Banana Flakes: Design of Controlling Molding Machine based on Proximity Sensors

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Abstract: Banana flakes can be an alternative of nutrient-rich breakfast. It had been developed by PPTTG LIPI since 2016 and was carried out on a laboratory scale production. The scaling up was constrained at the cutting stage. The sticky properties of the dough required a 2-stages roasting treatment before become flakes. The cutting process manually on the dough that was flattened on a special grill paper. In this study, a control was developed using a Programmable Logic Control (PLC). The banana flakes molding machine consists of three main parts, the oil spray, the dough molding part, and the cutting part. Each part had a proximity sensor as a detector the presence of baking sheets which became inputs for the PLC. The sensor on the spraying part will control the electric pump oil. And the sensor on the molding part of the dough and the cutter will control the solenoid valve. Solenoid valve will transmits pneumatic power from the compressor to drive the dough molding and cutting. A simulation using CX programmer software to ensure the rate of the spraying part and the cutting part meet the rate of the dough molding.

1 INTRODUCTION

Bananas are the most consumed fruits by Indonesian (BMKG, Kementerian Pertanian, BNPB, LAPAN, BPS, WFP, 2017 and Badan Pusat Statistik, 2017) with consumption levels reach more than 7 million in 2017(Subdirektorat Statistik Holtikultura, 2017). This condition is balanced by the growth of banana production which experienced a positive trend from 1980-2015 with an average value of 4.16% per year (Bappenas, 2016).

Bananas are rich in carbohydrates, food fiber, certain vitamins, and minerals (Sidhu and Zafar, 2018). Its short shelf life (Singh, Shrivastava and Kumar, 2018) provides an opportunity to process bananas into products that have a longer shelf life such as flour (Ratnasari *et al.*, 2018). Although it has changed shape, banana flour has high bioactive compounds especially resistant starch (Amini Khoozani, Birch and Bekhit, 2019). This further strengthens the opportunities for gluten-free banana flour-based processed products (Seguchi *et al.*, 2014) exclude from maize starch and rice flour (M. Rosell and Matos, 2015).

Cereal is a breakfast preferred by school-age children (Khehra, Fairchild and Morgan, 2018). In addition ready to eat, breakfast with cereal is part of a healthy lifestyle that plays an important role in order to meet the nutritional needs (Kruma *et al.*, 2018). Since 2016 the Center for Appropriate Technology Research has developed breakfast cereals in the form of flakes made from banana flour (Surahman *et al.*, 2016, Ratnawati *et al.*, 2017, Desnilasari *et al.*, 2018). The production process is still done manually using common equipment used in household kitchens such as mixers and hand ovens. The stages of making banana flakes include the stage of mixing ingredients, flattening, baking I, cutting, baking II, and packaging (Ekafitri *et al.*, 2016).

The manual production of banana flakes still has obstacles in the process of forming into flakes. The flakes can be formed after the flattened dough has been baked and continued by cutting process which done on a special baking paper by scissors. After becomes small pieces in the form of flakes then baked again until they reach a certain water content. The cutting process takes a longer time compared to other stages of the process because of the need of the first baking process and the cutting time itself. The objective of this research is to design a banana flakes molding machine with an automatic control process that is expected to overcome this problem. Programmable Logic Controller (PLC) takes an

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important role in the whole process to ensure the forming dough to the flakes process becomes efficient and effective by using a system that is easily programmed, flexible and reliable to be used, and effective in terms of the financial sector.

2 MATERIALS AND METHODS

Banana flake molding machine used in this study has 3 sub-systems, namely the oil spraying section, the dough molding section, and the dough cutting section. Each baking sheet will enter through the first to the third subsystems through a conveyor belt system. The controller will detect the baking sheet position and will control the actuator in each sub-system automatically. In this research, a control system was designed using CX-Programmer software which is the bundling PLC Omron brand software. The designed control system can be set up automatically or manually with a workflow as shown in Figure 1.

