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Modified Sugarcane Peeler

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Abstract : This project objective is to design, simulate and fabricate a tool to shorten the time needed to peel the sugarcane manually. The main goal of this project is to successfully create an improvised sugarcane peeler that can act as an alternative to solve the current issue of over-complicated sugarcane peeling process and efficiently shorten the time taken. This is because sugarcane, one of the crude materials to sugar that joins to numerous food products has an expanding in request over the years. However, the sugarcane skin removal takes 65% time of manual harvesting. Deficiency of skilled labour and apparatus for skin removal amid peak harvesting season causes around 10% derivation in selling price. In order to combat this issue, multiple conceptual design and sketches has been created. The idea of having double blades at horizontal and vertical axis for an all side cutting, at the same time fixed by band for a flexible all size sugarcane cutting is produced. Containers were added for more environment friendly operation that does not dirties the surrounding. The SolidWorks 2018 software was used to create the idea and final outcome of the modified sugarcane peeler. By using SolidWorks simulation, the result of drop test for its sustainability and hardness, and also the static test for its stress and strain distribution is collected and analyzed. Based on the result, the product has high ultimate tensile strength, high allowable stress and strain, in other word, the product is suitable for fabrication as it passed both drop test and static test and does not need to be afraid that it might encounter structural failure. The product is ready to be manufactured and will do a great job in increasing the efficiency in sugarcane peeling process.

Keywords: Sugarcane, Sugarcane Peeler, Peeling Process Efficiency

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1. Introduction

Sugarcane is one of the most important segments of agriculture in the world. This is because sugarcane is the raw material to sugar. In other word, sugarcane plays an integral role in our daily as a food necessity. Sugarcane has many uses such as medical treatment, food addictive and act as a quick burst of energy. The extracted juice from the sugarcane can be mixed with lime and being heated to form crystals and spun in a centrifuge to separate the molasses [1].

In order to get the sugarcane juice, peeling process plays a fundamental role in the production of sugarcane. Peeling process is the process where unwanted or inedible material from vegetable raw materials is removed [2]. The purpose of doing this is to let the final product taste better, in this case, to let the sugarcane tastes sweeter. There are various types of methods used in peeling process namely flash steam peeling, knife peeling, abrasion peeling, caustic peeling and flame peeling. This project aimed to focus on the knife peeling process where it involves blade on the peeler to peel the skin of the sugarcane.

1.1 Problem Statement

Figure 1 shows the statistic of sugarcane production in Malaysia from year 1961 to 2018. Starting in year 2000, the sugarcane production shown decreased trend of demand due to a few factors. The main factor contributing to these issues has to be the changes in the world. The main reason has to be the complication of making sugarcane juice and that is why people demand less for sugarcane juice. Due to the low demand of sugarcane, the production of sugarcane is getting slower and slower as there is no motivation to boost the production. Other than that, the peeling process is very time-consuming when it comes to large quantities.

The decreasing in production of sugarcane is mainly due to the manual sugarcane peeling process of sugarcane. This is because machine method is fast but is too expensive. Apart from that, the machine also causes waste of useful sugarcane flesh as the machine cutting part is not made to be flexible and is unable to adapt sugarcanes of different sizes, shapes and thickness [3]. Although the machine method did increase the efficiency and speed of sugarcane peeling process, but the productivity becomes the new problem as it waste too much of useful sugarcane flesh. For manual and traditional method of peeling sugarcane using blades, the sugarcane needs to be peeled at multiple angles and sides in order to remove the epidermis and skin of one sugarcane. In another word, the manual peeling process is slow. Not to mention the conventional peeling process is unhygienic as using a blade for peeling does not guarantee a thoroughly cleaned sugarcane skin from all sides. If the sugarcane is to be peeled thoroughly, it will waste a lot of useful sugarcane flesh [4].

