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Metal Sensing Automation

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Abstract

This paper is an overview of metal detection using PLC and SCADA. The main aim of the paper is to explain the functioning and working of metal detection in the industry and separation of non-defective metal pieces using robots. The main principle behind the project is its automatic control using a device called PLC. Also, in this project, the hardware model is interfaced with the software model, SCADA for better control and supervision.

Keywords: *Metal detection, PLC, SCADA, Interfacing, Robotic arm*

1. Introduction

Automation is the rising technology that is used in almost every industry. Automation means controlling the system automatically such that the same process is repeated based on the input fed. Automation helps in reducing human labor resulting in error free functioning and operation of the system. Through automation, we can control any process based on the industrial requirements from small scale to large scale. Automation has facilitated all the processes not just in industries but also in our day to day lives where the user has to press certain buttons and the process will start and stop automatically [2]. Nowadays, automobiles have a self-start button which is a common example of automation.

Our project is also based on automation in which we are sensing metal pieces and checking them for defects. In order to achieve our goal, we are using equipment like SMPS, relays, sensors, conveyor *etc*.

2. PLC (Programmable Logic Controller)

PLC is a device which can replace the sequential relay circuit. With the help of sensors the PLC checks the input every time and depending upon the state necessary action is taken. The sequence of steps is assigned to the PLC by writing a program on the software and burning it in the PLC.

As the desired logic control is achieved through programming hence it is called as PLC –Programmable Logic Controller.

PLCs are completely hard/solid device in comparison to hard-wired logic circuits. Average power consumption is only one-tenth as compared to hard-wired logic circuits.
Other benefits of PLCs are:-

- Modular replacement.
- Ease in troubleshooting.
- Ease in maintenance.
- A lesser number of moving parts reduces wear & tears as they are static devices.
- Low pay back period-Cost of PLC recovers within a short period
- One time investment; PLC is a more economical system.

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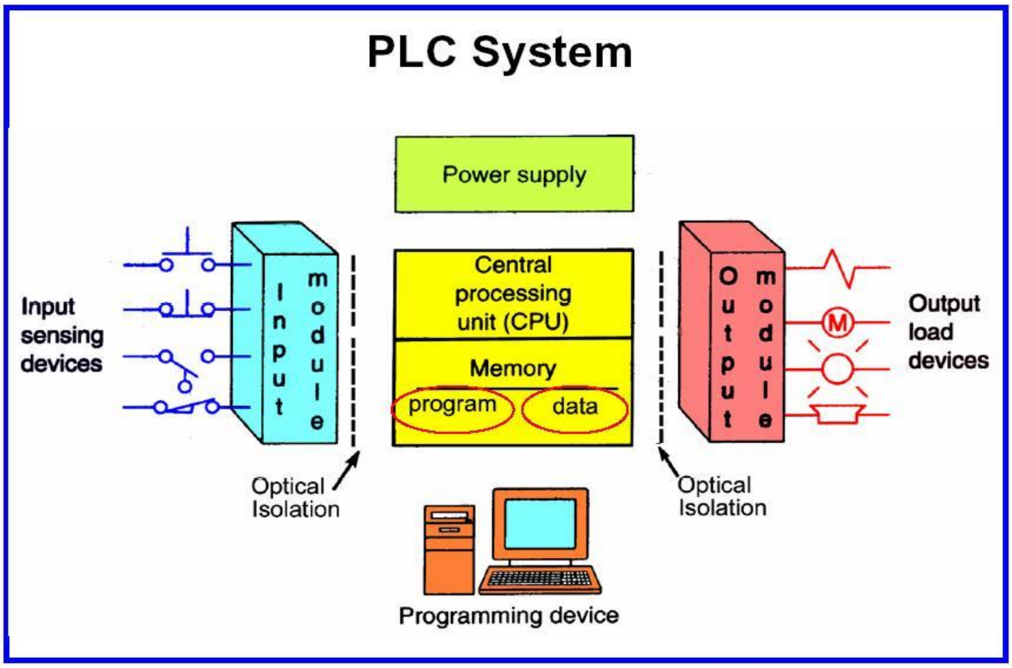

Figure 1. Architecture of PLC

The PLC requires the input from the sensors, power supply and desired programming for its functioning. After sensing the inputs, the CPU compares the data and after processing the desired output is sent to the output load devices.