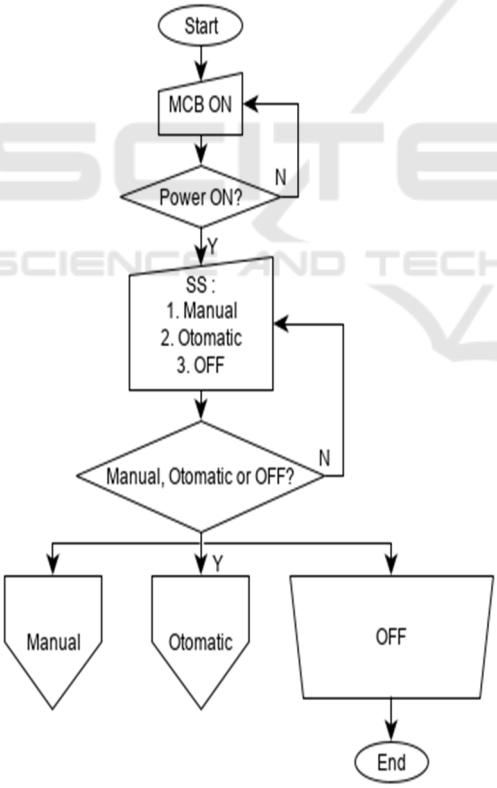

Figure 1: Control system on Banana flake dough molding machine.

The manual control system is used to anticipate unwanted circumstances. In other hand, the manual-automatic selector switch is used as an input in the system to prevent double settings. For automatic and manual control system workflows, see Figure 2 and Figure 3.

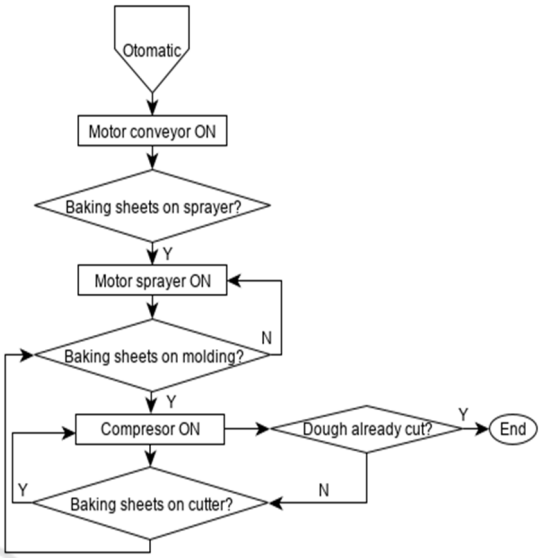

Figure 2: Otomatic control system.

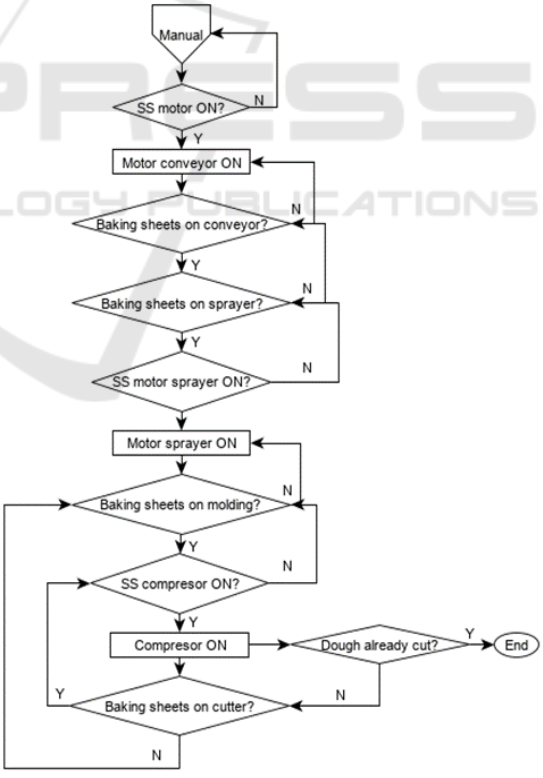

Figure 3: Manual control system.

The first sensor used in this research is inductive type proximity sensor. This sensor is very suitable to be applied in industry (Nguyen, 2017) compared to

capacitive ones because it is more sensitive (Guo, Shao and Li, 2016), has no moving parts, operates very fast, very reliable, requires no maintenance and operates in environmental extreme conditions (Naik *et al.*, 2016). The second sensor, limit switch is used for safety switches and the detection of the presence of container die in molding. Yeop Kim et al., 2014 explain that limit switches can be used for a long time with robustness is proven. The third sensor is reed sensor can help pneumatic up and down movements become faster. Reed sensor is an electric switch that is operated with a magnetic field, consisting of a pair of contacts on an iron metal body in a tightly closed glass envelope (Sadad, Iswanto and Sadad, 2011). All sensors are placed in a position as seen in Figure 4 with annotation (1) Inductive proximity sensor sprayer; (2) Inductive proximity sensor molding; (3) Inductive proximity sensor cutter; (4) Bottom reed sensor; (5) Up reed sensor; (6) Limit switch.

