

# Automation Systems for Regeneration Process of Demin Water to Maintain Quality Control using Programmable Logic Controller

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**Abstract**—The development of technology and the increasing demand for the quality, making all production systems in automotive manufacturing company should go well and a small error rate. Similarly, the control system that controls the plant utilities regeneration process of demin water. Demin water regeneration process is repeated water washing process to be demin water, which will be used in preventing rust on the body of the car, should be in good condition. The timing on regeneration demin water is still done manually by the operator, in which fewer mistakes are made by an operator in setting the time will lead to the difference of time of a predetermined time standard. This will lead to the greater difference in time that happens, so it will affect the final quality of the demin water. Therefore, to overcome these problems it is necessary to make a new control system in the form of automation in the process of regeneration of demin water. Control device used is a PLC (Programmable Logic Controller) that uses Omron PLC Sysmac CPM - 1A. In making this new control system has been carried out field observations , literature study , interviews with operators , group leaders , supervisors , analysis -related, design and manufacture of electrical and programs as well as some testing . The automation system can prevent operator error in setting the time manually with a time difference of standard is 0 minutes. Subsequently, the final quality demin water be guaranteed with no air bubbles marked when the water is heated to 100 ° C.

**Keywords**— regeneration process, demin water, automation, PLC (Programmable Logic Controller)

## I. INTRODUCTION

In a company engaged in automotive manufacturing, especially the four-wheeled vehicles assemble (Authorized Automotive General Assembler), there is a production process that includes: Welding, Painting and Assembly. The development of technology and the increasing demand for quality, making all production systems in these companies should go well with a small error rate. Good production process should be supported by the control system operated in accordance with the standard of work that has been determined.

Similarly, the control system that controls the plant utilities demin water regeneration process. Demin water regeneration process is repeated water washing process to be demin water, which will be used in preventing rust on the body of the car, should be in good condition. Things that affect the final quality of the process are setting the time on every stage of the process. Accuracy in the timing of this process is not always in accordance with the standards specified time. Occurs due to the time difference the timing is still operated manually by the operator accuracy in estimating time corresponding to the standard, the greater the difference in time that happen it is very influential on the quality of the end result of demin water.

To overcome these problems then, it is necessary to turn a new control system that can control the time at this stage of the regeneration process automatically demin water. The control system is made to be flexible (if it will

be improving the suitability or modification), available in the market, and must consider the affordability aspect, namely by using a PLC (Programmable Logic Controller) which uses PLC OMRON Sysmac CPM - 1A. Substitution control system is expected to cope with the possibility of error by the operator in setting the time manually, so there is no time difference occurs and the accuracy of the final quality demin water is guaranteed.

This study will discuss how to design and make the control system to run the regeneration of demin water without the need to set the time manually, which is adapted to the sequential process and the safety of work processes, as well as how the regeneration of demin water is controlled by PLC Omron Sysmac CPM - 1A, lapse of time can lessen the occurrence of the desired standard. Previously, we have researched about control system by using PLC [1, 2, 3, 4, and 5].

## II. BASIC THEORY

### A. Understanding Demin Water

Demin water is water that is made of a water purification process and free from minerals dissolved in water. Minerals dissolved in the water is a smaller number of minerals in solution, some examples are salt and sugar.

In the laboratory water with aqua demin-called distilata, its function is to wash laboratory equipment or as a mixer / solvent chemicals. In the automotive world demin water commonly called water batteries whose utility is to

add water to the battery. Due to the nature of the minerals in the demin water very small then it can not lead to a "surge" on batteries and can extend the battery life of the vehicle. In addition demin water can also be used to charge the vehicle radiator so the radiator free from rust and can be used in the pre-treatment process at the plant painting (paint area) to prevent rust on the body of the car.

