Control System Design in Production Machines Paving Block Made from Plastic Waste

M. Hariansyah[1], Abdul Karim Halim[2], M. Lutfi[3]

[1]IBN Khladun University, Department of Electrical Engineering, Jl. KH. Sholeh Iskandar KM 2 Bogor Jawa Barat Indonesia

[2]IBN Khaldun University, Department out of School Education Study Program, Jl. KH. Sholeh Iskandar KM 2 Bogor Jawa Barat Indonesia

[3]IBN Khladun University, Department of Civil Engineering, Jl. KH. Sholeh Iskandar KM 2 Bogor Jawa Barat Indonesia

Abstract: ***Garbage has not been handled properly, even waste is a national problem. Campus Ibn Khaldun University of Bogor in 2016 recorded as much as 12 m3 / day, resulting from canteen trash and office waste. Trash consists of type, organic and inorganic. This type of inorganic waste takes up to 450 years to break down naturally. Trash is considered as a source of diseases and disasters, such as air pollution, water, the environment until the occurrence of landslides caused by piles of garbage. One effort to overcome the waste of an organic (plastic bag crackle) is to create a production machine that can change the form of waste into paving blocks. The objectives and usefulness of the research are (a) to produce control system design in production machine to manage plastic waste into paving block, (b) obtain plastic heating time response in tube and response time of pressure in tube. The method is done by planning the form of technology and system control applied. as well as production machine capacity. The process control system uses temperature sensors and pressure sensors that can convert analog signals into digital 4-20 mA and forwarded to PLC (Program Logic Control). Temperature inside tube at setting 200 oC, and Pressure 2 bar. If the temperature set point T> 200 oC, then the PLC will order the relay to stop the supply voltage through the contactor. So also with pressure if set point P > 2 bar then control valve immediately opened until pressure in tube remain stable. The result of the design of high-heating tube of 50 cm, diameter 30 cm capable of producing 1 kg plastic produce 2 units of paving block (5x10x25) cm, with compressive strength reach 235 kg / cm2***

Keywords: Control System, Production Machine, Paving Block, Plastic Waste

1. Introduction

The volume of garbage in the Ibn Khaldun University Campus Bogor in 2016 was recorded at 12 m3 / day, generated from Household Waste (SRT) and Waste from the office, [1]. Garbage consists of types, organic and inorganic. This type of organic waste can be decomposed naturally, while inorganic waste is very difficult to decompose naturally, requiring up to 450 years, [2] To this day the waste is disposed of to the Final Disposal Site (TPA), so that waste becomes a problem as a source of diseases and calamities, such as air, water, environmental pollution and landslides due to mountainous landfill. One of the efforts to tackle organic waste (crackle plastic bags) is to create a production machine that can change the form of waste into paving blocks. The aims and benefits of the research that are to be obtained are (a) producing a production machine prototype to manage pressure in savings. The benefits of the research to be achieved are, (a) making the UIKA Bogor campus as a pilot project in terms of handling the problem of plastic waste coming from the UIKA Bogor canteen, (b) machines can be mass produced, and can be marketed to consumers. ased on the aforementioned background, it can be formulated, that organic waste is a national problem, so it needs to be solved by breaking down the form of plastic waste into paving blocks by building waste management machine technology.

2. Research Design

The planning of plastic heating machine production equipment is shown in the following Figure 1.[3]

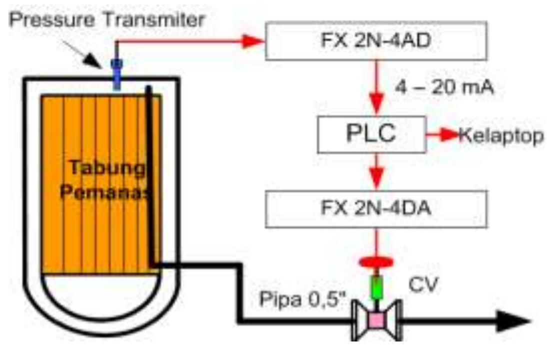


Figure 1: Concept diagram Research control system on heating tubes

Based on Figure 1 section, it can be seen that two thermocouple sensors are installed in two different places. T1 is installed to measure temperature on the heater and T2 is used to measure the temperature in the tube. The results of temperature sensor readings T1 and T2 sent to FX 2N-4AD TC in the form of a current (4-20 mA) then processed to the PLC. PLC can provide temperature measurement data to a laptop and can also give orders to FX2N-4DA to instruct the relay to insert the contactor, so that the supply of electrical power entering the heater is interrupted, if the heater temperature setting (300 oC <T1 <490 oC) and set temperature in the tube (150 oC <T2 <200 oC).

