International Journal For Technological Research In Engineering
Volume 8, Issue 6, February-2021 *(Online): 2347 - 4718*

AUTOMATIC INTEGRATION OF ROTOMOULDING PLATFORM WITH LOGIC PANEL

[1]Satriyo Teguh Rahardjo, [2]Susatyo Handoko, [3]Trias Andromeda, [4]Mochammad Facta, [5]Hermawan, [6]Iwan setiawan
[1,2,3,4,5,6] Electrical Engineering Department
Diponegoro University, Indonesia

Abstract - Rotomoulding process is widely used in industrial work for molding plastic materials by heating mechanism. In the molding process, the rotomoulding machine is rotated slowly causing the soft material to spread and stick to the mold wall. To maintain the thickness throughout the surface, the mold continues to rotate continuously during the heating phase. During cooling stage, the rotomoulding engine also needs to be maintained to avoid sagging or deformation. This paper presents an implementation of automatic rotomoulding integration with logic panel for a plastic industry in Central Java, Indonesia. This factory produces a water tank. Formerly, the manufacturing process for plastic water tank was carried out semi manual and it was operated by talented operators by using conventional relays configuration for all the processes. In conventional method the products are highly dependent on operator's expertise; the non-standard process sequences gave impact to many failures during production and low quality of product. In this work, automation in a rotomoulding plant is implemented by using a Programmable Logic Controller (PLC) as a platform or a tool to realize industrial automation for rotomoulding processes. The use of PLC is intended to assist in determining the standard process sequence in the rotomoulding process for producing water tanks. The use of this PLC will be a first step in to develop an efficient and cheaper automation production.

Keywords: Rotomoulding automation, PLC, water tank

I. INTRODUCTION

The need in industrial process is getting complicated to meet human needs as precision and efficiency become issues. This requires the manufacturing industry to find a solution or a way out in sustained production, improving productivity and profits. In this level, automation is urgently required to full fill the needs above and increase precision and safety.

As part of automation process, Programmable Logical Control or PLC with software-based offer many advantages over other peripheral products. A wide variety of applications in the industrial sector today use PLCs for upgrading and optimization as well as overall system flexibility. PLC technology changes the production process to a new era because of the many benefits that come with using this PLC.

Most of the conventional production process for water tanks depends on the operator. The order of the production process is determined by each operator, depending on the experience of each operator. The backwardness in this kind of process occurs due to the limited supported tools and the ability to mastering automation technology. The emerged of PLCs based technology is therefore will be proposed as the first step in implementing automation in a water tank factory using rotomoulding. This PLC-based system at an early stage is intended to provide a medium or way that allows finding the correct process sequence. After that, the automation process can be continued by realizing the automation process by using a microcontroller to achieve efficiency and cost savings for the realization of industrial automation.

II. THEORETICAL BACKGROUND

Programmable Logic Controller (PLC) is a microprocessor-based and solid-state electronic device that performs commands such as a ladder diagram [1] which is capable of controlling various types of industrial equipment and entire automated systems [2]. PLCs become the main part of automated systems in industry [3]. The realization of using PLC is very efficient and reliable in applications involving sequential control and process synchronization as well as additional elements in the manufacturing, chemical and process industries [4] [5]. Apart from having a wide range of advantages, the use of PLC is also able to reduce costs in realizing complex control systems [5] [6]. Currently, most of the control elements used to run system logic have been replaced by PLCs [7]

The term Logic is used because primarily. programming is concerned with implementing logic and switching operations. Input devices such as switches and output devices such as motors will become part of the system connected to the PLC, then the controller monitors the input and output according to the running process [8]. At initial design, Initially PLC is designed as a replacement for relay and timer and it is based on logic control systems. PLC consists of two parts i.e. hardware and PLC programming.

Buhrer et al. (2015) [9] designed a manufacturing automation system using an Orchestration Engine that allows flexibility in changes in PLCs. The Orchestration Engine is even able to adapt to the physical changes of the production environment. Hong (2011) [10] developed an automatic changeover device in a production line using a PLC-based control system. The use of a PLC-based hydraulic system improves system stability, level of reliability, safety in the automation system. Chua (2007) [11] developed an active feeder which is controlled and driven by PLC and electro-pneumatics. Swider et al. [7] also developed a system using PLCs to control electro-pneumatic systems. Saad and Arrofiq (2012) [4] developed and designed PLC-based induction motor control as shown in Figure 2.1. The controller uses PWM to control the speed of an induction motor and applies constant V / Hz ratio control. The PWM inverter functions as an interface between the PLC and the induction motor. The personal computer (PC) acts as a terminal for developing and inputting programs including fuzzy logic routines to the PLC and human-machine interface (HMI).

