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Interlock in Software in CED Paint Shop for Cost and Quality Improvement

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Abstract— **The purpose of this paper is to present an automation based on Programmable Logic Controller in CED paint shop for cost and quality improvement of the shop. Cathode Electrode Deposition (CED) paint shop has major role in automobile industry. There are various processes are involved for proper cleaning and painting of the vehicle. Some processes in CED paint shop controlled by manually therefore this manual control can affects the production quality .Some processes also causes wastage of available resources e.g. water wastage, this affects the cost.**

Therefore, Cost and Quality improvement is an important issue in the CED Paint Shop. Therefore, automation solution can be provided using programmable logic controller (PLC). The benefit of this automation to have auto control of processes and removal of need of manual control. Programmable logic Controller is used for water auto addition and spray ON/OFF confirmation for cost and quality improvement of CED paint shop in automobile industry.

Keywords—Cathode Electro deposition(CED), PLC,Water auto addition, Spray ON/OFF confirmation.

I. INTRODUCTION

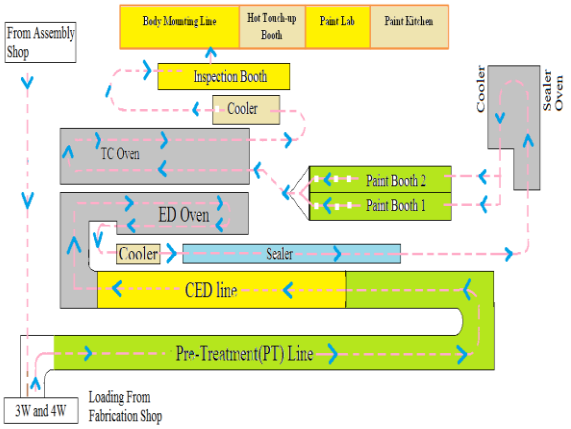


Figure 1: Layout of the paint shop

CED paint shop plays vital role for perfect color coating on the vehicle body in automobile industry. Quality of the paint coating is depends on the many processes in the CED paint shop. For perfect coating of paint on the vehicle body, cleaning of vehicle body must be done properly.

In CED paint shop, vehicle passes through the PT processes i.e. pre-treatment processes before CED.PT line is very useful to remove impurities from vehicle body which is important for perfect coating of paint on the vehicle body. There are twelve processes in Pre-treatment line i.e. for cleaning processes of vehicle:1) Hot water rinse 2) Pre-degrease 3) Degrease 4) Water rinse 1(WR1) 5)Water rinse 2(WR2) 6) Activation 7) Phosphating 8) Dip water rinse 9) Passivation 10) DM water rinse(PTRCDM) 11) Fresh water DM spray 12) Pre-drain after PT. There are five processes are involved in CED line for primer coating :1) Cathodic Electro deposition (CED) 2) UF1 spray 3)UF 2 rinse 4) UF3 spray 5) DM water sprays (EDRCDM).

Pre-treatment and CED processes use water for cleaning processes. Manual control of this processes cause water wastage and quality degradation. Also, there are some quality issues if vehicle passes without proper spraying. Therefore, there is scope of quality improvement and cost saving by using automation for 1) Water auto addition 2) Spray ON/OFF confirmation.

To achieve this control and automation techniques can be used.

II. METHODS USED FOR AUTOMATION

A. Conventional Methods for industrial Automation

1)Manual control

In this manual control, automation and control operations are carried by manual operations i.e. it requires human resource for control .But this method has some drawbacks:

- End product quality is affected due to human errors.
- Contactors and relays together with timers and counters were used for achieving desired level of automation.
- It requires hard wired logic control therefore complex and bulky system.
- It is very difficult task to implement some changes in the system.
- It requires more space

2) Control using logic gates

In this, contactors and relays together with timers and counters used in manual control replaced with logic gates and electronic timers in control circuitry. It has advantages over manual control

- It has lesser complexity and bulkiness as compared to manual control.
- It has reduced space requirement, less maintenance and energy saving.

