SMART WASTE MANAGEMENT FOR AN ECO ENVIRONMENT HOUSING AREA

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Abstract— **With the development and popularization of computer technology, digital technology, and digital equipment are the caused new system is created to replace the previous system. In this paper, the concept of smart waste management system as a whole system is introduced. SketchUp software is utilized to design the flow of the smart waste management system at the housing area. CX – Programmer application is used to create a program that will be transfer to the Programmable Logic Control (PLC). This system is completely program by using ladder diagram programming method. Then, the program being execute by Omron programmable controller. Then, TouchWin is interfaced with the Omron programmable controller via Universal Serial Bus (USB). TouchWin software is used to display the design flow of the system and use as Human Machine Interface (HMI). Basically, this system will be implemented at the housing area. This system also implemented to control the smart waste management system using CX – Programmer and to reduce the carbon emission to the environment. The result from this system showed that it can help to create the better environment.**

Keywords— Smart Waste Management system, SketchUp, Programmable Logic Control (PLC), CX-Programmer, Omron programmable controller, TouchWin, Human Machine Interface (HMI)

I. INTRODUCTION

Waste is unwanted or unusable materials. There are a few type of wastes such as liquid wastes, solid waste and organic wastes. The main wastes at the household is organic waste such as food waste, garden waste, manure and rotten meat and solid waste like plastic, paper and tins or metal. Household wastes is one of the factor that leads to the environment pollution which can give negative impact to human health[1]. This because the dumping garbage that expose to the environment contained greenhouse gases such as methane and carbon dioxide[2]. Indirectly, the environment is fulfilled by the greenhouse gases. Every year starting from 2010 to 2015, the waste is increasing year by year until 2020 and the waste generated is expected to increase more[3]. Based on the forecast in 2020, the waste of household is expected to be 70% means that more waste needs to be managed and treated by the authority concern[3].

It is possible to prevent negative impact of household wastes on the environment, as well as to improve the household wastes management by make wastes management system than can reduce the negative impact of household wastes from leads to the environment pollution[4]. In this era with high technology, the world is expose to build smart cities whose features are smart economy, smart mobility, smart environment, smart people and smart living. The dumping household waste is one of the factor that leads to increase the number mass production of bacteria, insects which finally spread different diseases and increase the percentage of greenhouse gases to the environment[5]. To overcome such severe problem, a smart system for the waste management must be develop that can safeguard the environment and reduce the human effort to clean their garbage from overflow by themselves[6].

Programmable Logic Controller (PLC) is recent practice in the industry. The PLC is use to provide flexible, ruggedized and easily to programmable controller to replace hard-wired relays, timers and sequencers. Since then, PLC have been widely adopted as high-reliability automation controllers suitable for harsh environments. PLC also can be applied in the field of waste management that would be instrumental in designing smart cities. Do a waste management system at the residential areas by use PLC can reduce the negative impact of household wastes from leads to environment pollution. It is a cause that will ensure good health, clean environment and pollution free society.

In this paper, underground smart waste management system to separate the food waste and recyclable items using PLC is proposed. This paper also will describe the flow design, the basic structure of ladder diagram of the smart waste management system and how this system will display and control in the TouchWin.

A. Problem Statement

Most of the countries in the world are confronting a gigantic of waste management system especially at housing areas. At the residential areas, every certain house has their dustbin at the outside. Dustbin is a container use for collecting all the household waste. With the increases of residential areas and population, this problem will increase the number of wastes in the country too. Waste is one of the factors that leads to environment pollution. This is because mostly dustbin especially at the residential areas are overfilled. The traditional way of knowing when the waste will be collected in the housing area is not accurate nowadays as sometimes, they fail to collect the waste without any reasons.

Besides, overfilled dustbin will create unhygienic condition that can increase unwanted gases release to environment. If the waste is idle to the environment, at the certain temperature, pH and time it will produce unwanted gases like methane (CH4) and carbon dioxide (CO2). In addition, some people do not have a time to clean up or wash their dustbin that can produced bad smell and toxic which is

can leads to pollutions. Therefore, to solve the problem it is crucial to have underground waste management system. CX – programmer and ladder diagram programming language will be implemented to control this system.

