Pneumatic pressure control system with microcontroller on bullet launcher

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ABSTRACT

Bullet launcher is a defense tool aimed at shooting targets, powered by gunpowder which can endanger its users. the use of gunpowder is dangerous because the resulting explosive power can harm the user. An alternative solution that can be done for this problem is to design a bullet launcher system that does not endanger its users. The system that has been implemented is a pneumatically powered bullet launcher. The pneumatic system is controlled using a microcontroller to control the input of sensors, solenoids, actuators and air pressure in the system. The pressure sensor used is a WPT-83G-EGG4 transmitter with a maximum pressure of 12 bar or 174 psi. Tests were carried out at a distance of 100 cm, 200 cm and 300 cm with an average accuracy value of 98.56% and an average precision value of 69.83%.

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1. INTRODUCTION

A bullet launcher is a defense tool intended for target shooting powered by gunpowder that can harm the user [1]. The use of gunpowder is dangerous because the explosive power produced can endanger the user so the use of gunpowder is limited [2]. Gunpowder is an explosive mixture made from a mixture of chemical substances used in firearms [3]. The use of gunpowder as a driving force can be replaced, such as electromagnetics or high-pressure.

Based on previous research, the use of gunpowder as a driving force can be replaced using electromagnetic power. This research aims to replace gunpowder propulsion with electromagnetic propulsion with high bullet ejection speed. [4]. Future research uses an electromagnetic coil module on a pneumatically assisted hybrid launcher [5], [6]. So that the use of gunpowder in bullet throwers can be replaced with a driving force that does not endanger its users.

Bullet throwers can be developed again by using a pneumatic system to replace gunpowder as a driving force. pneumatics is a system that utilizes compressed air to perform mechanical work. Pressurized air in pneumatics can be stored and supplied to launch bullets [7]. By using a pneumatic system on a bullet launcher, it certainly does not endanger its users like the use of gunpowder with a small risk to its users. Air pressure in pneumatics can be controlled based on predetermined pressure. This paper explains how to adjust the air pressure control of the pneumatic system on the bullet launcher using a microcontroller.

2. THEORETICAL BASIS

A bullet launcher is a device used to hit a target, using gunpowder as explosive power. Bullet launchers are used as a defense tool but their use is limited because gunpowder data endangers the user. Bullet launchers can be developed by using a safer system that replaces the use of gunpowder with a safer system. Pneumatics can be used as a substitute for gunpowder in bullet launchers [7], [8].

Pneumatics is a relatively safe system because it uses compressed air and the air pressure can be adjusted. Pneumatics is a fluid mechanics system consisting of air flow through channels and compressed air. Compressed air is air that comes from an air source and is then forcibly channeled into an air tube with a relatively small size. Pneumatics is usually used by industry for mechanical processes controlled by PLC systems[9], [10]. The PLC system in pneumatics can be replaced using a microcontroller.

Microcontroller is a functional computer system on a chip. Inside there is a CPU, ROM, RAM, and programmable input/output devices. Microcontrollers are used in automatically controlled devices, such as machine control systems, remote controls, smart homes, and others [11]. In this system, the microcontroller is used as the main control in the system, namely processing data received from sensors and controlling actuators.

The sensor used in this system is an air pressure sensor. The air pressure sensor is a sensor that functions to read the pressure value of liquid, air or gas material. Pressure sensors are used in air tubes to read air pressure values [12]. The air pressure sensor used is the WPT-83G-EGG4 transmitter with a maximum value of 12 bar or 174 psi.

Relay is a switch that uses an electromagnet to control a set of contacts, which consists of a coil of conducting wire wrapped around an iron core. The switch on the relay is controlled using an electric voltage with an input of 5-9 Volts DC on the contacts. The contacts on the relay can supply an AC voltage of 10-230V with a current of 1-5 A. The relay also functions to cut off the voltage from the source to the load [13]. Solenoid valve is a control element used in pneumatic systems. The solenoid valve serves as a regulator of the air channel that flows to the actuator [14].

