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PLC program design using state diagram method on insert nut installing machine

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Abstract

A method that can solve the solution of creating a program on a sequential machine includes the state diagram method. To solve the solution of sequential machine automation, it is not enough to use a flow chart as a problem-solving method. The application is in the form of an insert nut installation machine for connecting or joining learning sheet plates with PLC controllers, which is the object of research in this paper. The programming language used is Ladder Diagram (LAD). The state diagram method is applied as an alternative to the Ladder Diagram program design and compared with conventional algorithms such as flow charts. The final result is the design and implementation of the Ladder Diagram PLC program on the Insert Nut Installing Machine. As a result of using the state diagram method, programming becomes faster, more efficient and safer.

Keywords

PLC, Insert nut installer module, State diagram method, Ladder diagram, Automation

Introduction

Thanks to swift advancements in industrial automation, manufacturing processes have enhanced in efficiency, precision, and reliability. The Programmable Logic Controller (PLC), key to industrial control systems, is a crucial element of automation [1]. The need for sequential control machine logic (batch process) is often required for machine control in automation systems. State machine programming is a powerful technique that can be applied to traditional ladder diagram logic to fulfill this need [2]. This article provides existing information to discuss the implementation of building a software tool capable of automatically generating appropriate ladder logic from high-level state language descriptions.

Some journals that can describe erurutban control machines, both those that use traditional methods in program implementation, and those that already use diagrammatic methods include (1) Automatic Color Sorting Machine Using TCS230 Color Sensor And PIC Microcontroller [3], (2) Object sorting based on color using TCS3200 [4], (3) Design of Goods Sorting Tool Based on Color and Weight [5], (4) Broken Goods

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Sorting Simulator with State Method Diagram [6], (5) Ladder Diagram for Dual Conveyor Part Selection and Assembling Based on State Diagram [7]. Journals that use the state diagram method, but not on machines are as follows: (1) PLC based Biodiesel System Design based on State Diagram [8], (2) Design of 3 Story Elevator Simulator Using State Diagram [9].

The above articles all describe how the state diagram method is applied to both sequential machines and what are considered non-sequential machines. This can be used as a reference for comparison with what is made in this research paper. Meanwhile, this research is more focused on the program design process by emphasizing how the state diagram method is applied and can be understood by students, in this case at the college student level. Currently, in general, to create a PLC ladder diagram program only refers to the use of flowcharts in solving the problem.

Method

The research methodology used in this study involves steps that include system analysis, status diagram development, PLC program implementation, Simulation and testing:

System analysis

Analyzing the system's input/output requirements is how analysis is done. A thorough analysis of the specs and operational needs for the machine [1]. Determine the essential parts, including the controllers, sensors, and actuators [10][11].

State diagram development

State Diagram or hereinafter referred to as the state diagram is a method that visual representation of system behavior consisting of a series of states or states that may be experienced by the system. that may be experienced by the system [12]. State diagrams are used in software engineering software engineering to describe how the system reacts to inputs and how it transitions from one state to another. from one state to another.

Programming PLC

PLC programs are created using the Ladder Diagram Language (LAD). Using the PLC programming environment to convert the state diagram into ladder logic [11]. The PLC program is created based on the State Diagram Method that has been created.

Simulation and testing

Program simulation is carried out after PLC program creation is complete using PLC programming software. Simulation-based PLC program verification to guarantee functionality and specification compliance [10]. Testing is done by testing the function of the machine and the product results of the machine. To assess the program's dependability and functionality, test it on insertion machine [13].

Results and Discussion

Results

The research conducted by one of them resulted in a machine as shown in Figure 1.

Figure 1. State diagram

The machine consists of input and output. The input and output of the insert nut installation machine input and output can be seen in Table 1 and state diagram in Figure 2.