2.1 Control System

Planning the production machine, which is made automatically there are at least two that must be considered, namely temperature and pressure, [4] The use of thermocouples to produce heat sources needs to be adjusted to the material requirements that will be applied. Likewise with pressure. To detect temperature and pressure can be done with a thermocouple that is attached with a transmitter that can convert the signal heat into an amperage or voltage electrical signal, as well as a transmitter procedure. Some of the equipment that needs to be equipped are Analog Digital, PLC and digital analyzers, which are required in the control system, [4].

2.2.1 Control Valve

Control valve in this research produces 15 degrees of step, with spends 25 miliseconds per cycle, and error 0,5 according to motor specification. The response of the hydraulic piston movement encounters time delay, caused by limited the starting time of motor and the opening of control valve. Therefore, there is motor delay time *(t_m)*to the change of valve opening angle *($\otimes^{TM}_r$)*. Stepper motor response time is*(T_m)*, [5]

$$T_m = t_m . \Delta\delta r \qquad (1)$$

And the magnitude of error of working stepper motor is formulated below *($\sum o$)*:

$$\varepsilon_o = \delta_r - \delta_m \qquad (2)$$

Where $^{TM}_m$ is the valve opening angle controlled by stepper motor. The magnitude of valve opening angle is the function of reading time:

$$\delta_m = \delta_m, o \qquad , |\varepsilon_\phi| \le 0,5$$

$$= \delta_m, o + \frac{\mathrm{t}}{\mathrm{t_m}} \qquad , |\varepsilon_\phi| \rangle\, 0,5$$

$$= \delta_m, o - \frac{\mathrm{t}}{\mathrm{t_m}} \qquad , |\varepsilon_\phi| \langle\, 0,5$$

The block diagram of formula above can be seen in Figure 2. [5]

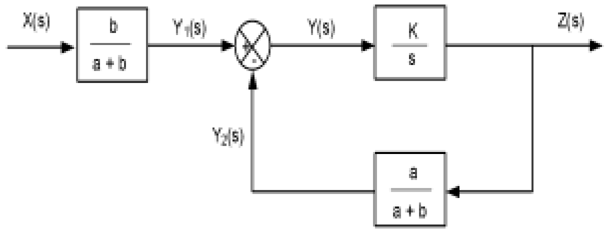


Figure 2: Control block diagram

Based on Figure 5, the next equation can be formulated as follows: [5]

$$Z(s) = \left[\frac{\frac{b}{a+b}X(s)}{\frac{s}{K_1}+\frac{a}{a+b}}\right] + \left[\frac{\frac{1}{K_1}z(0)}{\frac{s}{K_1}+\frac{a}{a+b}}\right] \quad \ldots(4)$$

First order in the right indicates steady state, with initial requirement equals to zero. The second order is the complement solving affected by initial requirement, called the transient condition of system. Steady state solution is gained by assuming the input as the step function:

$$x(t) = 0 \quad at \quad t < 0$$

$$x(t) = A \quad at \quad t \ge 0$$

$$maka$$

$$X(s) = A\int_0^\infty e^{-st}dt$$

$$X(s) = \frac{A}{s} \qquad (5)$$

By simplifying the equation (8) and (9), we can get:

$$Z(s)_k = \left[\frac{\frac{b}{a+b}\frac{A}{s}}{\frac{s}{K_1}+\frac{a}{a+b}}\right]$$

$$Z(s)_k = \left[\frac{\frac{b}{a+b}}{s\left(\frac{s}{K_1}+\frac{a}{a+b}\right)}\right] \qquad (6)$$

The order in the right can be divided partially into:

$$Z(s)_k = \left[\frac{\frac{Ab}{a}}{s} - \frac{\frac{Ab}{aK_1}}{\frac{s}{K_1}+\frac{a}{a+b}}\right] \qquad (7)$$

Response time of steady state condition of differential equation is gained from inverse Laplace transformation*$Z(s)_k$*as follows:

$$z(t)_k = L^{-1}\left[\frac{\frac{Ab}{a}}{s}\right] - L^{-1}\left[\frac{\frac{Ab}{a}}{s+\frac{aK_1}{a+b}}\right]$$

$$z(t)_k = \frac{Ab}{a} - \frac{b}{a}Ae^{-\left[\frac{aK_1}{a+b}t\right]}$$

$$z(t)_k = \frac{Ab}{a}\left[1 - e^{-\left[\frac{aK_1}{a+b}t\right]}\right] \qquad (8)$$

