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Automation System of Gallon Filling Valve Based on Outseal PLC and Haiwell Interface

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***Abstract** – Water is one of the basic needs that must be met by humans. To meet drinking needs in urban areas, the easiest and cheapest way for people is to buy refillable drinking water. However, the process of filling drinking water is still done manually by humans, making it prone to errors. Therefore, this study will automate gallon water filling using the Outseal Programmable Logic Controller (PLC) control system and the Haiwell Interface. This system can provide real-time water valve control based on water flow sensors. Control systems using PLCs are also more reliable when compared to using microcontrollers while remaining competitively priced. In this study, a trial will be conducted on a drinking water installation at the Indramayu State Polytechnic (Polindra). Before testing, the flow sensor used must first be calibrated. Calibration is carried out by comparing the results of the flow sensor readings with the PDAM water meter to obtain the conversion of pulses into liters of water. Based on the tests that have been carried out, the results obtained are that the system can work properly, namely the valve and pump turn on when the start button is pressed and will automatically turn off when the sensor has read a water volume of 19 liters. However, the sensor showed different readings when the water sources used had different water flow rates. In the first calibration using PDAM water flow rate, a pulse value of 464 was obtained for 1 liter of water, while in the second calibration using pump water flow rate, a pulse value of 566 was obtained for 1 liter of water. This was caused by the sensor being less sensitive to changes in water flow rate, which resulted in different readings for different water flow rates. Therefore, the sensor must be recalibrated if it is used in a water installation with a different water flow rate. Although the sensor readings were inconsistent, from 40 tests carried out, the difference in readings was less than 10%.*

Keywords – *PLC; Outseal; Haiwell; Gallon Filling Automation; Automation System.*

I. Introduction

WATER is one of the basic human needs that must be met. Humans can only survive without drinking water for three to four days [1]. Drinking water must also meet established quality standards to avoid causing digestive health problems. The need for clean, high-quality drinking water continues to increase in line with population growth and public awareness of the importance of health. High quality and clean drinking water is usually found in upstream areas of rivers where the water quality is still clear. The closer you get to downstream, especially in urban areas, the more deteriorating the water quality becomes. The use of groundwater in urban areas is also prohibited because it can cause long-term land subsidence [2–5]. The only way to meet this water demand is through river water treatment.

However, river water treatment cannot be done individually; it must be carried out by a business entity. Therefore, the refill drinking water business has become a popular and affordable solution to meet this need, especially in urban and densely populated areas. However, the manual refill drinking water filling process often presents several challenges, including a lack of accuracy in filling volume, the potential for contamination due to human interaction, and inefficiencies in time and labor. To improve the efficiency, accuracy, and cleanliness of the drinking water refilling process, the application of automation technology is a promising solution.

Microcontroller technology is often used to automate the water refilling process [6–8]. Microcontrollers are chosen because of their low cost, minimalist design, and relatively good durability. However, microcontrollers are not recommended for larger scale applications. Furthermore, microcontrollers also have several

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limitations in terms of durability and accuracy. Microcontrollers are highly susceptible to vibration, pressure, and high temperatures, which can affect the accuracy of sensor readings [9].

Instead, large industries often use Programmable Logic Controllers (PLCs). PLCs, as an industrial automation device, can control various equipment and processes precisely and flexibly [10–12]. PLCs also have the advantage of being more resistant to vibration, pressure, and higher temperatures than microcontrollers. The use of PLCs in refillable drinking water systems is expected to replace repetitive manual tasks that are prone to human error.

Various studies have demonstrated the potential of PLCs in automating various industrial processes, including liquid filling systems [13–15]. PLC implementation allows precise control of water pumps, solenoid valves, and water level sensors, allowing for accurate and consistent filling volume control. Furthermore, automation systems can be integrated with additional sensors to monitor water quality and detect potential problems early [16–19].

Programmable Logic Controllers (PLCs) have demonstrated significant potential in automating industrial processes, particularly in liquid filling systems. Multiple studies have shown that PLCs enable precise control of water pumps, solenoid valves, and level sensors, resulting in accurate and consistent filling volume control [20–22]. PLC-based systems offer advantages such as flexibility, reduced human intervention, and improved efficiency compared to traditional manual methods [23, 24]. These automated systems can integrate various sensors and actuators to monitor and control the filling process, enhancing productivity and minimizing errors [25, 26]. Furthermore, PLC implementation allows for easy troubleshooting, programming, and system modifications without changing electrical connections [27]. Overall, PLC-based automation in liquid filling systems offers benefits including lower operational costs, reduced power consumption, and increased accuracy across various industries such as beverages, pharmaceuticals, and chemicals.

