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Design and Build Automatic Cracker Machine Control System Based PLC-Pneumatic

[a]Agus Sifa*, [a]Badruzzaman, [b]A. Sumarudin, [a]Didi Wahyudi

[a]Mechanical Engineering Departement, Politeknik Negeri Indramayu, Indramayu 45252, Indonesia
[b]Informatic Engineering Departement, Politeknik Negeri Indramayu, Indramayu 45252, Indonesia

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ABSTRACT

Onion crackers are snacks categorized as crackers as complementary foods for the Indonesian people. Crackers are snacks that have a thin, round, and light shape. The process of packaging crackers is partially and fully manually done by humans. Packaging is representative of product quality. The packaging sealing process is influenced by pressure, temperature, and time. The method used in this study is to design and build a control system and test the results of the manufacture. The control is made based on PLC with CX-Programer software which the system control integrated with HMI made with CX-Designer software. The control system is designed to drive the AC motor of the dosing system, the Dc motor of the packaging puller system, and the vertical and pneumatic heating system on the horizontal sealer system. The control system is made and tested for the function of the I / O program, and the overall control system that has been made works well.

KEYWORDS

Packaging Machine
PLC
Control System
Crackers
HMI

INTRODUCTION

Onion crackers are snacks included in the crackers category as a complementary food for the Indonesian people, with various types of crackers based on the raw material source of starch which has a taste based on a mixture of raw materials in the form of fish or onions. Onion crackers have a thin, round, and light shape [1]. One area in Indonesia that produces crackers is Indramayu-west java, a cracker Industry Center with a production output of 1,200 tons per month [2]. However, the packaging process is still conventional and partial. The packaging process fully utilizes human labor. Packaging is representative of product quality. Food packaging design is one factor that affects the seal's quality. The packaging plastic film is folded differently based on the design requirements during the forming process. The packaging seal can accommodate the extra pressure formed by the side of the seal with heat and pressure parameters. Another problem is that the risk of leakage at the point interaction between two different seal directions (transverse and longitudinal) determines the quality of the packaging [3]. The parameters of the seal-making process with the welding process are pressure, heat, and time [4].

*Corresponding Author: agus.sifa@polindra.ac.id

Srivastava, et al. [5] conducted a study on increasing consumer demand, the main concern of the food packaging industry, by considering process efficiency, productivity levels, quality, and safety, offering solutions with computerized systems integrated with modular sensors. Mieszkalski, et al. [6] made a concept and a prototype for packaging vegetables using the Arduino control module system. Abdallah and Elmessery [7] propose a low-cost prototype innovation using an Arduino module to control dc and pneumatic motors in vegetable and fruit packaging machine systems. Arduino is equipped with a Liquid Crystal Display (LCD) with a weight sensor input to make a design control system for small packaging materials [8].

Chen, et al. [9] conducted a study on the packaging process with short, small, thin, and weak objects using pneumatic control using a Programmable Logic Control (PLC) control system. Alem and Vankdoth, [10] conducted research in the textile industry to control the liquid level with a limit switch activation system, solenoid valve, and drive a motor. Mahalik [11] reviews the development of modern, multidisciplinary packaging technology by paying attention to supply chains, process principles, packaging standards, materials, and the application of increasingly modern technologies. Namekar and Yadav [12] investigated the application of a more flexible and reliable PLC. Interfaces (HMI). The effectiveness of work during the packaging process, especially for cracker products with flat and round shapes, combines several processes in a system, from the dosing process to packaging. Current technological developments are in accordance with what has been done by Fatahillah, et al. [13] on a fast, accurate, and effective control system for sorting and packaging using a PLC that communicates with the HMI.

Based on the problems that occur in the industry, it is necessary to design a control system to control the cracker packaging machine automatically, this study aims to design and create a control system to drive the dosing system actuator, vertical sealer heating system, and horizontal heating system and packaging cutters as a solution to handle the packaging process in an integrated, effective, and efficient manner.