The transient solution is affected by initial condition

$$Z(s)_t = \left[\frac{\frac{1}{K_1}z(0)}{\frac{s}{K_1}+\frac{a}{a+b}}\right]$$

$$Z(s)_t = \left[\frac{z(0)}{s+\left(K_1\frac{a}{a+b}\right)}\right] \qquad (9)$$

If the inverse Laplace transformation is conducted, we will get the equation:

$$z(t)_t = L^{-1}\left[\frac{z(0)}{s+\frac{a}{a+b}}K_1\right]$$

$$z(t)_t = z(0).e^{\left[\frac{aK1}{a+b}t\right]} \quad (10)$$

From the equations above, the general equation will be:

$$z(t) = z(t)_k + z(t)t$$

$$z(t) = Z\left(1-e^{\tau t}\right) + z(0)e^{\tau t} \quad (15)$$

Where:

$$\tau = -\frac{aK_1}{a+b}$$

$$Z = \frac{Ab}{a} \quad (11)$$

According to the equation, if t ε 0, then:

$$z(t) = Z = \frac{Ab}{a} \quad (12)$$

Time needed to reach particular output value is:

$$t = \frac{\ln\left(\frac{z-Z}{z(0)-Z}\right)}{\tau} \quad (13)$$

Integral controller constant K_1 greatly affects the speed of hydraulic control response, therefore a more sensitive hydraulic system is desirable. According to Figure 4, the displacement of B at y = 24,62 mm resulted in hydraulic cylinder velocity 0,4 m/s. Thus,from equation (2) we can get integration constant 16,25 seconds, so that the time constant is -4,98 seconds. Using the equation (3-12), system response by replacing the value of A and output position with zero will result in the equations below:

$$z(t) = 2{,}262A(1-e^{-4{,}98t}) \quad (14)$$

When:

$$t = 0 \quad \Rightarrow \quad z(t) = 0$$

$$t = \infty \quad \Rightarrow \quad z(t) = Z = 2{,}264$$

The response occurs in hydraulic cylinder is the response from hydraulic proportional controller with the input stepper motor response to control the valve opening, in different positions.

3. Research Method

The research method is described as follows:

3.1 Time and Place of Research

The time and place of research is conducted from September 2017 to April 2018. Located at the Laboratory of Electric Power Engineering Conversion and Control System of the Electrical Engineering, Faculty of Engineering, Ibn Khaldun University in Bogor, Jl. KH. Sholeh Iskandar KM 2 Bogor.

3.2 Research Materials and Tools

The materials and research tools used for the study are shown in Table 1 below.

Table 1: Research Materials and Tools

No	Material and research tools	Volume	Units	No	Material and research tools	Volume	Unit
1.	Heating tube and table making			2.	Purchase of heating devices and control systems		
	Stenliss plate 120x242x0,8	2	sheet		Heater220 V, 1000W	1	set
	Light steel 1 mmx 70 mmx6m	5	stem		Heater isolation 5 cm x60 cm x 120cm	2	lembar
	Screw steel	1	box		Pressure control 0 -10 bar	1	unit
	Gurinda Stone 100 cm	5	unit		Control Temperature	1	set
	e. Stenliss plate 0x242x1,2mm	1	sheetr		Thermokopel 500oC, 4-20 mA	1	set
					Control Panel box 30x40x22	1	unir
3.	Control Panel Creation			4	The tools used:		
	a. PLC Omron Type ZAEN 20C1 DR	1	unit		a. Electrical welding machine 1 kW, 380 V, 50 Hz	1	set
	b. Control Cable program	1	set		b. Cutting machine,	1	set
	c. Contactor 380/220 V AC	1	unit		c. Tools	1	set
	d. Relay 24 V DC	1	unit		d. Cat saw	1	set
	e. TOR, 10 A, 380, 50 Hz	1	unit		e. Drill machine		
	f. MCB 4 A, 220V Scheneder	1	unit		f. Hacksaw		
	g. Phasa Light RST	3	unit		g. Sandpaper		
	h. Alaram	1	unit		h. Paint and brush		
	j. Instalation cable program, 0,75 mm2	50	rol				
	k. D Cable uck 40x60 mm	25	meter				

