Development of Learning Media for Pneumatic Control Systems for Separation and Transportation of Goods Based on Programmable Logic Controller (PLC)

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***Abstract*— Pneumatic systems have advantages compared to other systems, pneumatic systems can support quality, productivity and efficiency of work. The research process starts from designing, developing existing tools to testing pneumatic system tools controlled using PLC and HMI. The results show that the design and development process started from adding color sensors and HMI from the system to be created. Then make modeling with the Festo Fluidsim application. After the capitalization is carried out, the hardware assembly is divided into two parts, namely the main and supporting hardware. The main hardware consists of a metal separator system, color separator and robotic arm, while the supporting hardware such as tables, conveyors and control panels. Once the hardware is complete, the PLC and HMI programs are made, the PLC uses MELSOFT Series GX Works2 software and the HMI uses Live Studio software. When the hardware and software are complete, testing and data collection of the tool work are carried out. Tool testing is carried out to determine the required bar pressure with a 100% success rate.**

Keywords*— Pnuematic System, Programmable Logic Controller (PLC), Human Machine Interface (HMI).

I. Introduction

Pneumatic systems have advantages compared to other systems, pneumatic systems can support quality, productivity and efficiency of work. All systems that use energy stored in the form of compressed air to produce work. In other words, pneumatics means studying the movement of wind (air) which can be used as a transfer medium and as storing energy (power) obtained from the atmosphere and compressed into the compressor. [1]

Based on previous research, it is known that HMI has not been used, especially in the midst of technological advances, students are expected to be able to use HMI as a control system. While the current research is being developed into a learning media so that students can conduct simple experiments in the use of HMI. [2]

Based on these problems, the author wants to develop a tool based on research entitled "Development of Learning Media for Pneumatic Control Systems for Separating and Transporting Goods Based on Programmable Logic Controller (PLC).

II. Research Methodology

Pneumatics is the theory or knowledge of moving air, the conditions of air equilibrium and the conditions of equilibrium. Pneumatics uses the laws of aerodynamics that determine the state of equilibrium of gases and vapors.

Indeed, electronic systems have a very fast response to control signals. But pneumatic systems have better durability. In some applications, pneumatic systems can work in atmospheres that electronic systems cannot, and pneumatic systems can also be used in wet conditions (Mulianto, E Suanli, and T. Sutanto, 2002). [4]

Pneumatics is divided into fields based on its working pressure, from the field of very low pressure (1,001-1.1 bar), low pressure pneumatics (1.2-2.0 bar), medium pressure pneumatics or also called normal pressure pneumatics (2.8 bar) and high pneumatic pressure (>8 bar). [5]

A. Double Acting Cylinder

Double acting cylinders have holes for entering and releasing air at both ends. If the air source is inserted through the hole at the back of the cylinder, the piston will move forward and the air will exit through the hole at the front of the cylinder. This condition is usually called the extended condition. Conversely, if the air source is inserted through the hole at the front of the cylinder, the piston will move backward and the air will exit through the hole at the back of the cylinder. (6)

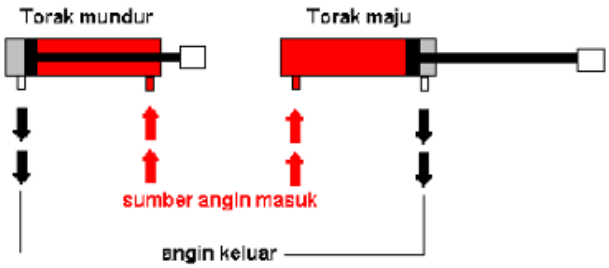

Figure 1 Illustration of how a Double Acting Cylinder works

B. PLC Parts

Basically, PLC consists of four main units, namely:

1. Program memory is a place for storing sequential logic control instructions.

2. Data memory is where the switch status, the last value of the data and other data that is currently working are stored.

3. Output devices are hardware or software driver parts for actuators in industrial processes, such as solenoid switches, motors and valves.

4. Input devices are hardware or software driver parts for sensors in industrial processes, such as switch status sensors and proximity detectors. [7]

The schematic of a PLC-based system can be seen in Figure 2 below. Each phase.

