

Increasing the Reliability and Productivity of a Tubular Furniture Packaging Operation

Peter Panev¹, Miglena Paneva¹, Nikolay Stoimenov^{1*}, Slav Dimitrov²

Institute of Information and Communication Technologies, Bulgarian Academy of Science, Sofia, Bulgaria¹

Technical University Sofia, Bulgaria²

nikistoimenow@gmail.com

Abstract: This paper discusses the programming and control of a multi-cycle tape machine. Part of the electrical equipment is also presented. The program code in the language "Ladder diagram" is selected and the input-output diagram is described. "Ladder diagram" is a programming language designed to resemble an electrical circuit. Due to this fact, it has a great advantage over other programming languages, because electrical logic is easy and simple to present. Most of the programs in discrete automation are created on the "Ladder Diagram" due to the simple operation and easy maintenance. The description and the cyclical approach of each executive body and automatic mode of operation are presented.

Keywords: PERFORMANCE, CONTROLLER, MACHINE, PACKAGING

1. Introduction

In the coming years, the main task is to increase the implementation of automation tools in production, as well as the implementation of quality complex tasks and topics, performing full mechatronic and automatic production of products and their packaging. Of particular importance are the factors influencing production [1-6].

The packaging is part of the most developed industries globally. The wide range of uses has an impact on the daily lives of consumers worldwide. Packaging helps consumers make decisions. The fast-growing consumer society is putting packaging manufacturers to the test to meet the growing demands for quality and convenience. One of the problems affecting the future vision of European packaging is the growing pressure to provide packaging solutions from environmentally friendly and biodegradable materials [6-11].

The purpose of this paper is to increase the reliability and productivity of the tubular furniture packaging operation by integrating an automatic machine by using appropriate controllers, power supplies, and optimized software.

2. Principle of Operation and Used Equipment

Before the design, construction, and implementation of an automatic machine, the packaging of tubular furniture for transport and storage of beds was carried out manually. An employee packed corrugated cardboard with tape. The tape is placed on the corrugated cardboard on the upper and lower side. This operation ensures reliable transportation and storage without compromising the overall appearance of the product. The process is slow requiring precision and man-hours. The equipment, controllers, and control software are used to make it possible to increase production [7-11].

2.1. Principle of operation of an automatic machine

- The system is started by the green button "B1" (Start).
- If no alarms occur, the system starts inverter 1 and starts the first conveyor.
 - If there is a box in the system, move to sensor "S2", if there is no box in the system, after 60 sec. the operating cycle is interrupted and the green button "B1" is expected to be pressed again (Start).
 - If there is a box in the system, conveyor number 1 moves it to sensor "S2" at the speed set by the operator panel.
 - After reaching the sensor, conveyor number 1 stops, and cylinders "V3" and "V4" are pulled to the front position until sensors "S11" and "S12" is reached.
 - After reaching the sensor "S11" and "S12". cylinders "V5" and "V6" go down to reach sensors "S9" and "S10".
 - When sensors "S9" and "S10" are reached, the tape is fed and cylinders "V1" and "V2" perform the gluing on the main and auxiliary box.
 - After gluing and reaching sensors "S7" and "S8", cylinders "V1" and "V2" are retracted to the upper position.

- After retracting cylinders "V1" and "V2", sensors "S13" and "S14" are activated.
 - When actuating sensors "S13" and "S14", cylinders "V5" and "V6" retract to the rear position and activate sensors "S15" and "S16".
 - After retracting cylinders "V3" and "V4", sensors "S17" and "S18" are activated.
 - When all cylinders are reached in the rear position, conveyor number 1 is restarted.
 - The box moves forward until it reaches the sensor "S3" and the gluing cycle is repeated.
 - After the second gluing, conveyor number 1 is restarted.
 - The box moves forward until it reaches the sensor "S1" and the gluing cycle is performed for the third time.
 - After the third gluing, conveyor number 1 is restarted.
 - The box moves forward until it reaches the sensor "S4" and the gluing cycle is performed for the last time.
 - After the last gluing, conveyor number 1 is restarted.
 - The box leaves the gluing area and moves to conveyor number 2.
 - When sensor "S5" is reached, conveyor number 2 is activated and the box is taken to the unloading area.
 - When sensor "S6" is reached, conveyor number 2 stops and the system waits for the box to be taken away.
 - Conveyor number 1 remains switched on until a new box reaches sensor "S2" or stops after 60 sec.

2.2. Basic equipment used

a) Controller

For controller is chosen a Siemens controller S7-1200 - 1212DC / DC / DC. Table 1 presents the characteristics of the Siemens S7-1200 - 1212DC / DC / DC controller (Fig. 1).

