RESEARCH PROGRESS IN MECHANICAL AND MANUFACTURING ENGINEERING VOL. 3 NO. 1
(2022) 26-36

RPMME

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

Design of Banana Slicing Machine

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DOI: https://doi.org/10.30880/rpmme.2022.03.01.003
Received 15 Nov. 2021; Accepted 15 April 2022; Available online 30 July 2022

Abstract: Banana Chips is one of the famous chips in Malaysia especially during Celebration of "Hari Raya". The demand will be high during this celebration. Slicing process is one of the important process in the making of Banana Chips. The productivity of the banana chips depend on how fast the banana slices can be sliced. Slicing using manual technique required more human energy and take a long time. To overcome this problem, Banana Slicing Machine have been designed to increase the productivity and reduce time consuming in the making of banana chips. This project used George E Dieter design process for design this machine. The design process consists of eight phase which are Define problem, Gather information, Concept generation, Concept evaluation, Product architecture, Configuration design, Parametric design and Detail design. The existing patent and available machine were referred to generate idea for the banana slicing machine. The selected idea and concept then will be modelled using Solidwork Software. Solidwork Software also being used to conduct some engineering analysis and Life Cycle Assessment (LCA). The author also making analysis using theoretical calculation. The result of the analysis shows that the machine can produce 64.8kg slices of banana in one hour. The overall dimension of the banana slicing machine is 700mm x 600mm x 755mm with the weight of 57 kilogram.

Keywords*:* *Hari Raya, Banana Chips, Slicing, Solidwork*

1. Introduction

Banana chips are one of the famous chips in Malaysia. Banana chips are made by deep-frying raw banana slice of 1.75mm to 2.0mm thickness in suitable cooking medium and salting them.[1] It is famous for Malaysian as they produce this chips in every year for "Hari Raya" celebration. The production quite good during that time as the high demand from the customer. Not just that, there are many people produce their own banana chips in their home instead of buying from the markets. There

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are two types of shape for banana chips which are round shape and longitudinal shape. In the banana chip production, the raw banana need to be sliced into a round or longitudinal shape before frying them. Along with the development of technology, some countries have developed variety of technologies to slice the banana from the simple knife until the modern machine. During this day machine is the best way to slice the banana faster and suitable for big scale production.

In Ledang Johor, there is a small-scale production of banana chips own by Mr Mohd Suhaimi Bin Baharuddin. His shop name is Mustalifah Rebo Enterprise. He was started to produce and selling the banana chips since year 2012. The process of producing the banana chip was take place at his house with the help of his wife and his worker. His product is name as "Kerepek Pisang Tanduk Haimus". His customer is not only from Malaysia but some of them are from Singapore and Brunei. In order to fulfil his customer demand Mr Suhaimi produce the banana chips almost 30kg - 40kg every day. He is one of the small medium enterprise (SMEs) that still using traditional method which is the manual type of slicer in the process of slicing the bananas. He used an adjustable multi-purpose slicer to slice the raw bananas. The main problem is the production of his banana chips is slower than the others that using modern machine. Mr Suhaimi only can produce banana chip in average of 30 kg - 40 kg of banana every day. The objective of this project is to design a banana slicing machine for banana chip production with the capacity more than 100 kg per day and below RM6000. The Banana Slicing Machine will give a great chance to the community who used to produce and sell banana chips. It will help to increase the banana chips production in a short time. The used of motor in slicing mechanism can produce larger amount of banana slices compare to the manual slicing technique by human energy. Through this project, all the disadvantages of the existing slicing device or machine can be improved either for their function or its design. The design will be more ergonomic for the user to make sure that the user feels comfortable while operating the new design of banana slicing machine. Lastly, this project can be a starting point to make sure the banana chips industries in Malaysia growth successfully. For that reason, the project will come out with the banana slicing machine that suitable and affordable for Small and Medium Enterprises (SMEs).

2. Literature Review and Methodology

The literature review is the method of collecting information on all relevant subjects or requirements of the project. It is carried out by collecting data through patent analysis, books, journals and current products that would be comparable and used for product design.