RESEARCH METHOD AND DESIGN

Method

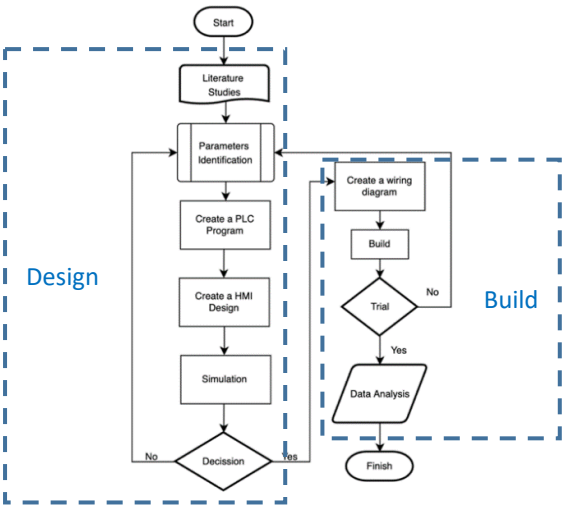

Figure 1. Flow chart of the design and build automatic control system

The steps applied to this research method are shown in the flow chart. Figure 1 presents the process of designing and manufacturing an automatic vertical cracker packaging machine based on PLC-Pneumatic. The first step starts with identifying packaging process parameters, making PLC designs and programs, making HMI and simulations, then building stages by making wiring circuits and making control systems for testing. The designed automatic system circuit has several input components, control/control components, and output components [14].

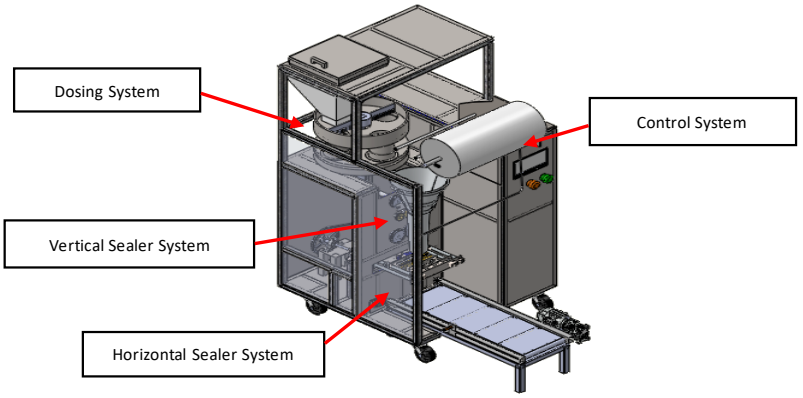

Figure 2. Design of automatic packaging machine work system

Figure 2 shows the mechanical system design and actuator of an automatic cracker packaging machine with motor DC and pneumatic actuators.

Automatic Control System Design

The control design is carried out to make simple interconnections of inputs and outputs that must be carried out according to needs [14]. In this automatic cracker packaging machine, two control designs are made, namely automatic mode control and manual mode, by moving several actuators to function effectively [15]. The design of the control system made for the automatic movement of the cracker packaging machine can be seen in Figure 3.

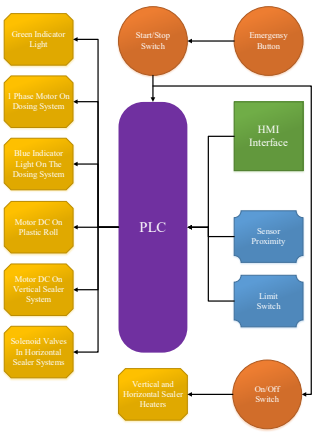

Figure 3. Design of automatic control system

Figure 3 shows the automatic control design mode, the automatic control design is grouped into input, process (system), and output parts [15]. The input section is shown in blue (proximity sensors and limit switches), the process section is shown in purple (PLC system), and the output section is yellow (indicator lights, dosing DC motors, DC motor filler plastic, vertical sealer DC motors, and pneumatic horizontal sealer). Each section is displayed on a Human Machine Interface (HMI) display with a touchscreen to activate [16]. This model is equipped with an on/off button to activate and start the engine with an emergency button and is equipped with a manual mode.

Control System Algorithm

In this research, an algorithm [17] is made; in arithmetic and software engineering, this algorithm is used to improve estimation, data processing, and computerized logic [16]. The following is an image of the control system algorithm on an automatic cracker packaging machine.