Table 1: Mechanical Characteristics of the Siemens controller.

| Product range | Controller Siemens S7-1200 - 1212DC / DC / DC |
|-----------------------------|---|
| [Us] nominal supply voltage | 24 VDC |
| Discrete input number | 14 Discrete input according to IEC 61131-2 |
| Type of discrete output | Transistor |
| Discrete output number | 10 Transistor |
| Discrete output voltage | 24 V DC |
| Discrete output current | 0.5 A |

The controller was chosen due to its following advantages:

- Very large working memory;
- Sufficient system memory to remember all variables;
- The controller contains non-volatile memory;
- The system has enough inputs and outputs to control the mechanical system;
- The controller has a "Scan Cycle" of less than 50 [ms], which guarantees fast operation and reading of all signals without errors;

- The controller contains the "Ladder Diagram" programming language;
- The controller contains a "Web Server" for remote access.

Due to these and other advantages, the controller is chosen to control the specific automatic machine.



Fig. 1 Siemens controller S7-1200 – 1212DC/DC/DC.

b) Switching power supply.

The switching power supply used is shown in fig. 2.



Fig. 2 The switching power supply.

Table 2 presents the characteristics of the switching power supply of the controller "Siemens 1200 - 1212DC / DC / DC".

Table 2: Characteristics of switching power supply.

| | |
|--------------------------------------|--|
| Input voltage | Single-phase, 100 to 240 VAC, 50/60 Hz |
| Output voltage | 24 VDC |
| Output current | 2.5 A |
| Output power | 60 W |
| Change of output voltage,% | From -10 to +15 |
| Efficiency at 230 VAC input,% | 88 |
| Dimensions W x L x H, mm | 32x110x90 |

c) Inverter

For inverter is chosen a Siemens V20, shown on Fig. 3. Table 3 presents the characteristics of the Siemens V20 inverter.

Table 3: Characteristics of Inverter Siemens V20.

| | |
|----------------------|------------------|
| Product range | Siemens V20 |
| Communication | USS / Modbus FSA |
| Input voltage | AC 240V |



Fig. 3 Inverter Siemens V20.

3. Electric Circuit Diagram of Basic Elements

The electrical diagram (Fig. 4) shows the main elements of the electrical panel. All types of power supply modules and reversible converters are shown. A logic diagram of the chosen controller is presented and the connections of sensors and actors to it are explained. A cable log has also been created for easier maintenance and development of the system.

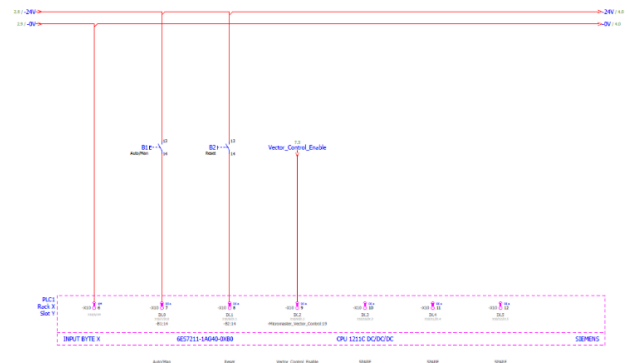


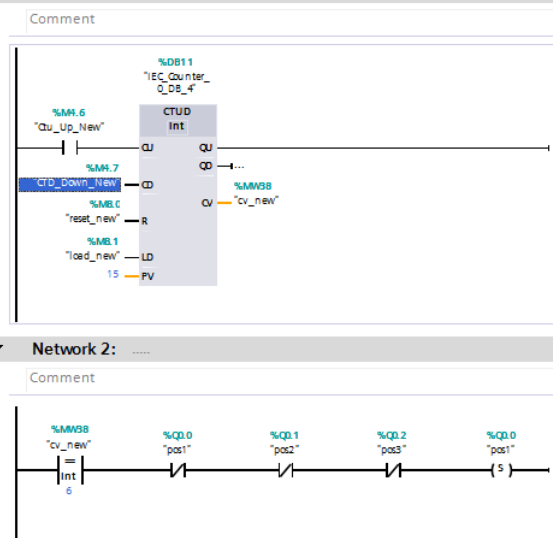
Fig. 4 Part of an electrical circuit.

4. Program Code and Diagram

The program part presents a large part of the logical elements of the „Ladder Diagram“ language. Various timers and counters necessary for creating program logic are presented. The program logic contains different control modes. There is a manual mode that allows the work of the various executive members separately. It also contains an automatic operating mode described in detail in point (2.1).

Input-output diagram - The diagram shown in fig. 6 contains a detailed description of all inputs and outputs:

- The described discrete input variables are: buttons, sensors and feedback from frequency regulators.
- The described discrete output variables are: relays, contactors and lamps.
- The described analog input variables are: Feedback from frequency regulators and speed measurement.
- The described analog output variables are: Set speed to frequency regulators.



