REKAYASA 19 (1) (2021): 01-10

REKAYASA

Jurnal Penerapan Teknologi dan Pembelajaran

http://journal.unnes.ac.id/nju/index.php/rekayasa

Design and Performance of The Raspberry Pi Control System on Packaging Machine Capacity 2400 Pcs/h

Kriswanto[1*], Karsan[1], Dony Hidayat Al-Janan[1], Ahmad Roziqin[1], Arimaz Hangga[2], Khoirudin Fathoni[2], and Bagus Wijayanto[3]

[1] Mechanical Engineering Department, Faculty of Engineering, Universitas Negeri Semarang Kampus Sekaran, Gunungpati, Semarang 50229 Indonesia
[2] Electrical Engineering Department, Faculty of Engineering, Universitas Negeri Semarang Kampus Sekaran, Gunungpati, Semarang 50229 Indonesia
[3] BPTIKM UPT Logam, Muktiharjo Lor, Semarang, Indonesia

Email: kriswanto@mail.unnes.ac.id [1]

DOI: http://dx.doi.org/10.15294/rekayasa.v19i1.28699
Submit: 25 January 2021; Revisi: 15 June 2021; Accepted: 09 July 2021

Abstract

The use of automatic technology machines characterizes technology Development in the era of industry 4.0. However, small and middle-scale industries still use conventional machines. Therefore, low-cost packaging machines need to be developed by utilizing the Raspberry Pi control system. This research aims to design, produce, and test the performance of powder packaging machines with the Raspberry Pi control system. This research uses an experimental research model with observational techniques in the form of a performance test. This research resulted in the design of the Raspberry Pi control system on a powder product packaging machine with a capacity of 2400 pcs/hour. Based on the control system's performance, it was found that the packaging was running well and consistently. The rotation and stop pause of the stepper motor, which has been set, produces an average weight of the packaging and its contents weigh 13.737 grams. The difference in weight of the average product with the highest weight and the lowest weight is 0.063 g and 0.057 g. A less than 0.1 g difference indicates that the weight resulting from packaging sugar products is excellent and consistent. In the pressing process, the temperature sensor takes temperature readings correctly so that the heater can reach the press temperature of 1500C. Based on the trials and calculations that have been done, it is obtained 2,640 packages within 1 hour. This amount fulfills the initial target of designing a powder product packaging machine with Raspberry Pi control.

Keywords: packaging, powder products, Raspberry Pi, control systems

INTRODUCTION

Developing technology rapidly in the era of the 4.0 industry (Muljani and Ellitan, 2019) is very useful for human life because it makes human activities and jobs more accessible and efficient. Improving technology occurs in almost all sectors, including the industrial sector, small, medium, and large-scale industries. The indicated by machines that use automated technology in the industry, including the food industry.

The food industry is many found in Indonesia, ranging from large-scale companies to small-scale companies. The food industry in this country is still growing (Sondakh et al., 2017). Small scale industries are in a pivotal position in the economic development of countries (Desai et al., 2016). Most of the small and medium, scale industries, production process activities use conventional machines. The pack is a forum that occupies a good to be secure, attractive, and bloodsucking gadflies that may depart from an want to buy a product. Packaging good products have the power to do producers as well as consumers.

The packaging process in small industries, including UMKM, still uses a manual packaging process, so it needs an automatic packaging machine that the production process becomes faster and more efficient. Therefore, low-cost packaging machines need to develop to benefit small industries (Saraf, et al., 2016). Furthermore, a low-cost automated packing machine can be used by small enterprises, which would help reduce the cost of the plant (Karthika & Vidhya Saraswathi, 2021). Therefore, a low-cost automatic weighing and packaging machine that can perform weighing, bag filling, and dispensing the bag with maximum efficiency is manufactured (Hambir, et al., 2019).

Control systems are widely used to facilitate machine work, increase production output, reduce output costs, and increase profits from the production process results. One type of control that is commonly used is the Raspberry Pi. The Raspberry Pi is a mini-computer that can run an operating system, Linux (Krauss, 2016). Raspberry Pi can control the operating system as well as a PLC controller (Programmable Logic Controller). In addition, Raspberry Pi is available for Python as the primary programming language (Rao and Uma, 2015). It comprises the general-purpose input/output (GPIO) pins, and they are a set of connections with various functions, but their main one is to connect to the Raspberry Pi with an electronic circuit (Raspberry Pi Trading Ltd, 2015).