Despite the significant potential of PLC-based automation in the refillable drinking water industry, its implementation at the small and medium enterprise level remains limited. This is likely due to various factors, including initial investment costs, lack of knowledge and skills in operating and maintaining PLC systems, and a lack of information regarding the design and implementation of automation systems appropriate to their business scale.

Programmable Logic Controllers (PLCs) offer significant potential for automating water filling and treatment processes in small to medium-scale industries. PLC-based systems can improve efficiency, reduce operational costs, and enhance water management capabilities [23, 28]. These systems typically incorporate sensors, pumps, and conveyor belts to automate bottle detection, filling, and movement [24, 29]. PLCs can be integrated with SCADA interfaces for real-time monitoring and control [30]. They are particularly useful in water purification plants, where they can automate various treatment stages and ensure water quality [31]. PLC-based automation offers advantages such as lower power consumption, reduced maintenance, and increased accuracy compared to traditional methods [32, 33]. However, the implementation of these systems may be limited by factors such as initial investment costs and the need for specialized knowledge in PLC programming and maintenance.

Therefore, this research will design and implement an effective and efficient PLC-based refillable drinking water automation system. This research is expected to contribute to improving the quality, productivity, and competitiveness of refillable drinking water businesses, as well as providing practical guidance for business owners in adopting automation technology. Furthermore, this research is also expected to identify challenges and opportunities in implementing PLC-based automation systems in the context of refillable drinking water businesses.

II. Research Methods

Briefly, the stages in this research can be explained in the flowchart below. The research began with a literature review to determine what methods are commonly used in the water filling automation process. After

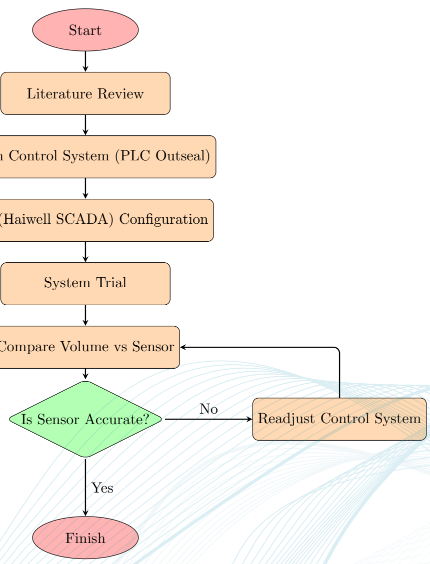

Figure 1: Research Flowchart

obtaining the appropriate method, the next stage was to design an automatic water filling control system. The control system used in this research is Outseal PLC. Then, for the HMI used from the PLC is Haiwell SCADA which functions to control and monitor the filled water. After the control system is completed, the next step is to conduct a system trial. The trial is carried out by comparing the volume of flowing water with the results of the sensor readings. If the results of the sensor readings differ from the volume of water flow rate, then the control system will be readjusted. If it is appropriate, the research process is complete.

The control system to be created can be seen in the block diagram below. The Haiwell HMI monitors water volume and controls the valve to open the flow. The flow sensor then reads the volume of water that has been released, and the PLC automatically closes the valve when the volume reaches the set point.

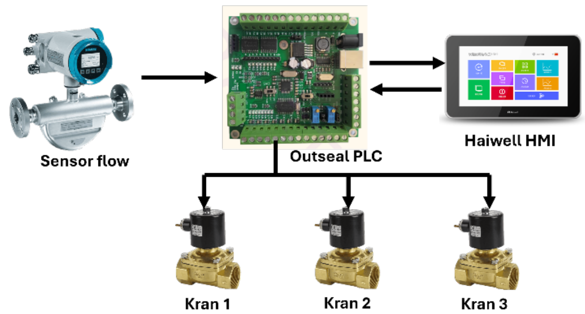

Figure 2: Automatic Water Filling Block Diagram

As can be seen in the block diagram, the water volume will be read by the flow sensor. The sensor works by reading pulses based on the rotation of the propeller on the sensor, then the read pulse value can be converted into a water volume value. Before it can be used, the sensor must be calibrated first, by comparing the flow sensor readings with a verified Perusahaan Daerah Air Minum (PDAM) water meter.