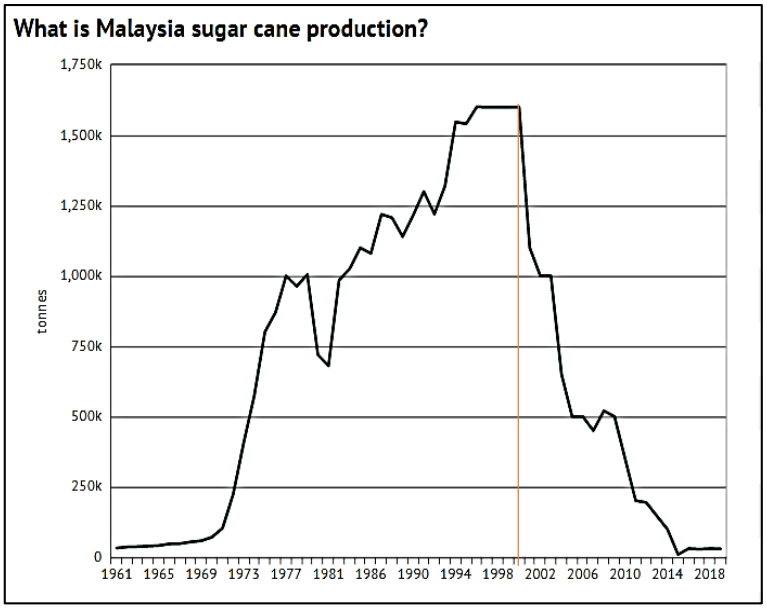

Figure 1: Statistic of sugarcane production in Malaysia from year 1961 to 2018 [5]

1.2 Objectives

Therefore, the objectives of this study were to explore the existing method of peeling sugarcane process in term of their strength and weakness using the current sugarcane peeler and to design and simulate a tool to shorten the time needed to peel the sugarcane manually.

2. Methodology

In order to conduct the research, this project has two main parts. In part 1, the planning on the design is conducted to have the ideas of the design and get in drawn in SolidWorks. In part 2, simulation is conducted as an analysis to get the results of the drawn product to check whether it fulfils the basic requirements.

Based on **Figure 2**, this project is initiated with researching the possible problems and solutions to the sugarcane peeler in the current market. Ideas are gathered to do some planning on the designs to develop a conceptual design that can be able to solve the possible problem, which is the peeling efficiency for manual peeler. The design is being sketched and built in SolidWorks for viewing the design in 3D model. Simulation analysis is conducted to make sure the design and the materials selected are in the best condition that achieve the safety measure regulated by the market. A conclusion on the function and specification of the design will be deduced based on the simulation result and analysis.