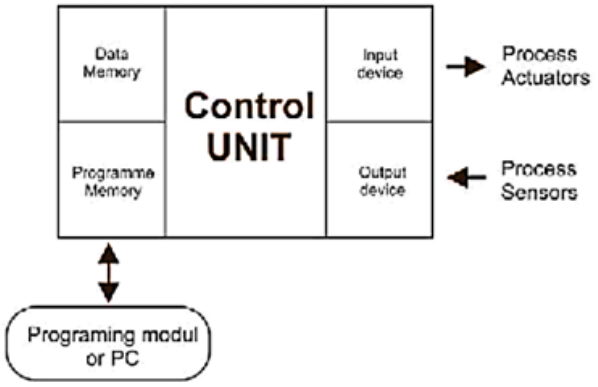

Figure 2 Schematic of a PLC-based system.

C. Gradient Boosting Algorithm

The definition of PLC is a system that can act as a manipulator, executor, or monitor the state of a fast process, with programmable data instructions and can store finished data instructions. PLC receives input and produces output in the form of electrical signals to control the system through a process. Processing in PLC is gradual or sequential (sequential process), which runs gradually towards the expected final condition, meaning that certain sub-processes can only be executed after the previous sub-process has been completed. PLC technology was first introduced around 1968-1970 with the aim of being an alternative to complex relay control systems. In the 1980s when microprocessors were easily available, with cheap memory, flexible input and output features, the modern PLC generation began. In the 1990s, the use of PLCs became more widespread along with the increasing sales of Personal Computers (Webb and Reis, 1995).

D. FX3U PLC. MITSUBISHI-FX3U 48MR PLC

PLC FX3U 48MR, contains specific information about the PLC configuration used, namely '48' means the total number of I/Os on the PLC unit, 'M' usually indicates that the PLC uses AC power which is generally around 220-240 VAC, and 'R' means the output type is relay. [8]

Figure 3. PLC FX3U 48MR

E. Melsoft series Gx works software2

GX-Developer/GX-Works is a software from Mitsubishi PLC that is used to write a PLC program using a programming language, namely ladder diagram. GX-Developer/GX-Works has programming command symbols, namely input (X), output (Y), Timer (T), Counter (C). Then there are basic logic commands AND, OR, SET, RESET, PULSE, Timer, and Counter (Rezaputra & Cahyono, 2021) Gx works2 is one of the software from Melsoft that is usually or often used to write programs that will later be entered or uploaded into the PLC or can also be used to download programs on the PLC. The language used in this software is a ladder diagram which contains several commands that can run timer counter commands, input output and many more. The following is an example of the initial display of GxWorks2.

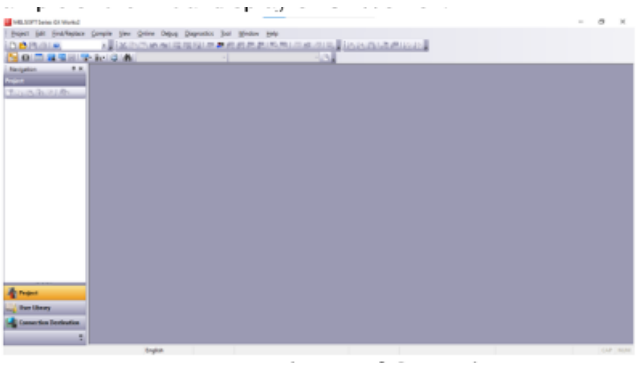

Figure 4 .Initial view of Gx works2

F. Festo Fluidsim Software

Festo Fluidsim software is a comprehensive software for the creation, simulation, instruction and study of electro pneumatic, electro hydraulic and digital circuits. All program functions interact smoothly, combining various forms of media and knowledge sources in an easily accessible way. Festo Fluidsim combines an intuitive circuit diagram editor with detailed descriptions of all components, component photos, sectional view animations and sequenced videos. Festo Fluidsim is therefore perfectly suitable not only for use in lessons but also as a self-study program. The essence of this simulation does not need to fear comparison with more expensive specialized programs. [9]

G. Human Machine Interface WECON

Human-Machine Interface (HMI) is a data display interface for operators and provides control input for users in various forms of data (schematics, menus, graphics, etc.). The HMI work system is to be able to perform monitoring, control and data acquisition systems. In general, automatic control system technology consists of plants, sensors, and controls (Priswanto et al., 2018). HMI is an important part of an automatic system because it allows humans to access and control the system in an easy and efficient way. In addition, HMI also allows humans to continuously monitor system conditions and make the right decisions according to existing conditions. The following is an example of an HMI image used. [10]

Figure 5. Wecon PI3070IE HMI, 7 Inch, Single Phase

III. Research Methods

Figure 6 describes the stages in making a Prototype of a Separator and Freight Carrier with a PLC-Based Pneumatic System, to the testing and analysis of the tool.

