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Cracker Material Cutting Machine Control System Arduino Based Automatic Pulley

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Abstract**—** *In the modern era like today, the role of automated technology is very important to help humans solve their problems. In the Puli cracker industry in the Madiun area, they still use conventional way. In the process of slicing itself is still manually so that the slicing takes a long time (5 kg/hour) and the results of the slices are less precise. From trouble therefore, an Automatic Puli Cracker Cutting Machine was made. The way this tool works is by slicing the material vertically and has 3 thickness options (1 mm, 2 mm, 3 mm). This tool uses Arduino Mega 2560 as a control as well as data processing using 4 sensors (speed sensor, proximity sensor, infrared sensor, and ultrasonic sensor) for improve tool performance. And using PID with constants Kp = 1.2, Ki =0,8 and Kd = 0.45 which works well to minimize errors in the thickness of the material so that it can be tolerated. This tool is also able to increase time efficiency by 65.7% of each slice thickness.*

Keywords**—** *Enter key words or phrases in alphabetical order, separated by colon.*

I. INTRODUCTION

In this modern era, the role of automated technology is very important to help humans solve their problems. Especially in the industrial era 4.0 which occurred at a time when this forces humans to automate tools in the company to increase productivity. The concept of application is centered on the concept of automation carried out by technology without the need for labor humans in the application process [7]. This certainly adds efficiency to a work environment where time management is seen as something which is vital and much needed by the players industry [1].

Things like this are certainly very influential on Micro Enterprises Small and Medium Enterprises (MSMEs) located in various cities. Of course it is impossible for MSME owners to continue to use conventional equipment that relies on human labor in the industrial era 4.0 as it is today. Tool automation required to support productivity and efficiency in the process production [2]. Besides, to face the competition and challenges from other entrepreneurs today and in the future.

This innovation is expected to be able to anticipate competition in the business world and can open up opportunities to compete. With the design of tools that pay attention to

human factors, it is hoped that the designed tools can operated comfortably and safely [3]. With evaluations related to human characteristics as the main segment for users. As in the area of Micro Small Medium Enterprises (MSMEs) of Puli crackers in Madiun City, for the production process starting from the manufacture of Puli crackers raw materials to the drying process of Puli crackers, they still use simple equipment and require more human labor. So that from some of these production processes many complaints arise, one of which is in the process of cutting the cracker pulleys [10].

Complaints felt by producers on the process cutting, i.e. inefficient production time, fatigue, requires a high level of concentration in order to avoid the risk of accidents, as well as the thickness level varies [4]. In this section, in the process of cutting the material, we still use a knife that is moved with a hand or conventional. MSME managers really need the design of cracker cutting tools pulleys that meet ergonomic values, are time efficient, and can increase business productivity.

Based on the complaints and problems above, this research takes the idea to make a final project with the title "Arduino-Based Automatic Pulley Cracker Cutting Machine Control System". With the effectiveness of faster cutting and precision in terms of material thickness allow this machine to increase MSME productivity. This tool uses DC motor as a driving force to push materials pulley crackers to the cutter. Capacitive sensor to detect materials will run out, infrared sensor to drive the motor booster when detecting obstacles and speed sensor for monitoring DC motor speed [6]. With capacity a large enough container for puli crackers, allows this machine to increase productivity SMEs, improve time efficiency in the process production, as well as minimizing the risk of work accidents when Puli cracker production process.

II. METHODOLOGY

In the planning and manufacture of writer tools determine some of the methods used in study. In this methodology describes block diagrams system and tool design of "Arduino-Based Automatic Pulley Cracker Machine Control System".

