



## Improvements to the Electric Cane Cutter by Design and Simulation

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**Abstract:** The Electric Cane Cutter (ECC) project is aimed at small-scale local sugarcane farmers who are incapable to hire staff or advanced cutting gear. As a result, the ECC's main goal is to assist small-scale local sugarcane farmers in reducing staff and sugarcane production time while also producing high-quality sugarcane in large quantities. This project's concept was once again developed, leading to the development of a new idea for combining cutting and packing simultaneously pace. This machine used gravitational force as its main principle. This function focuses on gravity to control the movement of the sugarcane during the cutting process. The Electric Cane Cutter project's prototype production includes secure materials such as alloy, High-Density Polyethylene, Mild Steel, Motor, and Saw Blade (for cutting sugarcane). Cutting, joining, welding, and bending are all parts of the fabrication process is suggested for this prototype. SolidWorks 2020 software was used to design the final prototype and analyze the products' structure such as their strength and durability. Upon conducting various tests on ECC with a maximum input of 4 sugarcanes, the estimated new cutting and packaging productivity improved to 24 packets per hour. The increase in productivity has been approximately 100 %. In a summary, this project could help small-scale local sugarcane farmers to produce a large amount of sugarcane at a low cost hence increasing the productivity of the small-scale sugarcane farmer.

**Keywords:** Electric, Cane, Cutter, Cutting, Packing, Simultaneously, Productivity, Improvement

## 1. Introduction

The project focuses on small-scale local sugarcane farmers. Additionally, the goal of this project is to invent the machine based on the planning and modeling of the sugarcane cutting and packaging process. Sugarcane cutting machines nowadays are available in a variety of styles, such as manual, semi-automatic, and fully automatic but the majority of the devices are sold at exorbitant rates.

Therefore, this project aims to develop an automatic sugarcane cutting machine capable of cutting sugarcane's yield in less time and packing it more efficiently. Moreover, this machine will be sold at a reasonable cost, providing opportunities to small-scale local sugarcane farmers.

## 2. Materials and Methods

Materials chosen for the products are very important to produce the solid sugarcane cutter machine for long-term use. To get a quality product, suitable material was selected for fabricating the product.

### 2.1 Materials

There are the material properties of Aluminum Alloy, High-Density Polyethylene, and Mild Steel that have been prepared for this product [1].

