Progress in Engineering Application and Technology Vol. 2 No. 1 (2021) 930–936

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Development of Vending Machine Operation System Using Programmable Logic Controller (PLC)

Muhamad Husni Samsuni[1], **Muhammad Farid Shaari** [1]*

[1]Department of Mechanical Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2021.02.01.089
Received 13 January 2021; Accepted 01 March 2021; Available online 25 June 2021

Abstract: Vending machine controller is one of the main parts in the vending machine. It acts as the brain which control the flow of the system that allow the consumer to purchase the product from the machine. However, the price for the vending machine controller is not fixed because it depends on the type of operation involved, number of input and output components and last but not least the programming which is the most crucial thing. As the alternative, the cost can be reduced by using the controller that much cheaper and more convenient to integrate the whole system. Therefore, a low-cost beverage vending machine control system has been designed and developed for this project. The programmable logic control (PLC) has been selected as the interface for the note acceptor and the beverage can dispenser. The program was then been generated and tested through the CX-programmer software. The results show the beverage vending machine control system work as designed and the function of dispenser on the beverage can dispenser was verified based on the reliability and consistency test. As the result, the beverage can dispensers are able to dispense all the 26 cans without any distraction which means the system will not encounter any problem until all the beverage can are sold out.

Keywords: Beverage Vending Machine, Control System, PLC, Vending Machine Controller

1. Introduction

Vending machines act as a supplier to humans during the time of injury. They become so famous because of higher consumer demand especially for someone who want to make a quick and easy purchase. Besides, the hectic lifestyle of people who lives in the rapid city that makes the vending machine looks so much needed. In Japan, they already came out with a lot of innovative vending machine which sell different kind of products [1]. For instance, shirts, flower gift and many more. Nevertheless, it could be a challenge for the vending machine manufacturer to design and develop those machines since they use a lot of combination logic circuit in the selling machines in order to create one output.

Corresponding author: mdfarid@uthm.edu.my

Early 2020, the whole world has been struck by the deadliest coronavirus which have affected a lot of business [2]. Many people are afraid to go out especially to the crowded places due to the infection. Thus, this could be a good timing for the people to start using the vending machine as they can feel more safer to buy things without having a close contact with other people. For that reason, businessperson nowadays prefer to use this platform to sell their product since it can minimize their expenses by paying lower rental fee for an operating time of 24 hours a day. Besides that, it can help to avoid any interaction between human to human as the machine might transform into touchless vending machine which can reduce the possibility of infection. Some of the machines have different variation in terms of the mechanism and goods depend on the manufacturer. Based on the latest survey from the vending machine manufacturer, it shows that the market price for beverage vending machine is around RM 28,000 – RM 30,000 and the cost of the vending machine controller is estimate about 10 percent of the cost of the vending machine [3]. Thus, it might be relatively high cost for Small and Medium Entreprise (SME) to start up their business by using vending machine platform. Besides that, the uses of the advance features such as cashless payment or touchless screen also will affect the cost of the vending machine [4].

Therefore, this project has been carried on to develop a control system for the beverage can vending machine. The programmable logic control (PLC) has been chosen in order to integrate the note acceptor and beverage can dispenser because it is more flexible and easier to troubleshoot [5]. The process includes in designing the PLC diagram using software which is CX programmer. This system is then be applied on note acceptor and the beverages can dispenser which has been developed by previous PSM project [6] [7]. Hence, the aim of this project is to come out with a low cost and convenient control system so that the consumer able to use the vending machine as well.

2. Material and Methods

2.1 Vending Machine Operation System

Generally the operation system of the developed vending machine can be divided into two parts which are the droping mechanism and the control system. The proposed design of dropping mechanism is exhibited in Figure 1. This design is based on sliding methods. The mechanism consists of three main parts which are the dc motor as the actuator, the connecting rod and can housing. The connecting rod converts the rotary motion of the dc motor to linear motion that pulls the can that positioned in the can housing to be dispensed. In this project, a 12 V dc motor with maximum 15 kg.cm torque capacity had been used. All of the structure were fabricated using alunimum alloy. Three sets of dropping mechanism had been fabricated to cater three different types of beverage can.