Our project is completely based on Panasonic FPOR PLC. Earlier we were using Allen Bradley PLC which had 4 inputs and 4 outputs. But as we made some additions to our project, we switched on to Panasonic PLC as it had 8 inputs and 8 outputs. Besides this Panasonic PLC supports 5 types of languages:-

a. Functional Block Diagram(FBD)
b. Instruction List (IL)
c. Sequential Function Chart (SFC)
d. Structured Text (ST)
e. Ladder Diagram (LD)

Our coding follows Ladder Logic language.

3. SCADA

Supervisory Control and Data Acquisition (SCADA) is used for remote controlling of any system. The system can work together with the data acquisition system by using the signals in coded form over the communication channel to collect the information about the status of the equipment in the remote area for the display and recording purpose. SCADA is basically a graphical user interface (GUI) of the plant/system which runs in synchronism with the real system [8]. An operator sitting in the control room can know about the status, check for errors and control the system in real time.

<u>Features of SCADA</u>

- Graphical process
- Alarm history and summary
- Trends based on real time data
- Trends based on stored data
- Security
- Connectivity of the database

- Connectivity of the device
- Scripts
- Recipe Management

4. Proposed Model

The equipment used in the project is:-

(i)MCB

MCBs/Miniature Circuit Breakers are electromechanical protective devices which protect a circuit from overcurrent. Overcurrent may lead to short circuit, overload or faulty design. Since MCB does not require replacement after an overload is detected, it is a good alternative to a fuse. Unlike a fuse, an MCB can easily be reset and thus provides greater convenience and improved operational safety without incurring a large operating cost.

(ii) SMPS

Switched-mode power supply (SMPS) is an electronic power supply having switching regulators which effectively convert AC power to DC power. SMPS while converting the voltage and current characteristics transfer the electrical power from the main power source to the load. SMPS spend a little time on high dissipation transition thereby it saves energy. Ideally, SMPS dissipates no power. By varying the ratio of on-to-off time, we can regulate the voltage of SMPS. On contrary output voltage of linear power supply is regulated by continual power dissipation in pass transistor. The most important advantage of SMPS is the high power conversion efficiency. In our model, we are converting 220 V AC to 24 V DC, 2.1 A. We need an SMPS because our PLC runs on 24V DC supply.

(iii) NO/NC switches

NO switch stands for normally open and NC switch stands for normally closed. An NO switch is generally green in colour while NC is red in colour. NO switch is named so because it is generally open; its contacts are closed only when the input voltage is applied across it. NC switch is always closed, whenever a supply voltage is applied across it the contacts get open.

(iv) Relays

A relay is a switch which is operated electrically. Electromagnet to a mechanical operation is mostly used in the relay. Relays are mostly used where ever there is a necessity to control a low power signal circuit or where a number of circuits are controlled by a single signal. The relay was first used in the long distance telegram circuit as an amplifier where it used to repeat the incoming signal from one circuit to another circuit. Extensive use of the relay is in telephone exchanges. Logical operations were performed by the relays in early computers. We are using 8 relays each having 11 pins.

(v) Sensors

A proximity sensor is also known as an inductive sensor [5]. It can detect objects (metallic) without touching them. A sensor consists of an oscillator, field sensors, demodulator and flip-flop. Whenever a metallic body comes in the range of sensor the magnetic field generated by the coil collapses with the metal producing eddy current on the surface. The magnetic field due to the eddy current collapses with the original magnetic field. This change in magnetic field is detected resulting in the sensor's operation. We are using 4 NPN sensors.

(vi) DC motors

A DC motor is a machine which converts electrical energy to mechanical energy. It works on the principle of Fleming's left-hand rule. A current carrying armature experiences a force when it is placed in magnetic field. In our model, we have used geared motors for running the conveyor belt, ejector and three joints of the robot. We have used both 24 V and 12 V DC motors having very low rpm, around 10-20 rpm.

(vii) Ejector

For discarding the defective pieces we have put an ejector in between the conveyor belt. The ejector will operate only when the sensor does not detect a cut on the top face. The ejector is operated by a 12V DC motor.

