Model Of Metal Sorting Conveyor System Using Siemens S7-1200 PLC

Nyan Phyo Aung, Mo Mo Myint Wai, Lwin Lwin Htay

Abstract: The automatic sorting system has been reported to be complex and a global problem. This is because of the inability of sorting machines to incorporate flexibility in their design concept. This research therefore designed and developed an automated sorting metal object of a conveyor belt. The developed automated sorting machine is able to incorporate flexibility and separate species of metal objects and at the same time move objects automatically to the basket as defined by the regulation of the Programmable Logic Controllers (PLC) with an inductive proximity sensor to detect a value range of objects. The result obtained shows that steel/metal is sorted into correct position with time of 10s. The proposed developed model of this research that is implemented with Siemens s7-1200 PLC and TIA portal v13.

Index Terms: Minimum Inductive, Metal, Proximity SensorS7-1200 PLC and TIA Portal V137

1 Introduction

Automation is the use of control systems for handling different processes and machineries to replace human efforts. Automated systems generally use complex algorithms which increase the cost of the design and the power consumed. Using automation also prevents danger which might occur when humans are made to work in hazardous environments. Thus, use of automation is effective in manufacturing industry. Sorting based on color, weight and type is done in many industries to ensure the quality of the object is consistent and up to the mark. Automated sorting also reduces the labor cost and the production time. The error cased due to human negligence are avoided by the use of automated system by metal based sorting using an inductive sensor. In this project, Automation System for sorting metal objects conveyor is developed in Programmable Logic Controller PLC. The project mainly focuses on sorting different metallic objects which is available in inductive sensor, solenoid and DC geared motors interfaced with Programmable Logic Controller (PLC). A DC motor is used for the flipper which is used for pushing the object from one conveyor to other conveyor line and also the rejection bin. The system consists of conveyor belt which takes the objects like bottles, small boxes or packages in front of sensors and thus sorting logic is decided by PLC. PLC is programmed with different logics, for sorting. The system consists of total an inductive sensor, solenoid and conveyor motor respectively. The function of conveyor belt is to take the objects in front inductive sensor. The sensor in the middle of the conveyor lines will segregate the objects and send the signal to the PLC, which will initiate the DC motor on which the circular container is mounted in which the objects would be rejected. In this project, the SIEMENS S7-1200 (1212 AC/DC/Rly) and Siemens TIA PORTAL V13 programming software were used. The objective of the system is to understand the new generation model of Siemens PLC model. This project will be model of PLC (s7-1200) based conveyor sorting system.

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2 Background

This section described about the background knowledge for the proposed system. And the parts of system is also expressed.

2.1 Sorting machine belt assembly and movement

Sorting machine is the belt assembly and movement. The sorting machine drive uses a conveyor belt and a 'Betel Coley' to transport objects from the origin to the destination. From literature, flat belts (Flat belt), conveyor wraps (Fold edge) and wedge belt (V-belt) are some of the reported commonly used conveyor belts for automatic sorting machines. This work follow suit from commonly adopted belts from literature. Hence the wedge, flat and fiber (natural fiber) belts were adapted for this research. The wedge belt is made of the synthetic ring encased in rubber that gave the core the desired strength. The drive of the automatic sorting machine uses a DC motor and gear reduction system to reduce the speed and increase the torque of the motor.

2.2 Characteristics of the systems sensors to detect objects

The detection section of the automatic sorting machine has a detection device, which is made of the proximity capacitive sensor. This sensor changes the capacitance due to the distance and the type of object to detect. This equipment has many advantages. For example their ability to detect objects of all kinds of metals and non-metals. In addition, they are cheap, available and easy to configure over the other types of proximity sensors. The operations of the capacitive proximity sensors entails that the dielectric constant of the object changes in capacitance when the object moves closer to the sensor which depend mainly on the speed of the conveyor belt. They sense fluid level, chemical concoctions etc. of any object within the range. They are generally used for industrial purposes. The electrical circuit formed by the DC oscillator slater has the capacity to change the magnetic field induced due to the current sensor. The objects to be sorted moves in logical order in such a way that as it gets closer to the capacitive proximity sensor, it gives a maximum output oscillation frequency. If however, the object moves further away from the sensor, a lower oscillation frequency is displayed. (Model design and simulation of automatic sorting machine using proximity sensor [1].