3. METHOD

The objective of the pneumatic pressure control system with a microcontroller on a bullet thrower is to implement a pneumatic system on a bullet thrower controlled by a microcontroller that can control air pressure. The air pressure in the system is controlled automatically by the microcontroller. This equipment is based on arduino nano which consists of several components including, arduino nano, 20x4 LCD, pressure sensor and relay.

The control of this system is arduino nano which serves as the main operation control for data processing, sensor calibration and actuator control. The air pressure sensor is tasked with detecting the pressure inside the air tube. If the air pressure has reached the specified limit, the data is sent to the microcontroller then the microcontroller controls the relay to turn off the compressor. The LCD serves as an indicator of air pressure and system conditions while running. When the air pressure has been reached, the microcontroller can control the relay to control the solenoid to shoot air into the tube.

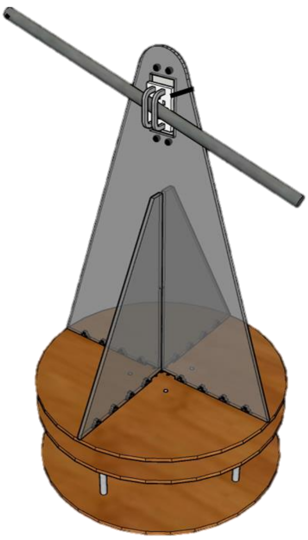

Figure 1. Bullet thrower design

Figure 1 is a drawing of the bullet launcher design. The design consists of a tower, a drive system and a sleeve. The air tube on the bullet launcher is mounted separately not on the launcher tower. The air pressure sensor is attached to the air tube while the compressor, relay and solenoid are attached to the box where the components for the bullet launcher system are.

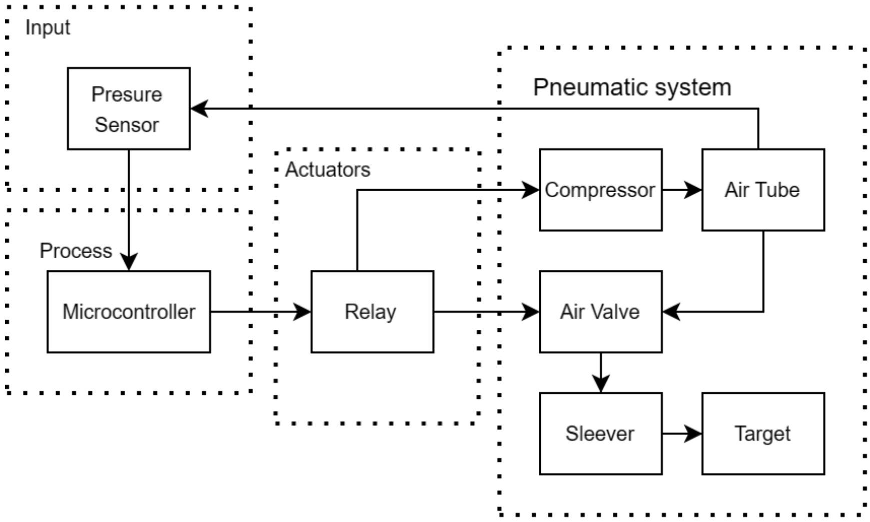

Figure 2. Block diagram system

Figure 2 block diagram of the system as a whole. The system consists of input, process, output and pneumatic system. The input consists of a pressure sensor connected to an air tube and a microcontroller. The actuator device consists of relays and servo motors controlled by the microcontroller to turn the pneumatic system on and off. The pneumatic system consists of compressor, air tube, air valve and sleeve.