Table 1. Input output machine

I/O	Name	Address
Input	Pressure Switch	X0
	Emergency Switch	X20
	Hydroulic Run	X21
	Reset Error	X22
	Overload	X23
	Limit Up	X24
	Limit Down	X25
	Foot Switch	X26
	Sensor 3	X27
Output	Hydroulic ON	Y25
	Punch Up Solenoide	Y26

Punch Down Solenoide Y27

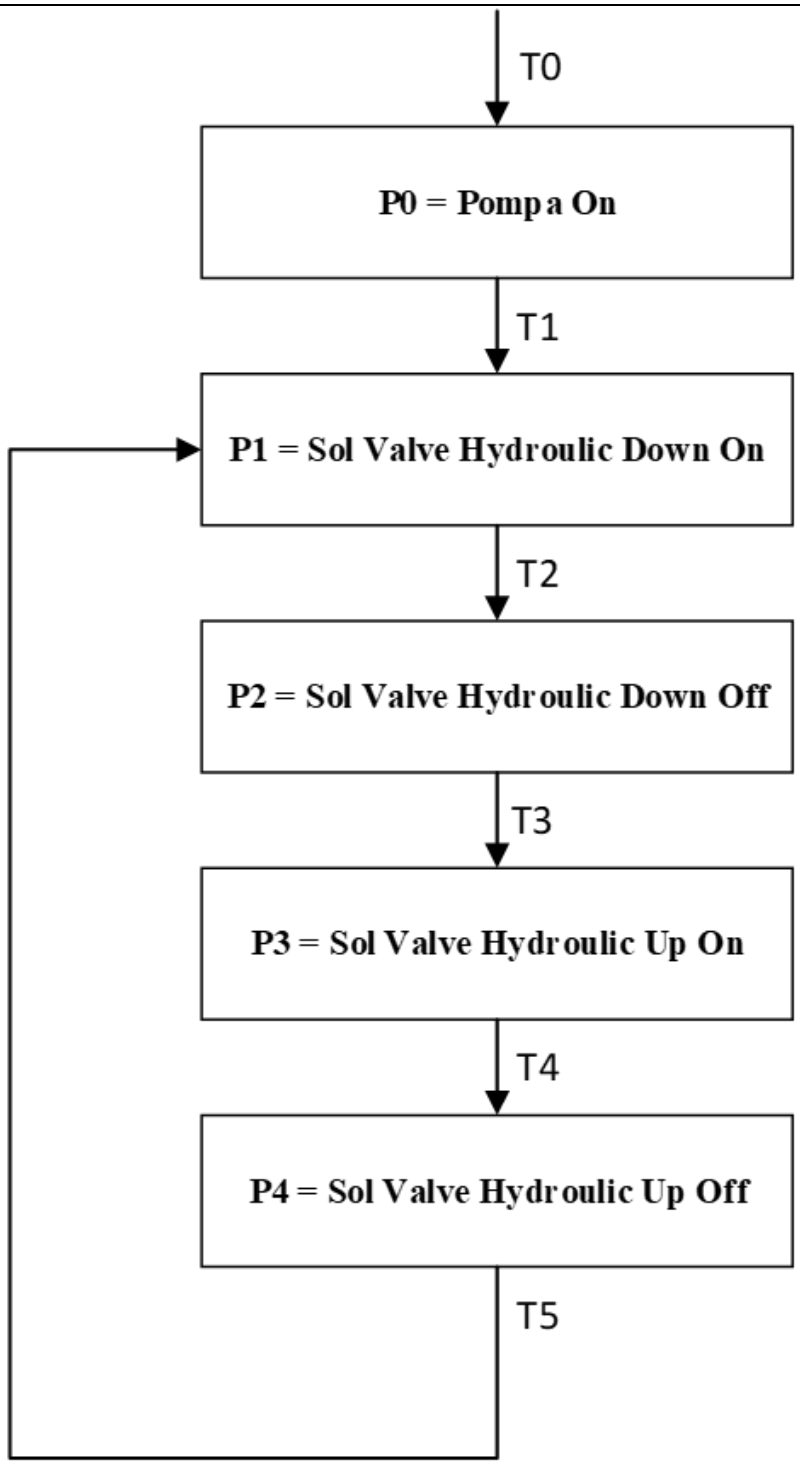

Figure 2. State diagram

Figure 2 shows the process state diagram of the auto process. T codes indicate process conditions. The P code indicates the condition of the actuator being turned on or off. PLC program can be seen in Figure 3.