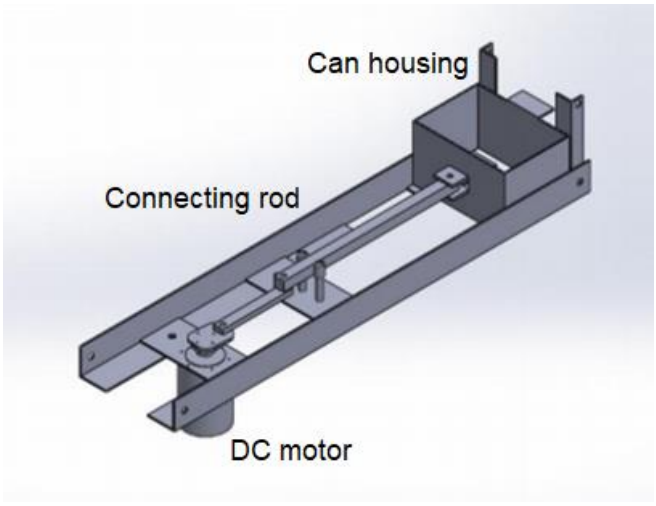

Figure 1: The slide dropping mechanism

2.2 Control system

The control system of this vending machine prototype was developed depending on the proposed dropping mechanism and operation sequence. The operation sequence determines the process steps to obtain the beverage can by the customer. These process steps must be continuous one after another and this can be achieved using proper signal control. Figure 2 shows the flow of the vending machine operation. The process started from inserting the bank note into the note accepter until the beverage can dispense from the vending machine. Firstly, the bank note was being insert into the note accepter. The note accepter for RM1 respond and activate the relay 1 if the amount of bank note was RM1. However, the note acceptor for RM2 then responds and activate the relay 2 and 3 if the amount of the bank note was RM2. After that, the relay 1, 2 and 3 were turn on the red lamp respectively. The lamps work as indicator to show to the consumer that the beverage can was ready to be selected.

Next, the push button was being pressed to automate the motor. However, the motor only can be rotate when the relay 1, 2 and 3 was activated. The connecting rod that connected with the motor pulled the can housing to allow the beverage to be dispensed. When the beverage can already be dispensed, the can housing hit the limit switch to activate the timer. The timer has been counted in 4 seconds and then the motor automatically stops the slider at its original position. Other than that, there was an orange lamp that turn off whenever the beverage can inside the storage was already empty. The operation sequence for this vending machine prototype was controlled by using the PLC. PLC was selected because of its robustness and easy to program and reprogrammed [8]. Table 1 depicts the list of all the input and output of the component that involved in the vending machine control system.

