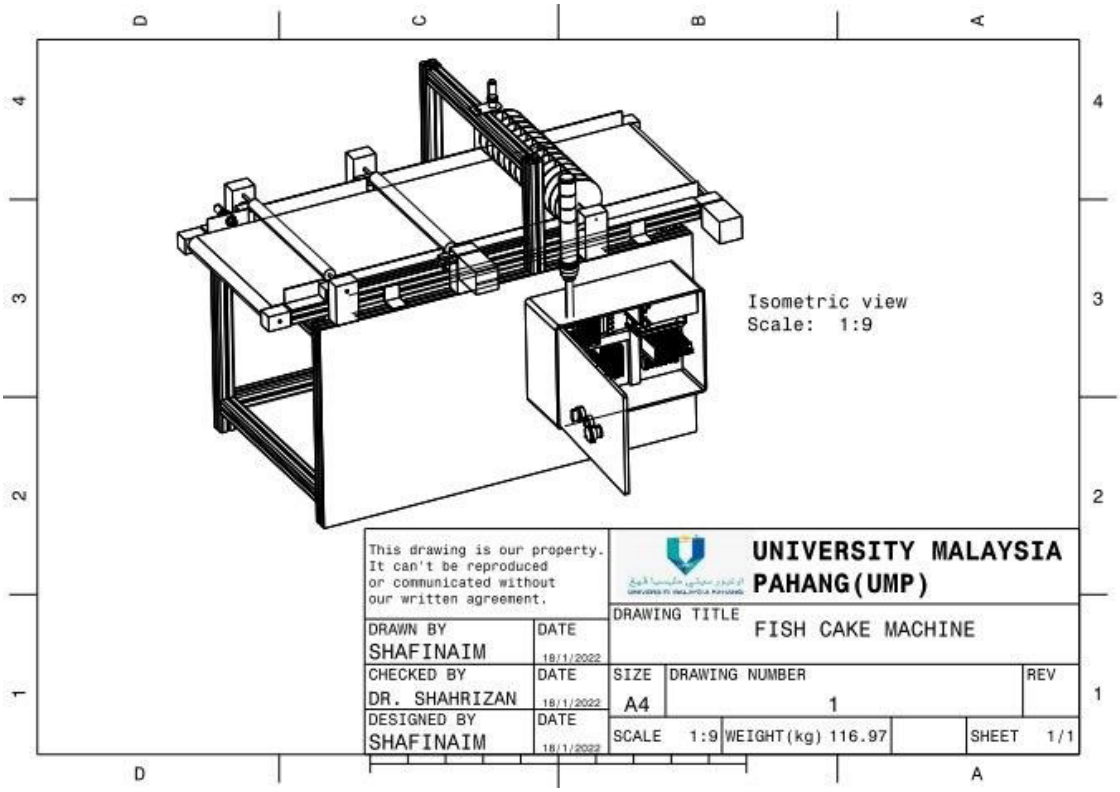
Appendix A: Isometric fishcake machine



Appendix B: Circuit diagram of the fishcake machine