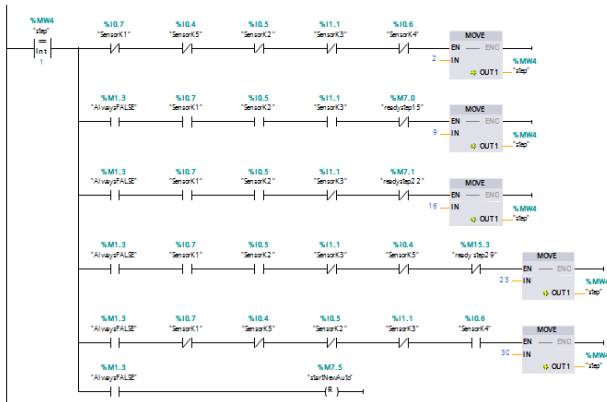


Fig. 4 Part of program code.

Table 4: Selected Inputs and Outputs for Machine Control.

| | | | |
|-----------------|-----|------|--------|
| UpNew | I/O | Bool | %I0.0 |
| DownNew | I/O | Bool | %I0.1 |
| OKprint | I/O | Bool | %I0.2 |
| PrinterEnd | I/O | Bool | %I0.3 |
| SensorK3 | I/O | Bool | %I1.1 |
| SensorK2 | I/O | Bool | %I0.5 |
| SensorK4 | I/O | Bool | %I0.6 |
| SensorK1 | I/O | Bool | %I0.7 |
| Warning Printer | I/O | Bool | %I1.0 |
| SensorK5 | I/O | Bool | %I0.4 |
| tag11 | I/O | Bool | %I1.2 |
| tag12 | I/O | Bool | %I1.3 |
| tag13 | I/O | Bool | %I1.4 |
| EndLeftTape | I/O | Bool | %I1.5 |
| BigRightDown | I/O | Bool | %I8.0 |
| BigRightUp | I/O | Bool | %I8.1 |
| MiddleRightDown | I/O | Bool | %I8.2 |
| MiddleRightUp | I/O | Bool | %I8.3 |
| SmallRightDown | I/O | Bool | %I8.4 |
| SmallRightUp | I/O | Bool | %I8.5 |
| EndRightTape | I/O | Bool | %I8.6 |
| BigLeftDown | I/O | Bool | %I8.7 |
| BigLeftUp | I/O | Bool | %I9.0 |
| MiddleLeftDown | I/O | Bool | %I9.1 |
| MiddleLeftUp | I/O | Bool | %I9.2 |
| SmallLeftDown | I/O | Bool | %I9.3 |
| SmallLeftUp | I/O | Bool | %I9.4 |
| ESTablo | I/O | Bool | %I9.5 |
| ButtonGreen | I/O | Bool | %I9.6 |
| ButtonRed | I/O | Bool | %I9.7 |
| BigRight | I/O | Bool | %Q0.0 |
| MiddleRight | I/O | Bool | %Q0.1 |
| SmallRight | I/O | Bool | %Q0.2 |
| BigLeft | I/O | Bool | %Q0.3 |
| MiddleLeft | I/O | Bool | %Q0.4 |
| SmallLeft | I/O | Bool | %Q0.5 |
| tag14 | I/O | Bool | %Q0.6 |
| tag15 | I/O | Bool | %Q0.7 |
| tag16 | I/O | Bool | %Q1.0 |
| tag17 | I/O | Bool | %Q1.1 |
| RedLamp | I/O | Bool | %Q9.0 |
| YellowLamp | I/O | Bool | %Q9.1 |
| GreenLamp | I/O | Bool | %Q9.2 |
| startOut | I/O | Bool | %Q9.3 |
| StopOut | I/O | Bool | %Q9.4 |
| tag20 | I/O | Bool | %Q9.5 |
| tag21 | I/O | Bool | %Q9.6 |
| tag22 | I/O | Bool | %Q9.7 |
| tag23 | I/O | Bool | %Q8.0 |
| tag24 | I/O | Bool | %Q8.1 |
| tag25 | I/O | Bool | %Q8.2 |
| NewCylinder1 | I/O | Bool | %Q8.3 |
| StartINV1 | I/O | Bool | %Q8.6 |
| FreeINV1 | I/O | Bool | %Q8.7 |
| INV1 | I/O | Int | %QW112 |
| INV2 | I/O | Int | %QW114 |

5. Conclusion

The ever-increasing demands for employee security, increased demand, and increased productivity require automation of operations. The used controllers, power supplies, and optimized software increase the reliability and productivity of the tape gluing operation compared to the previous state of packaging of the product. The operation of an automatic machine for packing tubular furniture is described. The machine provides a quality, reliable, and at the same time reduced level of waste. The employee's working environment has been improved and the safe use of the operation has been increased.

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