Automatic control model of water filling system with Allen Bradley Micrologix 1400 PLC

R Harahap¹, AF Adyatma¹ and F Fahmi*¹,²

¹Department of Electrical Engineering, Faculty of Engineering, University of Sumatera Utara, Jl. Dr. Mansur 9 Medan 20155, Indonesia
²Sustainable Energy and Biomaterial Centre of Excellent, University of Sumatera Utara, Jl. Almamater Kampus USU, Medan 20155, Indonesia

*Email: fahmimn@usu.ac.id

Abstract. Programmable Logic Controller or PLC today plays an important role in most industrial control systems. PLC usage can be encountered in almost all fields of industry, not only in the manufacturing world but also on many other things such as elevators in office buildings, hotels hospitals, and others. PLC is an electronic control tool that operates in logic that its programming can be modified with relative ease. As with any controller in general, the PLC processes input signals to further discharge output according to the desired program. PLC usage is very broad because of its high reliability, can be reprogrammed or modified with relative ease, and very helpful in the tracking troubleshooting. One type of existing PLC is Allen Bradley PLC. Allen Bradley PLC program is commonly used in various industries. PLC Allen Bradley (AB) has several types, and one of them is the type of Micrologic 1400. In this study we design a system as a comparison with the conventional system. For that to explore the use of a PLC program which will be supported by a simulator tool, including a program to RSLogic 500, how to programming, monitoring via RSView32, and modification. It is expected to understand the application aspect of operation and programming of this specific PLC and its potential. The purpose of this research is to design water filling automation system by using Allen Bradley Micrologic 1400 type 1766-L32BXB PLC, empowering the use of Allen Bradley Micrologic 1400 PLC and to regulate the desired process to obtain efficiency and effectiveness compared with conventional system arrangement using Relay.

1. Introduction

Factors that affect the efficiency and productivity of the industry itself, such as the human error factor and the level of excellence offered by the control system. One of the most widely used control systems is Programmable Logic Controller (PLC). Its applications cover a wide range of industries ranging from cigarette, automotive, petrochemical, paper, and even to the mining industry, for example in the control of gas turbines and advanced industrial units of mining products. The ease of transitioning from previous control systems (e.g., from mechanical relay-based control systems) and the ease of troubleshooting in system configurations are the two main factors driving the popularity of this PLC. PLC is a system that can manipulate, execute, and or monitor the state of the process at a very fast rate, on the basis of programmable data in an integral microprocessor-based system. PLC receives
inputs and produces an output electrical signals to control a system. Thus the controlled quantities of physics and chemistry, before being processed by the PLC, will be converted into electrical signals both analog and digital, which is the basic data.

The formulation of the problem is to know how to enter and run ladder logic PLC program Allen Bradley and understand ladder logic system Allen Bradley PLC with computer software. Besides, it will explain how to connect PLC with an induction motor.

The purpose of this research is to design water filling automation system by using Allen Bradley Micrologic 1400 type 1766-L32BXB PLC, empowering the use of Allen Bradley Micrologic 1400 PLC to know how PLC works in order to regulate the desired process so as to obtain efficiency and effectiveness compared with conventional system arrangement using Relay.

2. Materials and Methods

2.1. Allen Bradley PLC

There are two forms of Allen Bradley PLC namely compact and modular form. For a compact form, its PLC uses a rack system (CPU and I/O unit) with limited memory capacity. An example of a compact form is AB MicroLogic 1400. As for the modular form PLC consists of CPU module and I/O module (an integral part). Example PLC AB Modular type is SLC 5/05 (Figure 1).

![Figure 1. (a) PLC Allen Bradley MicroLogic 1400 and (b) PLC modular series SLC 5/05](image)

| No | Model          | Power Supply | Input                          | Output                      |
|----|----------------|--------------|--------------------------------|-----------------------------|
| 1  | 1766-L32BWA    | 120/240V AC  | 12 Fast 24V DC, 8 Normal 24V DC | 12 Relay                    |
| 2  | 1766-L32AWA    | 120/240V AC  | 20 120V AC                     | 12 Relay                    |
| 3  | 1766-L32BXB    | 24V DC       | 12 Fast 24V DC, 8 Normal 24V DC| 6 Relay, 3 Fast DC, 3 Normal DC|
| 4  | 1766-L32BWAA   | 120/240V AC  | 12 Fast 24V DC, 8 Normal 24V DC, 4 Analog V input | 12 Relay, 2 Analog V output |
| 5  | 1766-L32AWAA   | 120/240V AC  | 20 120V AC Input, 4 Analog V input | 12 Relay, 2 Analog V output |
| 6  | 1766-L32BXBA   | 24V DC       | 12 Fast 24V DC, 8 Normal 24V DC, 4 Analog V input | 6 Relay, 3 Fast DC, 3 Normal DC, 2 Analog V output |
There are several variants of Micrologix 1400 as shown in table 1. RSLinx is software used for setting communication between PLC and PC. RSView32 is one of the HMI software that allows monitoring of existing data in the field, in this case for example data from sensors and transducers in the field controlled by PLC. RSLogic is software used to create programs in PLC.