A. Diagram Block System

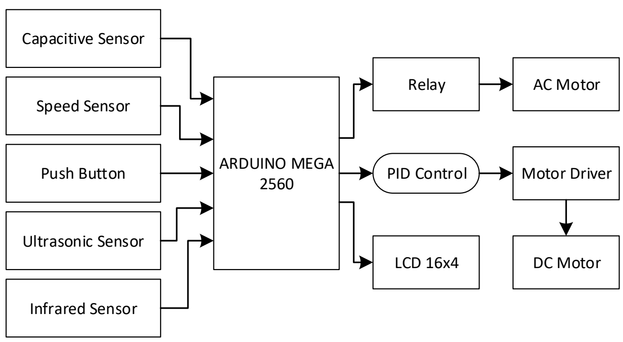

Fig. 1. System Block Diagram

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From the system block diagram in Figure 1 it can be explained as follows:

- Arduino Mega 2560 as control and data processing.
- PID control as control of DC motor speed.
- 16 × 4 LCD as a menu display for the choice of the thickness of the cracker cutting material.
- Push Button as input for the choice of the thickness of the cracker cutting material.
- DC motor as a pusher of the pulley cracker material to the cutter.
- AC motor as driving knife cutting.
- Speed sensor as a DC motor speed detector.
- A capacitive sensor for detecting crackers in the cutting container.
- Relay as an AC motor automatic switch.
- Motor driver to adjust motor speed DC.
- Ultrasonic sensor as a thickness validation gauge of the material being cut.
- Infrared sensor as feedback for the driving motor to work according to the specified speed.

B. *Tool Design For*

The design of Arduino-Based Automatic Pulley Cracker Cutting Machine Control System as follows:

- In this case, it has a size of W=110cm, L=90cm, and H=105cm.
- The cutting blades and material containers use stainless steel.
- For the frame using iron material.
- Then to move the knife and container using an AC motor that is connected to a fan belt.

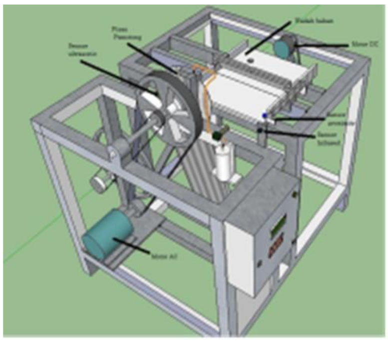

Fig. 2. Tool Design

Fig. 3. Tool Realization

III. RESULT AND DISCUSSION

At this stage, testing is carried out on the pulley cracker material that has been made. The results of this test will be used as data to obtain the desired results.

1. Ultrasonic Sensor Testing

US-100 Sensor test, this time the sensor functions as a detector for the thickness of the cut pulley cracker material [9]. The test this time was done by looking at the initial distance read by the US-100 sensor with a cutting knife. The data from the US-100 Sensor test results are shown in Table I.

TABLE I. Ultrasonic Sensor Test.

S. No.	Thick Selected	Sensor Initial Distance Reading	Reading Moment Trimmed	Calculation Thickness Ingredients	Tick End
1	1 mm	50 mm	49 mm	50 - 49	1 mm
2	2 mm	50 mm	48 mm	50 - 48	2 mm
3	3 mm	50 mm	47 mm	50 - 47	3 mm

2. Infrared Sensor Testing

In testing the infrared sensor E18-D80NK times This sensor functions as feedback for the pusher DC motors. When the infrared sensor detects an obstacle in the material container, the DC motor useful for pushing the material will work and start pushing the material according to the speed that has been adjusted according to their respective thickness. Testing of the E18-D80NK Infrared sensor can be seen in Table II.

TABLE II. Infrared Sensor Test.

Test	Obstacles / Thing	DC Motor Condition
1	There isn't any	Not Working/Silent
2	There is	Work/Forward

3. Testing Motor Drivers and DC Motors

The purpose of this test is to find out output of the motor driver when given different inputs. Data from the test can be viewed at Table III.

TABLE III. Testing Drivers and DC

PWM	V Motor (Volt)	RPM
25	1,42	1140
35	1,98	1884
50	2,82	2448
65	3,66	3678
75	4,22	3828
100	5,61	4566
110	6,18	5058
120	6,74	5262
125	7,02	5514
140	7,88	6180
150	8,45	6582
160	9,02	7290
175	9,89	7619

4. Tuning Check the PID

Parameter tuning serves to determine PID parameters (Kp, Ki and Kd)[5]. Step these methods are as follows:

a) Set the value of Kp, Ki and Kd starting from zero.
b) Running a DC motor.
c) Observing the graphic display of the rotary sensor encoder

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d) When the graph is not yet oscillating sustainability, increase Kp value, price increased from zero to a critical value of Kcr.