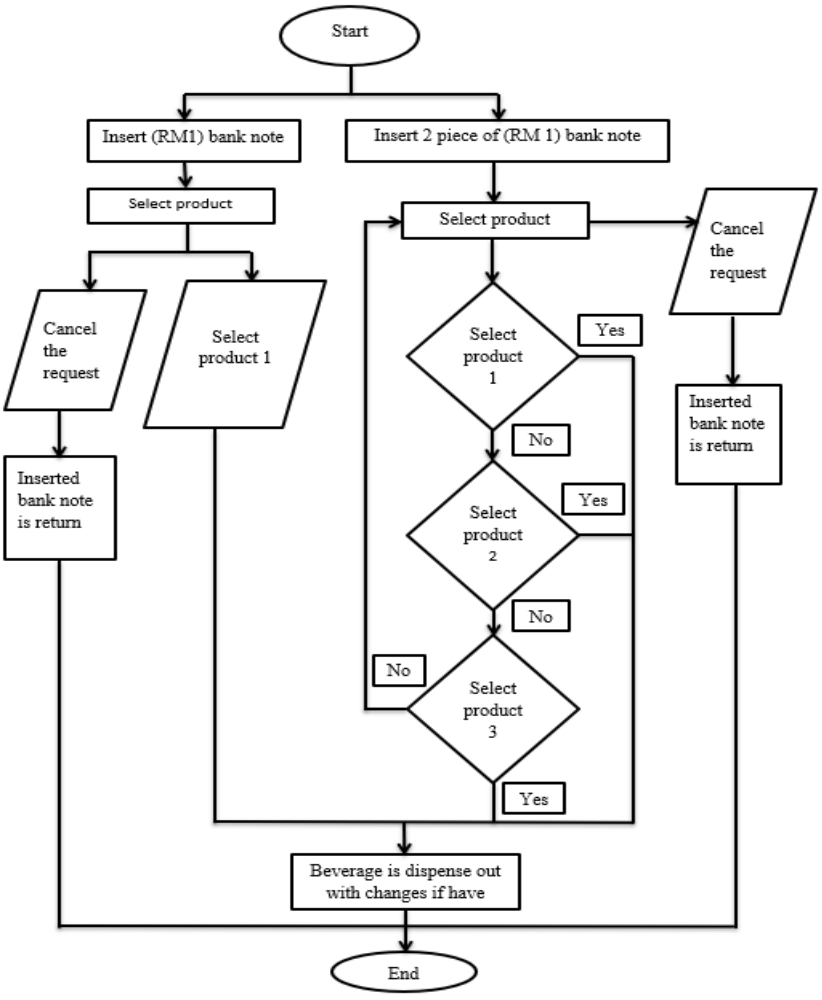

Figure 2: Flowchart of the vending machine operation sequence

Table 1: Input and output components

No.	Input/output	Description
1	Note acceptor	To show the amount of bank note is already enough.
2	Relay	To activate the lamp and allow the motor to rotate for each beverage can.
3	Lamp	To show the beverage can is available and ready to be dispense.
4	Push button	Automate the motor that move the slider to pushes the beverage can out from vending machine.
5	Motor	To dispense the beverage can out from the storage.
6	Limit switch	To control the movement of motor and sense the presence of beverage can.
7	Timer	To delay the motion of motor for certain time.

2.3 System architecture

The PLC controller received the data from the PC where all the input and output module were program by using the CX programmer software. As the data is going through the PLC, it directly running all the electrical components based on the sequences of the operation system [9]. The connection for both PC and note acceptor have been going through the USB cable while the other components such as push button, limit switch, led lamp, relay and motor were connected with cable wire to the PLC controller. The Figure 3 exhibits the architecture of the beverage vending machine system.