2.2 SCADA on Clean Water Treatment System

Commonly in a water treatment, there are three buildings or construction, namely:

a. Intake building is the first building or construction for the entry of water from a water source.
b. Water Treatment Plant (WTP), is a system or facility that works to treat water from contaminated water quality (influent) to get the desired water quality treatment as per quality standard or ready for consumption.
c. Reservoir, as a temporary shelter for clean water before being distributed.

![Display RSView for (a) Water Intake River, (b) Water Treatment Plant, (c) Reservoir](image)

2.3. Designing

Simulation model of automation control of water filling system using Allen Bradley MicroLogix 1400 PLC is adjusted with conventional water charging system. The design includes the example of conventional system design, automation system design, creation of automation system program based on PLC Allen Bradley type Micrologic 1400 with Rockwell Software. In automatic water filling system with the conventional system, the 1st and 2nd buoy models of type RADAR are employed. In general, the tools and materials for this conventional design model are tank/tub/water container wells, RADAR buoys, motors / Omron water relay pumps, for the semi-auto system, control panel, and rail cable.

Here is how the conventional water filling systems work. In normal conditions (the tank is empty), the water pump stops working (Off). Water enters through the inlet hole. Underwater conditions are still at low level, the water pump is not working yet. When the water level reaches high level, the water pump starts to work. The water pump will continue working until the water level is at low level. At the water position at low level, the pump stops working, and water enters through the inlet to fill the storage tank. When the water level is in high level position, the water pump starts to work. In the control panel, use the ON-OFF button to turn on the system, selector switch is used to make system Auto-Manual. Auto, where the system works automatically using the RADAR buoy as a switch. Manually, where the water pump can be run using the pushbutton, and the starting motor water pump works with the Direct on Line (DOL) system.

2.4. Automation system design

The simulation will use a board to embed the simulation tools. The substitute of the float water level setting is a light switch. The H1 mark light as a marker for the inlet water pump works. The H2 mark light as a marker for the distribution water pump works. H3 mark lights as markers for open inlet valve. H4 mark lights as markers for open valve outlets. H5 sign light as a marker for maximum water level. The H6 Sign lights as a marker for half the water level of the container. H7 mark lights as markers for minimum water level. To know the water level in the container, it will be shown on the RSView32 Work 100 display. The equipment is used to start/stop the induction motor 1 phase of the
water pump. The simulation is not equipped with the speed setting of 1 phase induction motor. Operation system used to fuse and mcb 1 phase. The materials used are as shown in table 2.

| No. | Component       | Specification       | Amount |
|-----|-----------------|---------------------|--------|
| 1   | Simulator Board | 50cm x 30cm         | 1 pc   |
| 2   | pilot lamp      | Green-red           | 8 pcs  |
| 3   | Fuse            | 2 ampere            | 2 pcs  |
| 4   | MCB 1 phasa     | 2 ampere            | 10 pcs |
| 5   | Relay           | 24 VDC              | 2 pcs  |
| 6   | Contractor      | Schneider            | 2 pcs  |
| 7   | Relay           | -                   | 4 pcs  |
| 8   | Ethernet        | -                   | 10 meter|
| 9   | Cable           | NYAF 0,5mm          | 1 roll |
| 10  | power supply    | VDC                 | 1 pc   |
| 11  | rel rank        | 1 meter             | 1 pc   |

Cables are installed according to the system work function. When the first level switch sends a 24 VDC signal to the PLC, the indicator light will illuminate in accordance with its replacement function, indicating the water level is at 25%. The switch will then be activated sequentially up to 100% level (full water, then sends the input signal to PLC to read and processed to next system) HMI display will show the position of water level in the shelter. For the wiring diagram of Input / Output PLC, and detail of relay/indicator lamp, are shown in figure 4.

