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ARDUINO-BASED AUTOMATIC CUTTING TOOL FOR COCONUT SHELL CHARCOAL BRIQUETTES

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ABSTRACT

Coconut shell waste is underutilized due to the high demand for coconut in Indonesia. To maximize the use value of the material, coconut shells are converted into biomass energy, specifically charcoal briquettes. Due to the rapid advancement of technology today, it is necessary to use equipment that can run automatically to increase productivity, reduce production time, and lower production costs. This research was conducted to make an automatic cutting tool based on an Arduino microcontroller. The first process identified with literature studies related to automatic briquette cutting tools. The second process is conceptualised by assessing several design variants, then the highest value is taken. The third process is designing by making detailed drawings per component. The fourth process of completing the design by assembling all the components that have been made, and then testing the Arduino-based automatic cutting tool. The results obtained by the automatic cutting tool produce a cutting consistency of 77.5% and produce a residue of 22.5%. From the test data, the Arduino-based automatic cutting tool can work more effectively and efficiently to increase production capacity.

Keywords: briquettes, waste, microcontroller, Arduino, coconut shell.

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1. INTRODUCTION

The shell of a coconut is a residual material that is produced during the extraction of coconut meat. Using coconut shells as the main raw material for charcoal briquettes could successfully resolve environmental concerns [1]–[4]. Furthermore, the use of byproducts for various applications is a way to increase both the additional value and economic worth [5]–[7]. Indonesia is a tropical country and the largest and highest-quality coconut producer in the world [8]. Indonesia is projected to become a leading global coconut producer in 2023, with an estimated production of 2.89 million tons. Most coconut production is concentrated in the provinces of Riau and North Sulawesi [9]. One coconut fruit produces 35% coir, 28% meat, and 12% coconut shell which includes residual waste [1]–[3]. Thus, the coconut shell waste generated in 2021 is estimated at 347,000 tons. This will have an impact on environmental pollution if it is not properly processed. Coconut shell is the result of coconut processing, 12% of coconut is coconut shell. It is usually used to make souvenirs, household items, or biomass fuel such as briquettes.

When the coconut shell is heated, it becomes charcoal. The charcoal contains water, ash, and volatile substances. High concentration of bound carbon, good hardness, and little ash are properties of coconut shell charcoal.

Coconut shell waste has not been fully utilized, even though the heat content in coconut shells is very high [10], [11]. Coconut shell briquettes are a type of biomass fuel that is compacted with a mixture of adhesives. Coconut shell charcoal briquettes are carbon-containing solid fuels that can burn deeply and have a high calorific value for a long time [10]–[13]. This biochar can be utilized by being converted into biochar briquettes. The briquette screw press tool is a tool designed to assist in moulding briquettes and help the blending process, with the screw pressing the coconut shell charcoal briquette material to speed up the briquette process (Figure 1). This tool uses a motor drive and an extruder screw press. The motor passes energy to the pulley rotating the extruder screw to press the briquettes out through the output of the screw press tool [14], [15]. Briquettes that come out of the output of the screw press are cut manually on a table using a plate or knife according to the desired size.

This results in inefficient cutting on size, product neatness and takes a long time.

Today's rapid technological advances demand the use of machines that can operate automatically to increase productivity, shorten production time, and reduce production costs. The need for automated equipment is increasing, and as a result, manual equipment is rapidly being replaced by more automated equipment. Automatic machines can complete tasks faster so they are more time-efficient [16]–[18]. Designing equipment that can operate automatically requires components that can calculate, remember, and make decisions.

Figure-1. Screw extruder machines.

The use of an Arduino kit module that functions as a microcontroller. This Arduino kit module can be configured to calculate based on needs and make the right decisions [19]. One of the uses for automation technology is the cutting of charcoal briquettes. This process usually uses a manually operated cutting tool. This technique has not proven to be efficient or practical in the workplace, which can certainly affect the cutting results [20]–[25].

This study will design a coconut shell briquette cutter, which is useful as a support in making biomass briquettes from coconut shells to increase effective and efficient production capacity. This cutting tool can cut products quickly and neatly and according to the desired size. This cutting tool will use Arduino as its control program. This cutting tool uses a cutter plate type as a cutting knife.