e) When the graphics sensor rotary encoder is already form a continuous oscillation, calculate Kcr and Pcr values.

f) Calculate the values of Ti and Td using Kcr and Pcr values.

g) Calculate the value of Kp, Ti and Td according to *Ziegler-Nichols* rule is
$K_p = 0{,}6 \times K_{cr}$, $T_i = 0{,}5 \times P_{cr}$ dan $T_d = 0{,}125 \times P_{cr}$.

h) Calculate the values of Ki and Kd using the values of Ti and Td.

i) The values of Ki and Kd are obtained by using the following calculations:
$$Ki = Kp \text{ and } Kd = Kp \times Td$$

Using the values of Kp, Ki and Kd that have been obtained, observe the rotational speed of the DC motor.

This test uses a close-loop control system or closed loop. The speed setpoint is entered in the motor driver which is useful for driving a DC motor [8].

The speed of the DC motor will be read by the speed sensor and if it is not appropriate, it will return to the motor driver for adjusted to the setpoint. The test of speed control using the Ziegler-Nichols oscillation method begins by giving a value of 0 to the Ti and Td parameters. While the value of Kp is increased little by little until A continuous oscillating graph is obtained. Results test for motor speed response with using a proportional controller with a value of 1 (Kp = 1) can be seen in figure 1.

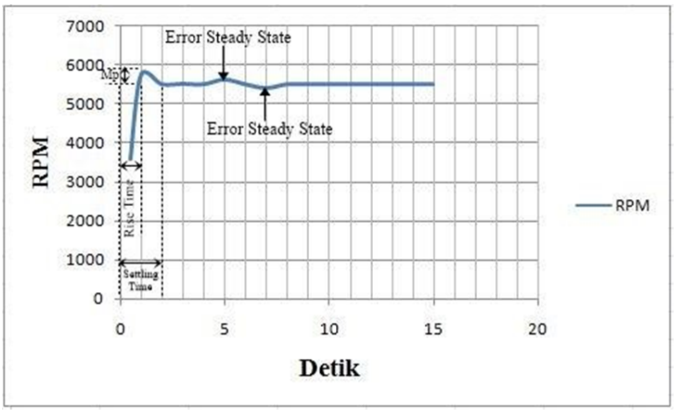

Fig. 1. Example of a figure caption.

It can be seen in the graph that the speed response has oscillation but it is not continuous so it is still necessary added Kp value. Test results using the value 2 (Kp = 2) can be seen in figure 2.

In testing using the value of Kp = 2 it can be seen that the response has experienced oscillations continuity at the 3rd second. It can be seen that at proportional controller with value 2 can form oscillation continuous compared to Kp = 1. So that from the graph with the value of Kp = 2 can be calculated the value of Kcrand Pcr namely:

- $K_{cr} = 2$
- $P_{cr} = (6 - 3) \times \textit{time sampling} = 3 \times 1s = 3\ s$

$K_p = 0{,}6 \times 2 = 1{,}2$

- $T_i = 0{,}5 \times P_{cr} = 0{,}5 \times 3 = 1{,}5$
- $T_d = 0{,}125 \times P_{cr} = 0{,}125 \times 3 = 0{,}375\ s$
- $K_i = \frac{K_p}{T_i} = \frac{1{,}2}{1{,}5} = 0{,}8$
- $K_d = K_p \times T_d = 0{,}45$

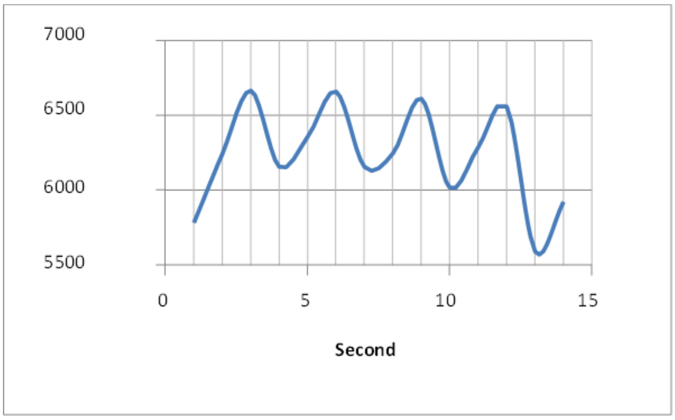

Fig. 2. Graph of DC Motor Speed Response with Kp = 2.