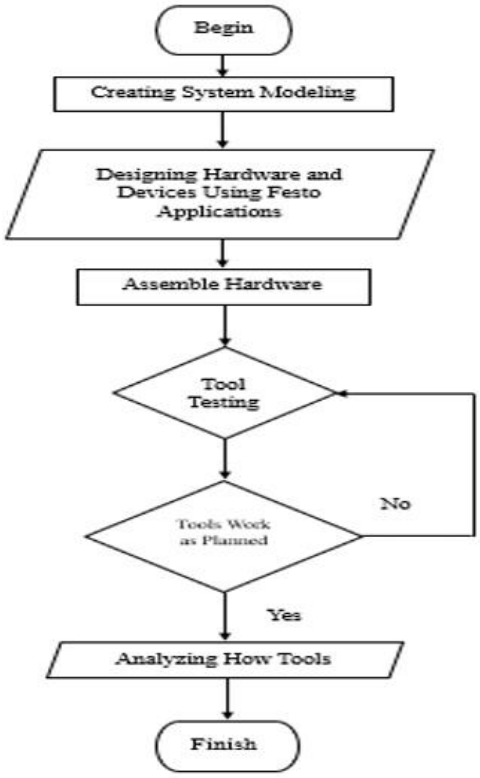

Figure 6. Pneumatic Control System Flowchart

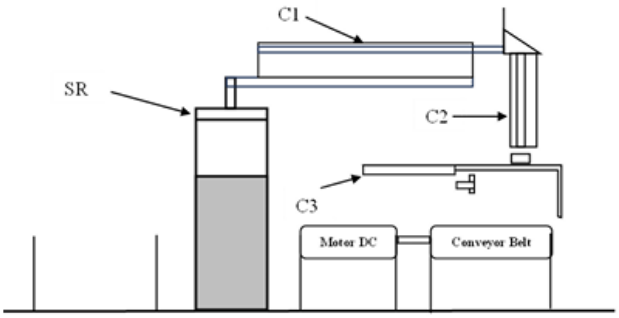

Figure 7. Robotic Arm Sketch

Note: SR = Semi Rotary, C = Cylinder

Figure 7 is a sketch of a robotic arm designed to be able to move materials.from the Conveyorbeltto the storage box.

In PLC programming, two methods are made as are common in the industrial world, namely automatic and manual methods. The following is a flow diagram of PLC program planning.

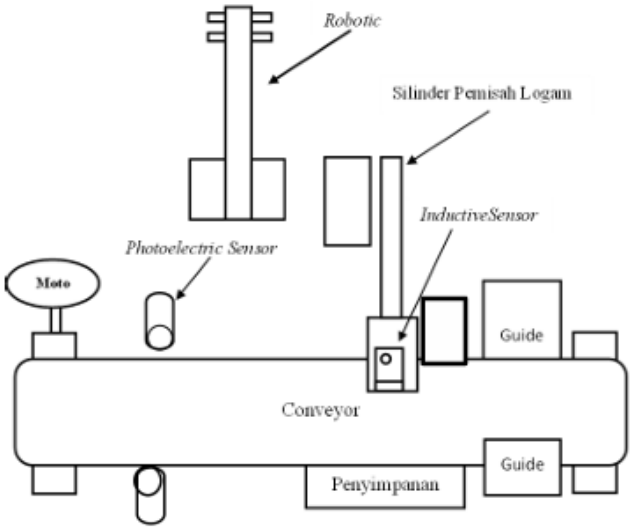

Figure 8. Conveyor Belt and sensor layout sketch

IV. Results and Discussion

This tool is divided into 2 parts, namely the robotic arm and the metal separator cylinder. The robotic arm uses four actuators, namely one semi-rotary actuator and three cylinders. These actuators are connected using strong iron to form a robotic arm system. If the material does not have a white color or does not contain metal elements, the conveyor belt will carry the material to the end of the conveyor belt which will later be lifted by the robotic arm.