(viii) Conveyor belt

There is a conveyor belt driven by the DC motor [4]. The metals to be tested are placed on it. Four sensors are kept near the edge of the belt.

(ix) Robotic arm

After the metal piece reaches the fourth sensor the robotic arm picks and places the metal piece to the desired location. Our robotic arm is having three degrees of freedom and is basically a pick and place robot [3].

5. Working of the Model

- The processed metal piece is brought to the testing model through the conveyor belt. Here the processed piece will be tested and those which remained unprocessed will be removed or resent for processing. In this way, the probability of defected/unprocessed products will be greatly reduced.
- Sensor 1 (S1) senses the side face of the metal piece by the induction process. The range of the inductive sensors is about 8mm.
- Then S1 sends a signal to the sensor 2 (S2) to stop the conveyor belt.
- S2 senses the top portion of the metal piece and then restarts the belt.
- If S2 senses a circular cut (or any other specific shape) on the metal piece then it will not send any signal to the sensor 3 (S3) and the metal piece will move forward.
- If S2 does not sense a circular cut then it will send a signal to S3. S3 will activate the ejector and the metal piece will be thrown out of the conveyor belt and collected for reprocessing. The timings for the movement of the belt and operation of the ejector are well timed [7].
- The sensor 4 (S4) is used to stop the conveyor so that the robotic arm can pick up the verified metal piece from the belt and place it at the required location. The pieces can be stacked or palletized. The robotic arm can be programmed accordingly.
- The speed of the conveyor belt and robotic arm has to be synchronized effectively.
- The hardware model is interfaced with the SCADA model using the communication channel. This is quite important as it helps in remote functioning of the system.
- Interfacing eases the operation of the system as the operator can control, supervise and take necessary actions sitting in the control room.