3 RESULTS AND DISCUSSION

All sensors become inputs to PLC to control actuators such as conveyor motors, solenoid sprayers, and pneumatic valves. PLC as the main controller is an important component in modern industrial control systems (Ghaleb, Zhioua and Almulhem, 2018) that is designed to be easy to install and maintain (Alphonsus and Abdullah, 2016) and is used for all needs in the industry (Katalin, 2019). The design of the PLC control system using CX-Programmer software as shown in Figure 5 with the input and output information shown in Table 1.

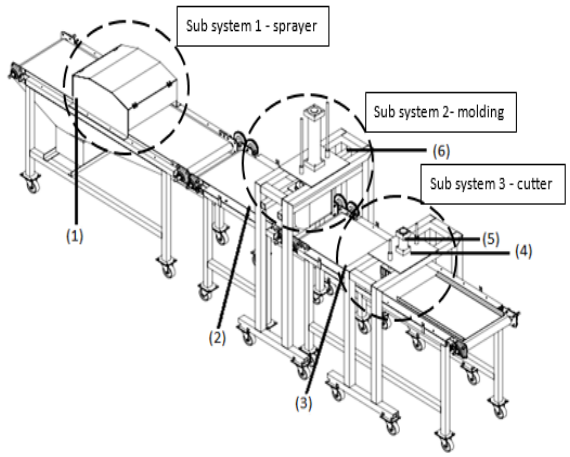

Figure 4: The position of sensors on banana flakes molding machine.

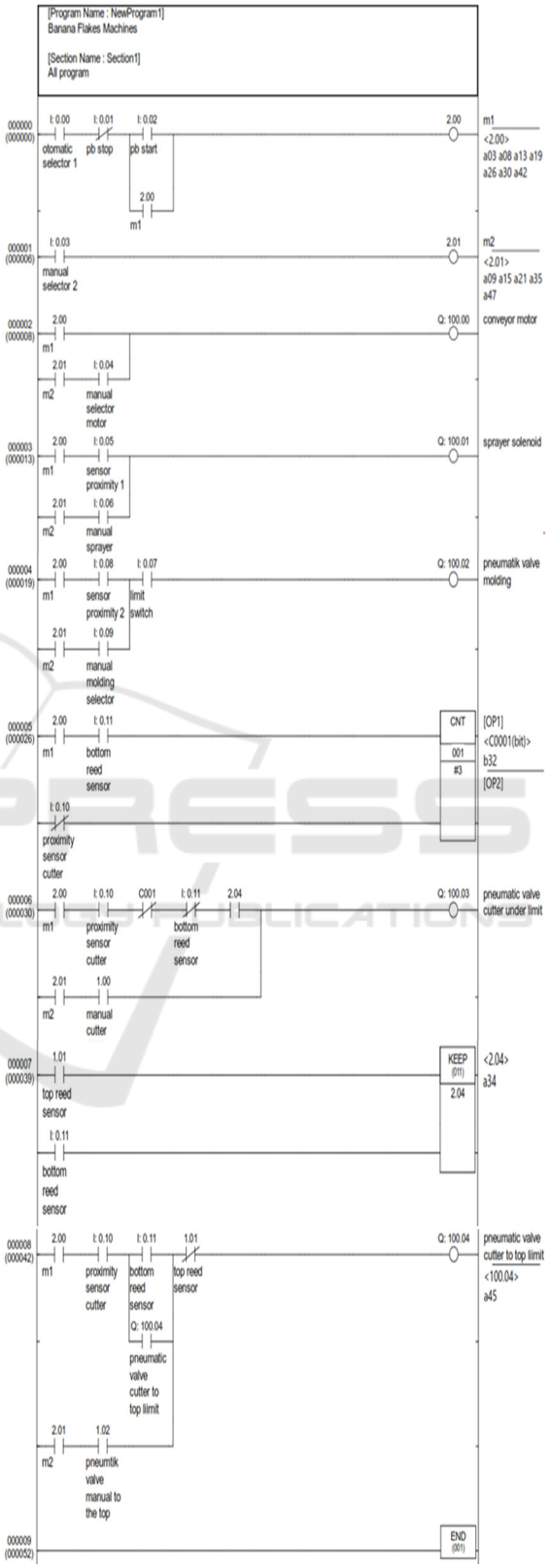

Figure 5: Ladder diagram of a banana flake dough molding machine control system.