In this case, the control uses the Raspberry Pi, which has several advantages such as low power and is relatively easy when connected with a web server compared to a microcontroller (Indra, et al., 2019). For example, in Zhang and Ai (2019), the Raspberry Pi communicates with the local hardware and the database to dispense and complete orders as they come in Zhang and Ai (2019).

Packaging machines in large companies generally use PLC control which is more expensive than the Raspberry Pi. Moreover, modular PLC cannot be installed directly on devices that require high power, such as electric motors, because the PLC output has limited capabilities (Kemendikbud, 2013). Besides, use in a high heat environment causes high vibration, which can damage the PLC. This deficiency led to combining a packaging machine using the Raspberry control system as an innovation and a solution to make packaging machines cheaper, more reliable, and efficient.

This research aims to design, produce, and test the performance of powder product packaging machines with the Raspberry Pi control system. More specifically, the purpose of this study is to apply the use of the Raspberry Pi control system to regulate the work of the packaging system and packaging pressing on a powder product packaging machine with a capacity of 2400 pcs/hour.

METHOD

This research was conducted in Workshop Room 1, CNC Room, and Pneumatic and Hydraulic Laboratory, Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Semarang. The research method used in this research is design and experimental methods. The experimental methods are the methodology used to find the influence of a particular treatment against another in conditions that will.

The steps taken in collecting research data include the planning stage of the Raspberry Pi control system design concept and the tools and materials needed. Creation of packaging management and packaging pressing programs with Raspberry Pi control. Testing the program is done through a monitor screen or laptop. After all, components were connected, it was followed by a performance test of the packaging system and packaging pressing. Program and data analysis was carried out to determine the work of the stepper motor in withdrawing plastic packaging and reading the heater temperature by the thermocouple through the module MAX6675 so that the heater can do proper heating in the packaging pressing process. MAX6675 module would convert the analog to a digital signal with the amplification mode ranging from 0^0C to 700^0C with 0.25^0C precision (Detmod, 2018). The last stage is the evaluation stage during the manufacturing process and the performance of the powder product packaging machine with a capacity of 2400 pcs/hour with the Raspberry Pi control system.

Data collection techniques are carried out through documentation and recording to obtain data from the analysis results. Testing the packaging machine with the Raspberry Pi control system includes testing the weight and capacity of packaging and pressing. This test uses an experimental method.

The measurable performance indicators of this stage are that accurate performance test results are obtained, namely: (1) able to operate with a laptop-based Raspberry Pi control system; (2) the stepper motor is capable of pulling the rollers precisely so that the weight and packing capacity are suitable; (3) the temperature reading by the MAX6675 module can be forwarded to a command by Raspberry Pi in regulating the heater heating.

RESULT AND DISCUSSION

This study aims to make a packaging control system and heating pressing of powder product packaging machines using the Raspberry Pi. The design of the Raspberry Pi control system on the packaging machine was divided into two systems: the packaging system controlled using a stepper motor and the pressing system, which is carried out by controlling the heating on the heater according to the packaging process. Overall, the design of a raspberry system control on powder product packaging is shown in Figure 1.