But this method also has drawbacks:

- Implementation of changes in control logic is not possible.

3) Programmable Logic Controller (PLC) for automation

Use of PLC for automation, gives combination of relay control system and computer technology.PLC interacts with world through its inputs and outputs. Control actions are taken according to logic operations performed by the PLC. It has advantages over all conventional methods:

- PLC has ease of installation, very flexible for industrial application.
- Instead of using physical wiring with control devices, control is achieved using programming.
- It has reduced space requirement, energy saving, cost effective, greater life and high reliability.

B. PLC for industrial automation

Programmable logic controller is used for conditional monitoring of AC motors due to its accuracy, cost effectiveness and safety than classical methods [1]. In pharmaceutical industry, water storage and distribution system is PH, flow control, conductivity, pressure and level controlled by PLC [2]. To make beer filling production line automatic and efficient, PLC is used. According to control procedures designed in the PLC ,motors and solenoid valves are operated and control action taken place [3].Control of boiler operations is changed from manually to automatic using PLC [4].Performance of the induction motor system driven by inverter and controlled by PLC gives higher accuracy in speed regulation compared to conventional system [5]. PLC based system for ignition of the gas and oil fired appliances provides level of safety, stability and reliability [6].

Therfore due to safety ,reliablity, accuracy and energy saving issues PLC is best choice for industrial automation.

III. PRAPOSED WORK

In this proposed system, cost and quality improvement is done by providing automation solution at different stages of CED paint shop. There is scope of water saving at water rinse 2, PTRCDM and EDRCDM stage by using auto addition only when vehicle present in the tank. Spray ON/OFF confirmation is required for quality improvement of the vehicle. Sometimes, conveyer is running and vehicle present in the tank but sprays are in OFF state. Because of this vehicles passes to the next stage without proper cleaning .This affects the coating of paint on the vehicle. Therefore, spray ON/OFF confirmation is required. The system is developed using PLC for auto addition of water for water saving and spray ON/OFF confirmation for quality improvement.

This proposed system consists of two parts 1) Power circuit and 2) control circuit.

Power circuitry provides power for operation of the control circuit and working of the input and output devices. MCB is used to protect circuit from an overcurrent.MCB interrupts an electrical flow through the circuit once fault is detected.230V AC input is given to the SMPS for operation of control circuitry.

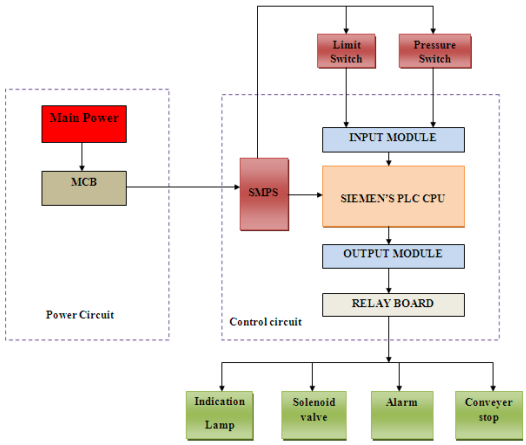


Figure 2: Block diagram of proposed work

SMPS gives 24 V DC outputs, which is applied to CPU of the PLC.SMPS also provides an input to the limit switch and pressure switch. Output of the sensors given to input module of the PLC.PLC performs operation according logic of the programming. Output bit set according result of the logic operation. ON/OFF output signal is send via output module. Output module gives only 24V DC ON/OFF output. This voltage is not sufficient for working of the output devices e.g. solenoid valve requires 230 V AC. Therefore relays are used. Control relays are used to control high voltage using low voltage. Output of the output module given to the solid state relay, this gives indication of the ON/OFF of the output. Then output of solid state relay applied to electromechanical relay which gives 230V AC output which is applied to output device.

IV. HARDWARE DESCRIPTION

A. SIEMEN's PLC S7 300

There are number of PLC's are available in the market. Programmable logic controller consists of Input and output modules, power supply, processor and programming device.