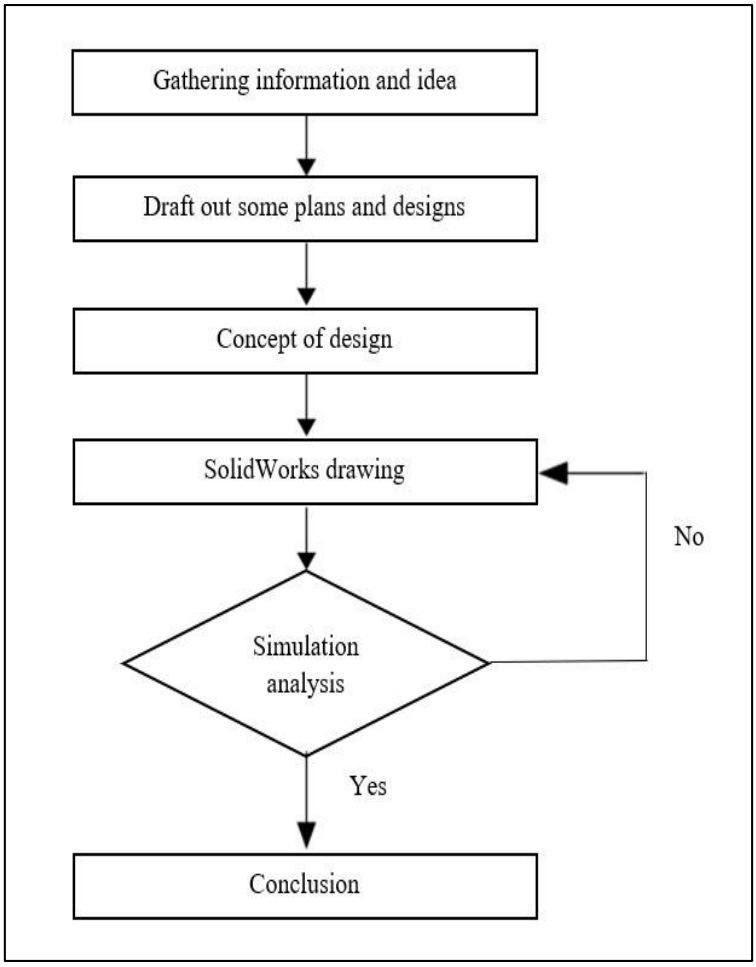

Figure 2: Research Flowchart

2.1 Project Architecture

Product architecture is defined as the functional elements of a product are arranged into physical building blocks that interact with each other to perform the overall function [6]. Design process is being magnified in this report as it is one of the most important processing systems in the manufacturing of a component. It is also a process to determine the functionality of the design and if the design is not working, the project have to go back to the stage of conceptual design.

2.1.1 Initial Sketch 1

Based on **Figure 3**, the concept of this design is letting the user having convenient in peeling but not practical for massive peeling process. Hence, this design is not applicable.

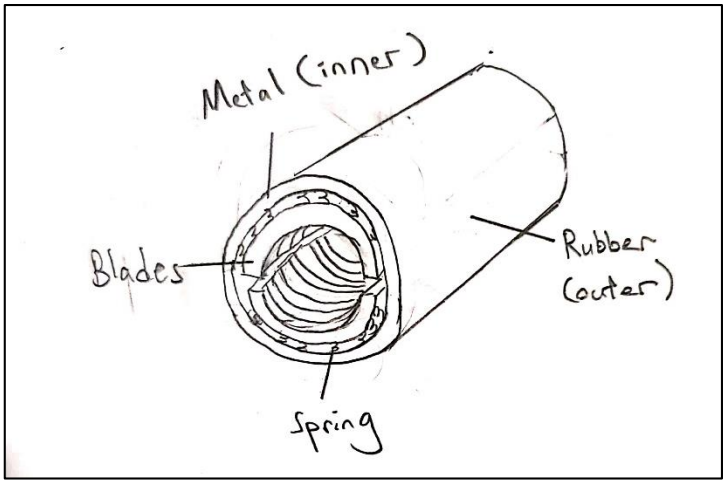

Figure 3: Initial Sketch 1

2.2.2 Initial Sketch 2

Based on **Figure 4**, the design is also convenient and in the same time it is able to peel the skin of the sugarcane more effectively and can store the skin of the sugarcane in the base. The size of cannot be adjust so this design is not applicable when it comes to various diameters of sugarcane.