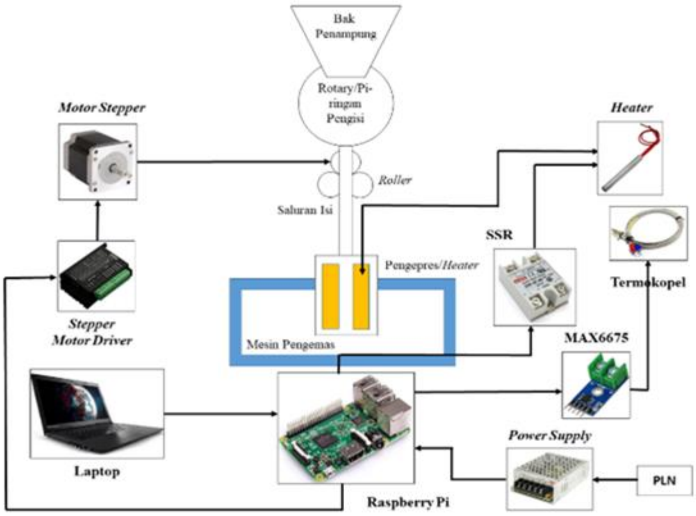

Figure 1. A switch circuit Raspberry Pi Control System on Packaging Machine

Packaging System Using a Stepper Motor

The packaging system is regulated using a stepper motor rotation to withdraw the plastic packaging and pause to stop the stepper motor from filling powdered products into the packaging. The stepper motor is a particular type of synchronous motor (Virgala, et al., 2015). The Raspberry Pi controls the stepper motor via a stepper motor driver TB6600 to pull out the plastic packaging according to the number and size of the desired product. Switch settings on the TB6600 motor driver affect the performance effectiveness of three installed stepper motors (Khairudin et al., 2020). In this case, the stepper motor can adjust its rotation speed to pull the plastic packaging according to the desired amount. A single-chip microcomputer controls the stepper motor after photoelectric switch detects the passing product, a signal to direct the stepper motor (Pei et al., 2010).

In addition, the stepper motor stop pause can be adjusted according to the weight of the powder product to be packaged. For example, the program scheme can be seen in the following Figure 2. The programs that are entered into the Raspberry Pi are as follows Figure 3.

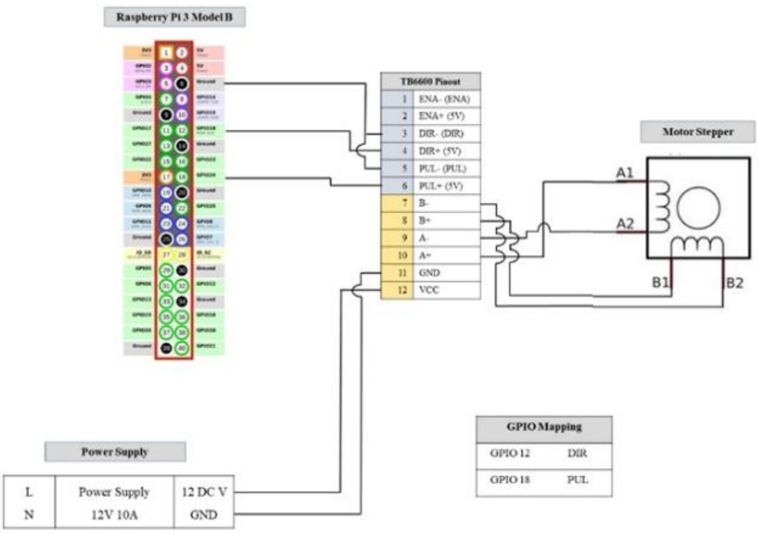

Figure 2. Packaging System Program Scheme

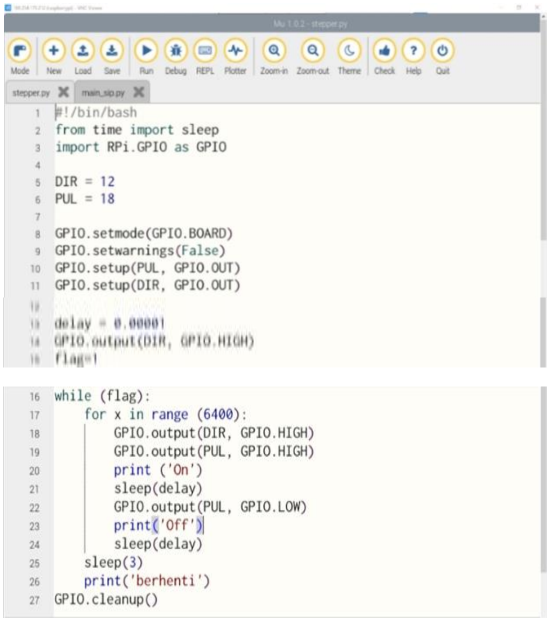

Figure 3. Packaging System Program

1. **Impressing System with Heater Control**

The pressing system is done by controlling the heating of the heater. There are two heaters attached to the sealer pair, which functions to press the plastic packaging. The temperature on the heater is adjusted to obtain proper heating during the pressing process. The thermocouple is placed on the bottom sealer to detect the heater temperature at work. The temperature read by the thermocouple via the MAX6675 thermocouple module is then forwarded to the Raspberry Pi to command the SSR in connecting and disconnecting the current to the heater. When it has not reached the critical temperature, the SSR will energize the heater to increase the temperature so that the desired pressing temperature is obtained. When it reaches the critical temperature, the current flowing into the heater will stop, so it does not warm up. The sealer will be maintained at the pressing temperature so that the packaging process can run smoothly. Figure 4 is a schematic of a press system with heater control. The pressing system program that inputs on the Raspberry Pi, as shown in Figure 5.