The equation used to convert pulse values into volume is as follows:

$$\text{Volume} = n \times \text{Pulses} \tag{1}$$

where n is the calibration coefficient obtained from comparison with the PDAM water meter [34].

The device's operating principle is as follows: The user enters the available volume on the HMI display. This value is adjusted to reflect the gallons to be refilled. The pump then automatically turns on, and the water valve opens. When the PLC calculates that the flowing water volume has reached the input volume, the pump automatically shuts off, and the water valve closes.

III. Results and Discussion

The sensor used is a propeller type, where the propeller will rotate and produce a pulse when water passes through it. The sensor must first be calibrated using a verified PDAM water meter. Calibration is carried out by reading the pulse produced by the sensor when the PDAM water meter measures 1 liter of water. Then the experiment was repeated 40 times and obtained the following results.

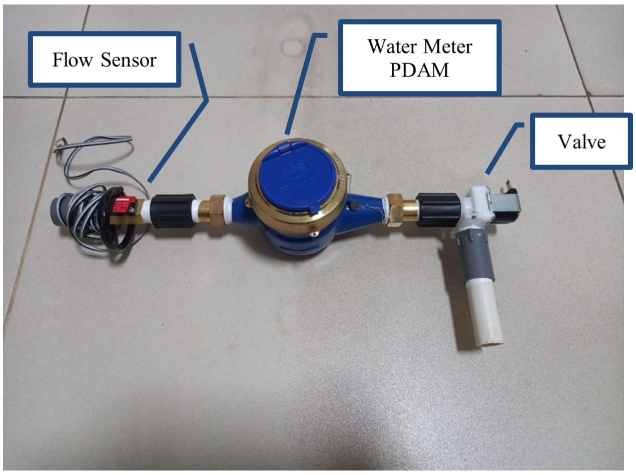

Figure 3: Flow Sensor Calibration Setup

The calibration was carried out twice with different water sources. The first experiment was carried out with water from PDAM, while the second experiment was carried out with water from the Politeknik Negeri Indramayu (Polindra) refill water installation.

Based on the first tests that have been carried out, the average pulse value for 1 liter of water is 464 pulses. The second test was also conducted 40 times and showed a higher reading compared to the PDAM

Figure 4: Calibration at the Polindra Drinking Water Plant

Table 1: Flow Sensor Pulse Test Results

No	PDAM Water Meter	Water Flow Sensor
1	1 Liter	464
2	1 Liter	470
3	1 Liter	466
4	1 Liter	459
5	1 Liter	458
6	1 Liter	431
7	1 Liter	469
8	1 Liter	490
9	1 Liter	437
10	1 Liter	440
11	1 Liter	467
12	1 Liter	446
13	1 Liter	452
14	1 Liter	465
15	1 Liter	432
16	1 Liter	430
17	1 Liter	491
18	1 Liter	485
19	1 Liter	447
20	1 Liter	472
21	1 Liter	454
22	1 Liter	484
23	1 Liter	457
24	1 Liter	466
25	1 Liter	460
26	1 Liter	478
27	1 Liter	481
28	1 Liter	449
29	1 Liter	476
30	1 Liter	469
31	1 Liter	478
32	1 Liter	481
33	1 Liter	475
34	1 Liter	487
35	1 Liter	473
36	1 Liter	460
37	1 Liter	458
38	1 Liter	454
39	1 Liter	486
40	1 Liter	459

water source. The second test showed that 1 liter of water is equivalent to 566 pulses read by the sensor.

Both test results showed that the pulses generated by the sensor were inconsistent. This inconsistent result was due to the sensor's operating principle, which is based on propeller rotation, and is therefore heavily influenced by turbulence. Additionally, if the water flow rate passing through the sensor is not the same, the sensor will display a different reading, as shown in the second experiment, which had a greater water flow rate than the first experiment, resulting in a larger pulse reading.

This is due to the sensor's poor reading sensitivity, resulting in unequal readings for different water flows. The pulse value obtained is not consistent but is still within reasonable limits; the difference is under 10% and the standard deviation is 15.53.

The pulse value obtained is then used to determine the n value in Equation (1), so that the n value is $1/464$ Liter per pulse. Then, we enter this value into the program to read the volume of water passing through.

