DESIGN OF SEPARATION METAL AND NON-METAL GOODS BASED ON CP1E-E30SDR-A AND PNEUMATIC

Sumardi[1)], Sri Mulyati[2)], Zaim Mubarok[3)]
[1,3)]Electrical Engineering Study Program, [2)] Informatics Study Program
Faculty of Engineering, University of Muhammadiyah Tangerang
Street: Perintis Kemerdekaan 1/33 Cikokol Kota Tangerang, Banten-Indonesia
mardiesadi99@gmail.com , lilysrimulyati@gmail.com

ABSTRACT
Design of separator based on PLC CP1E-E30SDR-A and Pneumatic metal and non-metal items is a prototype that can separate metal and non-metal goods working based on PLC programs with pneumatic actuators it works automatically. Making prototypes aims to simplify human work, especially in sorting metal and non-metal goods, to reduce the occurrence of errors in sort items, because if done manually it is likely that an error will occur because of the error factor. This tool uses Omron CP1E-E30SDR-A PLC, Roko SN4N-NPN proximity sensor, photo sensor BEN 5M-MFR, compressors, limit switches, pneumatic, selenoid valve Air Tac, 12V power supply and pressure switches. The method used in the preparation is laboratory experiments and testing tools to get the desired results. After testing, the distance that can be detected by the proximity sensor is 0-4 mm, the tool that is made can run in accordance with the expected description.

Keywords: PLC, Pneumatic, Photo sensor, Proximity, Selenoid Valve

1. INTRODUCTION

PLC as a very flexible and effective tool in industrial control (Ioannides 2004), PLC is a control system microprocessor based, which is designed for automation processes in industrial environments [1], [2],[3], [4]. The PLC architecture refers to its internal hardware and software. As a microprocessor-based system, the PLC system hardware is designed and built up with the following modules =[5]-[13]:

- central processor unit (CPU);
- discrete output module (DOM);
- discrete input module (DIM);
- analog outputs module (AOM)
- analog inputs module (AIM)
- power supply.

The programming method used is the ladder diagram method. The PLC system[1] provides a design environment in the form of software tools running on a host computer terminal which allows ladder diagrams to be developed, verified, tested, and diagnosed. First, the high-level program is written in ladder diagrams, [14], [15]. Control systems in industrial processes are expected to reduce production costs, reducing defects, more efficient in terms of time and labor. Various ways are done by companies to reduce production costs, one of which is an automatic control system. With the system PLC [2] and Pneumatic actuator [3] based controls hence the use of labor and time will be more efficient than manual controls which often occur error.Many factories use PLCs in automation processes to diminish production cost and to increase quality and reliability [16]–[21]. According to Muhammad Imaduddin, 2016 [22], the use of control systems in many industries was applied in combination between controller components and pneumatic components in the production process. Use of pressurized air already many developed for the purposes of the production process, for example to do mechanical movements

that have been so far done by human power, such as shifting, pushing, lifting, pressing, and separating. Use the control system can be applied in various industrial fields such as the waste recycling industry. In industry is required to sort goods according to their types such as organic and non-organic, metals and non-metals, and hazardous chemicals or not. The current problem is the separation of is done manually so there is a possibility of errors when sorting items. Settlement the problem with the selection of metals and non-metals is the making of a device that works automatically. In This study was made a prototype of a PLC and Pneumatic metal and non-metal based separator to avoid error due to human error.

2. RESEARCH METHOD

2.1. Diverse System Blocks

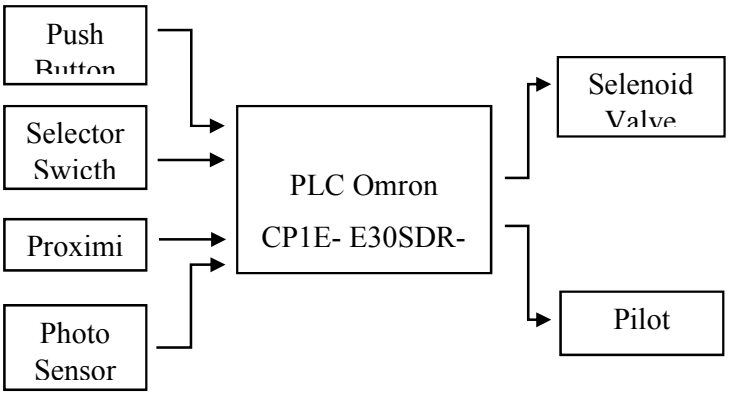


Figure 1 Block Overall Diagram

In the block diagram above there are several inputs consisting of switches and sensors, besides that there is also output namely selenoid valve and lamp.

- Push Button
  This push button is used as a start / stop button on the system tool and also as a button for activate selenoid when manual mode.
- Selector Switch
  The switch selector in this tool is used to switch on / off the input voltage and also as a selector switch auto / manual system mode.
- Proximity Sensor
  Proximity sensors in this tool are used to detect metal and non-metallic objects.
- Photo Sensor
  This photo sensor is used to know whether or not an object will be detected.
- PLC

The PLC is used here to control the overall work process of the tool.