2.5. Rockwell Software
Description of the work of this system is a specification of the design of the desired control as follows: The overall display of the system is shown in RSView32. To simulate the water filling, the valve inlet on the diagram in the open position (ON), the intake pump will work. At the water filling position, the valve outlet is closed, and the distribution pump works. Shortly after the water level of 25%, it will be displayed on the screen HMI monitor, distribution pump position and valve outlet not working (OFF). The water level will be shown with the switch as a simulation. Once the water is at its maximum level, the valve outlet opens, and the distribution pump will light up. When water level is sent from the
distribution pump, the intake pump position remains working. When the water level decreases to a height of half the shelter (50%), the system condition is still running normally. If the water level is at minimum height (0%), then the distribution pump will stop working, and the valve outlet will be closed. When the distribution pump turns off, the system will work from the start again. If one or both pumps are experiencing a technical malfunction, then the system will shut down the program automatically.

Figure 4. Wiring Diagram for (a) I/O system and (b) Relay and Indicator Lamp.

Here we will use 7 inputs and 5 outputs. All input outputs are digital input/output with 24VDC discrete voltage. The name and address of the input-output are shown in the following table.

| No. | Input Address | Name Tag | No. | Output Address | Name Tag |
|-----|---------------|----------|-----|---------------|----------|
| 1   | I:O/0         | Level 25 % | 1   | O:O/0         | Pump Intake |
| 2   | I:O/1         | Level 50 % | 2   | O:O/1         | PL Green |
| 3   | I:O/2         | Level 75 % | 3   | O:O/2         | Level 25% |
| 4   | I:O/3         | Level 100%| 4   | O:O/3         | Level 50 % |
| 5   | I:O/17        | Start Button | 5   | O:O/4         | Level 75 % |
| 6   | I:O/18        | Stop Button | 6   | O:O/5         | Level 100% |
|     |               |           | 7   | O:O/6         | Valve Output |
|     |               |           | 8   | O:O/7         | Distribution Pump |
|     |               |           | 9   | O:O/8         | Water Tap |

3. Results and Discussions
Testing was done to check the program that has been made. The control program works based on a conventional water fill system that uses a buoy to insert corrections. From here, we can see the performance of the simulation tool whether it works properly and correctly.

3.1. Normal Operation Test
In normal testing, the system will work when the intake pump and start button has been activated. Then in sequence, the switch is turned on as a water level limit marker. At the time the water is still
within 25%, the distribution pump is not working yet. Up to a height of 100%, then gradually open valve outlets. The distribution pump works within 3 seconds after the open valve outlet. Then lapse 3-second water tap in open position. It appears in Figure that when the intake pump works, it will change color. At this moment, it is simulated that the new water goes into the storage tank. In the figure above, the water position that has entered into the shelter reaches 50% (half full). The HMI display is indicated by the color change in the storage tank. In the picture above, it shows the position of the already full water in the storage tank. The figure also shows the color change of the valve outlet, the distribution pump, and the water indicating the working position. Furthermore, when the water intake pump stops working, then in sequence the position of the water level will decrease. When the water level has run out, then the distribution pump, valve outlet, and water faucet will be off automatically.

3.2. Testing software operations
In software testing, the three software components RSLogix500, RSView32, and RSLinx will be communication with 1 piece of computer/laptop. At RSLogix500, the way of running has been discussed earlier. The experimental in the form of input signal and output (I / O 24 VDC) was done. Here we use 6 inputs and 9 outputs. When the start button is pressed, then the rung will read signals enter. It is characterized by a green discoloration on the XIO rung. At the time of the stop, the button is pressed also happened that way. In the input table, when the button is pressed will read signal enter 1 for digital.

![Figure 5. Pump position at intake](image)

When the water level is full, it will activate the timer on delay (TON). TON works to activate the distribution pump motor after the valve outlet works. The following table shows the Timer On Delay (TON) operand.

| Operand | Type  | Format | Description                  |
|---------|-------|--------|------------------------------|
| Timer   | TIMER | Tag    | Timer format                 |
| Preset  | DINT  | Soon   | How long delay               |
| Accum   | DINT  | Soon   | Millisecond recorded with timer|

4. Conclusions
Systems designed by using switches instead of entering digital data for watertight monitoring can work and send signals to the PLC. Rockwell Software as Allen Bradley's PLC Alliance can work as desired and make it easier to apply PLC. PLC Allen Bradley Micrologic 1400 type 1766-L32BXB used to run and process the data has a lack of unavailability Input / Output analog. As for the CPU unit using 42 VDC. It is required to add a power supply of 220 VAC input and 24 VDC output. To make the view on RSView32 better, it is recommended to use one unit of type RADAR sensor that can send signal enter analog to PLC.
For the development of the system in the next application is expected to use Micrologic 1400 series 1766-L32AWAA or 1766-L32BWAA which has analog I / O socket and enter the 220 VAC power supply.

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