#### B. Water Purification Process (Demineralization)

Water purification process there is some kind of one of them is by way of demineralization / binding of the chemical elements. Demineralization process is the removal of minerals dissolved in the water, positive and negative charges in the water are bound to chemicals called cations and anions. Demineralization works according to the principle of ion exchange. Demin Plant generally consists of two ion exchange tank, the tank swap cations for H<sup>+</sup> ions and anions tank to exchange OH<sup>-</sup> ions. How it works demin plant are as follows:

- Cation exchange positive ions in water such as Ca, Mg, Na with H<sup>+</sup> ions.
- Water discharged from acidic cation.
- Anion exchange of negative ions in water such as Cl, SO<sub>4</sub>, SiO<sub>2</sub> with OH<sup>-</sup> ions.
- If Conductivity (ion concentration measurement tool) gained  $\geq 5$  microseconds said saturated units.
- If the unit is already saturated necessary to regenerate / re-washing process with chemicals such as NaOH and HCL that the ion exchange process is still going well.

#### C. The regeneration Mechanism Demin Water

In general, the regeneration process is driven by demin water solenoid valve, solenoid valve on the magnetic field generated is used to drive the valves or valve solenoid valve that serves as a water faucet in the open condition. So when the electrified coil occurs around the magnetic field between two solenoids and solenoid core is given that can move freely up and down, core or cores made of materials that can be pulled by a magnet so that when the magnetic field around the coil core is attracted to above .

Core that can move up and down is connected to the valve or valve so that if the valve core and above interested also attracted significant upward solenoid valve in an open state. Conversely, if the current in the coil is switched off then the magnetic field around the coil will also be lost and the iron core moves down as pressure mounted by spring force opposite to the direction of the magnetic field coils. This spring force pushing the valve cover and block the flow rate, so that the solenoid valve will be closed.

### III. DESIGN

#### A. Sequential process of regeneration work demin water before repair

Regeneration demin water process in automotive manufacturing company consists of 4 steps; include regeneration of cation / anion, slow rinse cation / anion, cation fast rinse, fast rinse anion. Each step has a different

time standards and standard sized mixing of different chemical compounds.

#### Step 1 (Regenerating Cation / Anion)

The first step in the process is the demin water regeneration process Cation / Anion. This process is operated by making sure all the inputs and outputs of a process that does not include the regeneration of demin water off, as follows:

- Close the faucet to fill the tank and valve of PAM
- Turn off the switch for the pump of PAM, CO<sub>2</sub>, and for the contents to the tank
- Turn off the switch operations waste
- Conductivity already reached 5 $\mu$ s

#### Step 2 (Slow Rinse Cation / Anion)

The second step in the regeneration of demin water is Slow Process Rinse Cation / Anion. This process is operated after the regeneration of the cation / anion has been completed, as well as ensuring the input and output of the regeneration of the cation / anion has been off. After that, give input via selector switch for step 2 and Pump 3 contained in the panel, then takes place using the compound NaOH washing with 200 litres, 430 litres HCL, and Demin Water 1500 litres. This mixing process lasted for 50 minutes and then discharged to the leaching process Waste Water Treatment (WWT) to process waste operations. The goal of Slow Rinse cation / anion is to wash the rest of HCL and NaOH are there in the cation / anion, this process uses 4 valve includes valve 51, valve 85, valve 83, and valve 49.

#### Step 3 (Fast Rinse Cations)

The third step in the process of regeneration is the Fast Rinse Demin water cations. This process is operated after the slow rinse cation / anion has been completed, as well as ensuring the input and output of a process of slow rinse cation / anion has been off. After that, give input via selector switch for step 3 and Pump 3 contained in the panel, then a process of leaching by demin water 10000 litres. This mixing process lasted for 10 minutes and then discharged to the leaching process Waste Water Treatment (WWT) to process waste operations. The purpose of Fast Rinse cation is to eliminate the remnants of the regeneration solution trapped in the cation resin. This process uses two valves, i.e: valve 48, and valve 52. In this process, setting valve 48 still operated manually by the operator by turning the valve. It is because the automatic valve is damaged and can not replace the maintenance and repair due to a series of automated data documentation lost of previous PLC UN 11.7. Therefore the valve is replaced with a manual valve.