2.1 Study of Banana Chips Production Process

There are two distinct ways that can be used in banana chips production. The first one is by deep-fried thin slices of banana in the hot oil such producing potato chips or crisps. The other one is by drying the banana slices using a solar or artificial dryer or dry them in the sun. There are several differences when using different method. The deep-fried chips are very tasty and high calorie food that is consumed as a snack. This is because the deep-fried oil has a comparatively short shelf life up to a maximum of 2 months when processed under the right conditions.[2]

Dry chips are a healthier product. They are frequently taken as snacks and are frequently added to cereal combinations such as muesli. Chips can be dried without any additions or dipped in syrup or honey dip before drying, resulting in a sweeter flavor, greater calorie content, and perhaps a more appealing-looking product. Drying chips have a longer shelf life (up to 6 months) if they are dried to low moisture content and kept in a cold, dry place.[2]

2.2 Study of Banana Slicing Process

Banana slicing may be a methodology of reduction in size involving the applying of cutting force on bananas with the guide of the cutter blade or knife to be sheared through the banana to get the least deformation and rupture of the cell membrane. The cutter blade is also in a mutual or spinning

motion.[3] The process for preparing the banana chips is the same as in another country except for the ripeness of the raw material and frying time. For the slicing process, the manufacturer claims that hand slicing with a sharp knife yields a uniform product and more reliable than mechanical slicing if a regular supply of electricity cannot be guaranteed.[4] There are several different thicknesses of banana slices in banana chip production. It is due to the different tools or slicers used. The different slicing machines or slicers will have different specifications that will affect the thickness of the banana. The banana's average cut thickness was approximately between 2.00 to 0.194 mm.[5]

In recent years, the development of banana slicing machines has been actively developed by certain companies to meet consumer demand. Motorized Banana Slicing machine helpful in banana chip production. Most of the bunches of raw peeled bananas can be cut at a uniform thickness in a few minutes instead of this 1 hour in the hand-operated banana slicer. The time saved by the person engaged in banana cutting can already be spent on other banana chip production tasks or other profitable activities.[6]

2.3 Study on Existing Product

Available product is product that was existing and currently sold in the market. The existing product search is essential because it can provide a lot of information. The products features and specification can be reviewed from the existing product. All the details and information will be useful to generate new creative and innovative idea in designing brand new product of banana slicing machine. The following table shows comparison of a few existing banana slicing machine in the market.

Table 1: Existing Product Comparison

Product Characteristic	Product 1	Product 2	Product 3	Product 4
				
Name	Manual Cutting Machine.	Vegetable Cutter DQ180A	IFC300 Banana Slicing Machine	GG501 Plantain Chips Machine
Made In	China	Malaysia	China	China
Price Range	RM 500-1000	RM 2000-3000	RM 4000-6000	RM 4000-6000
Dimension(mm)	360 x 190 x 430	400 x 290 x 570	540 x 820 x1060	640 x 500 x 840
Weight	8 Kg	25 Kg	90 Kg	75 Kg
Material	Stainless Steel	Aluminium Alloy and Stainless Steel	Stainless Steel	Stainless Steel
Operation	Manual	Semi-automatic	Semi-automatic	Semi-automatic
Power (Watt)	-	250W	750W	750W
Capacity	Depend on Human Energy	50-450Kg/hour	300-600kg/hour	100kg/hour

2.4 Methodology

The project will be conducted using a design process model from George E. Dieter. According to George E. Dieter, a design process consists of three phases and eight steps. First is conceptual design second is embodiment design and lastly is detail design. The steps in conceptual design include defining the problem, gathering information, developing concepts, and evaluating the concepts. The following steps for embodiment design include product architecture, configuration design, and parametric design.

The detail design will the last step in this design process model.[7] Figure 1 shows the flowchart of the project.