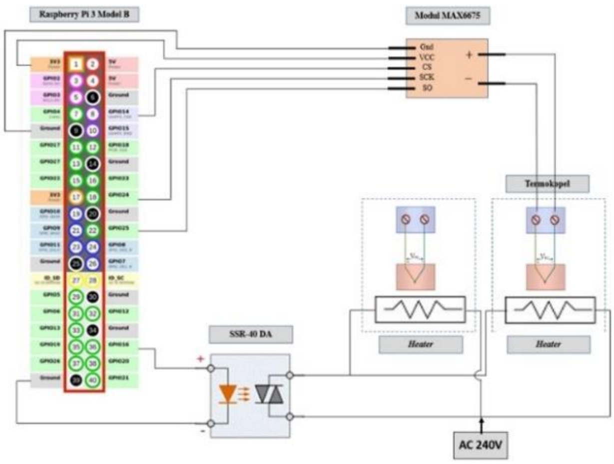

Figure 4. Pressing System Program Schematic with Control *Heater*

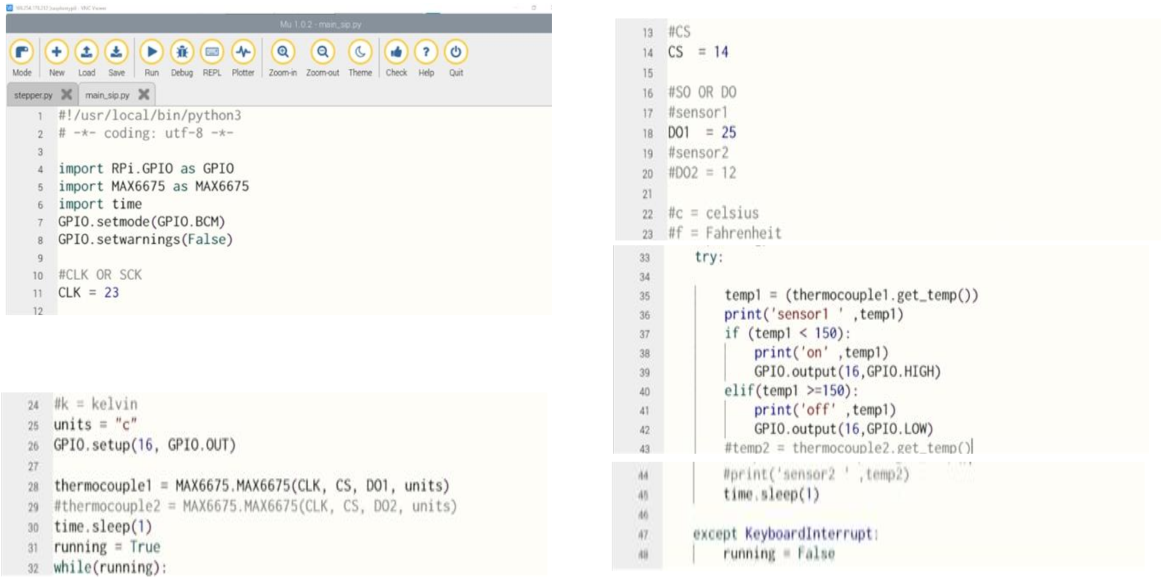

Figure 5. Pressing System Program

The two packaging and pressing system programs were then tested jointly. As a result, when the packaging machine is running, the two systems will run together. Based on the program tests (see figure 6) that have been carried out, it can be concluded that the program is running correctly and precisely so that it is ready to be installed on a series of packaging machines.

The results of designing the components of the packaging and pressing system are shown in the Figure 7. Both systems are regulated through a series of Raspberry Pi control systems mounted on a panel box.