3.3 Work Procedure

The complete work order is shown in Figure 3 below

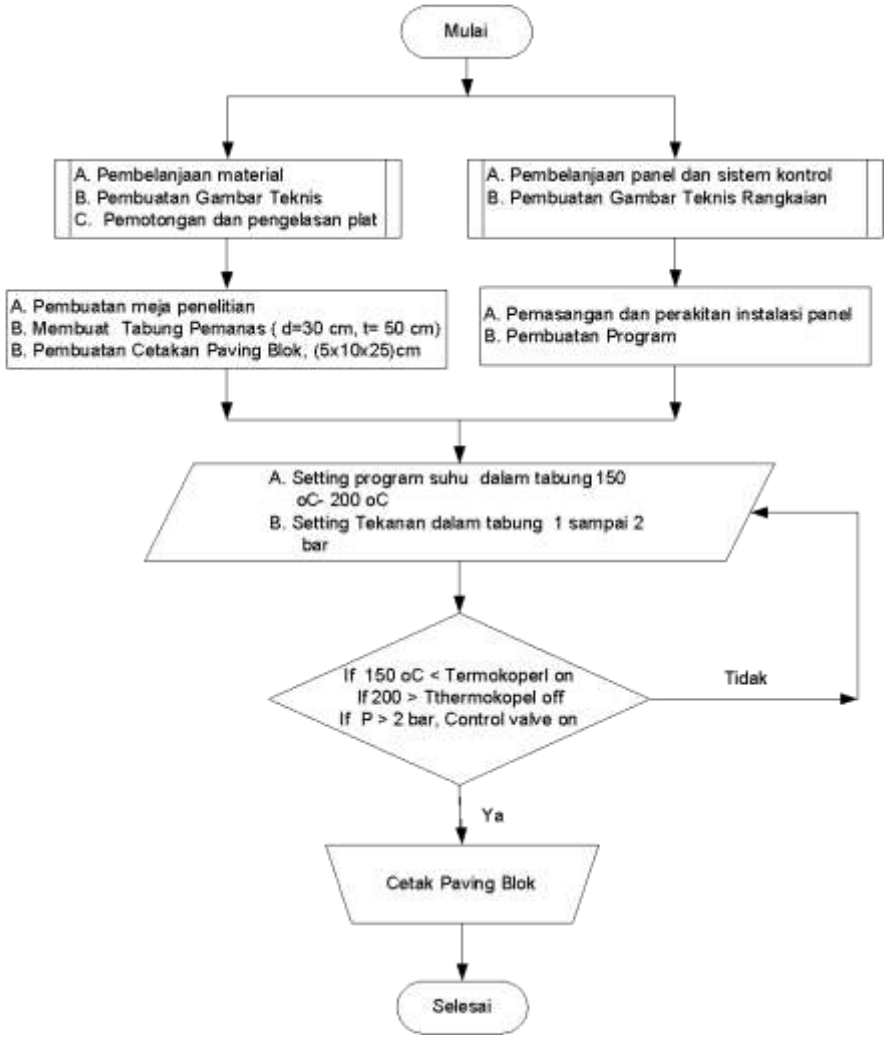


Figure 3: Research Flow Chart

4. Results and Discussion

4.1 Testing response time Temperature of empty tube conditions

Testing the temperature response time is done on the heater and in the heating tube in the case of the heater tank is still empty. The method of measurement and measurement results are shown in Figure 4 below

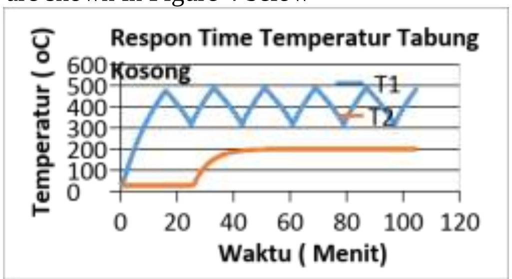
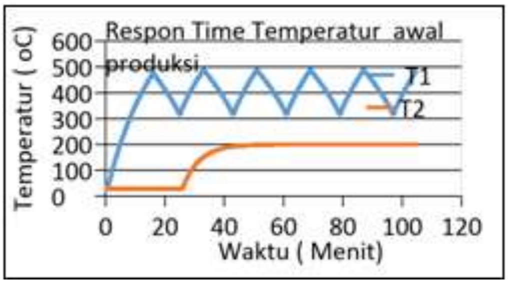


Figure 4: Temperature measurement range and time temperature response on the heater and inside the heating tube