B. Objective

There are objectives that associated with this project which is underground waste management system at residential areas. These objectives are contributing the expected result that will come up at the end of this research.
The objectives are:

- To design smart waste management system for eco environment in housing areas using TouchWin designer software.
- To control the smart waste garbage system using CX-Programmer.
- To interface smart waste garbage system of TouchWin designer software with CX-Programmer.

II. METHODOLOGY

This section will discuss on the flowchart, software and method to create new smart waste management system. Figure 1 shows the flowchart for the whole project designed.

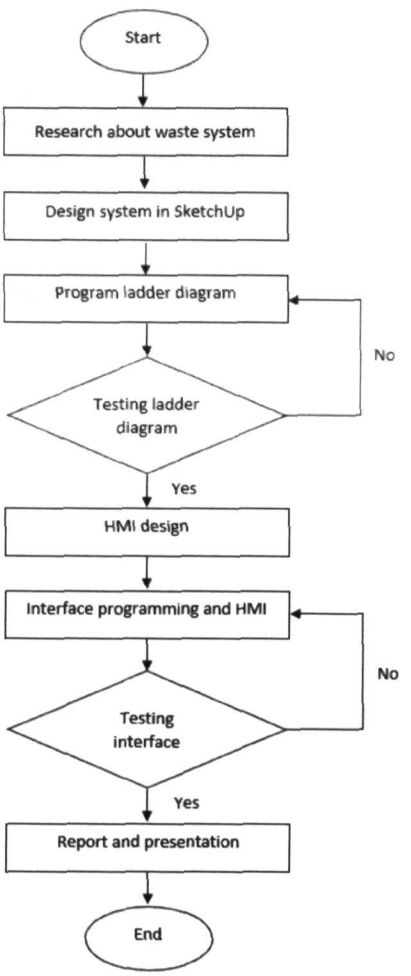

Figure 1: Flowchart of the project.

A. SketchUp Pro 2019

SketchUp is a 3D modeling computer program software for a wide of drawing application such as architectural, interior design, civil and mechanical engineering. For this project, the design had been done before do the ladder diagram implementation. SketchUp is used in this for design the flow of smart waste management system from the first stage which is the inlet of the dustbin to the last stage which is the central collection facility (waste compartment). Designing the flow of the system for this project is one of the difficult parts because need a creativity how to design the flow of the system. This designing part have taken the longest duration to complete the design.

B. CX – Programmer

CX-Programmer is the programming software for all Omron's PLC series, is fully integrated in to the CX One software suite. Designing, testing and enhanced of programs associated with Omron PLC is a PLC programming tools for the CX – Programmer. This software provides address information, foundation for the support of PLCs and for interfacing with Omron PLCs.

CX-Programmer includes a wide variety of features to speed up the development of PLC program. PLC is an electronic device that appropriate to understand the control circuit of manufacturing automation structure. So basically, the programming of the waste system management will be built on CX-Programmer. For this project, ladder diagram will be used to program the process of the waste system management from the start at outside garbage of the house until the end of the process at the main underground garbage. Ladder diagram is use because ladder diagram the simple method to program the process and easy to troubleshoot the errors.

C. TouchWin Software

TouchWin is the Human Machine Interface software for Omron PLC. This software is used to interface with PLC. This software also supports any font and size of character as well multi-language. Data display and monitoring, alarm, recipe are the basic functions of this software. It can communicate with most brands of PLC and two ports can communicate individually. In this project, this software communicates with Omron PLC.

This TouchWin programming software is used in this project because it has friendly interface and easy to operate. This software also can simulate online and offline (SCADA function). This software had been used in this project to display the flow of the smart waste management system on the TouchWin HMI screen and control all the sensor and actuator in this system. There three sensors that being control in this system by using this software which is opener sensor, divider sensor and blower sensor while the actuator is the opener, divider motor and the blower. The push button on the screen of the TouchWin HMI act as the input which is the sensor and the symbol of the actuator is act as an output for this system.

D. Ladder Diagram

Basically, the programming language that commonly used in industry have 5 different type of programming

language which is ladder diagram, instruction list, structured text, function block diagram and sequential function charts.

This project had been used ladder diagram programming language to make sure this system completely function. This is because ladder diagram is a simple logic construction and more reliable than an electronic circuit controller. Besides, ladder diagram one of the programming language that easy to learn and read the program as well as easy to troubleshoot. All the inputs and outputs of this system must be identified before start programming the PLC. Then, the sequences of the system should be defined.