The performance trial of the Raspberry Pi control system on the packaging machine aims to determine and test the performance of the packaging machine whether it is working correctly or not. That is, it can carry out the packaging correctly and precisely. This test is in the form of testing the plastic packaging of the stepper motor and pressing testing on heating the heater.

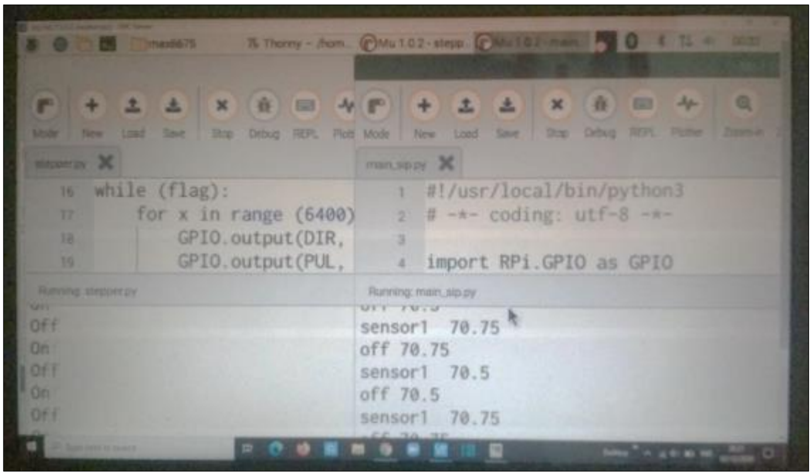

Figure 6. Results of Testing Packaging and Pressing Programs

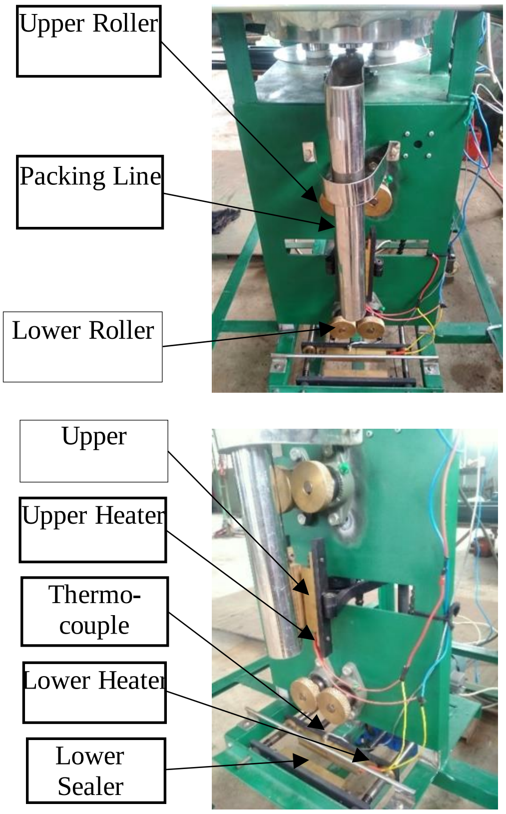

Figure 7. Results of Packaging and Pressing System Design

2. **Plastic Packing System Testing with a Stepper Motor**

Testing was held to find out the performance of the stepper motor in conducting the plastic packaging and pause stop during the process of filling the powder product on the packaging machine. The consistency of the stepper motor can be seen from the weight produced from each packaging of the powder product as many as ten experiments carried out. The packaging testing process is carried out using a digital scale. The packaging equipment's trial results resulted in an up and down weight from weighing product weight + packaging, packing weight, and product weight with each average value 13.737, 2.547, and 11.19, as shown in Figure 8.