In Figure 4 there is a response to the temperature time on the heater (T1) and inside the heater tube (T2). When the heater (T1) gets power supply the temperature rises hyperbolic, and takes 25 minutes to reach a temperature of 490 ° C, when the setting points are reached the contactor will stop supplying electrical power, so the temperature decreases at T1, after reaching the lowest T1 setting in 300 oC, the PLC instructs the relay to activate the contactor again, so that the heating process is repeated, and continues. The time needed to reduce the temperature at T1 from 490 oC to 300 oC, for 10 minutes. . Still in Figure 6 section (b), the response time at the temperature in the tube (T2), starting from 0 minutes to 30 minutes is still at a temperature of 28 oC, the temperature in the tube starts to rise hyper polically entering the 30 minutes, heat transfer process occurs. from the heater (T1) to the heating tube (T2). T1 and T2 are programmed with each other if the temperature at T1 drops then T2 is also expected to fall, but in response time the T2 temperature stays at 200 oC, this is because the heat transfer process in an isolated tube responds longer to heat transfer.

4.2 Response time testing Temperature Condition of Tubes Containing

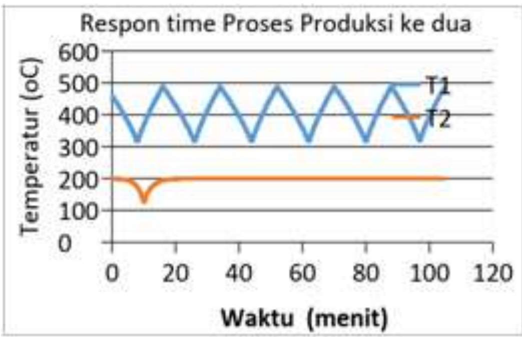
Testing the temperature response time is done on the heater and in the heating tube in the case of the tank the heater is filled with plastic. Plastic that is inserted into a heating tube weighing 1 kg consists of various types of plastic. The measurement method and measurement results are the same as shown in Figure 6 above, and the response time of the temperature transfer from the heater to the heating tube is shown in Figure 5 below.



(a) Respon time awal produksi paving blok

Figure 5: Material of plastic waste and respond time T1 and T2 when heating Plastic waste

Based on Figure 5 above part (a), there is a response to the temperature time on the heater (T1) and inside the heater tube (T2). When the heater (T1) gets power supply the temperature rises hyperbolic, and takes 25 minutes to reach a temperature of 490 ° C, when the setting points are reached the contactor will stop supplying electrical power, so the temperature decreases at T1, after reaching the lowest T1 setting in 300 oC, the PLC instructs the relay to activate the contactor again, so that the heating process is repeated, and continues. The time needed to reduce the temperature at T1 from 490 oC to 300 oC, for 10 minutes. Response time at the temperature in the tube (T2), starting from 0 minutes to 25 minutes still at a temperature of 28 oC, the temperature inside the tube began to rise hyper polically entering the 25 minute time, the process of transferring heat from the heater (T1) into the heating tube occurred. (T2). T1 and T2 are programmed with each other if the temperature at T1 drops then T2 is also expected to fall, but in response time the T2 temperature stays at 200 oC, this is because the heat transfer process in an isolated tube responds longer to heat transfer. The time used to complete the plastic melting process for 70 minutes, and removed from the tube through a 2 "valve. Based on Figure 7 above part (b), namely the second thermal heating production process. The temperature in T1 appears to decrease from 490 to 300. This happens because of a program that has been set for T1 in the PLC. At T2, the temperature drops from 200 oC to 130 oC, this is in line with the opening of the tube cap and when inserting plastic waste into the tube. The time needed to put 1 kg of garbage into the tube takes 1 minute, when the tube cap is closed again the temperature in the tube rises again as before. The time needed to melt plastic waste in a tube for 20 minutes.



(b) Respon time proses produksi paving blok kedua

4.3 Response to Time Pressure in a Heating Tube

Testing the time pressure response in a heating tube in a state of the tube is still empty and already contained. The measurement method and time pressure response are shown in Figure 6 below.