**Table 1: Type of material and their properties**

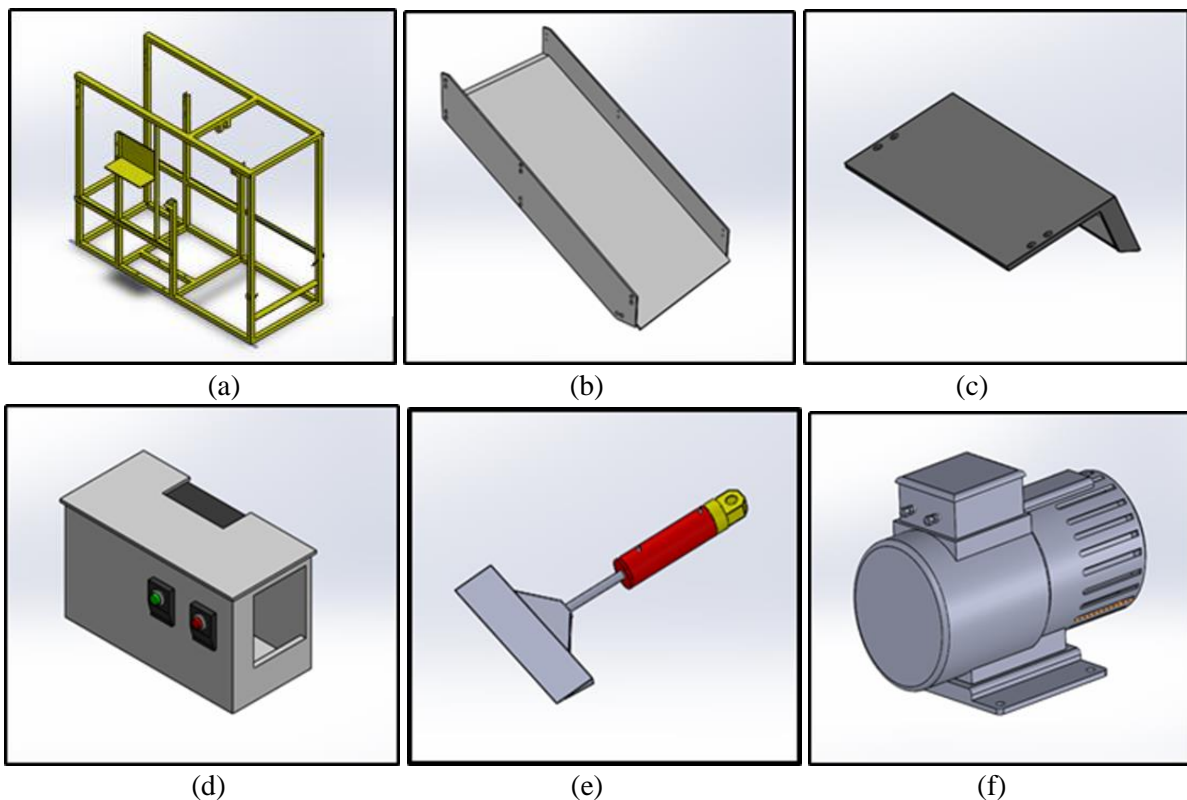
Material	Properties
Al Alloy	Density (kg/m <sup>3</sup> ) : 268
	Elastic Modulus (GPa) : 70-80
	Poisson's Ratio : 0.33
	Tensile Strength (MPa) : 230
	Yield Strength ( MPa) : 195
	Percent Elongation (%) : 12
	Hardness ( Brinell 3000k): 70
High Density Polyethylene	Density (kg/m <sup>3</sup> ) : 970
	Elastic Modulus (GPa) : 0.565 - 1.50
	Poisson's Ratio : 0.46
	Tensile Strength (MPa) : 15-40
	Yield Strength ( MPa) : 23- 30
	Percent Elongation (%) : 9-18
	Hardness ( Brinell 3000k): 69
Mild Steel	Density (kg/m <sup>3</sup> ) : 7850
	Elastic Modulus (GPa) : 210
	Poisson's Ratio : 0.3
	Tensile Strength (MPa) : 400
	Yield Strength ( MPa) : 370
	Percent Elongation (%) : 15
	Hardness ( Brinell 3000k): 130

Based on **Table 1**, mild steel has the highest density among the materials that is 7850 kg/m<sup>3</sup>. In the production of machines or tools, the materials used for the products are very important to ensure the quality of the machine for long-term use. When the input of the machine is increasing the amount of load will be increasing because of the higher density of the steel used to ensure the machine is strong

enough to accommodate the amount of input to be processed. Therefore, mild steel has been used as the main material for around 70% of the machine to build a solid simple machine.

## 2.2 Component Design of Electric Cane Cutter after improvement by using SolidWorks 2020

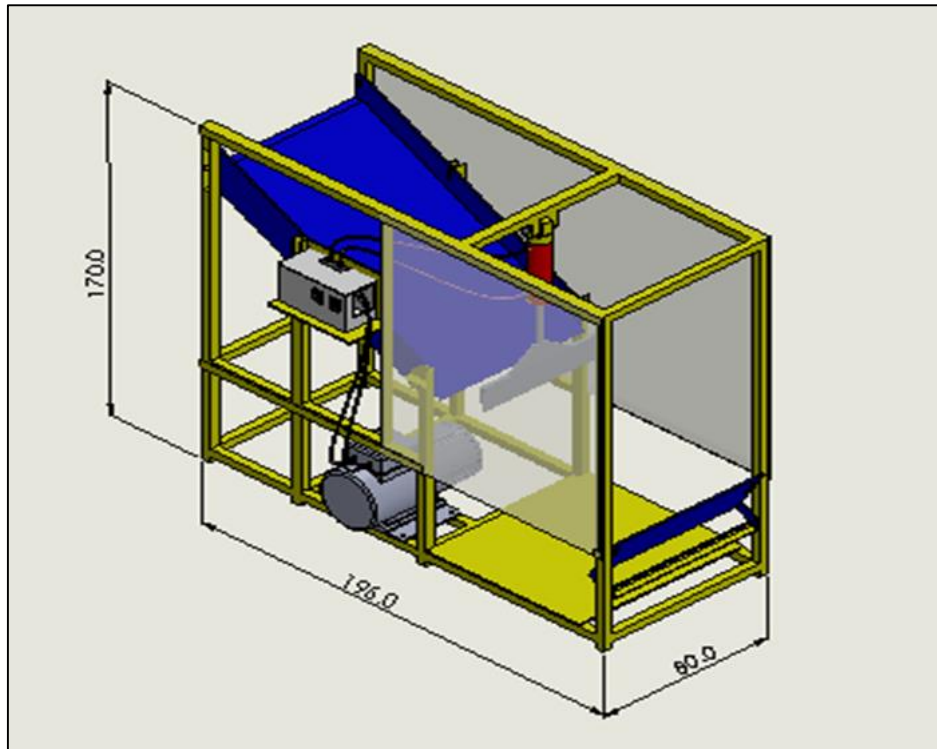
**Figure 1(a)** shows the support structure design for this proposed sugarcane cutting machine. This support is designed with four legs to support all components in this machine. The material that is used for this component is mild steel because it is tough and has high tensile strength. This steel can become higher cracking and rutting resistance. **Figure 1(b)** shows the slider component. The purpose of this component is to guide the sugarcane down to the blade. **Figure 1(c)** shows the stopper design. The purpose of this stopper is to avoid the sugarcane from over-limiting the machine or to get the accurate size of sugarcane that is demanded. **Figure 1(d)** shows the switch box with two buttons which are on and off buttons. The function of this box is to keep the circuit part that controls the function of the blade [2]. **Figure 1(e)** shows the blade that functions to cut the sugarcane into pieces before being packaged into the sacks [3]. **Figure 1(f)** shows the compressor that functions to increase the pressure of gas for the pneumatic system that is connected to the blade [4].