So that the parameter values obtained are $K_p = 1{,}2$, $K_i = 0{,}8$ and $K_d = 0{,}45$.

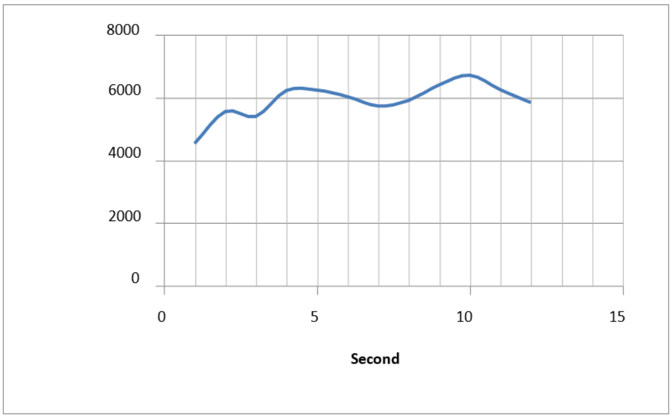

Fig. 3. DC Motor Speed Response

From figure 3, we get the value of time setting or ts, maximum overshoot or Mp and steady state error, the following will explain the meaning of time settling or ts, maximum overshoot or Mp and steady state error, along with their calculations.

- Settling *time* (t_S) is the time required for the response to reach a stable state (steady state) or be considered stable. The *settlingtime* obtained is = 2s
- Steady *state error* (Ess) is the magnitude of the error at steady state .*The steady state error* tha obtained from the test are:
$$E_{ss} = \frac{(5634 - 5514)}{5514} \times 100\% = 2{,}17\%$$
- *Maximum overshoot* (Mp) is the highest value of the graph is 5746 then:

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$$M_p = \frac{(5746 - 5514)}{5514} \times 100\% = 4{,}2\%$$

1. Thickness Test Using PID

In this test, it aims to find out if the given PID constant is already can minimize the difference between the thickness *setpoint* with the cut from the tool. Cutting thickness data can be seen inTable IV and Table V.

TABLE IV. Thickness Test Without PID

Testing	Measurement Thickness	Result Measurement
1	2 mm	3 mm
2	2 mm	2,5 mm
3	2 mm	1,7 mm
4	2 mm	4 mm
5	2 mm	3,5 mm
6	2 mm	4 mm
7	2 mm	2 mm
8	2 mm	1 mm
9	2 mm	2 mm
10	2 mm	4 mm

Fig. 4. Result Without PID

TABLE V. Thickness Test With PID

Testing	Measurement Thickness	Result Measurement
1	2 mm	2,2 mm
2	2 mm	2 mm
3	2 mm	2 mm
4	2 mm	2,5 mm
5	2 mm	2 mm
6	2 mm	2 mm
7	2 mm	2,2 mm
8	2 mm	2 mm
9	2 mm	2 mm
10	2 mm	2 mm

Fig. 5. Results With PID

2. Time Efficiency Test and Thickness Precision

In this test, the aim is to find out whether the time required forthis tool is to cut the material has been efficient or not. Time efficiency data from the cutting process at thickness can be seen in table VI.

TABLE VI. Time Efficiency Test

Cutting Thickness	Initial Length of Material	Material Weight	Cutting Time	Remaining Material Lenght
1 mm	27 cm	0,9 kg	4 minutes 40 seconds	9 cm
2 mm	32 cm	1,1 kg	4 minutes 10seconds	14 cm
3 mm	32 cm	1,1 kg	3 minutes 30 seconds	13 cm

From the cutting efficiency test that has been done, it can be seen that this tool has time efficiency in materials. For materials using manual techniques or with a knife, it can take ± 12 minutes for 1 kilogram of gel material. While this tool is capable of material with a time of ± 5 minutes for some spindle materials. However, this tool is still not able to material until there is nothing left. This happens because the mechanics collide with each other when the material pusher works until the material runs out. However, the remaining material from the previous cut can be cut back by placing it in front of the material that has been refilled in the material container provided.