III. METODOLOGY

Based on the background as mentioned before, several problems were formulated to create a rotomoulding automation system, as follow:

1. Determining the sequence of the water tank manufacturing process by rotomoulding
2. Selection of sensors, PLC and equipment in accordance with the process to be done.
3. Making a PLC program to match with the process of rotomoulding.
4. Realization of the protection system required so that the production process can run smoothly and safely.

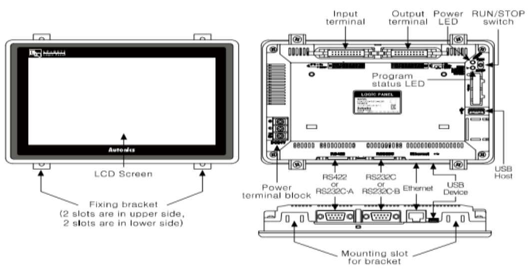
In the first problem which is determining the sequence of water tank manufacturing process by rotomoulding, the sequence process of the rotomoulding systems can be summarized as follows:

1. The heating process uses a temperature of 190°C-200°C with a total heating process of 385 seconds (6.4 minutes).
2. Material process
   Material 1 - cycle time: 165 seconds
   Material 2 - cycle time: 168 seconds
   Material 3 - cycle time: 175 seconds
   Material 4 - cycle time: 237 seconds
3. The process of ripening the material to the Kalis material (not attached to the tank wall) Cycle time: 776 seconds without the need of fire.
4. Cooling Process 442 seconds.
5. Product Retrieval 3112 seconds.
6. Molding preparation to be ready to operate again 670 seconds.
7. The total cycle processing time is 3,220 seconds.

Since the determining process time of the rotomoulding is using a timer, performance of the system is not accurate. The calculation of the process time will use a rotational counting based on the number of revolutions of the machine.

Several main components or equipment's must be provided for rotomoulding automation systems, those are: Logic Panel, Proximity sensors, Photo electric sensors, non-contact temperature sensors and converter current to RS485.

Programmable Logic controller (PLC) used in this work is a Logic Panel as shown in Fig.1



Logic Panel Autonics type LP-S070-9D6

Position of the rotomoulding will be captured using inductive proximity sensors as shown in Fig.2. Inductive proximity sensor will detect metal that is nearby to the sensor.

Induktif Proximity sensor

A photo electric sensor as shown in Fig. 3 is applied to determine the amount of rotation during machining process.

Photo electric sensor

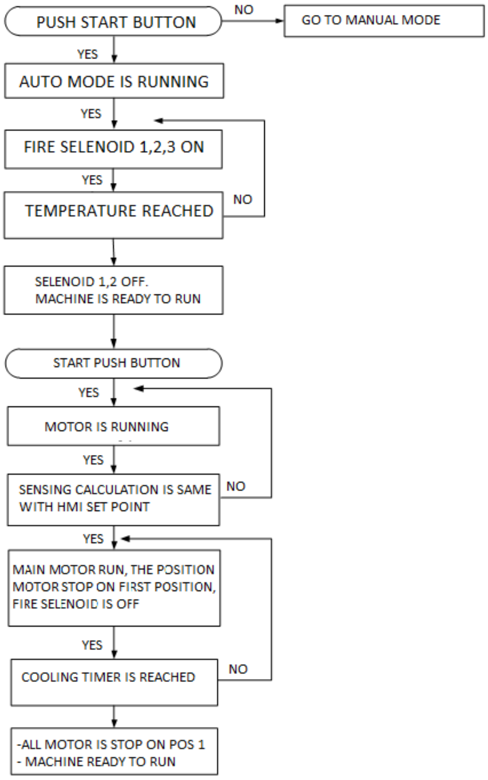
Temperature of the moulding is identified uses a non-contact temperature sensor as depicted in Fig.4

Infrared temperature sensor 4-20 ma

Since the distance between temperature sensor and the PLC is very far, a converter current to RS 485 in modbus protocol is required. This device converts current value into RS485 in modbus protocol as shown in Fig. 5. This device is applied to the communication part of these automation systems. The signal output from the temperature sensor,4-20 mA, will be converted to digital data which is follow the modbus format.