- Input module: Input module carries input signal from sensors to the controller.
- Output module: Output module sends output signal from controller to output devices.
- Power supply: The power supply provides power to the PLC system. The power supplies power to processor logic circuitry and input and output modules. Most common power used are 24V DC or 120VAC

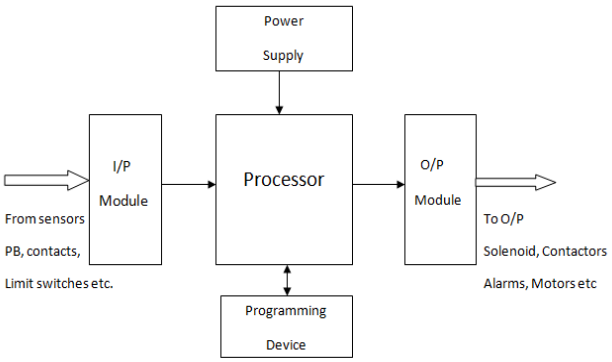


Figure 3: Main components of the PLC

- Processor: Processor is the brain of the PLC. Functions available for programming, available size for application logic, available memory, processing speed is depend upon the size and type of the PLC.
- Programming device: PLC is programmed using special software for PLC programming. Programming is done in the PC or Laptop and then program is downloaded into the PLC.

For this system, Siemens s7 313c CPU is used, which is having 32kb integrated memory. Power supply of 24V DC is given to the CPU by using Siemen's SMPS. Digital signal module SM 322 DO 32xDC24V/0.5A is having 32 digital input/output in the isolated group of 8.This module is suitable for solenoid valve, DC contactors and signal lamps. Interface module IM365 is used for interface between two racks i.e. in between rack 0 and 1[7].

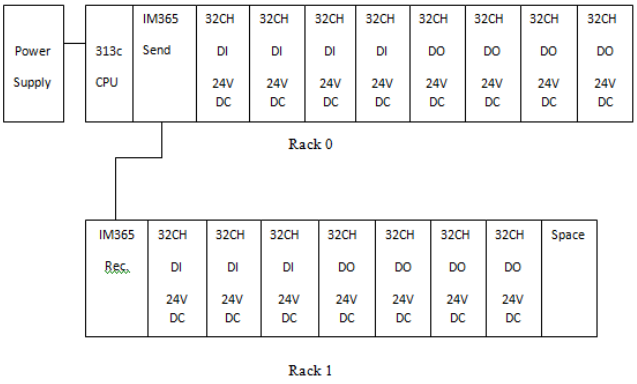


Figure 4: input and output module arrangement in panel

B. Limit switch

Limit switches consist of a switch body and a operating head. Switch body consist of electrical contacts to energize and de-energize a circuit. Operating head includes some type of lever arm or plunger, referred as actuator. Limit switch is mechanical device that uses physical contact to detect presence of an object. When an object comes into contact of actuator, actuator moves from its normal position to operating position. This mechanical operation activates the contacts within the switching body. The device operates the contacts to make or break an electrical connection.

Figure 5: Limit switch

C. Relays

A relay is an electromagnetic switch with set of contacts. Switching is done by electromagnetic operation of the coil. Relays are used when it is necessary to control a high power or high voltage circuit with low power circuit.

Figure 6: Solid state relay

Output of the relay depends upon the contacts closed NC,NO,COM.

D. Solenoid valve

Solenoid valve makes automation of the fluid and gas control possible. Opening and closing of an solenoid valve is controlled by electric current which is passing through the coil. When coil is energized, a magnetic field is created which causes a plunger to change its position depending on the design of the valve the plunger will either open or close the valve

E. Pressure switch

A pressure switch is a switch that closes an electrical contact when a certain set pressure has been reach on its i/p. The switch may be design to make contact either on pressure rise or on pressure fall.