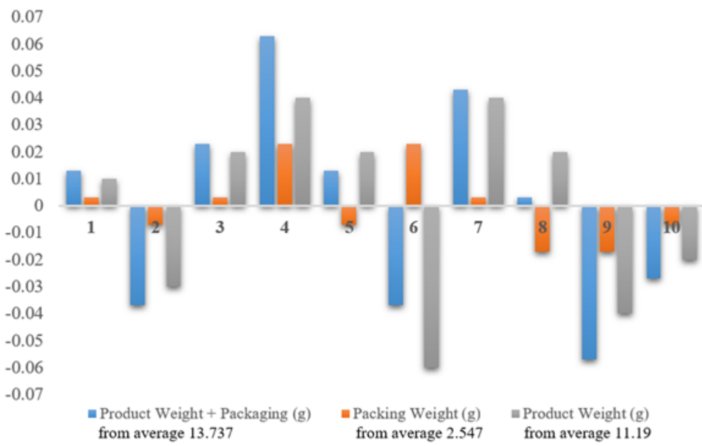

Figure 8. Packaging System Testing

Table 1. Temperature Reading by Thermocouple Sensor

Temperature Readings	Heating on Heater	
	on	off
<150⁰C	√	-
> = 150⁰C	-	√

The data in the table shows that the weight of the sugar product with packaging. The resulting average was 13.737 g. The weight of sugar products has an average of 11.19 g. Therefore, the difference in weight of sugar products with the average packaging with the highest weight is 0.063 g. Meanwhile, the difference between the mass of sugar products and the average package with the lowest mass is 0.057 g. Then 0.1 g indicates that the weight resulting from the packaging of sugar products is running well and consistently.

Testing The System Control Impressing with Heater

The second test is carried out on the pressing control system with a heater by the packaging process carried out. This test aims to determine whether the control system on the heater is working correctly or not in heating the sealer and keeping it at the pressing temperature, as shown in Table 1.

Based on the tests carried out, data is obtained that the thermocouple sensor shows the correct temperature reading. Under normal conditions, the pressing temperature on the heater in the packaging machine is around 150⁰C with a maximum tolerance limit of 200⁰C. Reaching the pressing temperature takes 2 min—22 s, calculated using a stopwatch and a cold machine that has never been used before.

The pressing quality can be seen from the density of the packaging's back, top, and bottom. In addition, packaged products are protected from leakage to be hygienically safe from the influence of outside air so that food does not degrade (Nura, et al., 2018). The packaging process has been designed with a package density rate of 100% from the second experiment.

The pressing results showed that it was not possible to do the pressing at the beginning to do pressing well because the pressing pair had not reached the desired pressing temperature. It is because the other press has not received heat conduction from the press partner. Therefore, 1-2 is required packaging first to obtain the desired pressing temperature. After 1-2 packs, then the press can work well and be able to pack firmly.

From the calculations that have been done, within 1 h, this packaging machine can pack 44x60 min = 2,640 packages. This calculation is based on the time for the measuring cup to reach the packaging channel through the divider plate is 1 second 36 milliseconds. This amount fulfills the initial target of designing a powder product packaging machine with Raspberry Pi control, 2400 pcs/h. The resulting powder product packaging has an adjustable length of 100 mm and a width of 95 mm, according to the number of turns of the stepper motor when withdrawing the plastic packaging. The microcontroller was implemented to control the immersion time and the speed of withdrawal of material out of the coating fluid through a stepper motor (Yohandri et al., 2019).

Furthermore, this stepper withdrawal can be adjusted according to the type and weight of the product to be packaged. The Raspberry Pi is used to monitor processes, is flexible, cost-effective, reduces complexity on the entire system (Shete et al., 2016). The following are the packaging results produced by a powder product packaging machine with the Raspberry Pi control system, as shown in Figure 9.

Figure 9. Powder Product Packaging Results

CONCLUSION

The results showed that the packaging machine was able to operate with a laptop-based Raspberry Pi control system. Based on the results of the control system performance tests, data is obtained that the packaging is running well and consistently. From the time of pulling and stopping the stepper motor, which the author has set, the average weight of the sugar product with its packaging is 13.737 g. The difference between the average product weight and the highest weight is 0.063 g. Meanwhile, the difference between the average product weight and the lowest weight is 0.057 g. Thus, a difference of less than 0.1 g shows that the weight resulting from packaging sugar products is excellent and consistent.Meanwhile, for the pressing process, the temperature sensor takes the temperature readings correctly so that the heater can reach the desired pressing temperature of 150^{0}C. It needed 1-2 packs first to get heat on the other press so that the sealer could work adequately and pack firmly. Based on the trials and calculations carried out by the author, it is obtained 2,640 packages within one h. This amount fulfills the initial target of designing a powder product packaging machine with Raspberry Pi control.