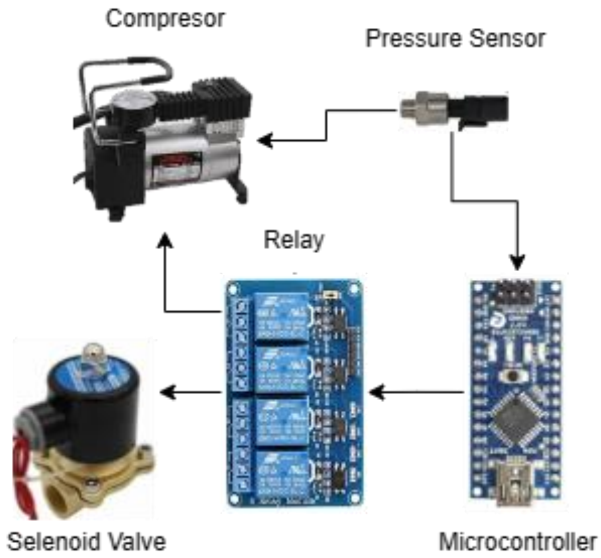

Figure 3. Hardware design

Figure 3 is an illustration of the hardware design. The microcontroller reads the pressure sensor value then the sensor value is processed and used as a command to control the relay actuator. The relay used serves to control the compressor and solenoid valve. The microcontroller controls the actuator based on the command given and the data value given by the pressure sensor.

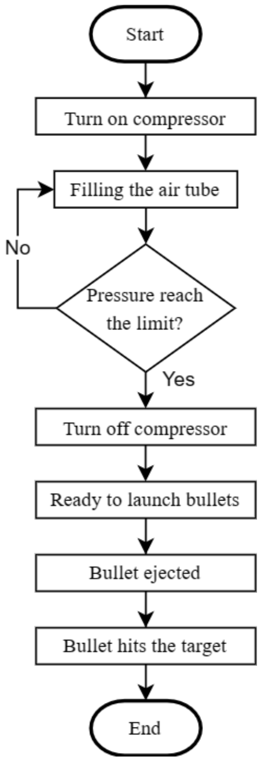

Figure 4. Flowchart

Figure 4. Is the workings of the system. when the system is ready to operate, we first turn on the compressor. The compressor will fill the air in the tube until it reaches a predetermined air pressure. When the required air pressure has been reached, the compressor will stop filling the tube. Once the filling is complete the system is ready to fire. When about to launch the bullet the system will open the air valve and then the bullet is ejected and hits the target.

4. RESULTS AND DISCUSSION

System testing is required to determine the performance of the system. The system has been tested to launch projectiles 10 times at distances of 1, 2, and 3 meters between the launcher and the target. The system is equipped with a laser to assist in aiming at the target. The system will fill the air container with pressurized air by an air compressor by pressing a button. The microcontroller will automatically turn off the air compressor through a relay when the air compressor sensor reads the air pressure value in the air container of 15 psi. The following shot results on the marked target can be seen in Figure 5.

Figure 5. Projectile test results

Analysis of the results is done when the test data has been obtained so that the data is analyzed and conclusions are drawn. The accuracy value in this test using the RMSE (Root Mean Square Error) calculation method is calculated by summing up all the squares of the prediction value error, then dividing by a lot of prediction data [15], [16]. Here is the equation for calculating RMSE.

$$\text{RMSE}=\sqrt{\frac{\sum_{i=1}^{n}\ (X_t - F_t)^2}{n}}$$

Description:
X_t : Actual data in period
F_t : Predicted value in period
n : Number of data

Furthermore, the precision value is calculated based on the error value obtained in each test and then the average value of the test is calculated. Then the value of each data is reduced by the average value and divided. The equation for calculating the precision value used.

$$precision_i = abs(\frac{y - y_i}{\hat{y}})$$

$$precision = \frac{\sum precision_i}{n}$$

Description:
y : Error value
y_i : Number of data
ŷ : Average error value

Table 1, is the test result data of launching the projectile 10 times at a distance of 100 cm between the launcher and the target. The actual value or aiming point of the target is 0 then reduced by the measurement results, the squared error value is obtained. The total squared value is 33.15 then the total value is divided by 10 (the amount of data) to get an RMSE value of 1.82.

Table 1. Projectile test results at a distance of 100 cm

Test	Actual	Measurements result	Error	Absolute error value	Squared error value
1	0	2,5	-2,5	2,5	6,25
2	0	2,9	-2,9	2,9	8,41
3	0	1,3	-1,3	1,3	1,69
4	0	1,8	-1,8	1,8	3,24
5	0	1,4	-1,4	1,4	1,96
6	0	0,5	-0,5	0,5	0,25
7	0	1,3	-1,3	1,3	1,69
8	0	1,1	-1,1	1,1	1,21
9	0	1,3	-1,3	1,3	1,69
10	0	2,6	-2,6	2,6	6,76
		Total squared error value			33,15
		RMSE			1,82

Table 2, is the result of testing the projectile launch 10 times at a distance of 200 cm between the launcher and the target. Each error value obtained is squared, then summed up with the calculation result of 65.02 with an RMSE value of 2.55.