2.3 PROGRAMMABLE LOGIC CONTROLLER (PLC)

All The term programmable logic controller is defined as a digitally operating electronic system which uses a programmable memory for the internal storage of user oriented instructions for implementing specific functions such as logic, sequencing, and programming In PLC Every PLC has associated programming software that allows the user to enter a program into the PLC. Before a PLC can perform any control task, it must be programmed to do so. In this project. The Software of the PLC is Siemens TIA V13 Programming Language. The controller offers two programming languages such as:

- Ladder Language (LD)
- Function Block Diagram (FBD)
- Sequential Flow Chart (SFC)

The common program language of PLC is ladder diagram is used in the research. The Ladder logic is widely used in programming PLC where sequential control of a process or manufacturing operation is required. It is a graphic Language and can be used to transcribe relay diagrams, and is suited to combinational processing. It provides basic graphic symbols, contacts, coils, and blocks. Specific calculations can be executed within the operation blocks[2]. PLCs architecture consist of CPU, memory, input and output module, power supply and communication module as shown in Fig 1. PLCs receive the information about the process through their input module. Some device may attached to input module like sensors and switches. This information collected and saved in memory. CPU run the instruction based on that information and later it will change the output status. PLCs control the process through the outputs, they allow for switching on and off the actuators such as motors or close and open the valve. Analog outputs have advance function since they can run motors in various speed or determine how a valve should be open, fast or slow, fully open or half open etc. Any control task modifications are done by changing the program. In this system, the Siemens s7-1200 (1212C) PLC is used.

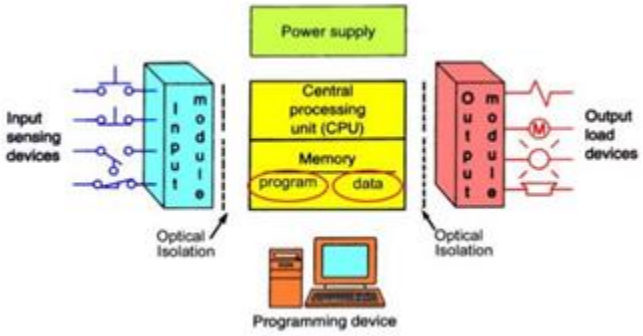

Fig 1. *The Block Diagram of PLC System [4]*

CPU1212C is one of Siemens S7-1200 PLC family. The CPU combines a microprocessor, an integrated power supply, input and output circuits, built-in PROFINET, high speed motion control I/O, and on-board analog inputs in a compact housing to create a powerful controller. The CPU contains the logic required to monitor and control the devices in many application. The CPU monitors the inputs and changes the outputs according to the logic of user program, which can include Boolean logic, counting, timing, complex math operations, and communications with other intelligent devices.

The Siemens s7-1200 (CPU1212C) PLC [3] is as shown in Fig. 2. CPU1212 has digital input type sink or source with rated voltage of 24 VDC while the output can be either a relay (mechanical) or a sourcing solid state (MOSFET). The analog input sense voltage variation between 0-10 V and the output will generates current within range 0-20 mA. In order to control the other process, PLCs can use additional expansion module:

1) Signal board (digital, analog, communication board, battery board).
2) Signal module (digital, analog, thermocouple, RTD, IO Link).
3) Communication module or communication processor.

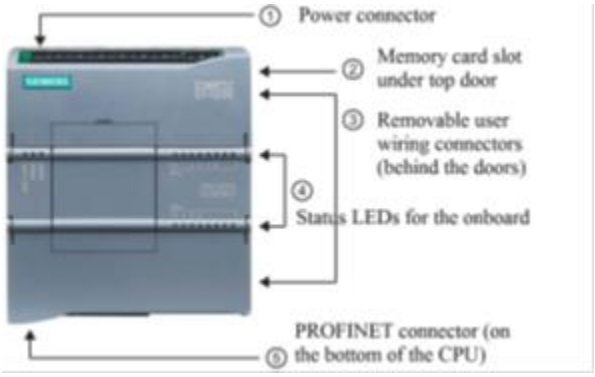

Fig 2. *CPU S7-1200 family Model*

2.4 Conveyor Belt

The system comprises of the main line and a subordinate line on which lighter objects are segregated. The conveyor line is driven by 60 rpm motors of the DC type. The belt is a flat belt conveyor made up of polyurethane.