Converter current 4-20 mA to rs 485 modbus

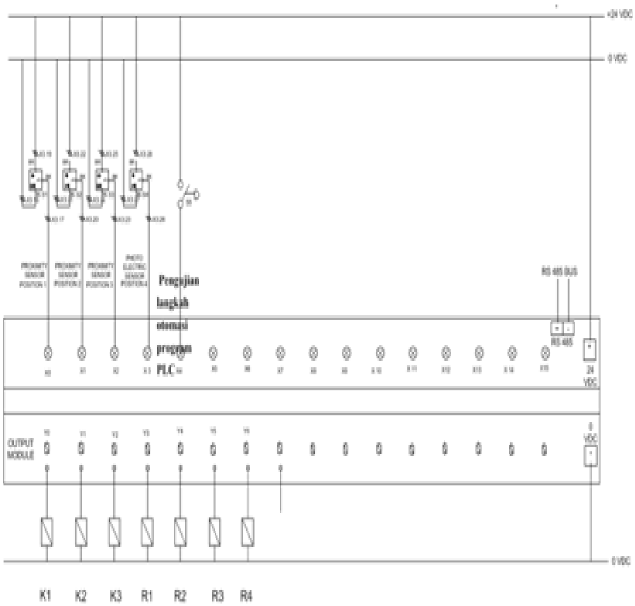
The sequence of rotomoulding process can be recognized following the flowchart as shown in Fig. 6. The figure explained of the PLC process steps based on the rotomoulding machine work process.



Flowchart of Rotomoulding process

From the flowchart in Fig. 6, a programming step must be provided for rotomoulding automation in PLCs. It is created in the Mnemonic language. To simplify programming, PLCs can also be programmed with a high level language, namely the ladder diagram programming language.

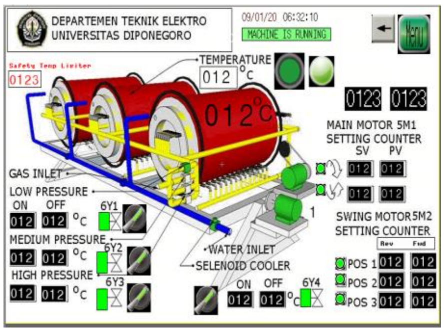
Input and output PLC configuration is depicted n in Fig. 7. This design will support for further implementation or installation work.



Input output PLC configuration

Modern PLC is equipped with an HMI. This feature makes the implemented systems more interactive and programming process can be conducted easier.

HMI is applied to facilitate operation, machine settings, and reading data from during machining process. Fig. 8 shows the layout of the components on the HMI in the form of a Touch Screen.

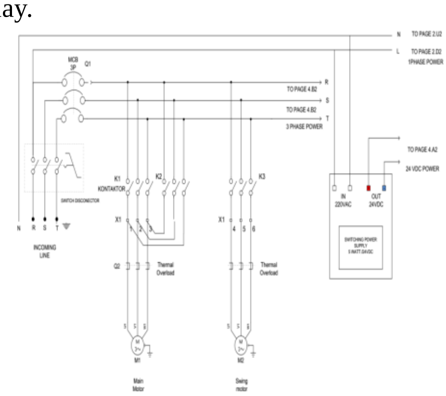


Human Machine Interface designs in Running position

Connection Infrared sensor and modbus converter

Figure 8 shows the connection of a temperature sensor whose output is a current of 4 mA to 20 mA connected to the current to RS485 converter. The temperature data can be retrieved via the modbus protocol by the logic panel. The addresses of the Modbus converter data registers are 40001 and 40065. Both addresses contain the same data, namely the temperature data from the infrared sensor with a current output of 4-20 mA.

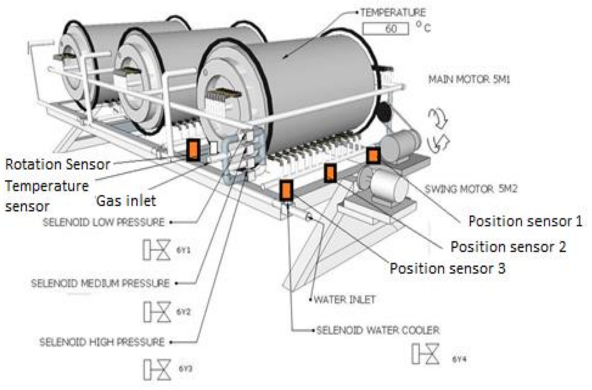
A protection system must be designed to ensure the safety operation. The production process can be run smoothly and safely. In Fig. 10, the main protection uses a Miniature circuit breaker, and for motor protection using a Thermal overload relay.