To create the ladder diagram, start and stop button must be included in the program. The start button is used to start all the system while the stop button is used to stop the system like emergency button. Ladder diagram is the only one directly modeled after electromechanical relay systems. It uses a long rung to be laid out between two vertical bars by representing system power. Along the rungs are contacts and coils. The contact act as input and usually represent switches or push buttons while the coils act as output such as motor or blower. If the contacts are placed in the series, it means represent AND logic and represent OR logic when the contacts in parallel. As same as with the real relays, there are normally open contacts and normally closed contact.

E. Interface

Interfacing between CX – Programmer and TouchWin software of the smart waste management system is the final part of this project. CX – Programmer is interfaced with the TouchWin by using the Universal Serial Bus (USB). By doing the interfacing method, all the inputs and outputs of this system can be control on the screen of the TouchWin HMI. This method can be done by transfering the ladder diagram program to the Omron PLC via USB. The important thing is the inputs and the outputs at the TouchWin software must use the same memory with the inputs and outputs at the CX – Programmer software. If the memory is different, the system cannot be control properly.

III. Result and Discussion

The result of this project can be divided into two parts which is on ladder diagram programming and simulation and HMI for this system.

A. Ladder Diagram programming and simulation

This smart waste management system used a ladder diagram programming language to make sure the system functional properly.

The first rung in this ladder diagram programming is used to program for the start and stop button for this system. Basically, start and stop button is the necessary input for all system to power up and to stop system.

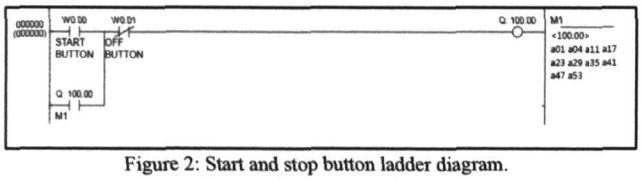

Figure 2: Start and stop button ladder diagram.

Figure 2 shows the rung has two input and one output. the input in this rung is start button (W0.00) and stop button (W0.01) while the output is M1 (100.00). The start button used the normally open switch because user must push or give a bit to the button for power up the system. The stop button used the normally close switch because when the user push or give a bit to the switch the system will turn off. The stop button is used to break the system circuit. In this rung the latching method was used. The start button was latched with the M1 to power up the system all the time. This is also because when the user pushes the start button the bit that sent to the switch just a temporary.

On the next rung, two different LED which is green LED and red LED will control by two inputs button.

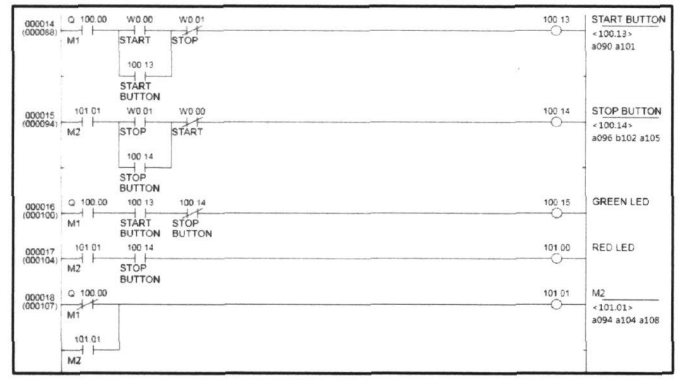

Figure 3: LED ladder diagram.

Figure 3 shows that the start button has been latching by the dummy output of the start button to control the green LED. When the user pushes the start button, the green LED will turn on and the green LED will turn off when the stop button is push by the user while the red LED will turn on. If the green LED is turn on that is means that the system is power up and if the red LED is turn that is means that the system is shutdown. The output at the last rung which is M2 (Q101.01) is used for second source to power the red LED when stop button is pressed by the user.

Dustbin lid one of the outputs in this system that has been program control by four external inputs and one internal input.

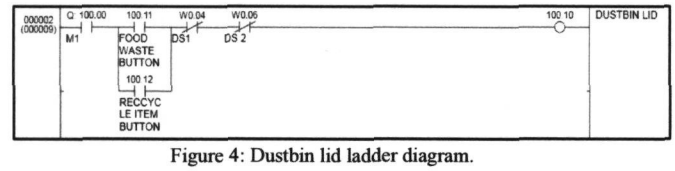

Figure 4: Dustbin lid ladder diagram.