**Figure 1: Component Design of Electric Cane Cutter, (a) Support structure, (b) Slider, (c) Stopper, (d) Switch box, (e) Blade, (f) Compressor**

## 2.4 Assembly Design of Electric Cane Cutter by using SolidWorks 2020

After components were established and improved, the final design of a sugarcane cutting machine with dimensions (196 cm x 80 cm x 170 cm) has been assembled as shown in **Figure 2**. The support structure component is imported as a fixed part at the first step in this assembly process. Then, the internal components as movable were assembled through the mate surface method following the sequence. The component sequence was assembled starting from Compressor, Switch box, Slider, Stopper, and Blade.



**Figure 2: Final Design of Sugarcane Cutting Machine**

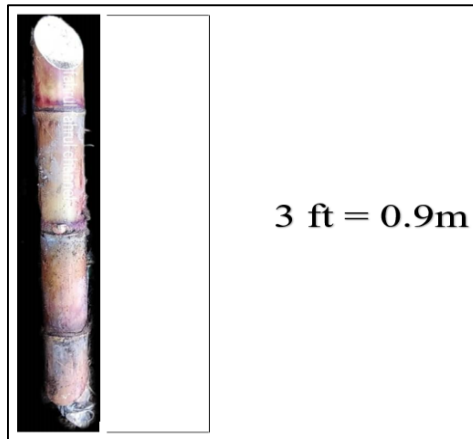
## **2.5 Suggestion of Fabrication Process**

The joining process was used more often to perform the process of the sheet metal joining for this machine. Joining is a process for joining component by component of the machine through mechanical methods, which are often used to replace the welding process. In other words, mechanical joining is safe compared to the welding process. This is because, the welding process can be harmful especially during the process of the welding that is caused by adverse gases that may be in the shape of fume that gives bad effect to the welder, for example, nitrous oxide, carbon dioxide, carbon monoxide, Argon, Helium, and Ozone.

## **3. Results and Discussion**

### **3.1 Current Packaging**

The main objective of this project is to study and improve the current cutting and packaging system used which is manually hand cutting and packaging sugarcane. The length of sugarcane will be cut to 3 ft or 0.91m as shown in **Figure 3**. The packaging of the sugarcane was using the sacks which are suitable for cutting machines as shown in **Figure 4**. The picture below shows the actual size of each sugarcane and sacks that were used for the packaging. **Figure 5** shows the method of cutting and packaging sugarcane without using a machine. This process takes more time and manpower. Cut the sugarcane manually using a sharp hand tool. Then the worker will bring the sugarcane that has been cut into the sack manually.