2. METHODS AND MATERIALS

The design and manufacture of automatic cutting tools for coconut shell briquettes are generally divided into three main stages as shown in Figure 2. Literature studies are used to identify needs in the process, as well as in the development process. Then the conceptualizing stage is to assess several design variants and select the best design. The tool design part includes the activities of making detailed design concepts, analysing and determining material components, and drawing detailed tool components.

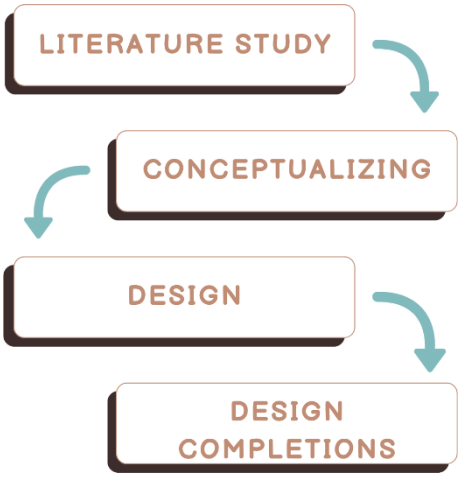

Figure-2. Flowchart of auto cutting tool manufacturing.

The last part of the design completion is tool making, tool fabrication with tool testing to ensure the tool is functioning properly. The testing process is carried out to determine the consistency of the briquette cutting results and determine how much residue is produced from the tool. Before the designing process, a design concept was selected. The design concept was created with several design variants. The design concept assessment uses a morphological matrix as in Table 1 as follows.

Table-1. Morphology matrix.

No	Selection Criteria	Weight	Concept		
			1	2	3
1	Resilience	9	-	+	+
2	Cutting ability	8	S	S	+
3	Blade strength	5	-	-	+
4	Ease of operation	6	+	+	+
5	*Maintenance* youthfulness	7	S	+	S
6	Manufacturing cost	4	+	-	-
7	Safety in operation	5	+	-	+
8	Ease of *assembly*	8	+	S	S
Total +			4	3	5
Total S			2	2	2
Total -			2	3	1
Grand Total with weight			9	8	29

After conducting the assessment process of the design concept decision-making matrix with several selection criteria, the selected design is the concept that has the highest total weight score. The concept that has a high score is the best design concept. From the data above, the design concept that has the highest score is design concept three while the lowest score is design concept one. So, the selected design concept is design concept three. Then design concept three will be carried out in the next

process, namely the completion of the design. The automatic cutting tool for coconut shell briquettes is shown in Figure 3.

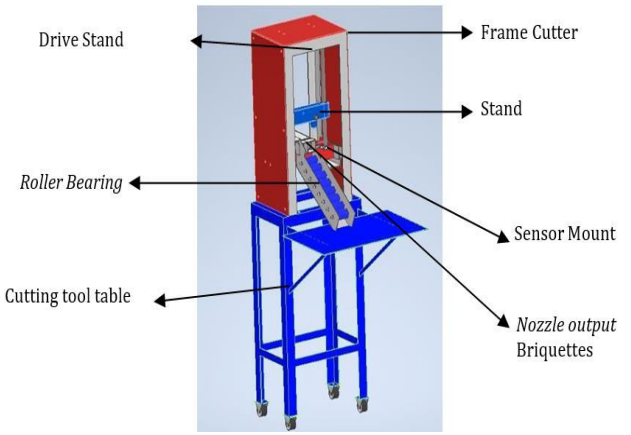

Figure-3. Automatic briquette cutter.

Designed using the Arduino uno automatic system, the servo motor becomes the driving component. The servo motor moves on the basis of Arduino through a proximity sensor. The knife uses a cutter plate system for neater cutting. The briquettes to be cut enter through the nozzle output of the screw extruder tool then the sensor will detect the briquettes to be cut according to a predetermined size as shown in Figure 3.

3. RESULTS AND DISCUSSION

In the literature study process is done to analyze how to make an automatic cutting tool based on Arduino. The second process of conceptualizing is to determine the design to be made by assessing several design concepts, the selected design will be made in the design process, as in Figure 3 is the selected image. Furthermore, the design process is the manufacture of detailed components in the selected design and the selection of materials that are in accordance with the function of the components. The last stage is the completion of the design by making the components used in the automatic cutting tool. The results of the design of the automatic briquette-cutting tool can be seen in Figure 4.

Figure-4. Design of automatic cutting tool.

This can be explained as follows, the flow of electricity from the 12V adapter to power all electronic components of the cutting tool.