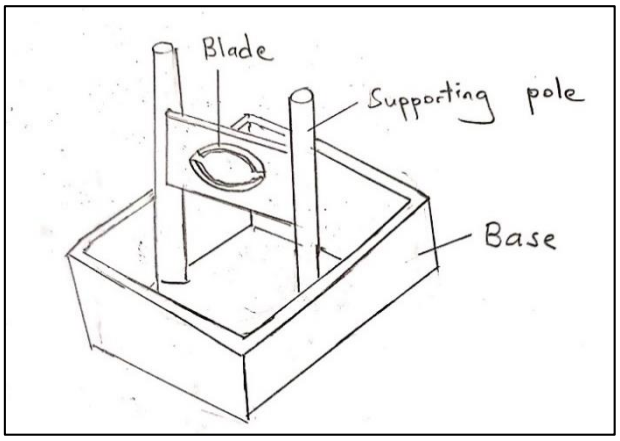

Figure 4: Initial Sketch 2

2.2.3 Final Design

Based on **Figure 5**, this design is selected as the final design because it fulfils all the characteristics and specifications needed for the sugarcane peeler tool to perform a good function. This design has two plastic containers to make it able to store the skin and working tools. The peeler port also enables peeling process to happen at all surface of the sugarcane. The rubber band makes the cutting diameter adjustable so that all sizes of sugarcane can be peeled with ease.

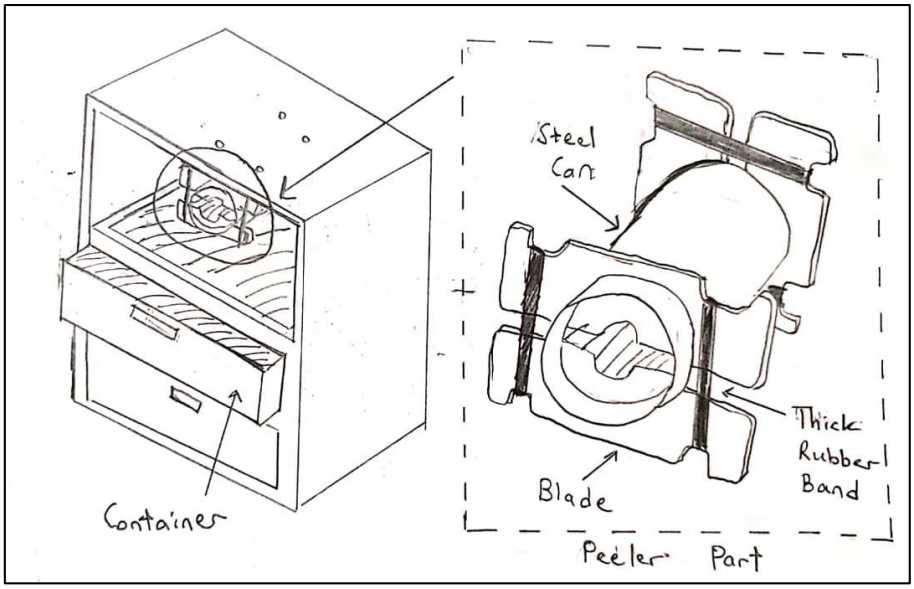

Figure 5: Sketch of final design

3. Results and Discussion

The design of the modified sugarcane peeler undergoes the simulation analysis to determine the minimum and maximum value of stress, resultant displacement and strain. There are two types of simulation test which are drop test and static test.

3.1 Simulation Results

The results of simulation have shown in **Table 1**, **Table 2** and **Table 3** below.

Table 1: Stress Study

Type	Min (Nm^{-2})	Max (Nm^{-2})
VON: von Mises Stress	3.595×10^{-5}	1.358×10^{8}

Table 2: Displacement Study

Type	Min (Nm^{-2})	Max (Nm^{-2})
URES: Resultant Displacement	0	1.745×10^{-3}

Table 3: Strain Study

Type	Min (Nm^{-2})	Max (Nm^{-2})
ESTRN: Equivalent Strain	1.229×10^{-16}	2.832×10^{-4}

Based on **Table 1**, **Table 2** and **Table 3**, the minimum and maximum values of the stress, displacement and strain is very convincing as it is perfectly fine for it to act as the blade to peel the skin of the sugarcane effectively. The yield strength obtained from Figure 3.3 is 6.204×10^{-8} Nm^{-2}.