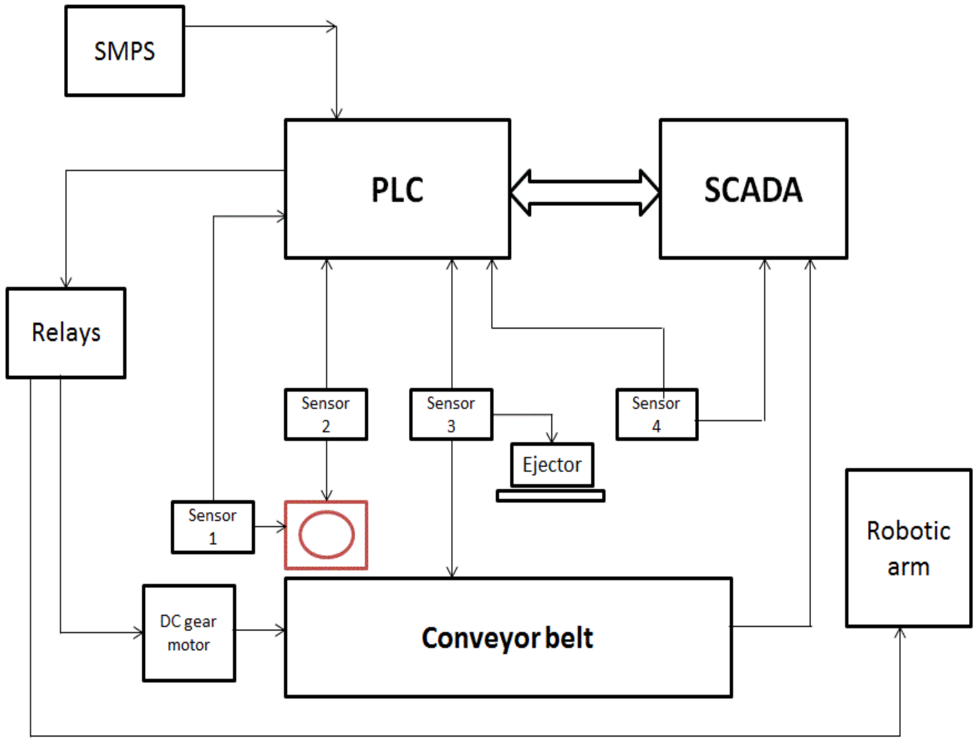

Figure 2. Block Diagram

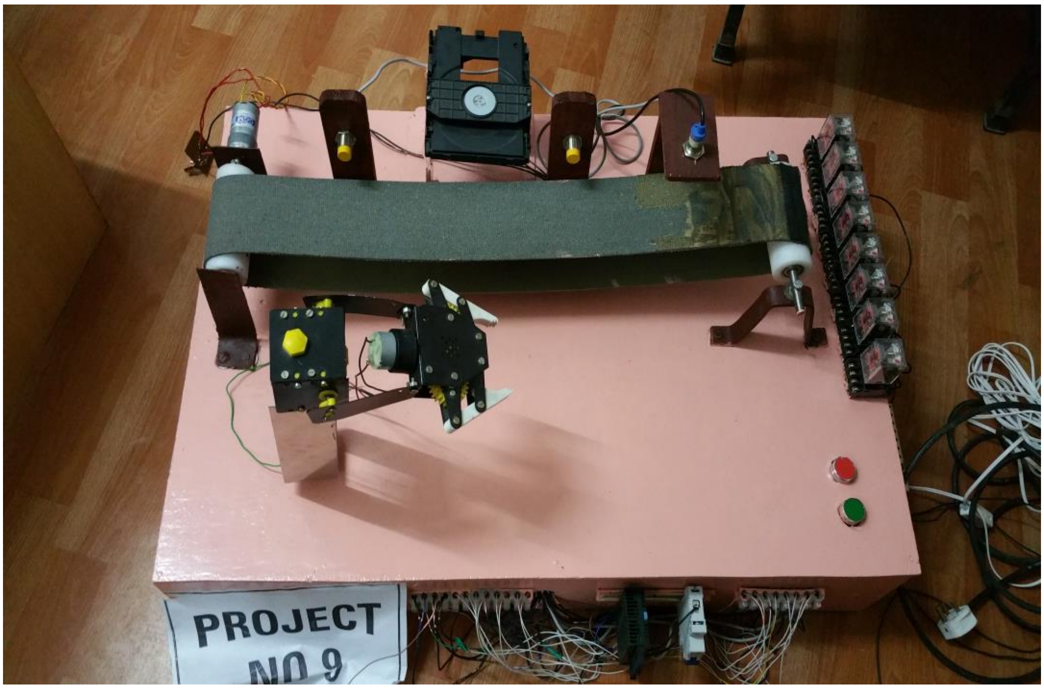

Figure 3. Hardware Model

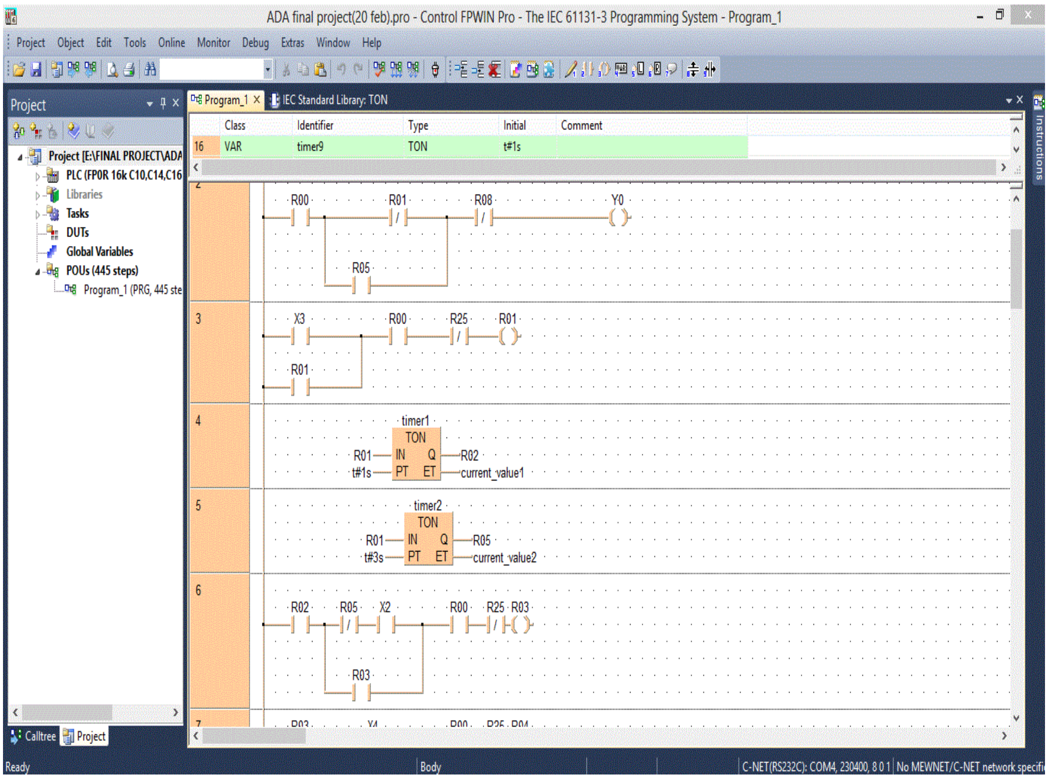

Figure 4. Coding on FPWin

6. Result

a. The metal pieces having circular cut will be collected as a stack or palletized. The number of non-defective pieces will be counted and displayed on the SCADA screen [1]. SCADA can be further linked to a database system which would keep a record of the quantity of products, costs, stocks, product specification, ingredients and an ease to access details of raw materials, intermediate and final products [6].

b. The defective ones will be removed and sent for reprocessing. This saves the metals from being wasted.

c. Hence this is to separate the non-defective and defective metal pieces in industries.

d. This not only minimizes the error but also generates an alarm whenever there is a fault in the system.

7. Conclusion

The proposed model is, in fact, the testing part of industrial automation. The model is very useful as it can be effectively interfaced with PLC (programmable logic control). The whole hardware model and the process are displayed on the computer screen in real-time which helps the operator to supervise and control the functioning besides acquiring the real-time data without actually monitoring the plant.

The model can be changed as per the need of the industry. Similar SCADA models can be planned on the software keeping in view the desired hardware model to be designed on the PLC.

The proposed model is not just cost effective but also provides an alternate solution to obsolete testing methods that are now almost redundant.

This model can be successfully implemented in the following industries

a. Automobile industry

b. Steel plant
c. It can be used in industries for separation of metals on a large scale and collecting the same type of metal at one place.

9. Future Scope