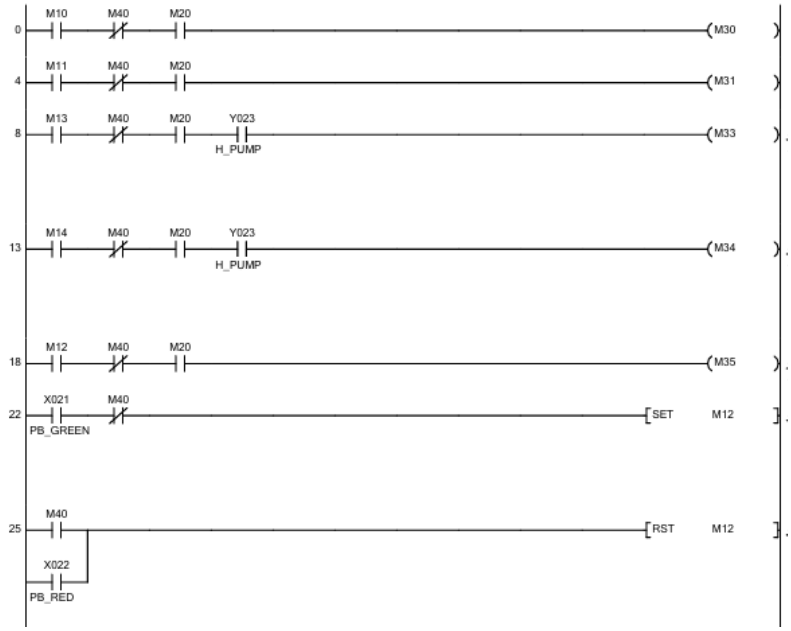

Figure 3. PLC program

Figure 3 shows the process state diagram of the auto process. T codes indicate process conditions. The P code indicates the condition of the actuator being turned on or off. Machine function results can be seen in Table 2.

Table 2. Machine function results

No	Process	Result
1	Hydroulic Manual	OK
2	Punch Up Solenoide Manual	OK
3	Punch Down Solenoide Manual	OK
4	Auto Process	OK
5	Maintenance Process	OK

Table 2 shows the results of the machine function process. The test results show that PLC programming using the state diagram method can execute all process conditions.

Discussion

The application of the State Diagram Method in designing the PLC program for the Nut Insertion Machine produced several key results:

a. Improved Program Clarity

Program development and debugging are made easier by the state diagram, which offers an understandable and straightforward depiction of the machine's operation. Engineers found it simpler to follow the system logic and make sure that every step in the process was carried out correctly thanks to the visual flow of states [11].

b. Enhanced System Performance

The PLC program effectively manages machine functions, guaranteeing precise and fast nut installation. Due to efficient program execution, cycle times are

reduced and overall productivity is increased. The system outperforms previous traditional programming techniques by 50%.

c. Reduction of Errors

Using state diagrams as an organized method reduces programming errors and inconsistencies. Error states such as process sequence errors are successfully managed through real-world simulation and testing, thus guaranteeing reliable and safe machine operation

d. Scalability and Maintainability

Future program upgrades and changes are made easier by the modular nature of PLC programs. For example, it is possible to include more operating states without requiring major modifications to the current program, or also for example in maintenance processes

Conclusion

The State Diagram method has proven to be an effective tool for designing PLC programs on complex industrial machines such as the Nut Fitting Machine. By providing a structured framework, the method improves program clarity, reliability, and performance. The successful implementation shows that this technique has potential for wider applications in industrial automation. Future work may consider the integration of this technique with advanced technologies such as the Internet of Things (IoT) and machine learning for additional optimization.

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