



# Control System for Plastic Molding Machine Using PLC at CV. Guna Teknik

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**Abstract**— An injection molding machine is a machine that uses an injection process into a mold to make a product according to the shape of the mold. In this study the aim was to apply the injection molding machine control system method which is still conventional at CV. Guna Teknik, where the previous method was no longer effective to be applied today. The design involves 2 core processes of an injection molding machine, namely the heater and injection processes. In this process, the heater has the role of melting/heating plastic materials, while in the injection process, the process of injecting thermoplastic material into the mold occurs with the help of a hydraulic arm and screw rotating in a barrel containing a heat band element and a product is formed in the mold. before finally the product can be taken and used. In running this automatic injection molding machine, we add a control system component in the form of a thermocouple sensor which is used to control the heater process and add a limit switch which is useful for controlling the injection process. In addition, we use a PLC (programmable logic controller) to control all existing components. on injection molding machines and implementing HMI (Human machine Interface) which is useful for operating a machine and also for monitoring the process flow of injection molding machines when running production processes. By following the process flow, a PLC-based injection molding machine design program is created, it is hoped that it will be more efficient in the control and repair process so as to save time and operational costs when damage occurs.

**Keywords**— PLC, HMI, Molding machine, Control, Heater

## I. INTRODUCTION

Currently, in the manufacturing industry, plastic injection molding The molding process is an important branch of manufacturing process of creating plastic components . Many types of plastic products are created from this process, from everyday products to auto parts and larger machinery [1][2]. Plastic products that naturally respond to our needs, adequate technology is required for injection molding machines, injection molding, materials, methods and people, with different parameters. One of the controlling factors in this case is the parameter setting on the injection molding machine. In the company where I researched, the existing molding machine control system is still conventionally based or still uses buttons as a means of running the machine, so the operator has to spend a lot of energy to operate the molding machine[3].

From these problems it is clear that the machine must be modernized so that the company can compete with its competitors, by adding a PLC control system, the operator can only manage the machine performance in front of the HMI screen. On the HMI screen, the operator can select the control system automatically or manually.

The purpose of this research is to modernize the existing molding machine control system at CV.Guna Teknik where the previous control system still used a conventional system. By adding PLC control it can produce time efficiency and save human labor. After conducting a series of trials, the researchers will compare the control systems before they are modernized [4].

## II. BACKGROUND AND RELATED WORK

### A. Modul Input

This input module is the module that is responsible for synchronizing the input device with the main control module, namely the PLC (Programmable Logic Control) device. In this section there are 3 main input devices, namely limit switches. After that, there is a personal computer device (PC/laptop) which is used to monitor the program being run and to create a program that will be sent to the PLC device. Then there is a thermocouple sensor which functions to measure the heat level of the heater. Apart from that, the value obtained from the thermocouple is used to set point for the temperature variation method which is applied based on the type of material that will be used before the inject process begins.

### B. Injection Molding

Injection molding is the most traditional manufacturing process for plastic parts. Use injection During the casting process, a variety of items are created, varying in size, complexity, and execution [5-6]. Hot channel is better than cold running, but rarely used due to high cost and difficulty [7]. This process is widely applied to the mass production of many types of plastics.parts, from LEGO bricks to advanced auto body panel [8]. Every substance needs a complex set of parameters such as injection temperature, injection pressure, flow rate, mold temperature, injection temperature, cooling rate and cycle time. An incorrect set of parameters leads to many flow lines, burn marks, warping, voids/air pockets, sink holes, weld seams, water jet. Small Defects include discoloration, resin use and segregation during storage. Faulty snapshot and flash trigger construction or repair. These criteria include process optimization and error collection. Impact these casting process criteria and recommendations for creating defect-free component requirements learn more[9].