The project can be modified by adding several other features. One of the things to be added is the weight sensors, which would check the weight of the metal piece and compare it to a reference weight. This will help in using the metal judiciously.

The robot's DOF (degree of freedom) can be extended to 6 making it more complex and capable of doing other functions. For extending the robot's DOF and adding more outputs, we would need a PLC having more number of inputs and outputs.

The number of conveyors can also be increased, the defective metal piece after rejection would be sent to another conveyor belt so that its manufacturing process is repeated.

References

[1] A. Jain, A. Babbar, D. Singh and S. Mahapatra, "Metal Sensing Using SCADA", IJERGS, vol. 3, Issue 1, **(2015)** January-February.
[2] G. Xiaohu and Z. Guangxi, "Empowering ubiquitous services in next-generation smart homes", Inform. Technol. J., vol. 5, **(2006)**, pp. 64-69.
[3] R. V. Sharan and G. C. Onwubolu, "Simulation the Arm Movements of a Stepper Motor Controlled Pick-and-Place Robot Using the Stepper Motor Model", International journal of advanced sciences and technology, vol. 60, **(2013)**, pp. 59-66.
[4] T. Krishnan and B. Ramaswamy, "A fast response dc motor speed control system", IEEE Transactions on Industrial App, vol. IA-10, no. 5, **(1974)** September/October, pp. 643-651.
[5] H. Ewald and H. Krüger, "Inductive Sensor for Metall Detection", Proceedings of the 21st International Manufacturing Conference IMC21, Limerick, **(2004)** September 1-3, pp.429-436.
[6] M. Endi, Y. Z. Elhalwagy and A. Hashad, "Three-Layer PLC/SCADA System Architecture in Process Automation and Data Monitoring", 978-1-4244-5586-7/10/C, IEEE, **(2010)**.
[7] Mader and H. Wuper, "Timed automation models for simple programmable logic controllers", in Proc. 11th Euromicro Conf. Real-Time Systems, **(1999)**, pp. 106–113.
[8] R. Kurnar, S. A. Karnal and F. M. Khan, "Designing And Implementing SCADA Subsystem for Textile Industry", IEEE, **(2004)**.