- Selenoid Valve
  This selenoid valve is used as a pneumatic movement regulator for push or pull.
- Pilot Lamp
  This pilot lamp is used for system on / off indicators and for pneumatic signs that work.

2.2. **Mechanical Design**

This mechanical design is very important because it can help in making tools. So that making tools can be in accordance with the desired shape and does not widen too far.

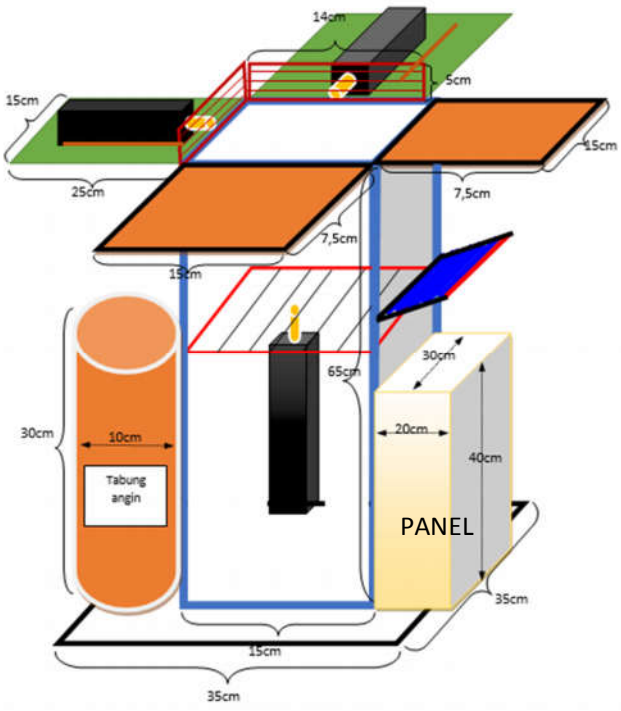


Figure 2 Mechanical Design

2.3. *Flow Chart Sistem*

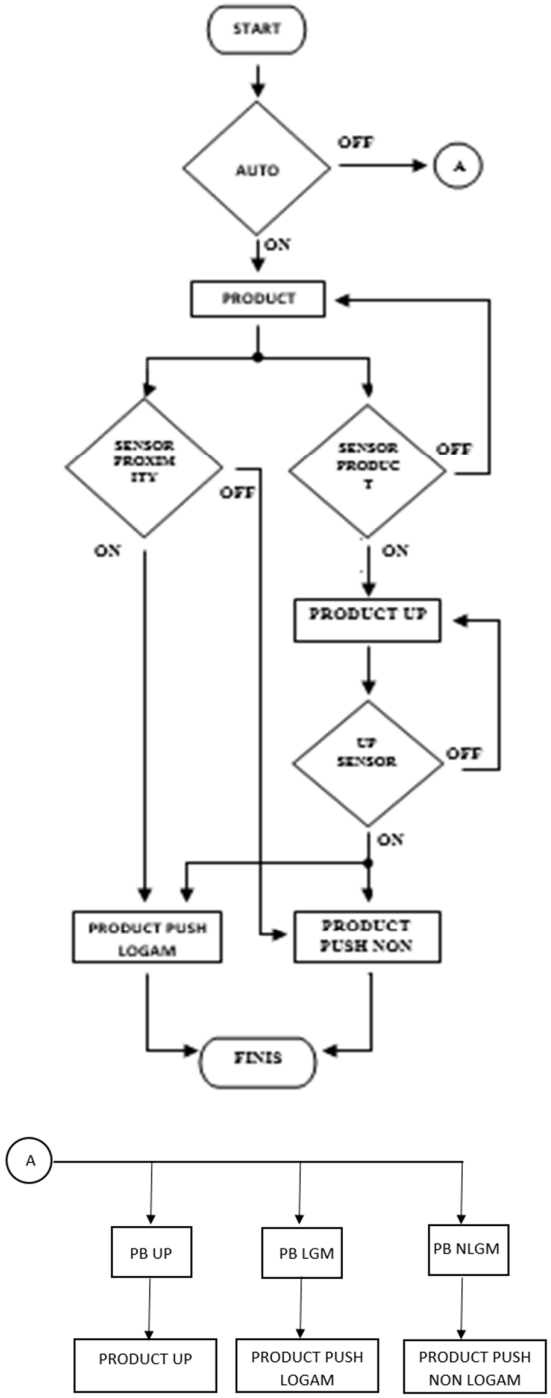


Figure 3 Flowchart

In the flow chart above it has been shown a sequence of work processes both manually and automatically. The auto process has several working sequences, namely:

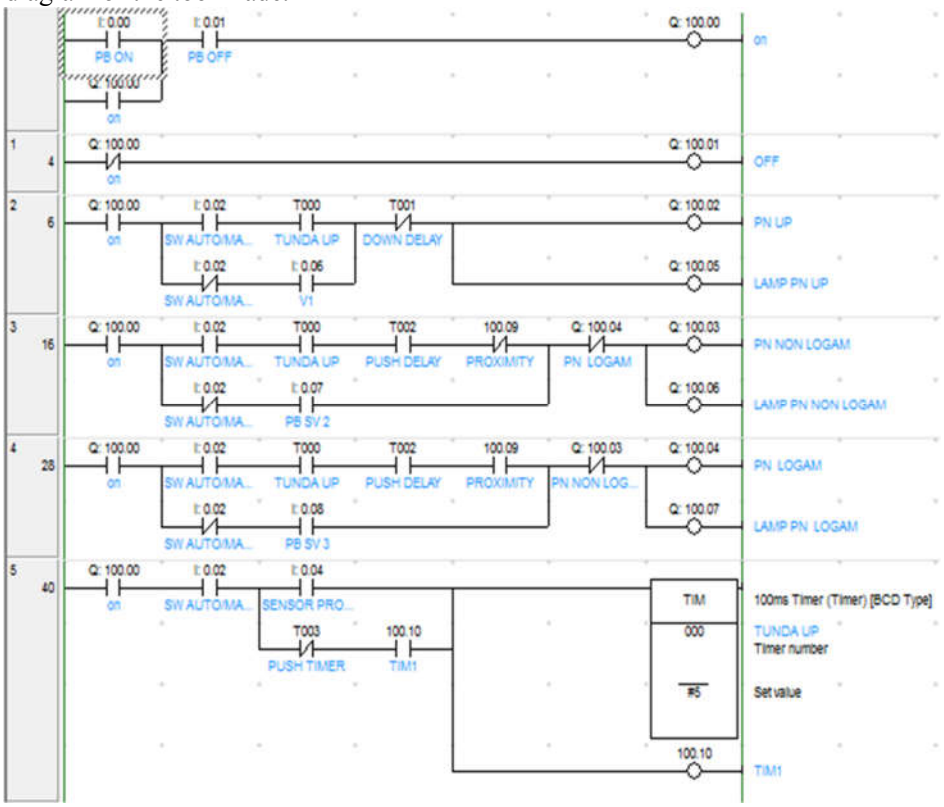
- When the system is on and the selector switches on, the tool is ready to run automatically
- Then insert the object you want to detect by the sorting tool.
- If proximity and photo sensor are on, pneumatic up will work and when touching the limit switch the pneumatic metal will push objects into containers.
- When proximity is off and the photo sensor is on, pneumatic up will work and when touching the limit switch then pneumatic nonmetals will push objects into the container, and so on until the system is turned off.

The manual process has several work sequences, namely:

- When the system is on and the auto / manual switch selector is off, the tool will work manually.
- In this mode pneumatic movement depends on the push button being pressed because in this mode it aims to test the condition of pneumonia.

2.4. Ladder Diagram Design

In the design this time the author uses cx programmer 9.0 software. The following is a system ladder diagram of the tool made.



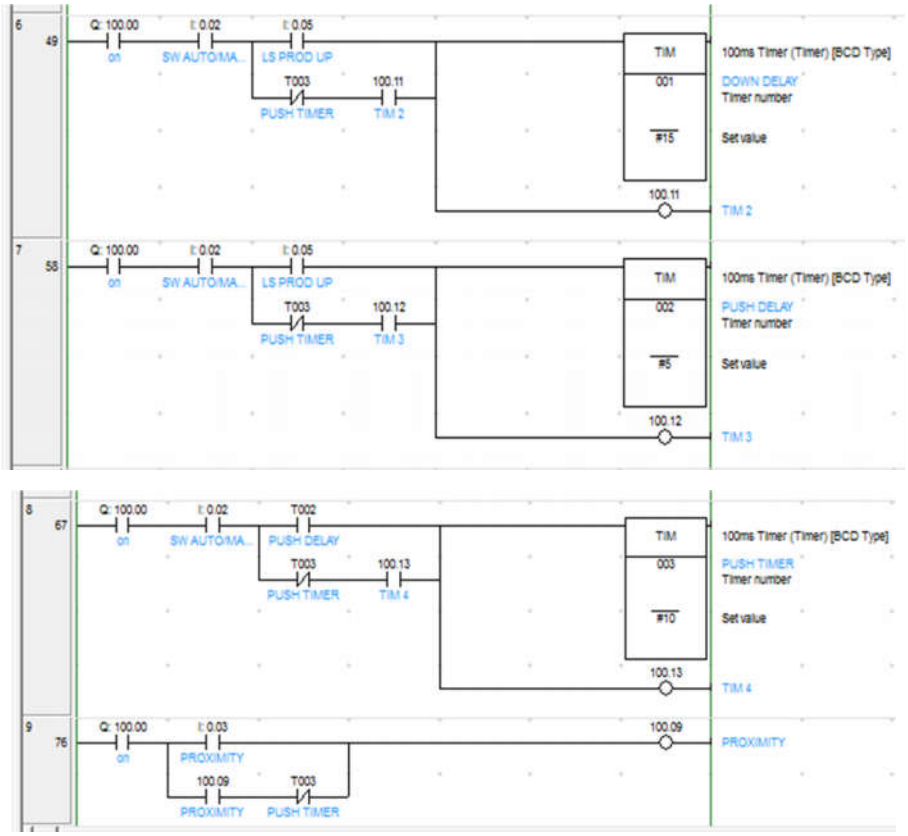


Figure 4 Ladder Diagram

2.5. Wiring Diagram

This Wiring Diagram is very important because it can help us when assembling and resolving problems that do not operate. Using this wiring can accelerate us to detect and repair the tool.