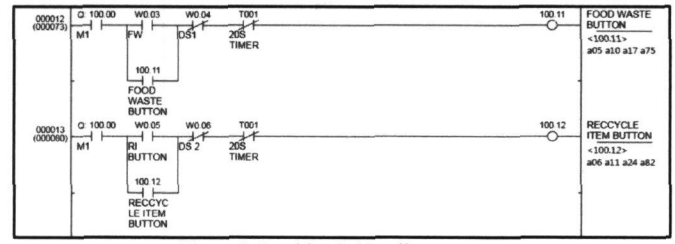

Figure 5: Latching ladder diagram.

Figure 4 shows the program to control the dustbin lid (Q100.10). The external inputs that control the dustbin lid is food waste button (Q100.11), recycle item button (Q100.02), divider sensor 1 (W0.04) and divider sensor 2 (W0.06) and one internal input which timer 1 (T001). The dustbin lid will open when the user pushes the button either food waste button or recycle item button. That is why both buttons are used normally open input switch and both buttons are parallel. Divider sensor 1 and divider sensor 2 is used normally close input switch button and connected in series. This because if either one of the divider sensors detect waste, the dustbin lid will close. The internal input which is timer is used when the user pushes the food waste button or recycle item button and the user not put their waste into the dustbin, with in 20 second the dustbin lid will close.

Figure 5 shows the latching ladder diagram for food waste button and recycle item button. If this method is not used for both buttons, when the user push the button the normally open input switch will close just temporary and the timer will not turn on. Figure 5 shows that both buttons have been latching with dummy output to make both normally open switch button will not close just in temporary when the user push it.

The next rung is used to program the next input and output. In this rung the two input which is food waste button and divider sensor 1 is used to control the motor to move divider to left or right.

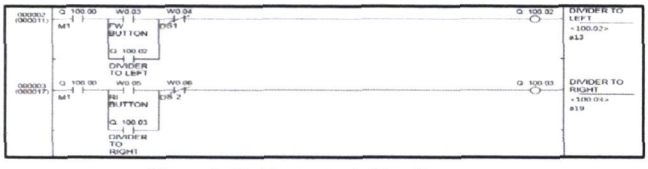

Figure 6: Divider motor ladder diagram.

Figure 6 shows that the outputs which is two different motor that will controlled by two external inputs and one internal input. For the first motor (Q100.02) is function rotate to left and the motor controlled by food waste button (W0.03) and divider sensor 1 (W0.04). The first motor will rotate to the left when the food waste button is pushed, and the motor will rotate to its original position when divider sensor 1 is detect. Same with the second motor (Q100.03) will rotate to the right when recycle item button (W0.05) is pushed and the second motor will rotate to its original position when divider sensor 2 (W0.06) is detect. In this rung also use the internal input to control the divider motor. Within 20 second if both divider sensor does not detect, both motors will rotate to its original position. At the in front all the rungs in this system have normally open switch that refer to the M1 which is the first output because it works to power up all the input and output in this system.

The plate opener has been program on the next rung. The plate opener has been controlled by plate sensor and divider sensor 1and divider sensor 2.

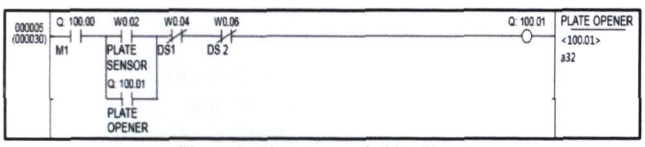

Figure 7: Plate opener ladder diagram.

The plate opener (Q100.01) has been controlled by 3 input which is plate opener sensor (W0.02), divider sensor 1 (W0.04) and divider sensor 2 (W0.06). The plate opener will open when the plate opener sensor detects the waste and the plate opener will close when either divider sensor 1 or divider sensor 2 to detect the waste.

The next rung will show how each blower will control by two inputs. This is the important part to collect all waste from every house to waste central collection facility.