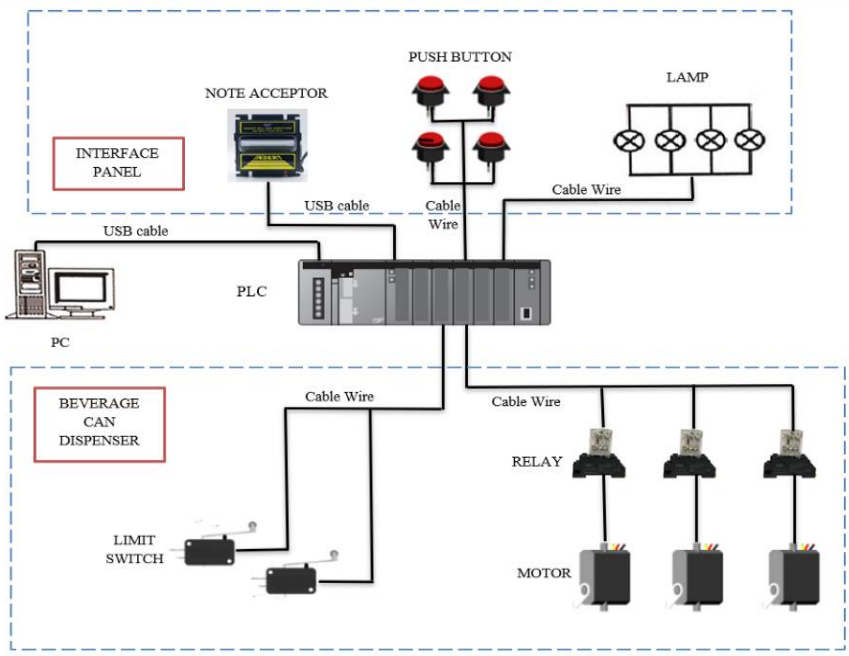

Figure 3: Architecture of the beverage vending machine system

2.4 Testing the drop mechanism

The drop mechanism was tested by the reliability and its consistency of the slider to dispense the beverage can. The program has been designed and then transfer into the PLC controller to analyse the control system. An observation had been made to see whether the slider can run smoothly. If the slider able to dispense the beverage can without any distraction, the results are going to be stated as 'not stuck'. However, if the beverage can fail to be dispense out smoothly, it will be stated as 'stuck'. Twenty-six trial were performed for each of the beverage can dispenser to analyse the sliding mechanism as the design of the modular storage able to hold up to twenty-six can in one time (Figure 4). It is important to make sure that the slider does not encounter any failure until the beverage can have

been sold out. The results were then tabulated to analyse the percentage of reliability and consistency. The percentage of reliability, can be described as in Eq. 1;

$$\text{Percentage of reliability} = \frac{\text{total of not stuck}}{\text{total number of testing}} \times 100\% \qquad \textit{Eq. 1}$$

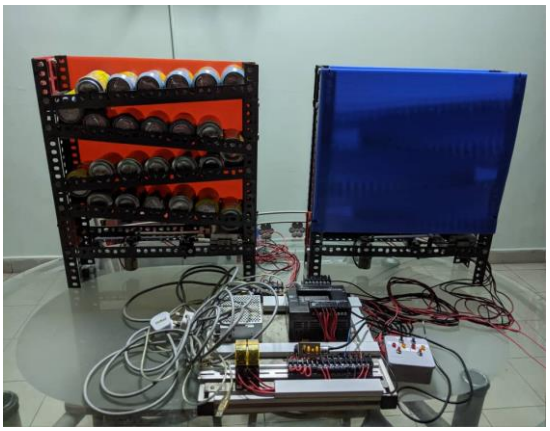

Figure 4: Testing setup

3. Results and Discussion

The overall system for the beverage vending machine works very well as the beverage can able to be dispensed when the selection button has been pressed after the note acceptor receive an enough amount of the bank note. However, there are some problems that happened during the initial trial where the position of the slider not exactly lies on the correct place. Thus, causes the beverage can to be stuck for a moment which distract the operation flow. In the end, the problems were solved. Therefore, the reliability and consistency test was performed to check the reliability of the dropping mechanism of the final design of the beverage vending machine. Table 2 shows the results obtained from the analysis performed.

Table 2: Reliability and consistency test result

No.	Reliability of the drop mechanism (Stuck/Not stuck)		
	Set 1	Set 2	Set 3
1.	Not stuck	Not stuck	Not stuck
2.	Not stuck	Not stuck	Not stuck
3.	Not stuck	Not stuck	Not stuck
4.	Not stuck	Not stuck	Not stuck
5.	Not stuck	Not stuck	Not stuck
6.	Not stuck	Not stuck	Not stuck
7.	Not stuck	Not stuck	Not stuck
8.	Not stuck	Not stuck	Not stuck
9.	Not stuck	Not stuck	Not stuck
10.	Not stuck	Not stuck	Not stuck
11.	Not stuck	Not stuck	Not stuck