### C. Program Logic Controller

In this section, the PLC functions as the main controller, namely as a program processor that will be entered into the programmable logic controller memory. In addition, the PLC is also responsible for processing input devices and controlling all output devices and visualizing them through

the HMI. Automation is mainly used in various industries to increase the speed, accuracy and efficiency of production and reduce risk. Programmable logic controller (PLC) is one of the controllers Automation equipment is widely used in industry and can be programmed to control the operation of machines [9-10]. PLCs are used for automation and electromechanical processes in many industries and machines used to control certain industrial processes and monitor systems [11]. Application of PLC in industry can improve production systems and efficiency so that the workforce is able and PLC technical expertise is required. Advantages of PLCs are favored by this trend, instead of being used Separate control system: The use of standard hardware ensures fast prototyping and quality parts at affordable prices. reasonable cost, dedicated maintenance support, availability of skilled and incremental programmers Upgrading to more powerful hardware can increase machine performance or add new features such as an internet connection, writing to a production data database or even flexible lines for close monitoring changing production needs [12].

#### D. HMI

Human Machine Interface (HMI) is an interface system that connects humans and PLCs or machine, so that the interaction between the operator and the machine is increased through the touch screen or computer screen. HMIs work to monitor actual factory conditions by providing visuals of the system in real time, and the alarms are a warning sign in the event of a problem in the system. HMI in The production is done by rendering a Graphical User Interface (GUI) which will be supervised by machine operators and users who need machine data [13].

#### E. Modul Output

This output module section is the part that regulates the relationship between the main PLC and HMI devices and the existing output devices. Devices connected to the output module include a heater whose state is read by a thermocouple, a hydraulic motor which functions to inject material into the mold which is connected to a timer as a timer when the hydraulic motor is running. The first stage is determining the title starting from March 6 2023, at this stage the researcher consults with the supervisor regarding the title of the research to be submitted, then the researcher carries out a literature study to collect data related to previous research [14].

The second stage of control system design, this stage starts on June 29 2023, after carrying out a literature study, the researcher began carrying out a series of control system designs starting from drawing flowcharts, making ladder diagrams, and a series of tests in order to get fairly accurate results and minimize errors. on the ladder diagram.

And the third stage is the preparation of a pre-research report, this stage will begin on July 1 2023, after carrying out a series of trials and so on, the researcher begins to prepare a report where the contents of the report include problems with the molding machine, the purpose of the research, the benefits of the research, the research methods used by the researchers to carry out this research are also explained, after all the series are completed at the end the results and conclusions of the research that has been carried out are included [15].

### III. RESEARCH METHODS

#### A. Research Flow Chart

The research flow consists of stages of research behavior, which begins with an interest in knowing a particular phenomenon and then develops into ideas, theories, concepts, and the choice of appropriate research methods. Researchers can manage research in a structured and orderly manner with this research flow. In this research, researchers used several steps, for example literature study, data collection, control system design, and analyzing research results. In general, the research flow is described in the following flowchart:

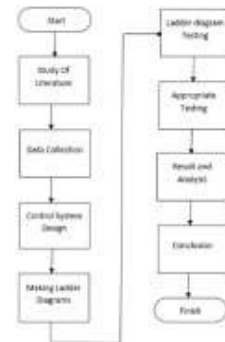


Fig 1. Research flow chart

#### B. Research Methods and System Design

##### 1. Research methods

In this design system, the program was initially created on a personal computer, the program was created using the ladder diagram programming language. Then the program is sent to the Programmable Logic Controller (PLC) which functions to align the input devices and output devices so that the input devices can be monitored by the PLC and the output devices can be controlled by the PLC via HMI (Human Machine Interface) which aims to visualize data from sensor measurements or automation processes which occurs in the PLC (Programmable Logic Controller). This HMI visualization can be in the form of graphs, values in the form of numbers, diagrams, buttons and so on so that the data sent by the PLC is easy to read, understood by humans and the internal contacts of the PLC relay can be easily operated. After the program is sent, the PLC will recognize the addresses of the input and output devices being controlled. Then the PLC waits for input from the input device (limit switch) to start the activity of this control module.

After the limit switch button is pressed, this limit switch is under the mold installation lever, which when the limit switch is pressed by the lever at the same time as the mold is installed, the PLC will activate the timer.