Meanwhile, for metal separators, if there is a metal element in the material, the inductive sensor will send a signal to the PLC to activate the solenoid valve, which functions to flow air into the cylinder to push the material down from the conveyor belt, as well as the color sensor, if there is a white color in the material, the color sensor will send a signal to the PLC to activate the solenoid valve, which functions to flow air into the cylinder to push the material down from the conveyor belt.

The development of this learning media works based on two modes, namely automatic and manual modes. In automatic mode, the conveyor belt will run and carry the material. When the material runs, the material will pass through the color sensor and the inductive sensor. If the material has a white color and a metal element, the

inductive sensor will send a signal to the PLC to activate the solenoid valve, which functions to flow air into the cylinder to push the material down from the conveyor belt as well as the color sensors. However, if the material does not have a white color or does notcontaining metal elements, the conveyor belt will carry the material to the end of the conveyor belt which will then be lifted by the robot arm. For manual mode, the actuator can be controlled separately, and can also be operated via HMI.

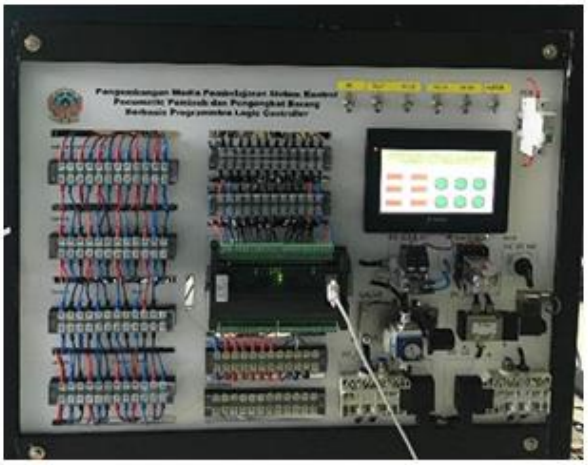

Figure 9. PLC and HMI circuit

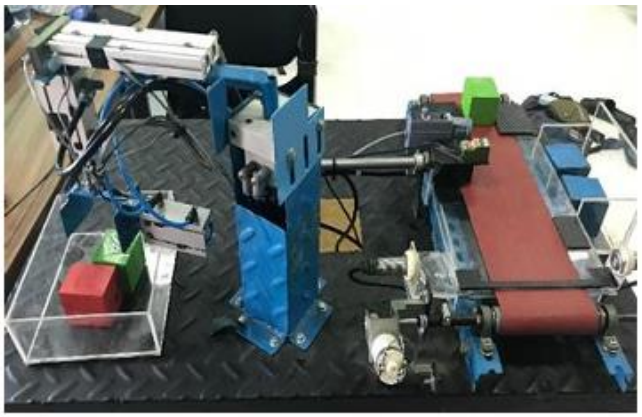

Figure 10. Pneumatic circuit

The working pressure test aims to determine the best working pressure and pressure limits that can be used to move the tool. In the robot arm test, the material to be used is in the form of a block with painted wood. While the cylinder pushes the material made of iron plate. Table 1 Robotic Arm Test Data with Several Working Pressures.

Table 1 shows the testing of the robotic arm system at several working pressures. The results show that this system can work well at working pressures between 3 to 4 bars.

While at a pressure of 5 bar this system cannot work perfectly because the semi-rotary can only work at a maximum pressure of 4 bar. This can be anticipated by installing a pressure regulator on the semi-rotary even at a pressure of 2.5 bar the system does not work properly because to move the C1 cylinder with a heavy load requires a minimum pressure of 3 bar.

Table 2 shows the test results of the metal separation system at several working pressures. The results show that the system can work 100% at every pressure tested.

When the two systems are combined, to work properly they require air with a working pressure of between 3 and 4 bars.

v. Conclusion

1. The design process begins by determining the working principle and components used. Then make developments on this tool by adding (Human-Machine Interface) HMI using live studio software, color sensors and replacing from Omron Programmable Logic Controller (PLC) to Mitsubishi Programmable Logic Controller (PLC). Furthermore, a ladder diagram is made using GX-Developer/GX Works software.
2. The working method shows that the separator and conveyor with PLC and HMI Based Pneumatic system can work with 100% success rate at 3 to 4 bar air pressure.

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