Power Protection Circuit

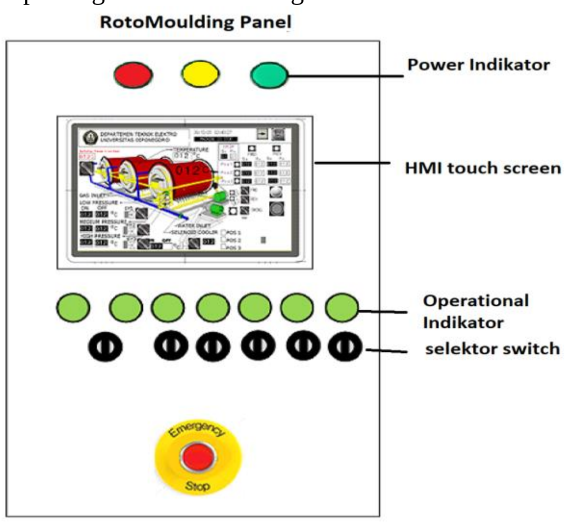
IV. IMPLEMENTATION

In order to have effective sensor then the sensors and other equipment are installed on the machine in the right position, so the sensor can sense objects in front of it. Fig. 11 illustrates the position of the sensor at the machine location in order to make the sensor properly sense the objects.



Device and sensor Position on rotomoulding machine

To facilitate the operator and the machine interraction, an operation panel is required so it can be accessed easily. Therefore it is necessary to make a panel box to place the interface for operation purpose. The panel box also functions to place other equipment supporting components so that it will ease the future maintenance. The panel box of rotompulding can be seen in Fig.12.



Rotomoulding Panel

V. TESTING AND EXPERIMENTAL

To sense temperature, rotation and engine position, sensor play important role to provide input to the PLC regarding the condition of the equipment being scanned. Therefore, steps need to be taken to ensure that the sensor has provided input in accordance with the reality of the object being sensed.

There are several experimental works are carried out to ensure the function of several important sensors and other devices, and those are:

1. The digital sensor test
2. The temperature sensor test
3. Actuator test
4. Automation sequence test

A sensor with a digital signal output is installed to sense the position of the rotomoulding tube and the number of rotation (turns). The test results are provided in Tabel I.

TABLE I.

The Digital Sensor Test Tabel Hasil pengetesan sensor digital pada obyek mesin

No	Sensor Type	Object	output	output	Actual Response
1	Position Sensor-1	metal	24 vdc	NPN	left tilt
2	Position Sensor-2	metal	24 vdc	NPN	flat position
3	Position Sensor-3	metal	24 vdc	NPN	right tilt
4	Rotation Sensor	metal	24 vdc	NPN	rotational number

The temperature sensing of the engine is carried out by using an infrared sensor with a current output of 4-20mA, with a temperature range of 0-500 degrees Celsius. To check the precision of temperature detection a contact less thermal gun Benetech GM20 is used. From Table II, it can be seen that the sensor readings appear quite linear between the censored temperature and the output current.

TABLE II.

Test results of infrared temperature sensor

No	Degree od Celsius	Sensor Output
1	25 ^{0}C	5 mA
2	50 ^{0}C	6.3 mA
3	100 ^{0}C	7,1 mA
4	150 ^{0}C	7.8 mA
5	250 ^{0}C	10 mA

In Table II, it can be seen that the sensor readings appear quite linear between the censored temperature and the output current

There are two electric motors operated in three phase to drive the rotomoulding machine. Each motor has an electric power of 5 KW, one motor is for the main drive and the second motor is called a swing motor which functions to move the position of the engine. In testing the motor operates as shown in Table III.

TABLE III.

Data of motor testing

No	Motor Type	Right rotation	Left Rotation	Currents	Phase Sequence
1	Main Motor	ok	ok	6A	RST
2	Swing Motor	ok	-	6A	RST

The program that is uploaded to the PLC will produce the steps of the rotomoulding machine according to the predetermined work system. Testing the work system is divided into 2 systems, and those are the heating system and the drive system.

In the moulding process on rotomoulding using a heating system is carried out by heating the moulding tubes directly with an open fire. For this reason, the temperature conditions that occur must be maintained so that the temperature is stable. The heat is successfully generated in accordance with the needs of the desired material formation. The low flame selenoid will work continuously until the temperature is reached; this selenoid maintains temperature stability when it is approaching the setting of the temperature set in HMI. Medium fire selenoid will turn off when the temperature is less than 5 degrees Celsius from the predetermined temperature setting. The big fire selenoid will go out when the temperature is 150 degrees Celsius, so that the tube temperature does not go fast in which it can cause an over temperature.