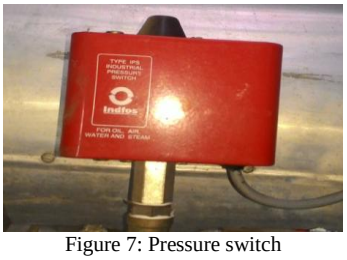


Figure 7: Pressure switch

V. SOFTWARE DESCRIPTION

STEP 7 is the basic programming and configuration software for SIMATIC. It consists of a series of applications, each of which does a specific job within the scope of programming an automation task, such as:

- Configuring and assigning parameters to the hardware
- Creating and debugging user programs
- Configuring networks and connections

A STEP 7 project is divided up into folders and objects. Objects which can contain other folders and objects are known as folders, STEP 7 consist of blocks for ease of programming.

- Organization block (OB): Organization blocks (OBs) represent the interface between the operating system and the user program.
- Function (FC): Function allows to pass parameters in the user program which means they are suitable for programming complex function that are required frequently. But do not have memory.
- Function block (FB):Function allows to pass parameters in the user program which means they are suitable for programming complex function that are required frequently.
- Data Block (DB): The data block (DB) is a block in which you can.

The programming languages Ladder Logic, Statement List, and Function Block Diagram for S7-300 are an integral part of the standard package.

Ladder Logic (LAD) is programming language which uses graphic representation for programming. Its syntax for the instructions is similar to a relay ladder logic diagram. Ladder allows you to track the power flow between power rails as it passes through various contacts, complex elements, and output coils. For this system automation, we are using ladder programming language [8].

VI. PROGRAMMING FLOWCHART

A. Water Auto addition

Water auto addition is done at water rinse 2, PTRCDM, and EDRCDM stages of the pre-treatment line

- WR2 stage

In the pre-treatment processes, WR2 uses dipping technique for the vehicle cleaning. Auto addition of the industrial water in the tank is done by solenoid valve. When the limit switch sense the vehicle in the tank, auto addition starts. Opening and closing of the solenoid valve is controlled by PLC. When limit switch closes the contact, output of the limit switch is given to the PLC and PLC performs the logic operation. Output of the PLC given to the relay to operate solenoid coil. After solenoid valve flow control valve is fitted. Flow is set 2000 LPH according to production plan. Here 100% saving of water is achieved through WR2 water is added in WR1 tank, that overflow is drain. Flowchart of the WR2 stage is gives in figure 8.