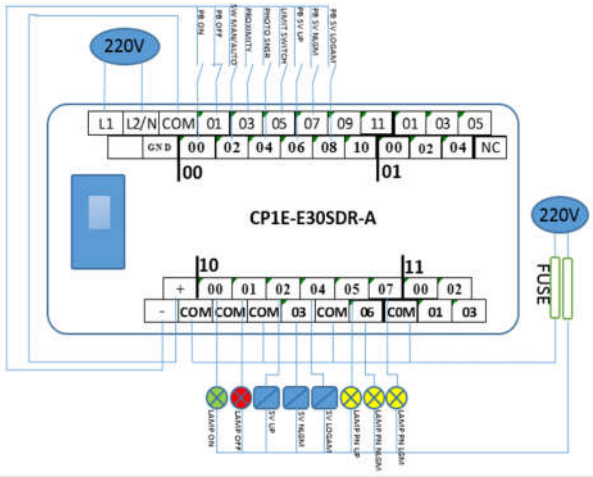


Figure 5 Wiring Diagram

2.6. Pneumatic Hose Installation

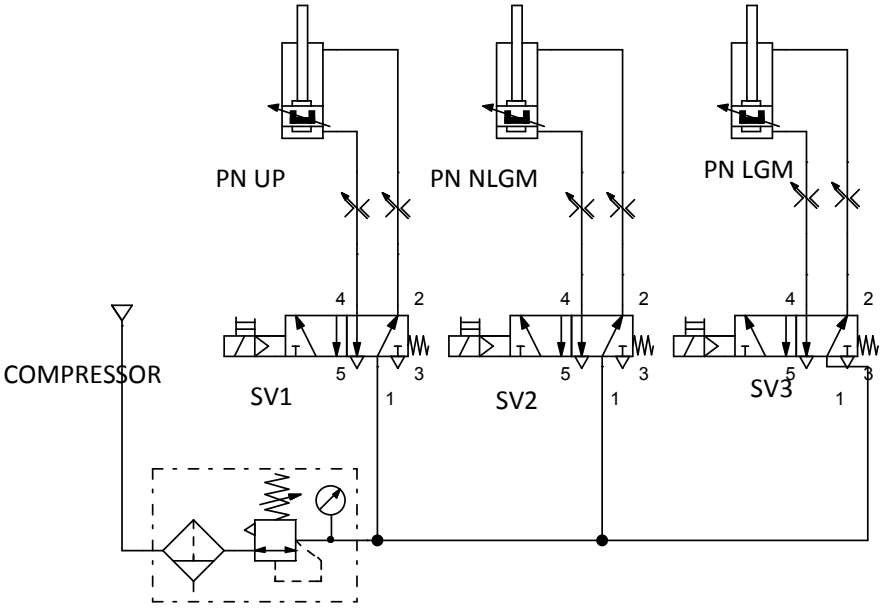


Figure 5 Pneumatic Hose Installation

3. RESULTS AND DISCUSSION

3.1. Power Supply Testing

In a power supply electronic device is the most important component. Because without the power supply the appliance will not be able to light up, let alone operate. Each component has a voltage specification each to work. Therefore it is very important for us to test the voltage entering or exiting a device. The following are the voltages measured on metal and non-metal sorters metal based on PLC and pneumatics.

Table 1 Input Power Supply Testing

Componen	Voltage (Volt AC)
Power	233.1
In PLC	227.2
In Power Suplay	226.9
In Photo Sensor	232.2
In Selenoid	231.2

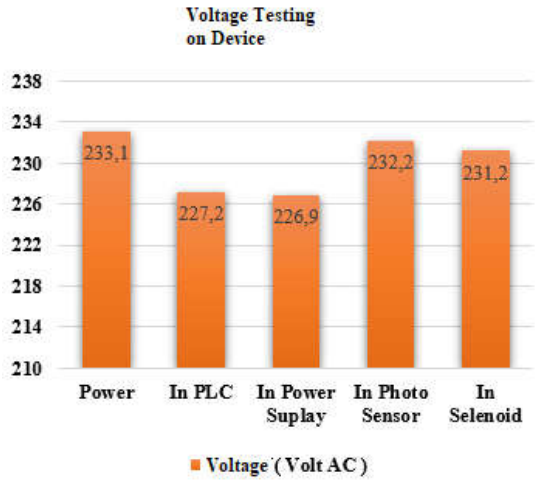


Figure 7 Voltage Testing on Device

Table 2 Output Power Supply Testing

Componen	Voltage (Volt DC)
Out PLC	24.13
Out Power Suplay	12.02
In kompressor	11.82
In Proximity	24.13