2.5 Inductive sensor

It is a non-contact type sensor which is the first sensor in the system to sense the incoming object. This sensor is used to distinguish between metals and non-metals. It utilizes the inductive effect for the detection of metals. In this work, two wire type inductive proximity switch is used as shown in Fig 3. It model is LJ18A3-8-Z/EX [5]. Proximity sensor that detects nearby metal, including aluminum foil; a great solution for heated bed calibration. The LJ18A3-8-Z/BX proximity sensor will detect large metal fields at 8mm distance with great precision. The sensor is equipped with a small red detection LED, indicating a nearby object. The LJ18A3 is a PNP Normally Open (NO) type of proximity sensor. This means that the signal lead will output a positive voltage (same as the input voltage) when a metal mass is detected. When nothing is detected, the signal is equal to ground. This sensor will be operated at 6-36V, so as the signal voltage is the same as the input voltage, also the signal will be 6-36V [3].

Fig 3. *The Photo of inductive sensor*

This sensor is used to differentiate between three colors i.e. black, brown and blue. The model of the sensor is LJ18A3-8-Z/EX. The object which is moving on the conveyor line is sensed by this sensor which sends the signal to the PLC according to the magnetic field produced wave. The object is further sorted on the basis of the magnetic.

2.6 Relay

This system 24V DC relay is used to drive the conveyor motor and solenoid. These are working with 12V DC supply. There is 24V DC level that is used in input/output of plc. There relay must be used as interfacing. The 24V DC relay is as shown in fig 4.

Fig 4. *The Photo of the Relay*

2.7 Power Supply

In this research, the 24V/50W switching power is used to supply the conveyor motors and sensor. But S7-1200 PLC can be worked with AC power. There is voltage step down circuit module to drive 12V conveyor motor and solenoid via relays. The switching mode power supply is as shown in fig5.

Fig 5. *The Photo of the Power Supply*

2.8 DC motors

The DC motors work using direct current instead of alternating current. The motors are used to drive the system i.e. the motor is coupled to the rollers on which the conveyor belt moves. The motor that is used as conveyor in this project is shown in fig 6.

Fig 6. *The Photo of DC motor*

2.9 Rejection Unit

It comprises of a bridge on which the DC motor is mounted to which the flipper is attached. As soon as the PLC receives a signal from the inductive sensor for a particular object, the flipper is initiated and if the object has undesired properties than the required ones, it slides the object into the rejection system.

3 Proposed model of Metal Sorting Conveyor system

The proposed model of Metal Sorting Conveyor system using Siemens S7-1200 PLC will be described. The block diagram of proposed system is shown in fig7. In the system, there are two parts: hardware section and software section.

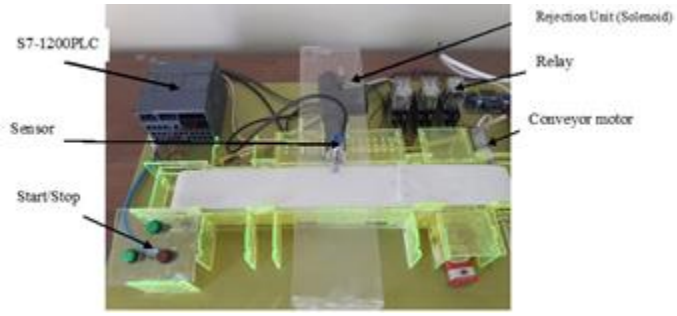

Fig 7. *The Block Diagram of the proposed system*

The hardware section will be construction of the system using PLC and other accories. And the software is developed for to control and work the system correctly. In this section, Programming concept to implement software from hardware point of view.

4 Hardware Implementation of the proposed system

Above the proposed system block diagram, there is two sections: hardware and software of the system. In this system, at first the hardware is implemented as shown in fig 8. From this figure, the main is S7-1200 PLC and its acts the controller in the system. The conveyor motor is running until the sensor detects the metal. The sensor is inductive proximity sensor. When the sensor detected the metal, the electrical solenoid is reject it from the conveyor.

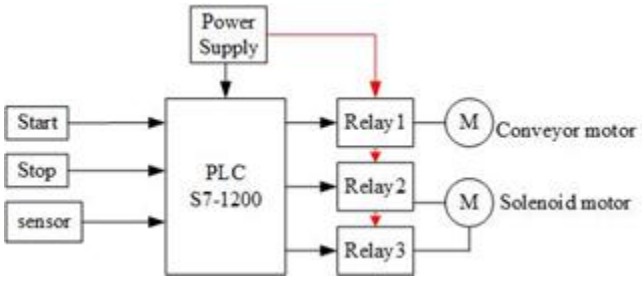

Fig 8. *The Hardware Implementation of the proposed system*

5 Software Development of the System

After the implementing the hardware, the program of PLC must be developed by using Siemens PLC TiA Portal V13 [6]. In this research, the PLC that used in this is S7-1200 (1212C CPU) model. It is the Siemens model and the programming software must be the same. Siemens TIAPORTAL V13 is used to develop the software for the PLC in this. The system must have the fail-safe operation. The fig 9 shows the flow chart of the proposed system. From the fig 9, the first step of the