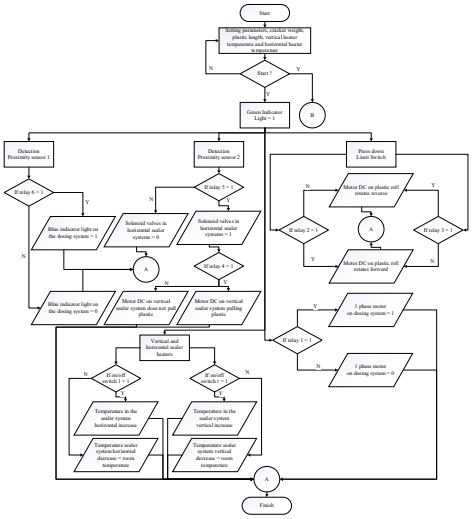

Figure 4. Automatic cracker packaging machine control algorithm

Figure 4 the automatic cracker packaging machine works using a PLC. Before starting this machine, it is necessary to set the parameters, the weight of the crackers, the length of the plastic, the vertical heater temperature, and the horizontal heater temperature. The machine can work by utilizing proximity sensors and limit switches to be able to run actuator processes such as forward-reverse plastic DC motors [18], crackers presence indicators, pneumatic pressing, plastic puller dc motors, machine process light indicators, main motors, vertical heaters, and horizontal heaters.

Wiring Diagram

A wiring diagram is a schematic that describes the relationship between one component and another in detail. The wiring diagram is a connection between all components in a particular electrical installation circuit [19]. In connecting electrical components into a single unit, the

researchers made 2-dimensional wiring using Solidworks Electrical Software, and the results are presented in Figure 5.

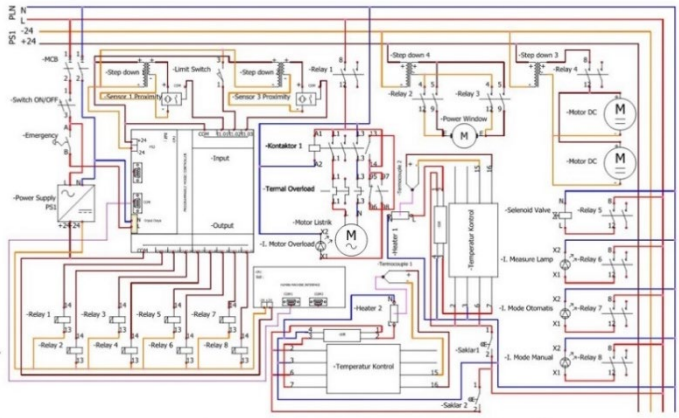

Figure 5. Wiring diagram of packaging machine

The automatic packaging machine control system based on Programmable Logic Controllers (PLC) is run and connected to the Human Machine Interface (HMI) installed with a power supply and a Mini Circuit Breaker (MCB). The connection for each component can be seen as follows:

- MCB is connected to an AC power source.
- The power supply is connected to an AC source from the MCB outlet cable.
- PLC connected 100-240 VAC power source.
- HMI power source 24 VDC from the output power supply.
- The HMI is connected to the PLC using an RS232 cable.

On/off and emergency switches function to run the packaging machine as well as to cut off electric current as protection [20].

Gate Logic

Before making a packaging machine wiring diagram, make a block diagram first to determine the flow of connecting the components used. The component connecting the block diagram is presented in Figure 6.