##### 2. Research Subjects

The subject of this research is modernizing the molding machine control system at CV.Guna Teknik where the previous control system still used a conventional system. By adding PLC control, it can produce time efficiency and save human energy and can compare between conventional control systems and control systems that have been modernized by adding a PLC control system in terms of time so that it becomes a consideration whether or not this machine is worth adding a PLC control system. In this design the author describes the system design as shown in Figure below.

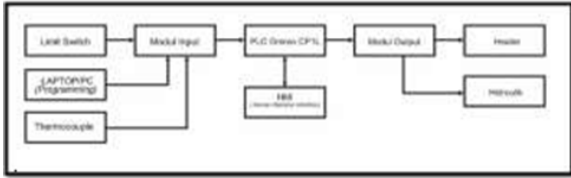


Fig 2. System Design Drawings

IV. RESULTS AND DISCUSSION

A. Hardware design

Hardware design is carried out to simplify the system creation process and minimize errors during cable installation or the wiring process. The following is a drawing of a PLC and HMI-based molding machine control hardware design. Dryers or dryers in hydrogen cooling systems for generators are used to remove moisture (water content) from the hydrogen gas used as a coolant. Removing moisture is very important because the presence of water in the hydrogen cooling system can cause corrosion of generator components and reduce their efficiency and operational life.

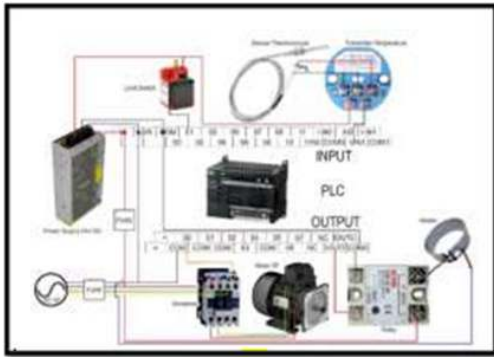


Fig 3. Hardware Design

The design diagram above shows the wiring between input and output components of the PLC, 3-phase voltage source for the Hydraulic Motor, and 1-phase voltage for the 24 VDC Power Supply and PLC voltage source. Next, the input and output cables are connected according to the addresses that have been adjusted in the PLC ladder program..

B. Making Ladder Diagrams

The software for creating ladder diagrams is CX-Programmer Ver 9.0. The first step in creating a ladder diagram with CXProgrammer is as follows. In the [Start] menu. Start CXProgrammer by selecting [Program] > [OMRON] > [CX-one] > [CX Programmer] > [CX Programmer]. (Or select [All Programs] > [OMRON] > [CX-one] > [CX Programmer] > [CX Programmer]). Then click NEW to start a new project (Ctrl + N) or choose File > New.



Fig 4. screenshot New Project

Then the following screen appears. Right click using the arrows to select the type of PLC model being used, then click Settings to select the type of CPU being used and then click OK.

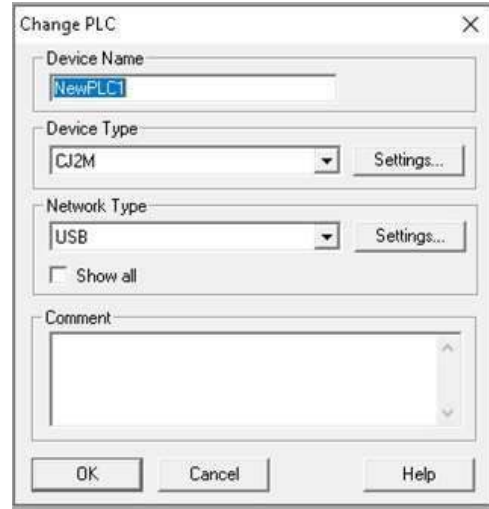


Fig 5. Screenshot Selection of CPU type

After that, the above dialog box will disappear and appear on the main screen of the newly created project image below