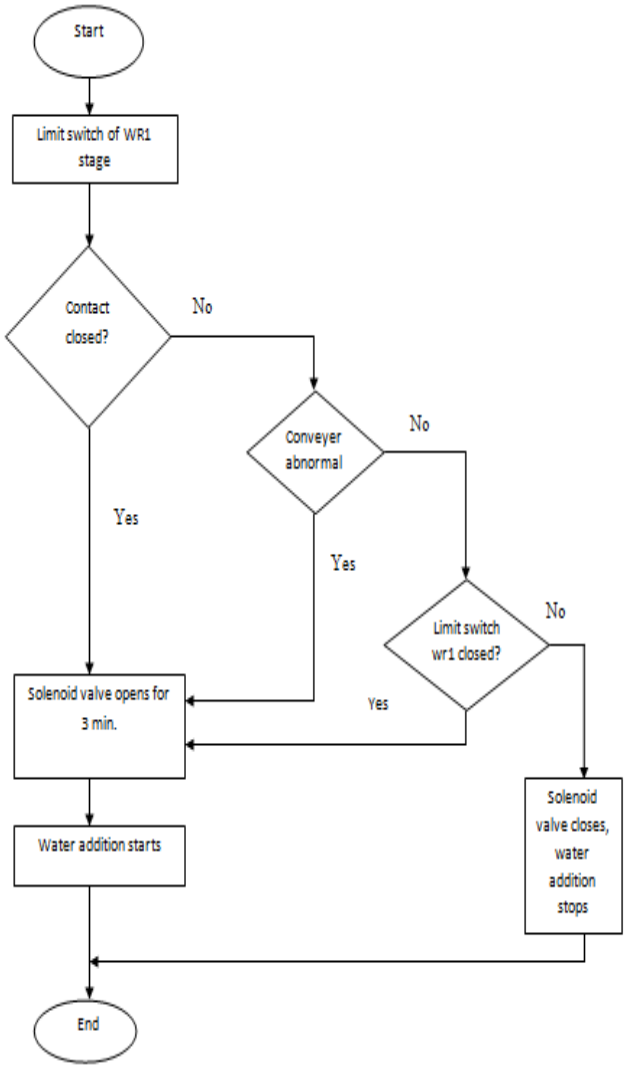


Figure 8: Auto addition at WR2

- PTRCDM auto addition

In pre-treatment process, PTRCDM uses dipping in DM water technique. When fresh DM water limit switch sense the vehicle, its output is given to the PLC then PLC logic operation opens solenoid valve and sprays are on. Then, it starts water addition from fresh DM stage to PTRCDM tank. This addition of water from fresh DM stage to PTRCDM saves water. Working of ladder programming is given into the flowchart in figure 9.

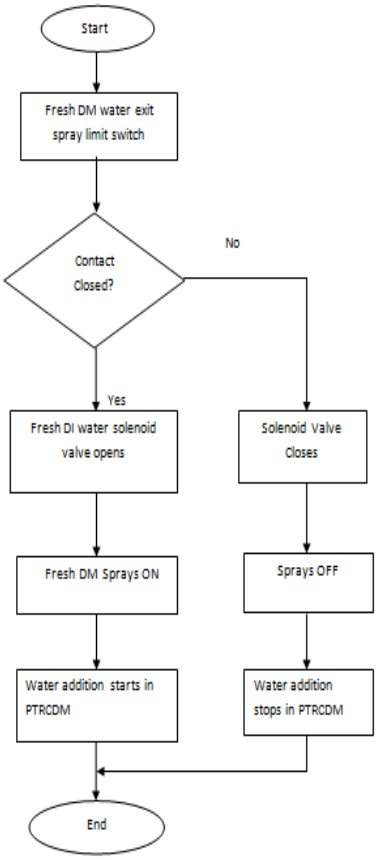


Figure 9: Auto addition at PTRCDM

- EDRCDM auto addition

In CED process, when fresh DM water stage limit switch sense the vehicle, its output is given to the PLC then PLC performs logic operation for opening and closing of solenoid valve and sprays are on. This ON/OFF of sprays occurs when vehicle present in the tank saves DM water. Flow of the programming is given in the figure 10.

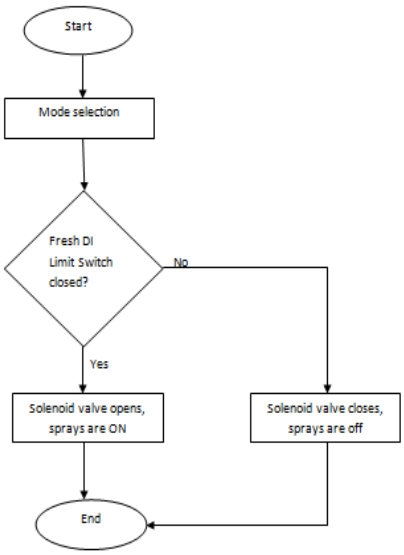


Figure 10: Auto addition at EDRCDM stage

B. *Spray ON/OFF confirmation*

Spray ON/OFF confirmation is required for quality improvement of the vehicle. Sometimes, conveyer is running and vehicle present in the tank but sprays are in OFF state. Because of this vehicles passes to the next stage without proper cleaning .This affects the coating of paint on the vehicle. Therefore, spray ON/OFF confirmation is required. Spray ON/OFF confirmation is done using pressure switch. Output of the pressure switch is given to the PLC.PLC performs logic operation when pressure of sprays below set point and generate an alarm.