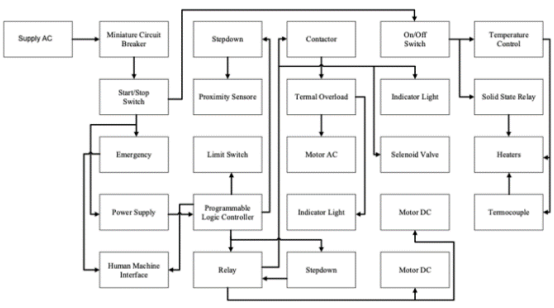

Figure 6. Block diagram of packaging machine

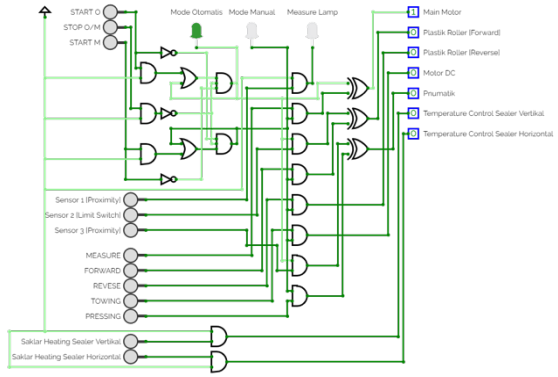

Figure 7. Gate logic cracker packaging machine manual state

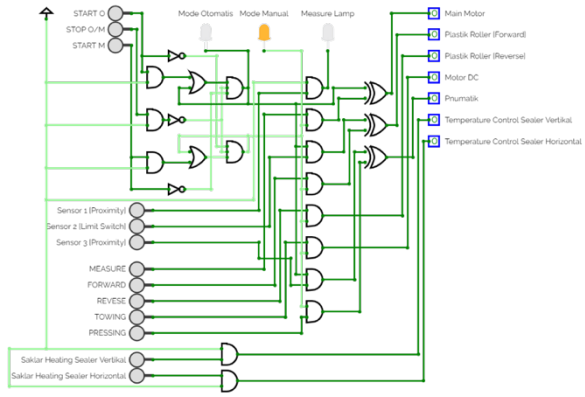

Figure 8. Gate logic cracker packaging machine automatic state

Gate logic is a circuit with one or more input signals but produces only one output signal. Gate logic is a digital (two-state) circuit because the input signal and the output signal are only high voltage (high) or low voltage (low) [16]. As for the explanation above, the researcher contains the creation of gate logic to map the input, process, and output addresses [19].

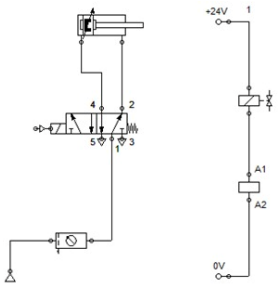

Figure 9. Pneumatic schematic

Figure 9 shows a series of electric-pneumatic systems for driving horizontal sealers in carrying out the process of making seals and cutting that require pressure, where the components used are a solenoid for activation and a double-acting actuator [21].

Human Machine Interface

Human Machine Interface (HMI) is a user interface or dashboard that connects a person to a machine, system, or device [19]. HMI is software that is useful in controlling and monitoring a process in the industry, with the aim of increasing effectiveness, efficiency, and satisfaction in its use [22]. In monitoring the packaging machine process. Researchers make HMI displays for packaging machines using CX-Designer software and the HMI display design in Figure 10.

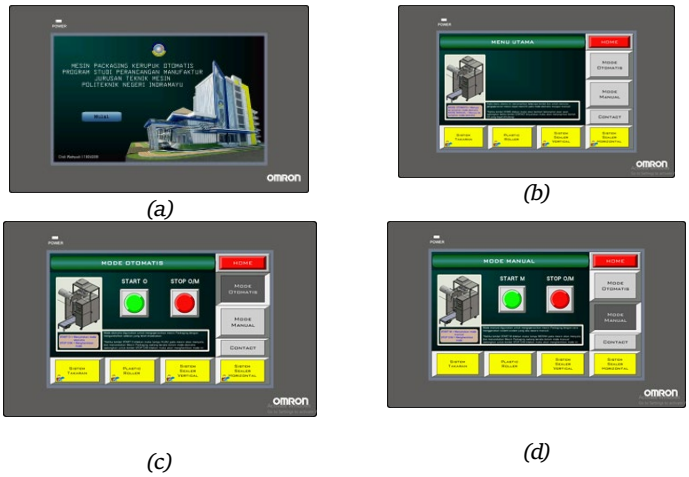

Figure 10. HMI display (a) cover (b) Main menu (c) Auto mode (d) Manual mode

RESULTS AND DISCUSSION

Programming, wiring design, and HMI design have been completed. In this study, a control system was created, carried out by assembling hardware and compiling the program leader logic. In the control system made using the Omron CP1E-N40DR-A PLC hardware integrated with the CX-Programmer by using an RS232 cable connection [23], the results of the manufacture are shown in Figure 11.