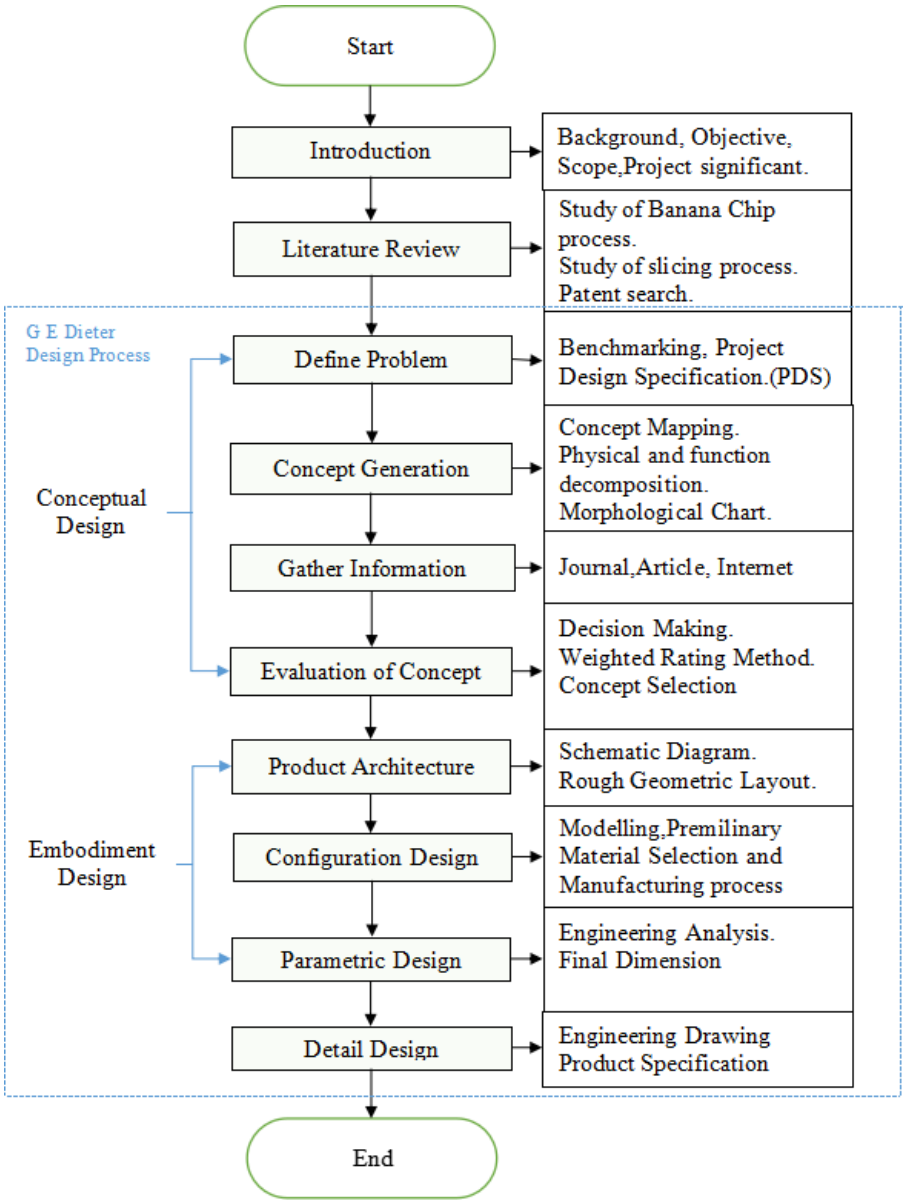

Figure 1: Project Flowchart

3. Design Process

3.1 Product Design Specification

In order to collect information, the interview session was conducted with Mr Suhaimi Bin Baharuddin which is owner of Mustalifah Rebo Enterprise. Then the survey also conducted through questionnaire. The questionnaire is divided into 3 sections. The first section is about respondent information, second section is about their general knowledge and Section C the customer requirement. The data obtained in the customer survey will be used to obtain the objective tree, and useful to generate Product Design Specification (PDS). Figure 2 and table 2 shows the Objective tree and product design specification respectively.