Table 1: Input and Output port definition of PLC.

Input		Output	
0.00	automatic selector switch for power	100.00	conveyor belt motor driver
0.01	stop push button	100.01	sprayer solenoid
0.02	start push button	100.02	the pneumatic valve on the molding section
0.03	manual selector switch for power	100.03	pneumatic valve cutter under limit
0.04	manual selector switch for motor	100.04	pneumatic valve cutter to top limit
0.05	proximity sensor on the sprayer section		
0.06	manual selector switch for sprayer		
0.07	limit switch sensor on the molding section		
0.08	proximity sensor on the molding section		
0.09	manual selector switch for molding		
0.10	proximity sensor on the cutting section		
0.11	bottom reed sensor		
1.01	top reed sensor		

From the ladder diagram, the control system of the banana flake dough molding machine can be seen by using the timing diagram for each output as Figure 6.

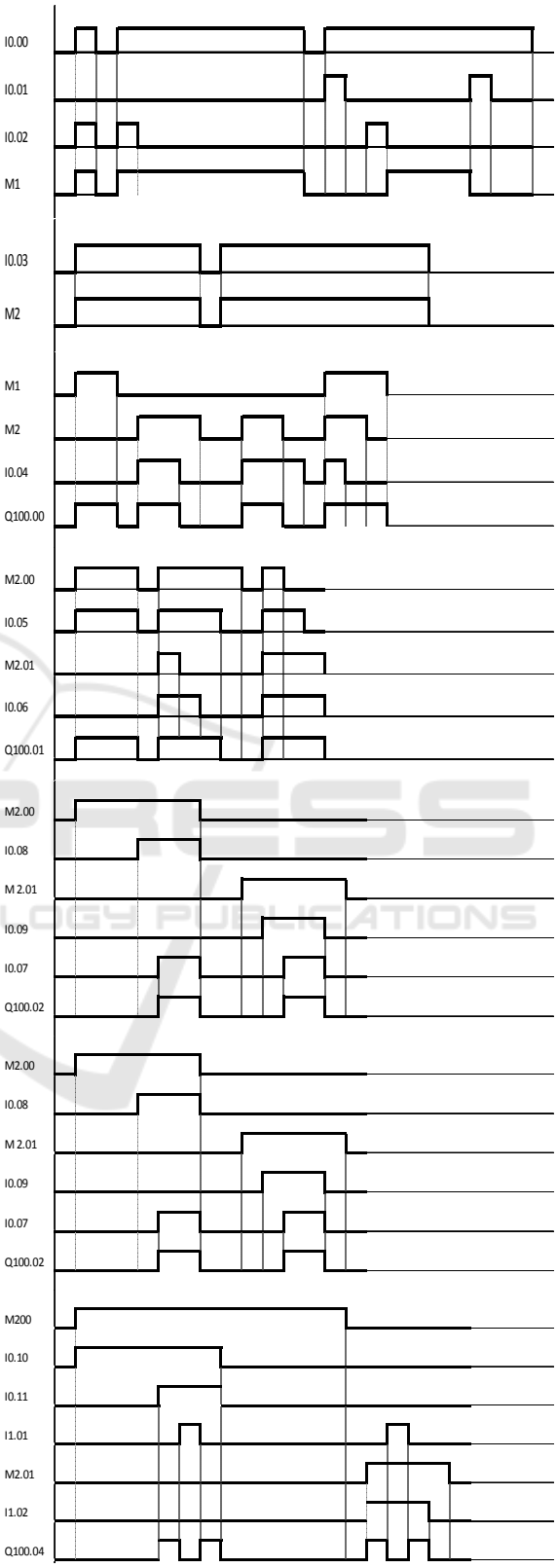

Figure 6: Timing diagram on banana flake dough molding machine control system.

4 CONCLUSIONS

The design of a control system for the banana flakes molding machine to minimize the bottleneck production process has been simulated. The main components in this control system are PLC, CX-Programmer, proximity sensors, limit switch and reed sensors. Simulation design using the CX-Programmer can describe system has been running as desired. The next work of this research is to carry out construction and testing of the banana flakes molding machine and the control system that has been designed.

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