The addresses and instructions used to control the automatic cracker packaging machine are as needed. Several area types are used, and even the instructions used have different functions in the circuit made for activating on/off components in the form of relays and solids. State relay connected to limit switch as input, dc motor, and solenoid as output [21].

Table 1. Address and instructions ladder logic diagram

Area Type		Intructions
Common I/O	*Work Area*	
1.01 = Proximity Sensor 1	W0.00 = START O	KEEP = 10.00
1.02 = Limit Switch	W0.01 = START M	DIFD 1 = 10.04
1.03 = Proximity Sensor 2	W0.02 = STOP O/M	DIFD 2 = 10.05
100.02 = *Main Motor*	W0.03 = FORWARD	TIM 1 = T000
100.03 = Motor DC On Plastic Roll (Forward)	W0.04 = REVERSE	TIM 2 = T001
100.04 = Motor DC On Plastic Roll (Reverse)	W0.05 = PRESSING	TIM 3 = T002
100.05 = Motor DC On Vertical Sealer System	W0.07 = TOWING	TIM 4 = T003
100.06 = Selenoid Valve	W0.10 = MEASURE	CNT 000
101.00 = Blue Indicator Light	W2.00 = Start O (Active)	CNT 001

Area Type		Intructions
Common I/O	*Work Area*	
101.01 = Automatic Mode	W2.01 = Stop O/M (Active)	CMP
101.02 = Manual Mode	W2.02 = Start M (Active)	
	W2.03 = Main Motor (Active)	
	W2.04 = Blue Indicator Light (Active)	
	W2.05 = Selenoid Valve (Active)	
	W2.06 = Waiting	
	W2.07 = Plastic Pulled (Active)	
	W2.08 = Plastic Roll Rotates Forward	
	W2.09 = Plastic Roll Rotates Reverse	
	W2.10 = CMP (Active)	
	W2.11 = Reset CNT	
	W2.12 = Plastic Pulled	

Ladder Logic Program

The Ladder Logic Program that is made includes sensor inputs, and buttons that must run actuators such as AC motors, lights, DC motors, and pneumatics, the software used uses CX-programmer to create leader logic programs and CX-Designer to create interactive designs. On HMI with Omron brand hardware [24].

Figure 12 shows the leader logic that has been created for an automatic cracker packaging machine that drives an AC motor actuator to drive the dosing system, a dc motor to drive the package pulling system, a vertical heating roll system, and a pneumatic horizontal heating solenoid for plastic cutters. In the leader diagram, which is programmed as the main program in communicating and executing the hardware wiring address according to Table 1 with the program leader [25].

The control program created is displayed with the Omron NB7W-TW00B HMI, with a 24V DC voltage source, 7 w power, com1 output, 5V DC power, and 250mA current. The test results are shown in Figure 13 and Figure 14.

Figure 14 shows the results of testing the operation of the automatic cracker machine control system. Testing with the packaging machine directly on the condition that the output from the packaging machine is activated on the relay control runs stable [26]. Testing the vertical sealer movement system using a motor actuator and horizontal sealer using a pneumatic actuator moving well [27]. From these tests, researchers produced several experiments in automatic mode and manual modes. In the manual system, testing was carried out at every stage of the system process, with the results running according to the design by showing that the I/O indicator light is on and the actuator can move. For the automatic system, the test results are functioning properly[28], the overall system that has been built has worked well according to the design.

CONCLUSION

In this study, from the design and build of control systems on automatic packaging machines with AC motors, DC motors, and pneumatics based on a PLC system that is integrated with HMI, the researchers concluded that in designing a control system using a PLC one must know how many inputs and outputs will be used. In this case, it can overcome the lack of ports from various types of existing PLC types.

In the functioning of this control system, it requires program logic or ladder diagrams to be used. By transferring it to the PLC from the computer via an intermediary cable, then when the program is in a run state, the machine can operate automatically according to the program that has been made. The overall dosing control system, vertical heating system, and horizontal heating system work well.

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