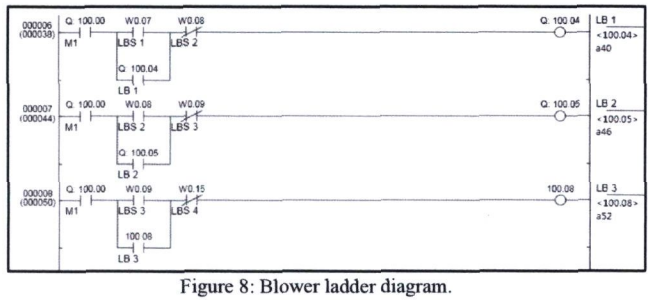

Figure 8: Blower ladder diagram.

Figure 8 shows that have three blower which is blower 1 (Q100.04), blower 2 (Q100.5) and blower 3 (Q100.08) will control by two different inputs. The first blower will turn on when the blower sensor 1 (W0.07) is detect waste. If the blower sensor 2 (W0.08) is detect, the first blower will turn off and second blower will turn off. The second blower will turn off when blower sensor 3 (W0.09) is detect, while blower 3 will turn on. This process will repeat until the waste is transferred to the waste central collection facility. The number of the blower is depending on how many houses and how far the central collection facility.

B. Human Machine Interface (HMI)

Figure 9 shows the HMI simulation design for the whole system. The HMI design is displayed on the TouchWin HMI screen panel. Figure 9 also shows the flow of the smart waste management system from the inlet to the waste collection center.

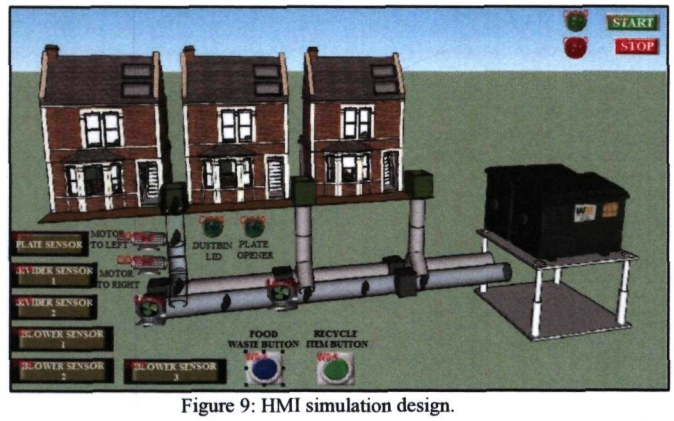

Figure 9: HMI simulation design.

Step of simulation:

1. When the system off, all the inputs and outputs of this system is off.
2. When the START button is pressed:
   - Green LED will turn on.

3. When the food waste button is pressed:
   - Dustbin lid will open.
   - Motor will rotate to left.
   - Timer is on.
4. When the recycle item button is pressed:
   - Dustbin lid will open.
   - Motor will rotate to right.
   - Timer is on.
5. When timer is off:
   - Dustbin lid will close.
   - Motor will rotate to its original position.
6. When plate sensor is detecting:
   - Plate opener will open.
7. When divider sensor detecting:
   - Dustbin lid will close.
   - Plate opener will close.
   - Motor will rotate to its original position.
8. When blower sensor 1 detecting:
   - Blower 1 turn on.
   - Blower 2 turn off.
   - Blower 3 turn off.
9. When blower sensor 2 detecting:
   - Blower 1 turn off.
   - Blower 2 turn on.
   - Blower 3 turn off.
10. When blower sensor 3 detecting:
   - Blower 1 turn off.
   - Blower 2 turn off.
   - Blower 3 turn on.

IV. Conclusion

System that have been develop or design by using OMRON CX – Programmer that will give positive advantages in controlling the smart waste management system. The ladder diagram programming language that have been used in CX – Programmer is successfully created. This software provides easy interface with the TouchWin software, friendly PLC language and easy to do troubleshooting as well as this software is very suitable in developing this smart waste management system. For the control panel use to control this system is successfully designed by using SketchUp 3D model and TouchWin designer software. The TouchWin software provide many elements that can easily create this control system and easy to interface with the CX – Programmer. By using TouchWin designer software, this smart waste management system can easily control on the touch win HMI panel. The whole flow of this system has been successfully displayed on the TouchWin HMI panel. The HMI design simulate properly based on the ladder diagram that has been created by using CX – Programmer. The ladder diagram is successfully integrated with the all elements that used in the TouchWin designer software. The objectives for this project are successfully achieved.

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