#### Step 4 (Fast Rinse Anion)

The fourth step in the process of regeneration is the Fast Rinse Demin water anions. This process is operated after the Fast rinse cation has been completed, as well as ensuring the input and output of the cation has been fast rinse off. After that, give input via selector switch for step 4 and Pump 3 contained in the panel, then a process of leaching by Demin Water 6000 litres. This mixing process lasts for 60 minutes or until the above 5 microseconds

Conductivity and pH of approximately 6-7. Then, discharged to the leaching process Waste Water Treatment (WWT) in process waste operations. The purpose of Fast Rinse Anion resin is to wash, where the process is using the 2 valve covers valve 86, and valve 82. In this process, setting valve 82 is the same as the third step, which is still operated manually by the operator by turning the valve. It is because the automatic valve is damaged. It can not replace the maintenance and repair due to a series of automated data documentation lost of previous PLC UN 11.7, therefore the valve is replaced with a manual faucet.

### B. Problems in Regeneration Process Demin Water

Regeneration process Demin Water produced directly in automotive manufacturing company plant division 1 utility area. The control system in the regulation time in the regeneration of the demin water previously operated automatically using PLC UN 11.7 produced Durr, but the PLC is damaged. It can not be repaired and is not produced anymore; the data and drawing electrical circuit PLC system demin water regeneration panel has been lost. It is difficult to carry out maintenance repairs if there is a problem, so the control system using PLC was changed to use a manual system to move the selector switch solenoid valve.

Manual control system on demin water regeneration process consists of 4 steps with different time settings complicate the operator in demin water regeneration process manually. Experienced operator Idle Power Man, because it requires that the operator is always in the area until the regeneration is complete, this is due to the time that has been standardized to be precise, so the accuracy of the final quality demin water regeneration should be guaranteed. In addition, operators are also easily influenced by the decrease in concentration at work, feeling tired, and other circumstances, so it is in fact based on the data obtained in the field, the average time has been estimated by the operator is not always accordance with the standards specified time.

It does not affect the final quality demin water, due to the difference in the time difference with the standard specified time is still small, but the longer the control system is used, the greater the possibility of operator error in estimating the time and the greater the difference in the time that happens so very influential on the quality the end result of demin water. It required a replacement engine control system using this type of control system that is flexible, available at the company, and can control the regeneration of demin water automatically.

### C. The Specifications

In turn and manufacture of new control systems on the regeneration of the demin water, automotive manufacturing company has determined the specifications required to make the control system tailored to the needs of the working process of the regeneration area demin water, which is as follows:

- Substitution control system in the regeneration process demin water using a control device such as a PLC (Programmable Logic Controller).

- The control system uses PLC can be used to operate the machine automatically demin water regeneration. As well as the addition of a manual system this is controlled directly by the PLC.
- If necessary modifications or turn on the PLC system, not complicate maintenance and does not exceed 1.5 hours.
- System timing in the regeneration process by timer dkontrol demin water contained in the PLC.
- The timing is controlled by the PLC is in the process of regeneration of demin water must comply with the standard of work that is 150 minutes.
- PLC used is contained in the company and in accordance with the number of inputs and outputs that will be used is Sysmac CPM Omron PLC - 1 A with type 30 CDR - A - V1, which has 30 terminal I / O, I / O modules can be plus, current 0.6 A, has a 100-240 volt AC Operational voltage and the output voltage 24 volts DC.
- Process Automation in demin water regeneration can be done with only 2 input. Ie Button Start and Auto Switch.
- The system uses PLC should be able to drive the output of the solenoid valve with AC voltage of 24 volts.
- Can be integrated with other systems.
- It takes a warning sign for the operator if the process has been completed.
- The process of regeneration work to be sequential demin water during operation using the control system.

### D. Design Concept

To meet the above specifications, we design a concept in the making of a new control system using PLC automation. Figure 7 shows an illustration concept design using PLC control circuit.