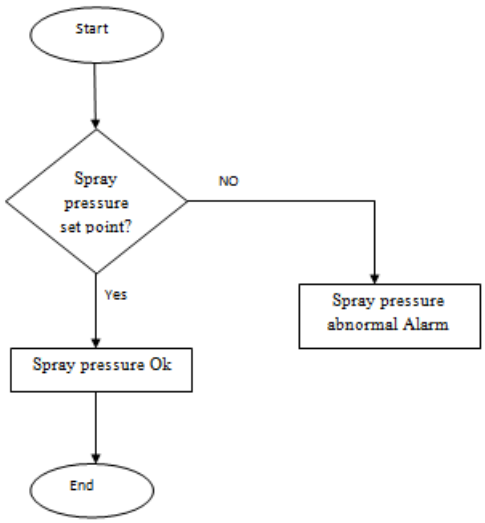


Figure 11: Spray ON/OFF confirmation

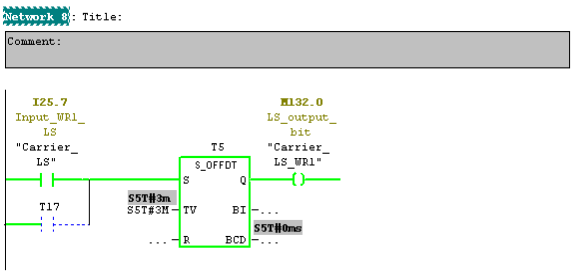
VII. RESULTS

The proposed system is implemented and tested using SIMATIC step 7software on SIEMENs PLC.

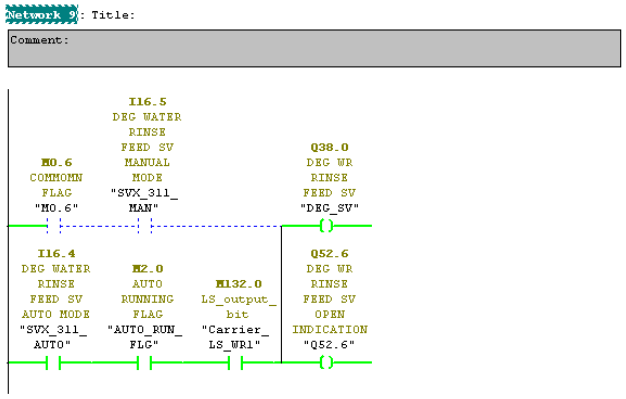
A. *WR2 simulation*

Limit switch sense the vehicle present in the tank, closes its contact and send signal to the PLC. Logic operation performed by PLC as explained in flowchart in figure 8. Result of logic operation gives opening and closing of solenoid valve, which controls water addition process. Simulation of WR2 stage is given below in (a), (b) and (c) using STEP 7 software.

- When present in the tank

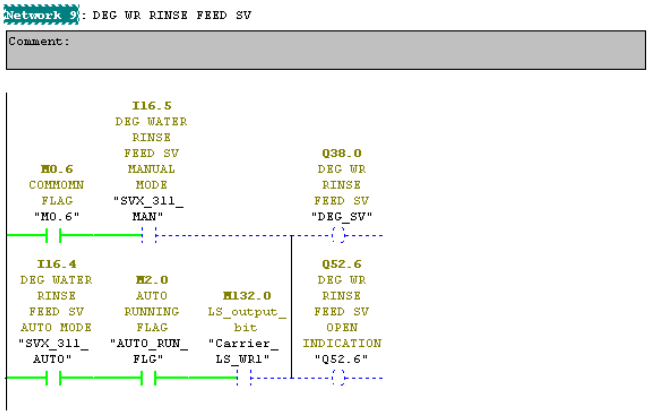


(a)



(b)

- When vehicle is absent in the tank.