According to the simulation result shown by the **Figure 6**, **Figure 7** and **Figure 8**, the colour of the fixed force is green whereas the colour of the force acting onto the blade is blue. The force acting onto the blade is 6000N. Based on the ESTRN equivalent stress colour, it shows that the blade is safe to use and able to withstand the forces acted on it. In short, the blade is well-designed and can be the component of the modified sugarcane peeler.

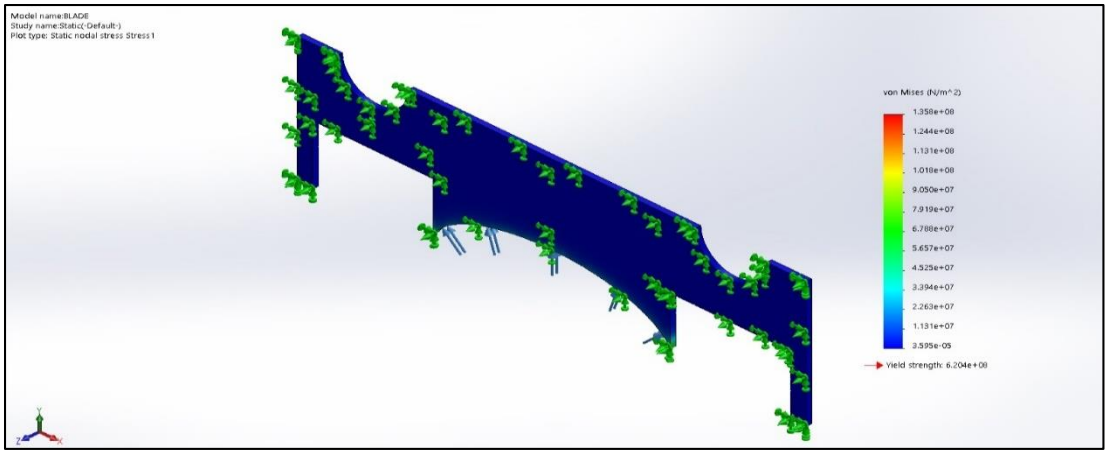

Figure 6: Stress Simulation

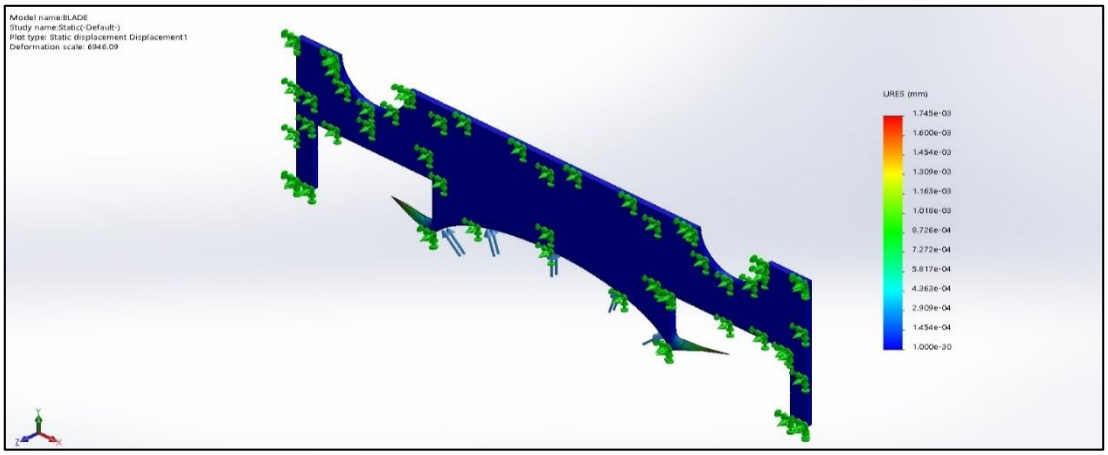

Figure 7: Displacement Simulation

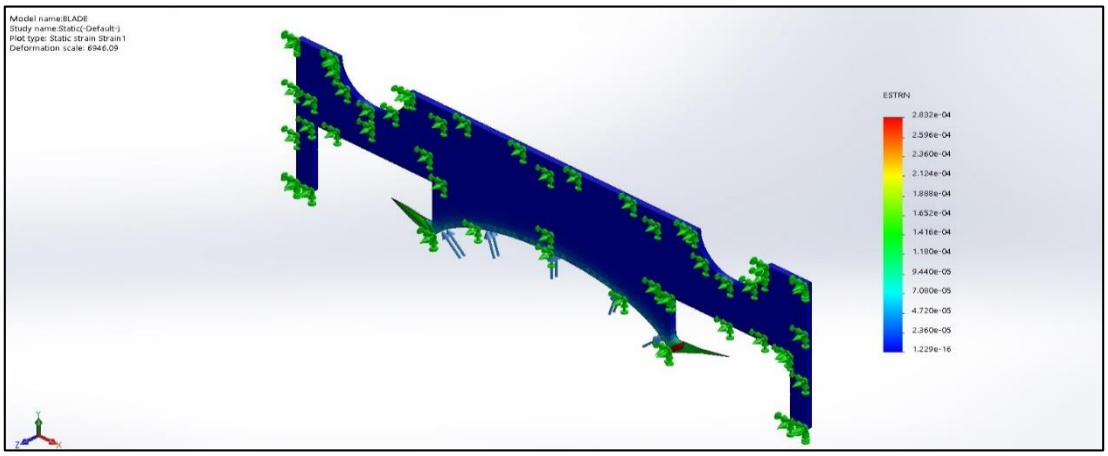

Figure 8: Strain Simulation

3.2 Calculation on the cutter

By using the torsion formula

$D = 40mm$

$$J = \frac{\pi}{32}(D^4 - d^4) \qquad \textbf{Eq. 1}$$

$$J = \frac{\pi}{32}(0.04^4)$$

$$J = 2.5132 \times 10^{-7} m^4$$

Maximum shear stress of the cutter

$$T = 3N \qquad \textbf{Eq. 2}$$

$$\tau = \frac{Tr}{J} \qquad \textbf{Eq. 3}$$

$$\tau = \frac{3(0.02)}{2.5132 \times 10^{-7} m^4}$$

$$\tau = 2.3874 \times 10^5 Pa$$

The peeling speed of meeting output product of 60 sugarcane per hour provided one sugarcane is peeled in one minute

$L = 500mm$

$1\ hour = 3600\ sec$

$$\frac{3600}{60} = 60\ \text{sec}\ (\ for\ 500mm\ of\ sugarcane\ )$$

$$v = \frac{0.5m}{60s} = \frac{8.3333 \times 10^{-3} m}{s}$$

Based on the calculation above, the maximum shear stress of the cutter is $2.3874 \times 10^5\ Pa$. This value is good enough for the cutter to perform its function without breaking. The desired peeling speed of the cutter is at $8.3333 \times 10^{-3}\ ms^{-1}$, which is a decent speed for a manual cutter in the peeling process.

4. Conclusion

In this project, the first objective to study the existing method of peeling sugarcane process in term of their strength and weakness using the current sugarcane peeler has been achieved. The second objective which is to design and simulate a tool to shorten the time needed to peel the sugarcane manually is also achieved. The simulation analysis has contributed to the improvement of the mechanical properties of the design of the modified sugarcane peeler. Improvements are made onto the design to make the design has a larger allowable stress and a faster peeling speed. The elasticity of the rubber band attached to the cutter has bring significant value in the increased range of peeling diameter and better product outcome. Throughout this project, there are certain significant limitations which have been identified, that is this product only have one cutting side thus constrain the product from achieving a high efficiency and capability. For further improvisation, the product is recommended to increase more cutter in order to allow more users to use the product at the same time. This will be able to also enhance the peeling efficiency as more peeling process can be carried out at one time.

Acknowledgement

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