Besides using Equation (1), we can also determine the water volume by using the scale function in Outseal Studio.

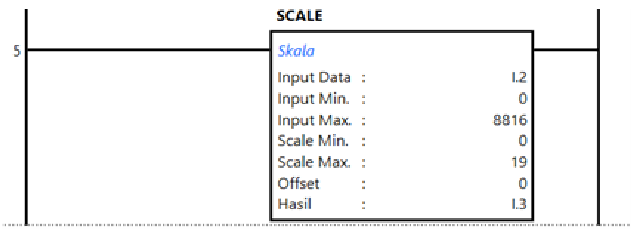

Figure 5: Scale Function on Outseal Studio

The Input Min. is the minimum pulse value read, while the Input Max. is the maximum pulse value read. After the calibration process, it is known that 1 liter of water will equal 464 pulses. So, for 19 liters of water, the Input Max. is 8816 pulses, and the Input Min. is 0. The pulse value will be scaled to 0 to 19 liters by entering the Scale Max. value of 19 and the Scale Min. value of 0.

In general, the ladder diagram for reading the flow sensor using Outseal can be shown in Figure 6. The flow sensor pulse value is read using the RHSCU function block, but first it must be initialized with the WHSCU function block to provide the initial value. Then the pulse value read on the L.2 line is copied to bit I.2 using the COPY function block. Bit I.2 is then scaled using the SCALE function block. Finally, the GEQ function block is used to determine the condition of the motor and valve when the input value has been reached.

The PLC that has been created and programmed is then interfaced with Haiwell SCADA. The Haiwell SCADA screen will display several functions such as buttons to turn on and off the pump and valve, an indicator for active valves, and an indicator for the volume of water filled.

The system trial was conducted at the Politeknik Negeri Indramayu (Polindra) drinking water filling unit.