REFERENCES

Desai, D. A. (2006). Improving customer delivery commitments the Six Sigma way: case study of an Indian small scale industry. *International Journal of Six Sigma and Competitive Advantage*, *2*(1), 23-47.

Detmod, T., Özmen, Y., Songkaitiwong, K., Saenyot, K., Locharoenrat, K., & Lekchaum, S. (2018). Home-made Temperature Monitoring System from Four-channel K-Type Thermocouples via Internet of Thing Technology Platform. *AIP Conference Proceedings on International Conference on Civil, Mechanical and Material Engineering*, 020022-1 – 020022-5.

Hambir, P., N. Joshi, P. Karande, & A. Kolhe. (2019). Automatic Weighing and Packaging Machine. *International Research Journal of Engineering and Technology (IRJET)* 06(05), 2129-2138.

Indra, D., Tasmil, Herman, S. H. Mansyur, & E. I. Alwi. (2019). Design Web-Based Electrical Control System Using Raspberry Pi. *Journal of Information Technology and Its Utilization* 2(1), 1-3.

Karthika, P., & Vidhya Saraswathi, P. (2021). IoT using machine learning security enhancement in video steganography allocation for Raspberry Pi. *Journal of Ambient Intelligence and Humanized Computing*,*12*(6), 5835-5844.

Kemendikbud. (2013). *Sistem Kontrol Terprogram*. Jakarta: Kementerian Pendidikan dan Kebudayaan Republik Indonesia.

Khairudin, M., R. Asnawi, & A. Shah. (2020). The Characteristics of TB6600 Motor Driver in

Producing Optimal Movement for The NEMA23 Stepper Motor on CNC Machine. *TELKOMNIKA Telecommunication, Computing, Electronics and Control Journal* 18(1), 343-350.

Krauss, R. (2016). Combining Raspberry Pi and Arduino to Form a Low-Cost, Real-Time Autonomous Vehicle Platform. *American Control Conference (ACC).* Boston: July 6-8, 2016. 1-6.

Muljani, N. & L. Ellitan. (2019). Developing Competitiveness in Industrial Revolution 4.0. *International Journal of Trend in Research and Development* 6(5), 1-3.

Nura, A. (2018). Advances in food packaging technology-a review. *Journal of Postharvest Technology*, *6*(4), 55-64.

Pei, L., Peng, C., Guo, J., & Wen, L. (2010, May). Pipelining design controlled by stepper motor based on SCM. In *2010 Chinese Control and Decision Conference* (pp. 3703-3706). IEEE.

Rao, P. B. & S. K. Uma. (2015). Raspberry Pi Home Automation with Wireless Sensors Using Smart Phone. *Jurnal IJCSMC* 4(5), 797-803.

Raspberry Pi (Trading) Ltd. (2015). *The Official Raspberry Pi Projects Book.* Cambridge: The Magpi.

Saraf, M. R., V. V. Riuwale, V. V. Kulkarni, & S. M. Kulkarni. (2016). Design and Development of Cost-Effective Automatic Machine for Powder Packaging. *International Journal of Current Engineering and Technology* 4, 420-424.

Shete, P. V., Raundale Minal, V., Shahanas, S., & Bhosale, K. D. S. (2016). Automatic Vessel Filling System Using Raspberry-pi. *International Engineering Research Journal*, *2*(3), 1449-1451.

Sondakh, O., B. Christiananta, & L. Ellitan. (2017). Measuring Organizational Performance: A Case Study of Food Industry SMEs in Surabaya-Indonesia. *International Journal of scientific research and management (IJSRM)* 5(12), 7681-7689.

Virgala, I., M. Kelemen, A. Gmiterko, & T. Lipták. (2015). Control of Stepper Motor by Microcontroller. *Journal of Automation and Control* 3(3), 131-134.

Yohandri, Y., Khairunnisa, K., Ramli, R., & Zainul, R. (2019). Development of a Digital Dip Coating System Based Microcontroller. *Eksakta: Berkala Ilmiah Bidang MIPA (E-ISSN: 2549-7464)*, *20*(2), 62-69.

Zhang, Q. Ling, & Ting Ai. (2019). TeaBOT Order Packaging Machine Design. *Journal of Physics: Conference Series* 1213 (2019) 042043.