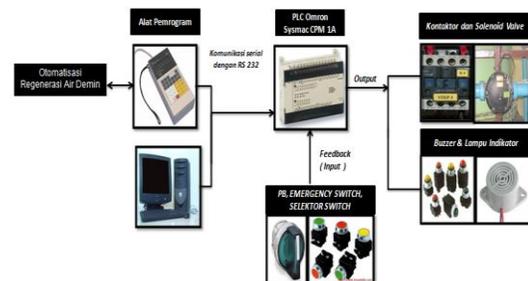


Figure 7. Illustration of the concept of control circuit design using PLC

PLC control system made by Omron Sysmac CPM - 1A is programmed with a PC or console. The working principle of what happens when an operator operate the regeneration of demin water, the operator presses the push button voltage source and switch the auto- regeneration and pressing the push button auto to give input and command on the PLC to move / turn on the output of solenoid valves, contactors, lamps indicator, and buzzer [5, 6, 7, 8, 9, and 10].

The order is then received by PLC Omron CPM - 1A Sysmac programmed via PC with software such as CX - Programmer or console is a tool programmer's use

language mnemonic. The order will be processed by the PLC. If the command line with the PLC program will execute to turn off or turn on the output.

Once the execution is done then the PLC reads the status of the output is dead or flame. Then the PLC will provide information on the output of the solenoid valve, contactor, indicator lights, and a buzzer, which indicates that the output status in accordance with the commands that have been programmed. The design of the tool is expected to solve problems that occur in the process of regeneration demin water to avoid possible errors in setting the time manually by the operator and allows an operator to operate the machine without experiencing idle man power. Based on the specification of the required field and then be made to the draft concept design demin water regeneration process controller with specification tools:

- Using Omron PLC Sysmac CPM - 1A with type 1 and 30 CDR-A-V 220volt AC operating voltage and the output voltage is 24 volts DC.
- Using 7 pieces of contactor as the output device specification voltage 220-230 volts.
- Using 1 selector switch for automatic or manual mode, and 4 selector switch, as the input of demin water regeneration process manually but not directly controlled by a PLC which has a voltage of 220 volts.
- Using the Push Button 1, for the input modes operate automatically in demin water regeneration process with a voltage of 220 volts.
- Using the Buzzer and light indicator with a voltage of 220 volts as well as the output device, a warning sign for the operator.
- Using the CX - Programmer 8.1 as the software and hardware in the console as programming.
- Using RS232 DB9 serial connector to connect to either a PC programming tool or consoles.

#### IV. TESTING

Programs that have been made to go through the testing stage, either the hardware or its software. The purpose of the test itself is to find a variety of potential causes of system failure or. Basically the manufacture of control systems using PLC, the largest percentage of system failures comes from the input PLC, actuators and wiring connections, rather than a failure caused by an internal error of the PLC itself. Therefore, the test is not only focused on testing the program but also the testing of input and output devices and other external factors. Tests conducted in this thesis is once a week for three months after a change of control systems. Here is some of the testing that has been done.

##### *A. Testing of Cycle Process*

In this process cycle testing conformance testing program that has been created to cycle processes and specifications desired program.

##### *B. Difference in standard time after repairs*

The main objective in conducting the turn system controls the regeneration process is the demin water to prevent or eliminate the possibility of a lapse of time of labor standards that have been determined.

#### V. CONCLUSIONS

Automation of the process of regeneration of demin water designed and fabricated using Omron PLC Sysmac CPM-1A is functioning properly with the timing is controlled directly by the PLC, and in accordance with the sequential and safety of the work process. The programming use Omron PLC CPM-1A Sysmac by ladder language and mnemonic with the help of a PC or a console programmer tool. Omron PLC Control System using CPM-1A Sysmac 7 input activates a push button, selector switches and 11 outputs to activate the motor contactors, solenoid valve, indicator light, and buzzer. Through timing of PLC controlled directly by the lapse of time which happens to be 0 minutes and the final quality assured demin water with no air bubbles marked when water is heated 100 °C.

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