program must set the parameters of the system. And the program can be start by pressing the start button as shown in fig 8. And then the pilot light is turn on that means the system is starting. And conveyor is running. When the sensor detects the metal object, the conveyor is stopped. And the solenoid is energized by PLC. The arm from solenoid is extended to remove the metal from the conveyor line. After that, the conveyor is restarting. This is process of the proposed system. This is developed with TiA Portal V13. And the ladder diagram of the process of the system is as shown in fig 10(a) and (b). From the fig 10, the operation time of solenoid is controlled by the timer. The energized time and DE energized time of the solenoid is set by two timer as shown in fig 10. The symbolic name & absolute address of adder diagram for proposed system is as shown in table 1.

TABLE 1

SYMBOLIC NAME & ABSOLUTE ADDRESS OF PROGRAM OF SYSTEM

Symbolic Name	Absolute address	I/O type
Start	I0.0	Input
stop	I0.1	Input
sensor	I0.2	Input
Power_on	Q0.0	Output
Conv_motor	Q0.1	Output
Sol_motor	Q0.2	Output
Sol_rev	Q0.3	Output

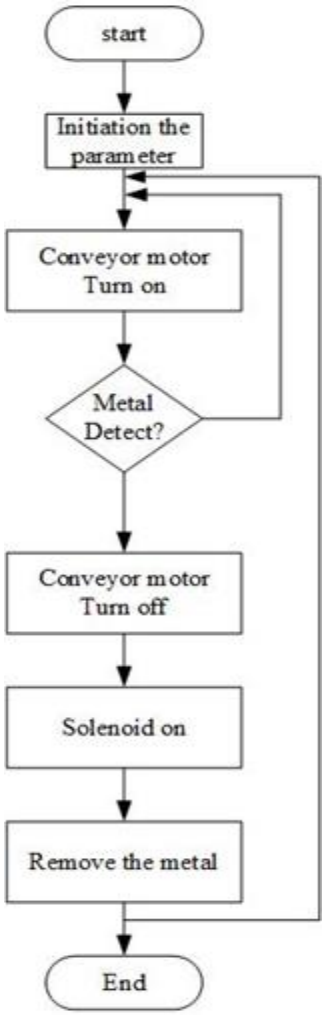

Fig 9. *The flow chart of the proposed system*

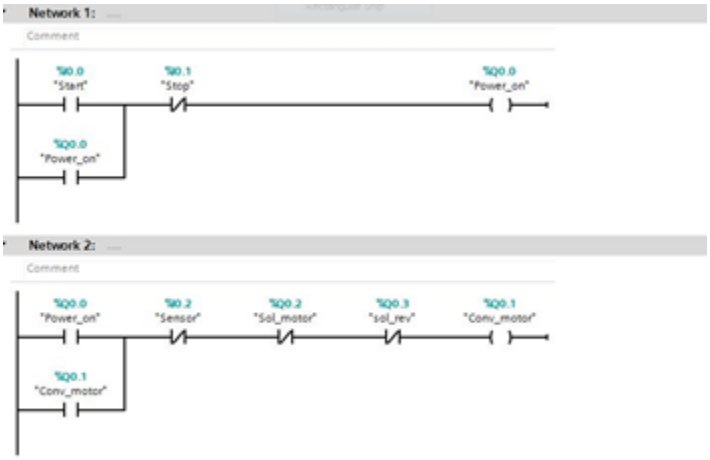

Fig 10(a). *The Ladder diagram of the proposed system*

Fig 10(b). *The Ladder diagram of the proposed system*

6 CONCLUSION

Because today ,Siemens PLCs are advancing in terms of applicability and capability. The System works during normal operation and greatly improved the automation processes with the use of the PLC ladder diagram using Tia Portal. The project presents an overview of hardware and software tools used to support PLC program to support metal sorting objects. This presents the concept using an example of a simple belt conveyor to remove or sort the object depend on the applications. The project intend to develop in future a model of universal industrial objects, e.g. a one-direction drive, a motor-operated valve, for the simulator. By combining models of simple elements, the user will be able to quickly build a simulator model for its specific installation.

7 REFERENCES

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