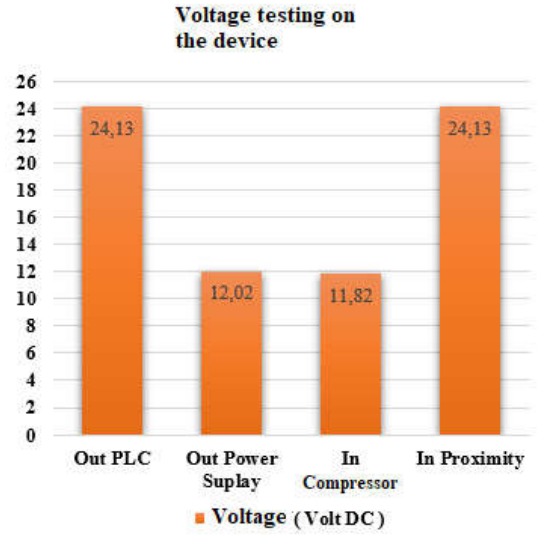


Figure 8 Voltage Testing on the Device

3.2. Proximity Sensor Testing

Proximity sensors are used to find metal and non-metal objects. This sensor is very important in the device that is made. As for testing that The aim is to find out whether this sensor can work properly or not. Besides this, with this test we can find out the distance the maximum that can be detected by this sensor.

Table 3 Proximity Sensor Testing

Sensor Distance with Objects	Type of Object	Sensor Condition	Sensor Input Voltage	Sensor output Voltage
1 mm	Metal	ON	24.12	23.40
1 mm	Non-Metal	OFF	24.12	0
2 mm	Metal	ON	24.12	23.39
2 mm	Non-Metal	OFF	24.12	0
3 mm	Metal	ON	24.12	23.40
3 mm	Non-Metal	OFF	24.12	0
4 mm	Metal	ON	24.12	23.40
4 mm	Non-Metal	OFF	24.12	0
5 mm	Metal	OFF	24.12	0
5 mm	Non-Metal	OFF	24.12	0

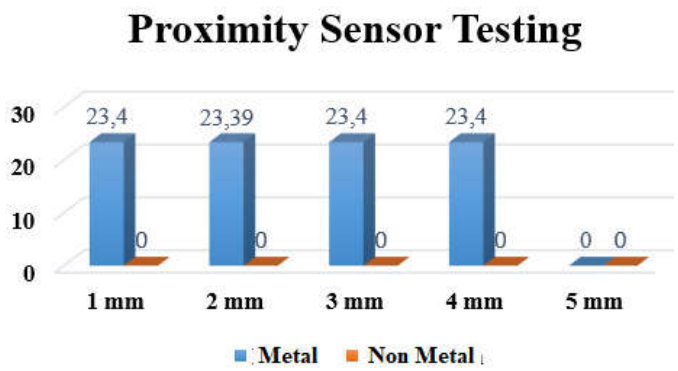


Figure 9 Proximity Sensor Testing

In the above test it can be seen that the existing proximity sensors are still functioning properly. That distance can be measured by a minimum sensor is 0 mm to a maximum of 4 mm. The measured output voltage is voltage between the sensor output with the PLC input PLC. Input voltage from the sensor is obtained from the output voltage of the PLC. Besides that we can also know that only metal objects can be detected by this sensor.

3.3. Photo Sensor Testing

In this sorting tool use photo sensor as a detector for the presence or absence of objects sorted. The photo sensor used is the BEN5M-MFR type with input voltage ranging from 24-240V AC/DC and output in the form of relay.

Table 4 Photo Sensor Testing

Objects Condition	Sensor Condition	Relay Condition	Relay Contact
No Objects	OFF	OFF	OFF
Metal	ON	ON	ON
Non-Metal	ON	ON	ON

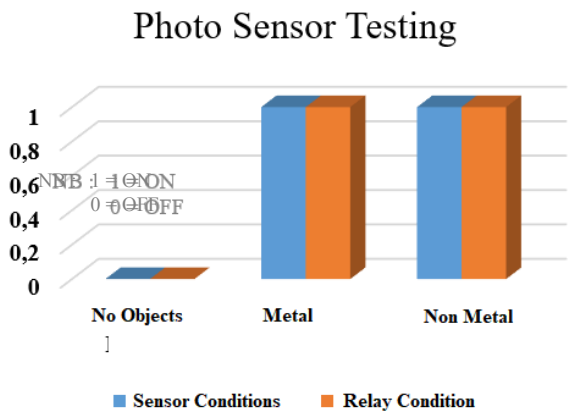


Figure 10 Photo Sensor Testing

With the test above, it can be seen that the sensor works well. This sensor is not only can only detect metal other than metal can be detected as long as the object is blocking the light that will reflected by the reflector. This sensor has an output in the form of a relay with NO/NC contacts. In this tool the author only use NO contacts only. The measurement results with Ohm meter indicate that when there are no intermediate objects the measured sensor and reflector between com and contact NO sensor are OL (over load), sensor conditions and relay off. And the measurement results when there are objects between the sensor and the reflector whether metal or non-metal is 0 Ω, with sensor conditions and relays on.

3.4. Program PLC Testing

Before testing the tool as a whole, the program is first made and tested ladder diagram PLC on cx - programmer. Ladder diagrams can be tested directly whether they are correct or wrong and ladder can be changed as desired.