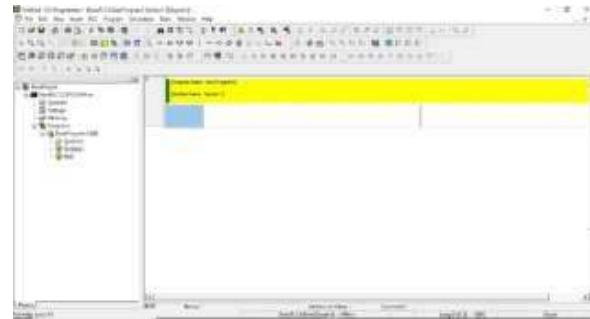


Fig 6. Screenshot of the Workspace Diagram

C. Ladder Diagram Testing

This ladder diagram test is carried out with the aim of finding out the expected program and simulation results whether they run according to the instructions or not in the CX programmer software program and simulation software rather than the ladder program that has been created using CX Designer. The program in this ladder is instructed to run in two ways, namely the program can be run automatically and manually. The following are the results of the ladder diagram test which we explain sequentially, including:

1. Output testing (heater)

In the ladder diagram test, the first output that is expected to be active is the heater, because this heater is required to always be on standby to melt the material before being pushed by hydraulics. This heater, active and inactive is controlled by a thermocouple temperature sensor and in this ladder diagram the instructions used to operate the thermocouple temperature sensor are using the compare instructions available on the PLC type CP1E-NA20DR-A and the following is a ladder display

and the following is a ladder display and heater and sensor animation simulation thermocouple temperature.



Fig 7. The heater test program is controlled by the thermocouple sensor in ON condition



Fig 8. HMI heater and temperature ON

In the picture above is the condition when the program is run and it is connected between the CX programmer and CX designer using the compare instruction which has two temperature control variables, namely with addresses D2 (Temperature) and D3 (Set point/maximum temperature limit). The output heater in the program above has address 100.01, the heater is active because it gets a signal from the input in the form of an always on + temperature button. The temperature is at a value of 80°C. The heater can be active because the maximum temperature limit is set at 80°C, so if the temperature is <math>80^{\circ}\text{C}</math> or <math>80^{\circ}\text{C}</math> the heater will be active and if the temperature exceeds the maximum limit then the heater will automatically turn off

2. Output testing (heater)

In this second test, the program was instructed that the condition of the heater must turn off when the temperature exceeds the maximum predetermined set point, which is 80°C. And here is what the ladder and HMI will look like when the program is running:



Fig 9. The heater test program is controlled by a thermocouple sensor in OFF condition



Fig 10. HMI heater and temperature OFF

The picture above shows that the heater is off both on the ladder and the HMI with address 100.01 and the light is red on the HMI with the program instruction using compare. The heater turns off because the temperature is at 81°C exceeding the maximum limit at address D3 set point at 80°C, the P\_GT (Greater Than) sensor is active causing relay address W006 to be active thereby turning off the range relay on the heater at address 100.01

3. Output testing (Inject) automatically

In testing the following ladder diagram, the program is expected to activate the output (inject) to move forward to be operated automatically with a duration of 15 seconds. When the output heater is active and the input limitswitch button is pressed. So this injection is activated by hydraulics to push the material which will later be printed on the molding. after the inject moves forward for 15 seconds, the inject will move backwards automatically and this cycle continues to repeat as long as the heater is active according to the specified temperature. The following is a ladder and HMI display of the injection output



Fig 11. The injection test program is active

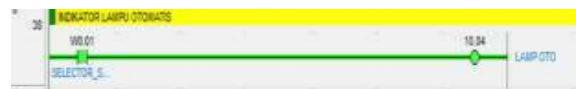


Fig 12. Marker lights automatically activate



Fig 13. HMI inject is active

The image above is the ladder and HMI display for the inject output, the inject display on the HMI with a green sign and a green marker light with address relay 10.04. This program runs automatically which is marked by a green marker light and the heater is also active with a red sign. Apart from that, in the input section the selector switch is set to the automatic mark, the limit switch is set to the on mark for temperature, the temperature is also in the 80°C position and The timer is set at 15 seconds with the timer currently being calculated reaching 10.9 seconds, that means the inject is actively moving forward, so on the ladder above this inject is active when input selector switch, limit switch (LS\_START), LS\_S1 (internal input system ) is pressed simultaneously, it will provide voltage to the injection relay using the auxiliary relay with address 10.03, after that it will activate the automatic relay with address 10.01, after that it will activate the relay again (second automatic) with address 10.02. relay 10.02 will activate the timer which is set for 15 seconds and the injector will move forward after the timer reaches 15 seconds then the timer is active and will turn off the movement of the injector so that the injector will reverse automatically where the ladder and HMI will be displayed as follows.