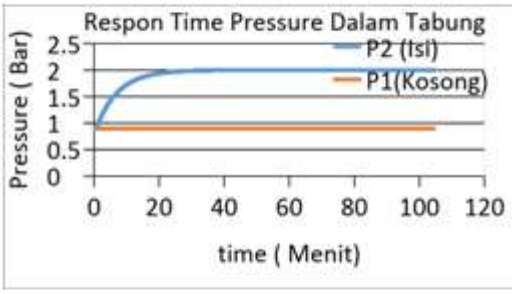


Figure 6: Pressure control system circuit and response time pressure in a heating tube

Based on Figure 6 section (a) it is shown that the heating tube is equipped with a pressure transmitter, which can change the pressure to an electric current signal (4-20) mA. The signal is forwarded to FX 2N-AD and then forwarded to the PLC. In the PLC programming has been done if (2> P) bar, then the CV will open several%, until the pressure inside the tube is released proportionally and the pressure in the tube remains stable, ie 2 bars. In Figure 9, part (b) shows the time pressure response in the heating tube, when the tube is still empty (P1), the pressure remains stable at 0.8 bar, up to 100 minutes, there is no added pressure in the tube. When the tube is filled, the plastic waste time pressure response appears to increase parabolically. At 20 minutes, the pressure starts at 2 bars. This is due to the occurrence of heating presoes on the raw material of waste in the tube, causing the temperature to rise slowly.

4.4 Response Time Control Valve (CV)

The response time CV when used to open and close the valve, which serves to remove more pressure in the tank, is shown in Figure 7 below

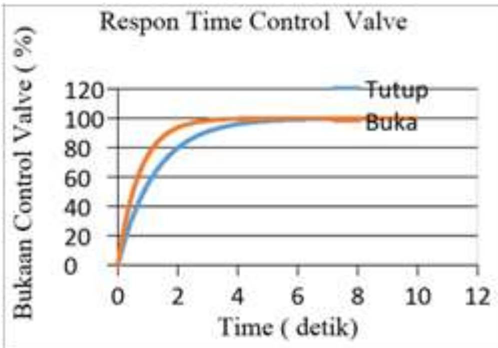


Figure 7: Response Time Valve Control

Based on Figure 10, the CV response time when opening and closing the valve can take 7 seconds. When going to open the valve response time the opening is faster than closing, especially occurs at openings 25% to 95%, this is due to a delay in the PLC when it will give orders to FX2N-4DA, so the CV motor, too late to respond. During the production process, the valve opening paving blocks are used between 0% and 10%, which takes 2 seconds. This is consistent with the need to keep the temperature and pressure in the tube constant.

4.5 Press Strength Testing Paving Blocks

Paving block compressive strength testing is carried out to determine the strength of the block vaving when it gets a load from above. The test is carried out by applying hydraulic pressure. Starting from the lowest to the highest pressure. Test results of the average compressive strength of the 10 simple units tested were 230kg / cm2.

5. Conclusion

Based on the results and discussion above it can be concluded, that the prototype of the production of paving blocks made from plastic waste consists of a heating tube measuring 50 cm high, 30 cm diameter made from stainlis plate capable of accommodating 1 kg of waste in a single production process. The temperature determined in the heating tube is 200^{o}C, sourced dare heater with a temperature set at 500 ^{o}C. To produce 2 units of sized paving blocks (5x10x25) cm. time 70 minutes, when the initial production of paving blocks and subsequent production for 20 minutes. Laboratory test results of the compressive strength of paving bok reached 230 kg /cm2. To maintain temperature and temperature stability, 2 temperature sensors are installed, ie 1 sensor unit is installed in a heating tube and 1 unit is installed in the heater section. As a pressure controller in a tube fitted with a pressure sensor, the pressure is set to 2 bar, if the excess pressure then FX-4N 2AD, will give a signal to the PLC to then order FX-4N DA, immediately open the control valve so that more pressure is issued dare in the tube through the pipe planned

References

[1] M. Hariansyah, Ahcyar Eldine, 2016. Development of Appropriate Technology in Plastic Waste Management, Financial Balance Vol 11 No 2, September 2016, ISSN 1858-2214, Scientific Journal of Accounting and Finance Accounting Study Program, Faculty of Economics, Ibn Khaldun University Bogor. 2016
[2] Basriyanto, 2017, Harvesting Trash. Canisius-accessed dare the Internet. WIKIPEDIA, Thursday, April 16 2017, at 15.00 WIB.
[3] M. Budianto, A. Wijaya, 2013, Introduction to the Porgram Logic Controller Basics. Gava Media, Yogyakarta.
[4] Mitsubishi, 2013, FX Series Programming Manual, Mitsubishi, Tokyo.
[5] M. Hariansyah, dkk, The Design And Response Characteristics Of Electronic Control System On Hydraulic-Driven Mole Plough International Journal of Science and Research (IJSR)ISSN (Online): 2319-7064 Volume 2 Issue 11, November 2013www.ijsr.net

Paper ID: ART20192161 DOI: 10.21275/ART20192161