The proximity sensor sends a signal when an object passes in front of the sensor to the Arduino, then the Arduino will process and issue an output to command the servo motor to move up or down. On the cutter holder is installed a cutter plate which functions to cut the briquettes neatly. The cutter holder has linear bearings on the right and left sides so that it easily moves up and down from the stainless shaft. The output nozzle below it is paired with a roller bearing with a 45-degree slope so that the briquettes that have been cut will immediately fall to the table by itself. The test results show that the device functions properly as shown in Table 1.

Table-1. Testing 1 automatic cutting tool.

Briquette Dough (kg)	Shaped Briquettes Cube (2.5x2.5x2.5 cm)	Residue
4 kg	34	16
Total	50	

The first test of the automatic cutting tool using a dough capacity of 4 kg produced 34 cube-shaped briquettes with a size of 2.5 x 2.5 x 2.5 cm, and produced 16 pieces of residue. Therefore, the consistency and residue results of the tool can be known as follows.

Consistency:

$$\frac{\text{Amount of cube shaped pieces}}{\text{Total amount}} \times 100\% = \frac{34}{50} \times 100\% = 68\%$$

Residue:

$$\frac{\text{Amount of non} - \text{cube shaped pieces}}{\text{Total amount}} \times 100\% = \frac{16}{50} \times 100\% = 32\%$$

The second test was conducted after modifying the device to get the best consistency and minimal residual results. The results of the 2nd test are shown in Table 2. Some of the modified components are as follows:

- Changed the placement of the sensor so that the cutting was exactly 2.5 cm.
- Using a thicker cutter plate.
- Adding a plate with a length of 2.5 cm from the output hole.

Table-2. 2nd test result on the automatic cutting tools.

Testing	Briquette dough (Kg)	Shaped Briquettes Cube (pcs)	Non-briquettes Cube (pcs)
1	4.6 kg	42	11
2	3.5 kg	27	9
Total		69	20

The results of the second test after modification, in testing 1 using 4.6 Kg dough produced cube-shaped briquettes with a size of 2.5 x 2.5 x 2.5 cm as many as 42 pieces and produced 11 pieces of residue. Furthermore, testing 2 with 3.5 Kg dough produced cube-shaped briquettes with a size of 2.5 x 2.5 x 2.5 cm as many as 27 pieces and produced 9 pieces of residue. The residue is the

rest of the cutting results that do not match the size that can be put back into the briquette printing machine, so the more residue produced the tool is not time efficient. Therefore, it can be seen that the consistency and residue produced by the automatic cutting tool in the second test are:

Consistency (%):

$$\frac{\text{Amount of cube shaped pieces}}{\text{Total amount}} \times 100\% = \frac{69}{89} \times 100\% = 77.5\%$$

Residue (%):

$$\frac{\text{Amount of Residue}}{\text{Total amount}} \times 100\% = \frac{20}{89} \times 100\% = 22.5\%$$

So, after testing for two times, the best data was taken, namely in the second test getting a consistency of 77.5% and producing a residue of 22.5%. Based on the results of field studies at PT Arka Tama Indonesia, the existing briquette cutter at PT Arka Tama Indonesia produces a residue of around 50%. Therefore, this Arduino-based automatic coconut shell charcoal briquette cutter can be said to be more effective and efficient by producing 22.5% residue. Thus, it can increase the production capacity of briquettes in the briquette industry. The results of cutting briquettes can be seen in Figure 5.

Figure-5. Briquettes produced by the automatic cutter.

4. CONCLUSIONS

The design of an automatic briquette cutter has been produced by requiring several design concepts. Several design concepts were scored to determine the advantages and disadvantages. The result of the design concept is taken from the design that has the highest score. An automatic briquette-cutting system using a microcontroller chip, namely Arduino, has been produced. Arduino runs the command according to the coding that has been made and then inputted through the computer. The proximity sensor gives a signal to the Arduino when it detects the briquettes, so the Arduino commands the servo motor to cut the briquettes using the cutter plate.

In increasing the production capacity of briquettes, tools are needed that support the briquetting industry. By using an automatic briquette cutting tool that can replace manual cutting tools so that briquette production will be more effective and more efficient, by producing a residue of 22.5%.

The results of cutting briquettes can be influenced by the rotation of the engine, the texture of the briquette dough and the vibration of the briquette molding machine.

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CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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