Rotomoulding Drive System Test is run by checking the response in accordance with a program for the PLC under the following conditions:

1. The main motor can be operated in two directions, namely left and right rotation.
2. The swing motor rotates in one direction but has 3 stopping positions (positions 1, 2, 3).
3. When in position 1 the motor will rotate left for n (setting), then rotate to the right for n (setting) after that, the swing motor will rotate and stop in position 2.
4. In position 2 the motor rotates to the left for n (setting), rotates to the right for n (setting), then the swing motor rotates and stops in position 3.
5. When in position 3 the motor rotates left n (setting), rotates right n (setting), then the swing motor rotates and stops in position 1.

Based on the test results, the actuator has operated successfully in accordance with the design.

VI. RESULTS AND DISCUSSION

From the results of the discussion that has been carried out, there are several conclusions as follows:

1. Rotomoulding machines can function better with an automated system. The change from the timer to the counting function makes the process more accurate because it controls the original rotation and position of the machine. The resulting temperature is more stable because it is controlled automatically using a temperature sensor integrated with PLC.
2. Rotomoulding machines can be in automated mode by using a PLC and run according to the desired design.

REFERENCES

[1] E. Science, “Programmable Logic Controllers versus Personal Computers for Process Control,” vol. 33, no. 97, pp. 421–424, 1997.
[2] T. Bartelt, *Industrial Control Electronics*, vol. 66. 2012.
[3] R. Bayindir and Y. Cetinceviz, “A water pumping control system with a programmable logic controller (PLC) and industrial wireless modules for industrial plants-An experimental setup,” *ISA Trans.*, vol. 50, no. 2, pp. 321–328, 2011, doi: 10.1016/j.isatra.2010.10.006.
[4] N. Saad and M. Arrofiq, “A PLC-based modified-fuzzy controller for PWM-driven induction motor drive with constant V/Hz ratio control,” *Robot. Comput. Integr. Manuf.*, vol. 28, no. 2, pp. 95–112, 2012, doi: 10.1016/j.rcim.2011.07.001.
[5] O. Aydogmus and M. F. Talu, “A vision-based measurement installation for programmable logic controllers,” *Meas. J. Int. Meas. Confed.*, vol. 45, no. 5, pp. 1098–1104, 2012, doi: 10.1016/j.measurement.2012.01.031.
[6] K. Ali, R. Ghoni, and A. N. Abdalla, “Advanced control of hybrid-PLC system,” *Procedia Eng.*, vol. 38, pp. 218–225, 2012, doi: 10.1016/j.proeng.2012.06.029.
[7] J. Świder, G. Wszołek, and W. Carvalho, “Programmable controller designed for electro-pneumatic systems,” *J. Mater. Process. Technol.*, vol. 164–165, pp. 1459–1465, 2005, doi: 10.1016/j.jmatprotec.2005.02.200.
[8] S. J. Bolton *et al.*, “Changes in Clara Cell 10 kDa Protein (CC10)-positive Cell Distribution in Acute Lung Injury Following Repeated Lipopolysaccharide Challenge in the Rat,” *Toxicol. Pathol.*, vol. 36, no. 3, pp. 440–448, 2008, doi: 10.1177/0192623308315357.
[9] U. T. Bührer, C. Legat, and B. Vogel-Heuser, “Changeability of manufacturing automation systems using an orchestration engine for programmable logic controllers,” *IFAC-PapersOnLine*, vol. 28, no. 3, pp. 1573–1579, 2015, doi: 10.1016/j.ifacol.2015.06.310.
[10] W. Hong, “Design of PLC-based hydraulic system for workpiece turnover,” *Procedia Eng.*, vol. 15, pp. 122–126, 2011, doi: 10.1016/j.proeng.2011.08.025.
[11] P. S. K. Chua, “Novel design and development of an active feeder,” *Assem. Autom.*, vol. 27, no. 1, pp. 31–37, 2007, doi: 10.1108/01445150710724685.
[12] E. B. Naz, E. Naveed, A. Jaffari, E. Faisal, and K. Khani, “Automation of ROTOMOULDING PLANT (RP) Using PLC,” no. November 2012, pp. 2016–2020, 2020.
[13] M. Löhner and Di. Drummer, “Characterization of layer built-up and inter-layer boundaries in rotational molding of multi-material parts in dependency of the filling strategy,” *J. Polym. Eng.*, vol. 37, no. 4, pp. 411–420, 2017, doi: 10.1515/polyeng-2016-0175.