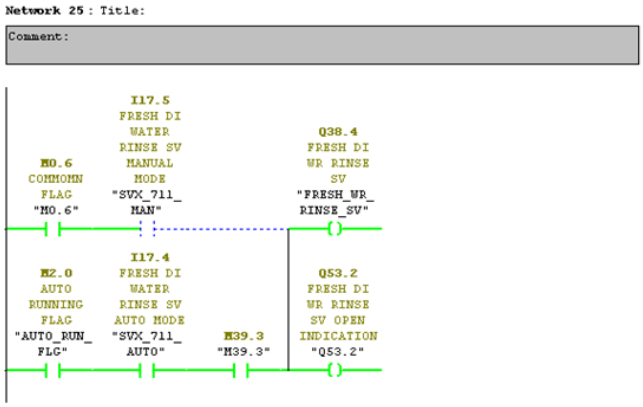


(c)

B. *PTRCDM simulation*

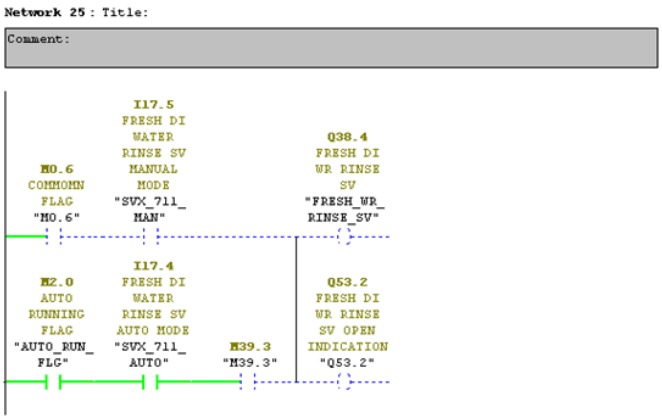
PTRCDM stage is dip water rinse stage, fresh DM exit spray limit switch sense the vehicle and sends signal to the PLC. Logic operation performed by PLC opens solenoid valve and exit sprays are ON. Addition of water from fresh DM sprays to PTRCDM tank has been done. Simulation of PTRCDM tank is given below in (d) and (e) using STEP 7 software.

- When vehicle present in the tank



(d)

- When vehicle absent in the tank

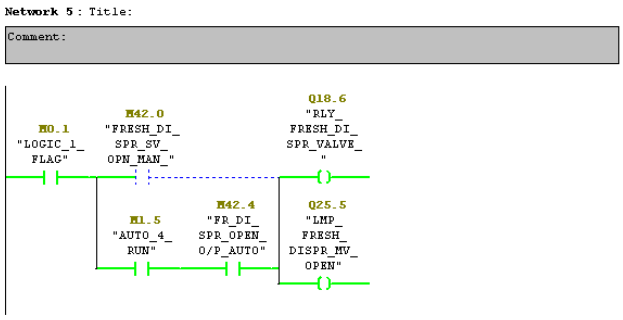


(e)

C. *EDRCDM simulation*

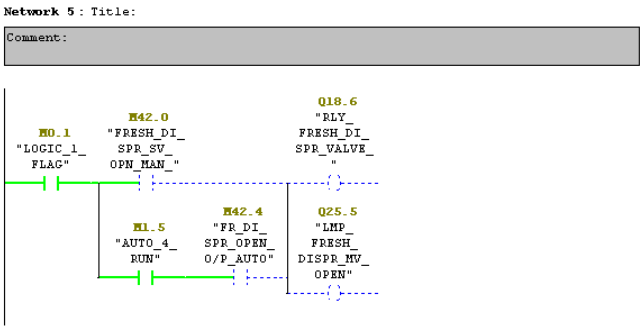
EDRCDM uses DM water sprays for cleaning of the vehicle after primer coating has been done by Cathodic Electro Deposition. Fresh DM limit switch sense the vehicle in the tank and sends signal to the PLC. Logic operations performed by the PLC for opening and closing of the solenoid valve perform ON and OFF operation of sprays. Simulation of EDRCDM stage is given below in (f) and (g) using STEP 7 software.