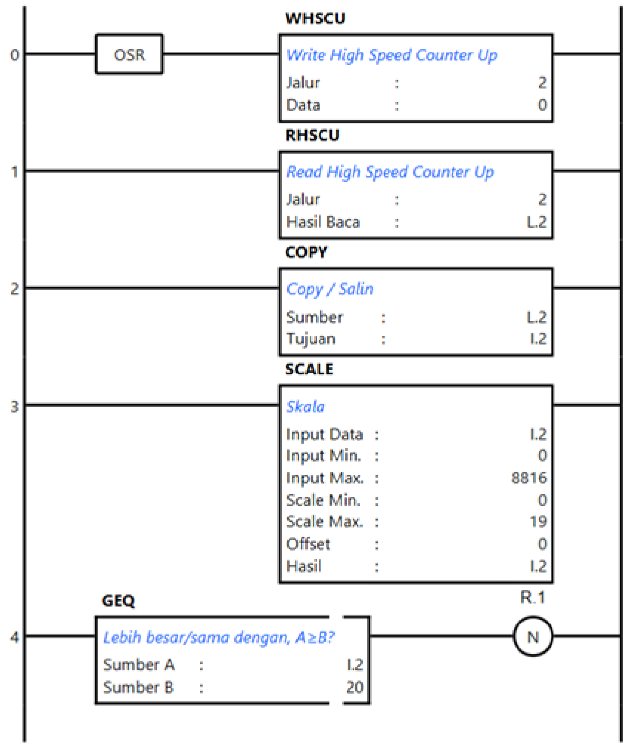

Figure 6: Ladder Diagram of Flow Sensor Readings

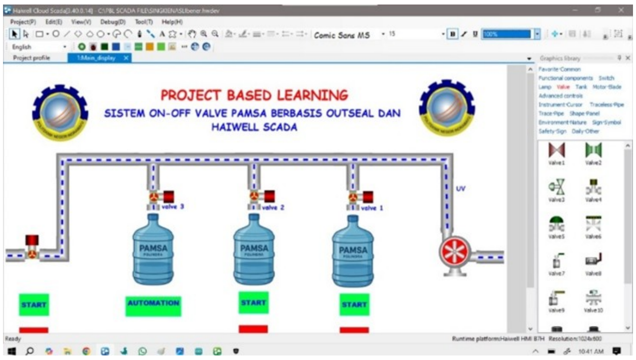

Figure 7: Haiwell SCADA HMI Display

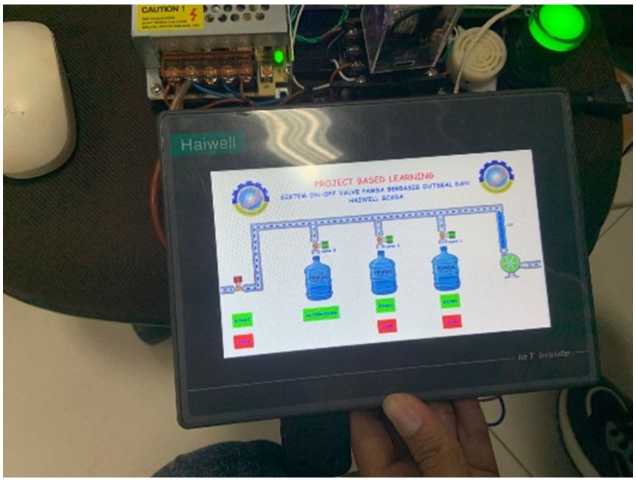

Figure 8: Gallon Filling Test Using Haiwell SCADA HMI Commands

The unit has three valves for filling gallons, one valve for cleaning gallons, and one pump. It also has a UV lamp for water sterilization. The automation trial will only be conducted on one valve to avoid disrupting the production process.

The testing process begins by activating the system through the SCADA interface. When the ON button on the interface is pressed, the valve opens and water flows into the gallon jug. The flow meter measures and records the accumulated water volume in real time, which is then transmitted to the PLC, which continuously compares it to the target volume limit of 19 liters. When the water volume reaches 19 liters, the PLC issues a logic command to deactivate the output signal, which then causes the valve to automatically close. The valve's operational status is immediately displayed on the SCADA interface as *Off*, indicating that the filling process is complete.

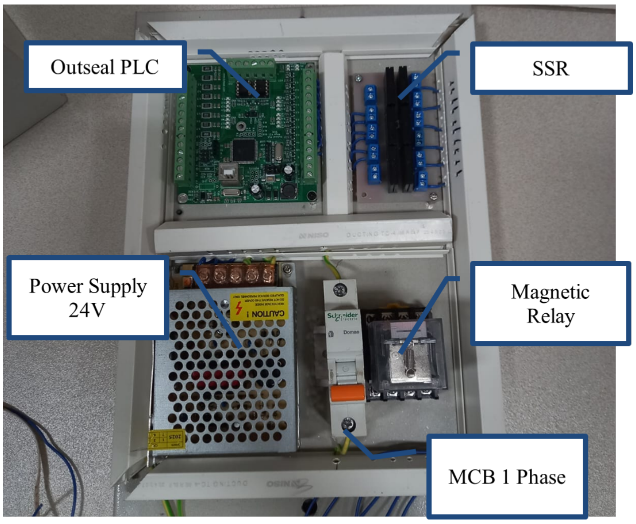

Figure 9: Outseal PLC Control Circuit

The HMI and control circuits that have been made are then arranged into a panel box to make it neater, as shown in the following picture.

The control system generally consists of a power supply that supplies voltage to the Outseal and relay. This system uses two types of relays: solid-state relays and magnetic relays. Solid-state relays are used to control valve loads, while magnetic relays are used to control pump loads. Furthermore, this system is also equipped with a safety system in the form of a single-phase MCB.

IV. Conclusion

Based on the research conducted, the results obtained are that the control system can work well, namely the valve will open when the start button is pressed and will automatically turn off when the sensor has calculated a volume of 19 liters.

However, sensor accuracy remains a major obstacle in this research. The flow sensor used is very susceptible to turbulence and produces different readings for different water flow rates. The higher the water flow rate used, the greater the sensor reading will be. In the first experiment with a standard PDAM water flow rate, a pulse value of 464 was obtained for 1 liter of water. Meanwhile, in the second experiment with a faster water flow rate, a pulse value of 566 was obtained for 1 liter of water.

Therefore, the sensor must always be calibrated for different water sources. After calibration, the difference in measurement results between the sensor and the PDAM water meter showed a difference of less than 10%. Therefore, this tool can replace the process of filling gallons that were previously done manually.

In general, control systems using PLCs or microcontrollers, the accuracy of the readings is highly determined by the sensor used. Therefore, future research is to strive for the best water flow sensor with the most accurate readings. However, a PLC control system has advantages in its resistance to temperature, vibration, and pressure compared to a microcontroller. Furthermore, further research will develop the system to connect to the Internet of Things (IoT).

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