Fig 14. The injection test program is in an inactive state



Fig 15. HMI inject is off

In the image of the ladder diagram and HMI above it shows that the inject condition is inactive but the marker light is automatically active with the address relay 10.04 because when the timer counts for 15 seconds according to the sign on the HMI and the address (T0000) is marked with the NC contact on the relay range inject (10.07) then the timer will be active and turn off the movement of the inject, so that the inject will reverse automatically according to the sign on the green inject output HMI which turns off after that this cycle will continue to repeat as long as the heater is active and the temperature has been determined

4. Manual output testing (Inject).

In the next ladder diagram test, the program is instructed to activate the Inject to move forward manually, its function is so that this molding machine can be tested/prepare before the production process is carried out to ensure whether the machine is in a ready state or whether it is possible to carry out production other than that when maintenance is needed then the injection can be operated manually. so this injection will move forward with a duration of 15 seconds. When the input selector switch is in manual condition and the start pushbutton is pressed and the inject will die. in an active state

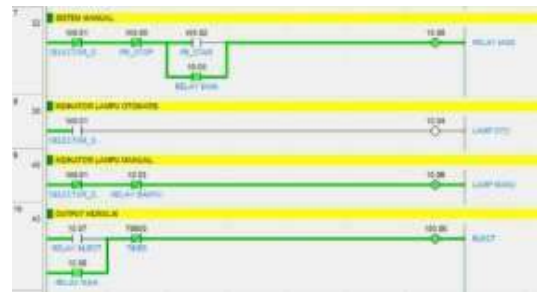


Fig 16. Manually active injection ladder diagram testing



Fig 17. HMI inject activates manually

In the ladder diagram image above, the injector will be activated manually. When the input selector switch is in the NC/closed contact condition and the pushbutton start, it will activate the manual relay with address 10.08 and will activate 100.00 as the inject address relay and the blue manual signal light will activate with the address relay 10.06 on the HMI and ladder as well as the heater condition will continue to be active due to preparation for production activities. The injector will move forward for 15 seconds, according to the timer set on the HMI and the injector will move backwards when the pushbutton stops and is pressed as shown in the image below showing the inject is manually reversed when the stop pushbutton is pressed.

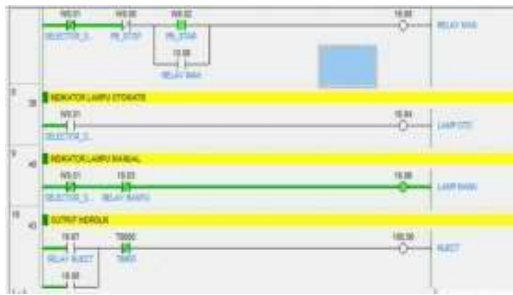


Fig 18. Testing the injection ladder diagram is not active manually



Fig. 19. HMI inject is not activated manually

In the ladder diagram and HMI above, the condition shows that the injection output is in an inactive condition. When the selector switch button with address W0.01 is in manual condition and the stop pushbutton with address W0.00 is pressed, the injector will reverse because it cuts off the voltage to the relay address 10.08 as the address of inject and marked with an active blue light output with address 10.06 and the heater also remains active.

## V. CONCLUSION

The application carried out in the flow molding machine process involves a heater which functions as a heater for the plastic material and also involves an injection system which functions to push the melted plastic material into the heater.

In carrying out the control system process on this molding machine, using PLC programming in the form of a ladder diagram using CX programmer software and also using CX Designer which has the function of controlling and monitoring the flow of the molding machine process when carrying out the production process.

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