- When vehicle present in the tank



(f)

- When vehicle is absent in the tank



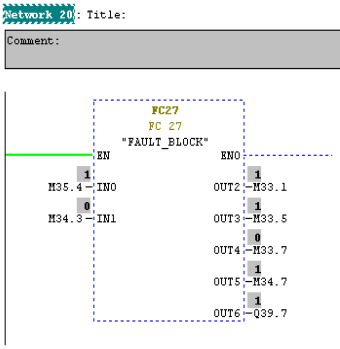
(g)

D. *Spray ON/OFF confirmation simulation*

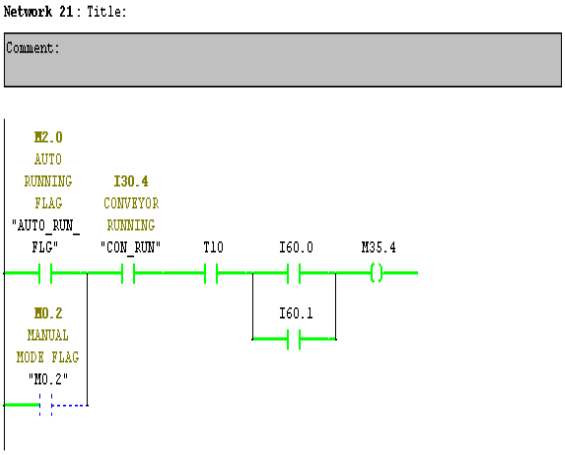
For spray ON/OFF confirmation, pressure switch is used. When pressure is abnormal i.e. below the set point, contact is

closed and signal given to the PLC.PLC performs logic operation for generate buzzer to indicate pressure is below set point. Simulation of spray ON/OFF confirmation is given below in (a) and (b) using STEP 7 software.

- When pressure is abnormal.



(a)



(b)

VIII. CONCLUSION

Thus, developing proposed system using PLC gives water saving and quality improvement in CED paint shop. Water is an important resource used in automobile industry for cleaning of vehicle. Therefore, wastage of water is an important issue in industry. By implementation of water auto-addition logic, wastage of water is reduced hence water saving has been done.

Vehicle quality issues are occurred without proper cleaning using sprays. Implementing spray ON/OFF confirmation logic, vehicle passes by proper cleaning. If sprays are OFF state in the tanks, indication is given to operator to take some control action. Hence quality of the paint coating on the vehicle has been improved.

Hence, by implementation of automation using PLC cost and quality has been improved in CED paint shop.

REFERENCES

1. Muhammad Irfan , Nordin Saad, Rosdiazli Ibrahim, Vijanth S. Asirvadam "An Intelligent Diagnostic System for the Condition Monitoring of AC Motors" IEEE 8th Conference on Industrial Electronics and Applications (ICIEA) 2013,pp: 1248-1253.
2. V Rajeswari, L Padma Suresh and Y.Rajeshwari, "Water Storage and Distribution System for Pharmaceuticals using PLC and SCADA", International Conference on Circuits, Power and Computing Technologies, 2013, pp 79-86
3. ZHANG Tianxia, DONG Feng, YUAN Hao "Application of PLC for Arranging Bottle in Beer Filling Production Line" IEEE 24th Chinese Control and Decision Conference (CCDC) 2012,pp: 1215-1220.
4. K. Gowri Shankar "Control of Boiler Operation using PLC – SCADA" Proceedings of the International Multi Conference of Engineers and Computer Scientists Vol. 2, March 2008.
5. Maria G. Ioannides, "Design and Implementation of PLC-Based Monitoring Control System for Induction Motor", IEEE transaction on energy conversion, Vol.19, No. 3, 2004, pp 469-476.
6. H. D. Dongargaonkar and Rajesh G. Jamkar, "*PLC Based Ignition System*", IEEE Industry Applications Conference, Vol.2, 1999, pp 1380-1387.
7. SIMATIC S7-300 CPU 31xC and CPU 31x: Technical Specifications Manual.
8. SIEMENS Ladder Logic (LAD) for S7-300 and S7-400 Programming Manual.