**Figure 3: Length of Sugarcane**



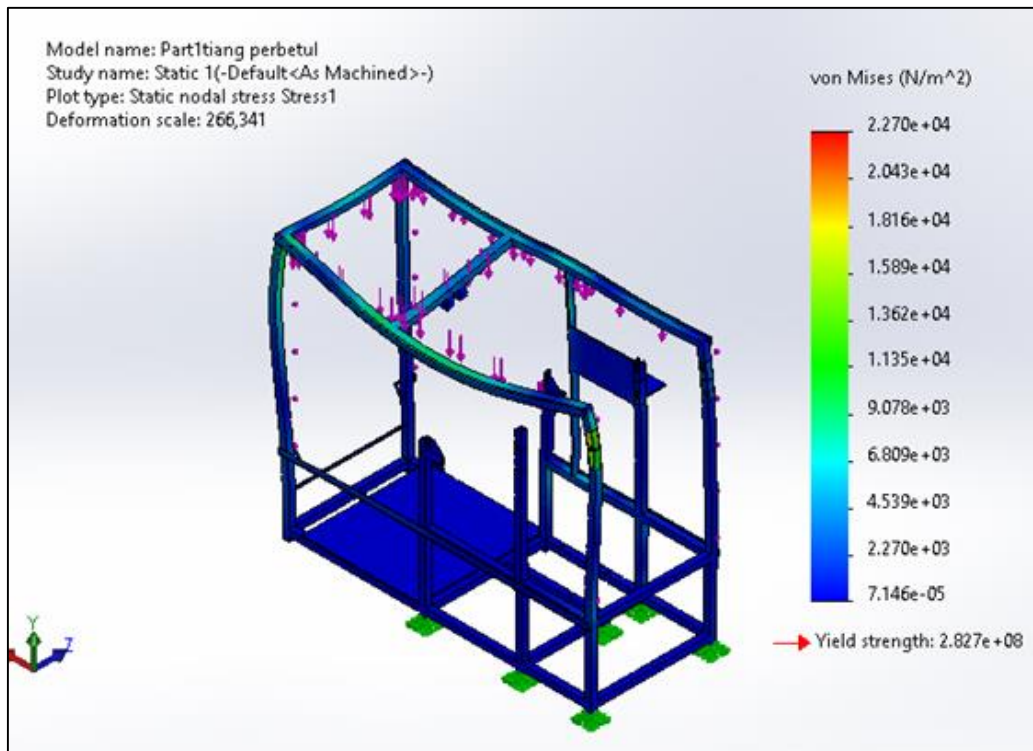
**Figure 4: Sacks that suitable for Machine**



**Figure 5: Traditional Cutting and Packaging Process**

### 3.2 Simulation Result using SolidWorks 2020

This final design of the sugarcane cutting machine is applied with mild steel material to identify density in the mass properties. The Finite Element Analysis (FEA) was also conducted using SolidWorks 2020 to determine the maximum strength that happened on the machine's support component when the maximum weight of internal components has been assembled [5],[6]. **Figure 6** shows the maximum mass and density of this machine from mass properties result is 531.53kg and 28827377.34 kg/m<sup>2</sup> respectively. Then, the maximum strength is  $2.270 \times 10^4$  N/m<sup>2</sup> has happened at the center top of the support component. This value is less than the yield strength of the support material. Therefore, the support structure is still in a safe condition when the maximum mass of the internal component is used and assembled.



**Figure 6: Simulation result in SolidWorks 2020**

### 3.3 Productivity Improvement

Productivity is the ratio of outputs produced based on time refer to **Eq.1**

$$\text{Productivity} = \frac{\text{Output}}{\text{input}} \quad \text{Eq. 1}$$

From the interviews' findings, the normal length for one sugarcane is 8 to 9 feet and the time taken to cut one sugarcane takes 1 or 2 minutes. The mass for one sugarcane is 2 kilograms. The current packaging productivity of packaging was 12 packets/hour. After doing some tests of estimation on electric sugarcane cutters, with the input of the machine being a maximum of four sugarcane, the estimation of new productivity of the cutting and packaging process was increased up to 24 packets/hour. The productivity improvement that has been achieved is almost 100%. The result is then compared to the current productivity of the Electric Sugarcane Cutter.

#### 4. Conclusion

The conclusion of this project has been achieved to design and simulate the electrical sugarcane cutter. This sugarcane cutting machine has been improved in various ways, including the amount of sugarcane input (more than 2 sticks each cutting) and the place where the cut products are collected. In a summary, this project could help small-scale local sugarcane farmers to produce a large amount of sugarcane at a low cost hence increasing the productivity of the small-scale sugarcane farmer.

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