12.	Not stuck	Not stuck	Not stuck
13.	Not stuck	Not stuck	Not stuck
14.	Not stuck	Not stuck	Not stuck
15.	Not stuck	Not stuck	Not stuck
16.	Not stuck	Not stuck	Not stuck
17.	Not stuck	Not stuck	Not stuck
18.	Not stuck	Not stuck	Not stuck
19.	Not stuck	Not stuck	Not stuck
20.	Not stuck	Not stuck	Not stuck
21.	Not stuck	Not stuck	Not stuck
22.	Not stuck	Not stuck	Not stuck
23.	Not stuck	Not stuck	Not stuck
24.	Not stuck	Not stuck	Not stuck
25.	Not stuck	Not stuck	Not stuck
26.	Not stuck	Not stuck	Not stuck

From the result obtained, it shows that there was no distraction on the beverage can inside the slider along the twenty-six set of trial for all set of beverages can dispenser. After that, the percentage of reliability was calculated which the total number of stuck divided by the total number of testing and times by 100. Based the calculation using Eq. 1, the percentage of reliability of the sliding mechanism was 100 %. It means that the mechanism for the beverage vending machine was considered reliable as the beverage can does not encounter any problem until the whole product was been sold out.

4. Conclusion

The low-cost vending machine control system had been successfully designed and developed. The beverage vending machine control system was successfully implemented on Programmable Logic Control by OMRON. Ladder diagram used for PLC is a graphical language which is easier to be understand and implement. The performance of the developed integrated system had been verified as the beverage can dispenser able to dispense twenty-six of beverage cans in a row without any distraction. In the future, the interface panel for the selection purpose can be improve by using the touchscreen interface where it can be more futuristic compared using the push button hardware. The touch screen can be utilized for the cashless payment where the customer can also purchase the product although they did not have enough money on that time. Not only that, it also can give more spaces for the vending machine to increase their storage rather than installing the note and coin acceptor.

Acknowledgement

The author would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support and sponsoring this project.

References

[1] Alexander, D., "17+ Interesting Vending Machines in Japan You'll be Surprised to Know Exist," June 22, 2020. [Online]. Available: https://interestingengineering.com/17-interesting-vending-machines-in-japan-youll-be-surprised-to-know-exist. [Accessed Aug 15, 2020].

[2] Elengoe, A., "COVID-19 Outbreak in Malaysia, " Osong Public Health and Research Perspectives, vol. 11(3), pp. 93–100, 2020, doi: 10.24171/j.phrp.2020.11.3.08.

[3] Miller et al., "Vending machine controller and system," U.S. Patent 5,959,869, Sep. 28, 1999.

[4] Summak, M. B. et al., "Designing Touch Screen Vending Machine Control System (VMCS) Simulator," vol. X, no. X, pp. 1-5, 2018.

[5] Warankar, S. V. et al., "Implementation of PLC Controlled Juice Machine," International Journal of Engineering Technology Science and Research (IJETSR), vol. 5, issue 3, pp. 825-828, 2018.

[6] Salehudin, A., "Design And Develop Low-Cost Note Recognition System In Self Designed Note Acceptor Prototype For Vending Machine," Bachelor thesis, Dept. Eng. Tech., Universiti Tun Hussein Onn Malaysia, 2020.

[7] Samakun, M. Q., "Design and Development of Modular Storage Mechanism For Vending Machine," Bachelor thesis, Dept. Eng. Tech., Universiti Tun Hussein Onn Malaysia, 2019.

[8] Niu, Y., & Chu, J., "The Design of Beverage Vending Machines Based on PLC," International Conference on Information Technology and Management Innovation (ICITMI), pp. 414–419, 2015, doi: 10.2991/icitmi-15.2015.65.

[9] Ramanamma, P., "Implementation of a Vending machine using Programmable Logic Controller, " International Journal for Research in Applied Science and Engineering Technology (IJRASET), vol. 6, issue VI, pp. 1510–1515, 2018, doi: 10.22214/ijraset.2018.6221.