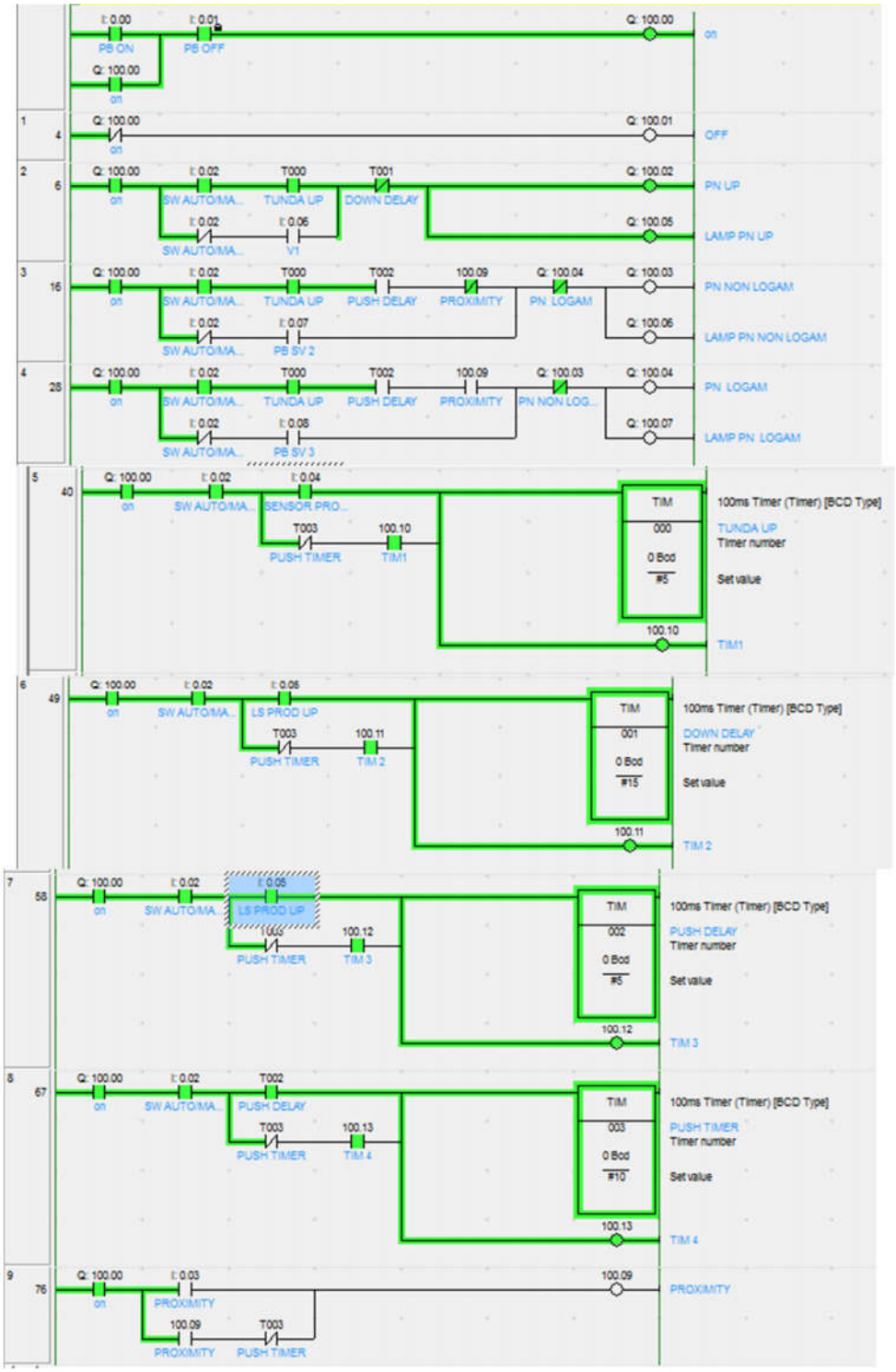


Figure 11 Ladder Diagram

After testing on the ladder above it is shown that I: 0.00 is the input for the system, and I: 0.01 is the system off. When I: 0.00 is turned on, the Q100.00 system will be active. After that,

select auto mode by activating I: 0.02. In this mode the system will run automatically. Then turn on I: 0.04 which is the product sensor input. So that T000 (delay up) will light up for 0.5 seconds and then pneumatically up (Q: 100.02) lights up for T001 accompanied by Pneumatic lights up (Q: 100.05) lit. Then turn on the LS up (I: 0.05) then the non-metallic pumum (Q: 100.03) will work as long as T003 is accompanied by lights Non-metal Pneumatic (Q: 100.06). If the proximity sensor (I: 0.03) lights up before the LS up is on, then the one that will work is pneumatic metal (Q: 100.04) accompanied by a metal Pneumatic lamp (Q: 100.07) lit up during T003. When I: 002 is turned off, the system will work manually. In this test, turn on I: 0.06, the Pneumatic up will turn on for I: 0.06 on. Similarly, when I: 0.07 is turned on, the non-metallic Pneumatic will light up as long as I: 0.07 is pressed. A similar thing will happen also when I: 0.08 is turned on then the metal Pneumatic will turn on as long as I: 0.08 turns on. In manual mode metal Pneumatic and non-metal Pneumatic cannot be activated simultaneously depending on which one is first turned on.