Table 2. Projectile test results at a distance of 200 cm

Test	Actual	Measurements result	Error	Absolute error value	Squared error value
1	0	2,9	-2,9	2,9	8,41
2	0	3	-3	3	9
3	0	1,5	-1,5	1,5	2,25
4	0	1,5	-1,5	1,5	2,25
5	0	0,8	-0,8	0,8	0,64
6	0	3,4	-3,4	3,4	11,56
7	0	2,9	-2,9	2,9	8,41
8	0	2,5	-2,5	2,5	6,25
9	0	2	-2	2	4
10	0	3,5	-3,5	3,5	12,25
		Total squared error value			65,02
		RMSE			2,55

Based on the previous calculations, the data in table 3 is the result of testing the projectile 10 times at a distance of 300 cm, this data is processed using the RMSE method, namely the error value obtained is then squared and summed up and then divided by the amount of data. The total squared error value is 137.31 with an RMSE value of 3.71.

Table 3. Projectile test results at a distance of 100 cm

Test	Actual	Measurements result	Error	Absolute error value	Squared error value
1	0	2,7	-2,7	2,7	7,29
2	0	3,2	-3,2	3,2	10,24
3	0	2	-2	2	4
4	0	4,5	-4,5	4,5	20,25
5	0	2,7	-2,7	2,7	7,29
6	0	3,7	-3,7	3,7	13,69
7	0	4,7	-4,7	4,7	22,09
8	0	5	-5	5	25
9	0	3,5	-3,5	3,5	12,25
10	0	3,9	-3,9	3,9	15,21
		Total squared error value			137,31
		RMSE			3,71

After processing the projectile test data at a distance of 100 cm, 200 cm and 300 cm. Then the next step is to analyze the data to get the accuracy and precision value of the bullet launcher based on the data obtained previously. Table 4, is the final result of the accuracy and precision analysis on the bullet thrower.

Table 4. Accuracy and preacquisition value analysis

Test	Object distance		
	100 cm	200 cm	300 cm
1	2,9	2,5	2,7
2	3	2,9	2
3	1,5	1,3	2
4	1,5	1,8	0,3
5	0,8	1,4	2,7
6	3,4	0,5	1,7
7	2,9	1,3	2,7
8	2,5	2,7	3
9	2	1,3	3,5
10	3,5	2,6	3,9
RMSEn (cm)	1,82	2,55	3,71
Accuracy	98,18%	98,73%	98,76%
Precision	62,63%	68,33%	78,55%

Table 4, describes the results of the analysis of accuracy and precision calculations on the bullet launcher, the distance between the launcher and the target center point using cm units for distance values. The RMSE value that has been obtained is then processed to determine the accuracy value in percentage form. The RMSE value (cm) in each test is divided by the distance (cm) then the calculation results are calculated in percentage form. The accuracy value in testing shooting projectiles 100 cm 98.18%, testing shooting projectiles 200 cm 98.73% and testing shooting projectiles 300 cm 98.76% with an average accuracy value of 98.56%.

Calculation of the precision value, the error value of each test is calculated as the average value. The value of each test is reduced by the average value and then divided. After obtaining the results of the calculation of each data, the data is converted into a percentage. The precision value in testing shooting 100 cm projectiles is 62.63%, testing shooting 200 cm projectiles 68.33% and testing shooting 300 cm projectiles 78.55% with an average precision value of 69.83%.

5. CONCLUSION

Based on the tests that have been carried out previously in Pneumatic Pressure Control System with Microcontroller on Bullet Launcher, conclusions can be drawn. The system can throw projectiles at a distance of 100 cm, 200 cm and 300 cm on the target with an average shot accuracy value of 98.56% with an average shot precision value of 69.83% on the bullet launcher system. Therefore, the system has achieved the goal of throwing bullets with accuracy and precision. Suggestions for further research can improve the accuracy and precision of the system with a longer distance to throw the projectile.

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