The precision test of the material that has been cutaims to determine whether the thickness of the material after the cutting process is precision or not. Precision data from the material cutting process can be seen in Table VII, Table VIII and Table IX.

TABLE VII. Precision Testing of 1 mm Thickness and Weight

Measurement	Initial Length	Material Weight	Material Size	Result Cutting
1	27 cm	0,9 kg	1 mm	1 mm
2	27 cm	0,9 kg	1 mm	1 mm
3	27 cm	0,9 kg	1 mm	1,2 mm
4	27 cm	0,9 kg	1 mm	1 mm
5	27 cm	0,9 kg	1 mm	1,2 mm
6	27 cm	0,9 kg	1 mm	1 mm
7	27 cm	0,9 kg	1 mm	1,5 mm
8	27 cm	0,9 kg	1 mm	1,2 mm
9	27 cm	0,9 kg	1 mm	1 mm
10	27 cm	0,9 kg	1 mm	1,2 mm
Cutting Average				1,13 mm
Cutting Time				4 minutes 40 seconds

TABLE VIII. Precision Testing of 2 mm Thickness and Weight

Measurement	Initial Length	Material Weight	Material Size	Result Cutting
1	32 cm	1,1 kg	2 mm	2 mm
2	32 cm	1,1 kg	2 mm	2 mm
3	32 cm	1,1 kg	2 mm	2 mm
4	32 cm	1,1 kg	2 mm	2 mm
5	32 cm	1,1 kg	2 mm	2,2 mm
6	32 cm	1,1 kg	2 mm	2 mm
7	32 cm	1,1 kg	2 mm	2 mm
8	32 cm	1,1 kg	2 mm	2,2 mm
9	32 cm	1,1 kg	2 mm	2 mm
10	32 cm	1,1 kg	2 mm	2 mm
Cutting Average				2,04 mm
Cutting Time				4 minutes 10 seconds

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TABLE IX. Precision Testing of 3 mm Thickness and Weight

Measurement	Initial Length	Material Weight	Material Size	Result Cutting
1	32 cm	1,1 kg	3 mm	3 mm
2	32 cm	1,1 kg	3 mm	3,2 mm
3	32 cm	1,1 kg	3 mm	3 mm
4	32 cm	1,1 kg	3 mm	3 mm
5	32 cm	1,1 kg	3 mm	3 mm
6	32 cm	1,1 kg	3 mm	3 mm
7	32 cm	1,1 kg	3 mm	3 mm
8	32 cm	1,1 kg	3 mm	3,2 mm
9	32 cm	1,1 kg	3 mm	3 mm
10	32 cm	1,1 kg	3 mm	3 mm
Cutting Average				3,04 mm
Cutting Time				3 minutes 30 seconds

Fig. 6. Measurement 1 mm

Fig. 7. Measurement 2 mm

Fig. 8. Measurement 3 mm

In the tests that have been carried out, it can be seen that there is still a difference between the thickness setpoints that have been determined by the results of cutting the material from the tool. However the difference from the cut is still tolerable. And if the thickness setpoint is getting thicker, the difference is getting bigger reduced and there is not even a difference from the results of the cuts.

IV. Conclusion

Based on the results of design, testing, and analysis what has been done on the Cutting Machine Control System Automatic Puli Cracker Ingredients can be concluded:

1. This Automatic Puli Cracker Cutting Machine Control System can cut with a high level of precision and hasbeen tested directly for cutting Puli crackers. This cutstill has an *error* in thickness precision, but an *error* at the thickness can still be tolerated and ifthe thicker the cut, the *error* will be reduce
2. Cutting using this automatic pulley cutting machine can increase time efficiency. At a cutting thickness of 1 mm, it can increase time efficiency by 61.1% from manual cutting, at a cutting thickness of 2 mm it can increase time efficiency by 65.3%, at a cutting thickness of 3 mm it can increase time efficiency by 70.8%.
3. The application of PID in this tool system is able to minimize an error of 34% in thickness precision because it is able to stabilize the speed of a DC motor which is useful for driving pulley crackers.
4. The use of the PID controller with the Ziegler-Nichols oscillation method provides a parameter value that is suitable for the system and provides a faster response to achieve a steady state. The PID parameters used are = 1.2, = 0.8, = 0.45.

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