3.5. Overall Tool Testing

Overall system testing is carried out after testing on each part of the tool from the control system. The whole program on the cx programmer is first loaded into the PLC (Programmable Logic Controller). Then ensure the installation of components is in accordance with the planned wiring diagram as shown in Figure 4.2. The purpose of testing the whole system is to find out how the tool works accordingly as expected or not.

3.5.1. Testing Input PLC Output

In the tool there are several inputs and outputs connected to the PLC, each input and output address has a different function. The purpose of testing input and output is to control the whole input and output can work in accordance with the desired working principle. The PLC used in this device is Omron CP1E-E30SDR-A with the number of I/O 30 and input voltage 100 - 240 VAC

Table 5 Testing Input PLC Output

Address Input	Devices	Indicator on the PLC when the tool is OFF	Indicator on the PLC when the tool is ON	Informations
0.00	PB On System	OFF	ON	Function
0.01	PB Off System	ON	OFF	Function
0.02	SW Auto/Manual	OFF	ON	Function
0.03	Proximity Sensot	OFF	ON	Function
0.04	Photo sensor	OFF	ON	Function
0.05	Limit Switch	OFF	ON	Function
0.06	PB Pneumatic Up	OFF	ON	Function
0.07	PB Pneumatic Non-Metal	OFF	ON	Function
0.08	PB Pneumatic Metal	OFF	ON	Function

Table 6 Testing Tools PLC

Input Address	Tools	Indicator on PLC when the tool is off	Tools Condition	Information
100.00	Indicator On Sistem	ON	Work	Function
100.01	Indicator Off Sistem	ON	Work	Function
100.02	Selenoid Pneumatic UP	ON	Work	Function
100.03	Selenoid Pneumatic Non-Metal	ON	Work	Function
100.04	Selenoid Pneumatic Metal	ON	Work	Function
100.05	Indicator Pneumatic UP	ON	Work	Function
100.06	Indicator Pneumatic Non-Metal	ON	Work	Function
100.07	Indicator Pneumatic Metal	ON	Work	Function

From the test table above it is known that all inputs and outputs can work properly without causing damage to the equipment connected to it and in accordance with the input output address code which is given.

3.5.2. Stages of Tool Testing

There are several steps in testing a tool, namely:

1. First connect the device with a 220 VAC voltage source.
2. Turn on the main ON-OFF switch on the device and press the start button.
3. Turn the auto / manual switch selector towards Auto.
4. Enter the items to be sorted in the available places alternately.
5. To find out the condition of pneumatics, move the switch selector in manual mode.
6. Press the SV1 button to move PN UP, SV2 to move the non-metallic PN, SV3 to move the metal PN.

The results of testing PLC and pneumatic based metal and non-metal sorting tools, it can be seen that the analysis of this equipment is as follows:

1. When the switch selector is power on the compressor will turn on and will turn off when the pressure reaches 6.6 The bar is marked by the operation of the pressure switch and will turn on again after a pressure of less than 4.4 Bar.
2. When the selector switch is in the auto position, the tool will run with an automatic system.
3. After the object to be detected is put in place, the object will fall and will be detected by the proximity sensor and photo sensor.
4. If the detected one is non-metallic, then only the sensor will light up.
5. Then the object will be pushed up to the limit switch on and then the non-metallic PN will drive it to a non-metallic container.
6. If the detected is metal then the one that is lit is a photo sensor and proximity sensor.
7. Then the object will be pushed up to the limit switch on and then the metal PN will drive it to the metal object container so on until the system is turned off.

From the testing above is an automated test where everything is going according to the working principle. Test results are automatically shown in the table below.

Table 7 Automated Test

Detected Objects	Photo Sensor Condition	Proximity Sensor Condition	Pneumatic UP Condition	Pneumatic Non-Metal Condition	Penumatic Metal Condition
Metal	ON	ON	ON	OFF	ON
Metal	ON	ON	ON	OFF	ON
Non-Metal	ON	OFF	ON	ON	OFF
Metal	ON	ON	ON	OFF	ON
Non-Metal	ON	OFF	ON	ON	OFF
Non-Metal	ON	OFF	ON	ON	OFF
Metal	ON	ON	ON	OFF	ON
Non-Metal	ON	OFF	ON	ON	OFF
Metal	ON	ON	ON	OFF	ON

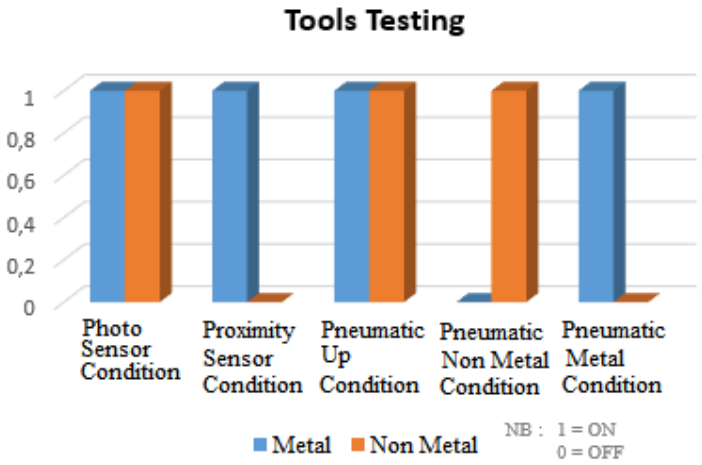


Figure 12 Tools Testing

4. Conclusions

Based on the problems, results and testing of tools, conclusions can be taken as follows:

1. Roko SN04-N Proximity sensor can only detect metal objects.
2. The proximity detection distance is above 0-4 mm from the sensor.
3. BEN5M Photo sensor-MFR can detect every object that passes between the sensor and reflector other than objects that can be detected can be metal and non-metal.
4. Based on the design, test results and working principle, then the tool has worked according to what was planned before, then the tool can be said to function.
5. This tool can not only be used to sort metal or non-metal items but can also be used to move objects from line 1 (bottom) to line 2 (above).

5. Recommendations

Some things that need to be considered in the realization process and effectiveness testing are usually:

1. When detection can be added a counter circuit to calculate how many objects detected both metal and non-metal.
2. In non-metal containers an alarm and proximity sensor can be added to determine whether there is a wrong sort of object due to a system error.
3. In the storage of objects both metal and non-metal can be replaced with conveyors to carry objects that will have been sorted into the next process.

6. References

[1] Rancang Bangun Sistem Otomasi Lini Produksi Quality Control Berbasis Programmable Logic Controller (Plc) Nama : Siddha Pradipta," p. 717.

[2] S. Sadi, S. Mulyati, and D. A. Kurniawan, "Items' Filling System Prototype with Sorting System According to the Color and Height of the Conveyors based on PLC Omron CPE1E," *Int. Res. J. Eng. Technol.*, vol. 869, 2008.

[3] D. K. Č. Áková and R. Zahoranský, "Laboratory Workplace Of Automated Assembly – Contribution To The Education Quality Emprovement Darina KUMI Č ÁKOVÁ, Róbert ZAHORANSKÝ," pp. 34–41.

[4] Valencia-Palomo, G., & Rossiter, J. A. (2011). Programmable logic controller implementation of an auto-tuned predictive control based on minimal plant information. ISA Transactions, 50(1), 92–100. doi:10.1016/j.isatra.2010.10.002

[5] Programmable Controllers. Part 2: Equipment Requirements and Tests, 1994.

[6] British Standard, BS EN 61131-2, 1995.

[7] A. J. Crispin, Programmable Logic Controllers and their Engineering Applications, 2nd ed. New York: McGraw-Hill, 1997.

[8] M. G. Ioannides and P. J. Papadopoulos, "Speed and power factor con- troller for AC adjustable speed drives," IEEETrans. Energy Conversion, vol. 6, pp. 469–475, Sept. 1991.

[9] Programmable Controllers. Part 3: Programming Languages, 1993.

[10] British Standard, BS EN 61131-3, 1993.

[11] M. G. Ioannides and I. M. Katiniotis, Laboratory of Electric Drives. Athens, Greece: Editions National Tech. Univ., 2000.

[12] L. Hristofovou and K. Hatzipetvou, "System with PLC for the control of asynchronous motor," Diploma work, National Tech. Univ., Athens, Greece, 1998.

[13] M. G. Ioannides, P. J. Papadopoulos, and J. A. Tegopoulos, "Digital tech- niques for AC voltage regulation," in Proc. 6th Int. Conf. Power Elec- tronics Motion Control, Budapest, Hungary, 1990, pp. 975–979.

[14] Programmable Controllers. Part 3: Programming Languages, 1993.

[15] British Standard, BS EN 61131-3, 1993.

[16] A. Hossain and S. M. Suyut, "Monitoring and controlling of a real time industrial process using dynamic model control technology," in Proc. IEEE Ind. Applicat. Soc. Workshop on Dynamic Modeling Control Ap- plications for Industry, 1997, pp. 20–25.

[17] K. T. Erickson, "Programmable logic controllers," IEEE Potentials, vol. 15, pp. 14–17, Feb./Mar. 1996.

[18] B. Maaref, S. Nasri, and P. Sicard, "Communication system for indus- trial automation," in Proc. IEEE Int. Symp. Industrial Electronics, vol. 3, 1997, pp.

1286–1291.
[19] A. Mader and H. Wuper, “Timed automation models for simple pro- grammable logic controllers,” in Proc. 11th Euromicro Conf. Real-Time Systems, 1999, pp. 106–113.
[20] J. Marcos, E. Mandado, and C. M. Penalver, “Implementation of fail-safe control systems using programmable logic controllers,” in Proc. IEEE/IAS Int. Conf. Industrial Automation and Control, 1995, pp. 395–400.
[21] Z. Futao, D. Wei, X. Yiheng, and H. Zhiren, “Programmable logic con- troller applied in steam generators water levels,” in Proc. IEEE/IAS 31st Annu. Meeting Conf. Rec., vol. 3, 1996, pp. 1551–1556.
[22] Imaduddin, M., 2016. Rancang Bangun Trainer Alat Penyortir Barang Logam Dan Non Logam Sebagai Media Pembelajaran Pada Mata Kuliah Dasar Sistem Kontrol, Skripsi, Jurusan Teknik Elektro, FT UNES , Semarang.