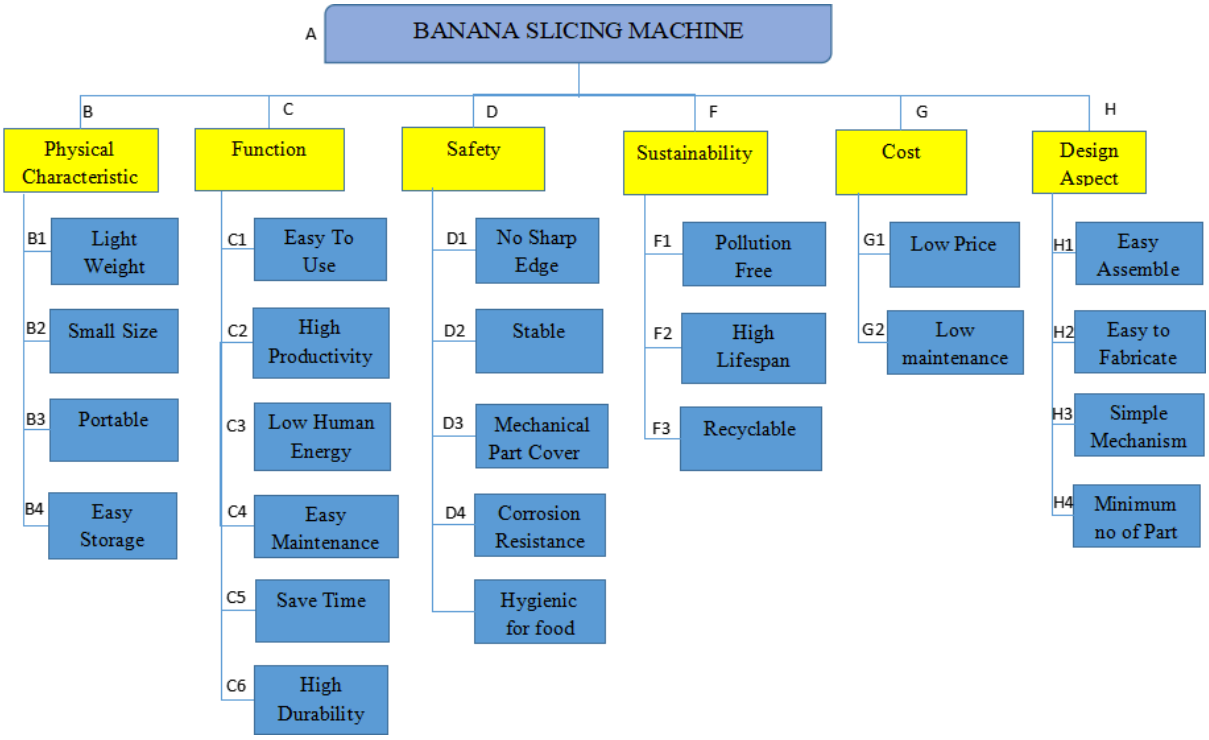

Figure 3: Objective Tree of Banana Slicing Machine

Table 2: Product Design Specification

Introduction	
Title	Banana Slicing Machine
Design Problem	Slicing Banana for Banana Chips Production
Purpose	To increase the rate of banana slicing compared to manual slicing method
Special Feature	Has speed controller for motor.
	Customer Requirement
Functional Performance	-Produce more than 50 kg in 1 hour -Can be operated by only one person -Easy to use
Life Cycle Target	-More than ten (10) Years
Economic	-Cost Less Than RM6000 -No or Little Cost of Maintenance
Maintenance	-Easy for Cleaning Process
Reliability	-No failure occurs during machine lifespan. -Heavy Duty
Safety	-Has Safety cover for rotating mechanism. -No Sharp Edge -Corrosion Resistance -Hygienic for food -Stable
Physical Description	Dimension (L x W x H): 700mm x 600mm x 755mm Weight: Less Than 20 kg
Sustainability	-Material use can be recycled -Pollution Free

3.2 Concept Generation

The most creative products are the consequence of retaining beneficial design principles as well as recognizing potential concepts that emerge in other fields.[7] Methods for creating design thoughts that are practical for boosting creativity, such as brainstorming. During this phase, concept generation were consisting of mapping concept, functional and physical decomposition, function structure, and morphological chart. Figure 4 shows the function structure of Banana Slicing Machine.

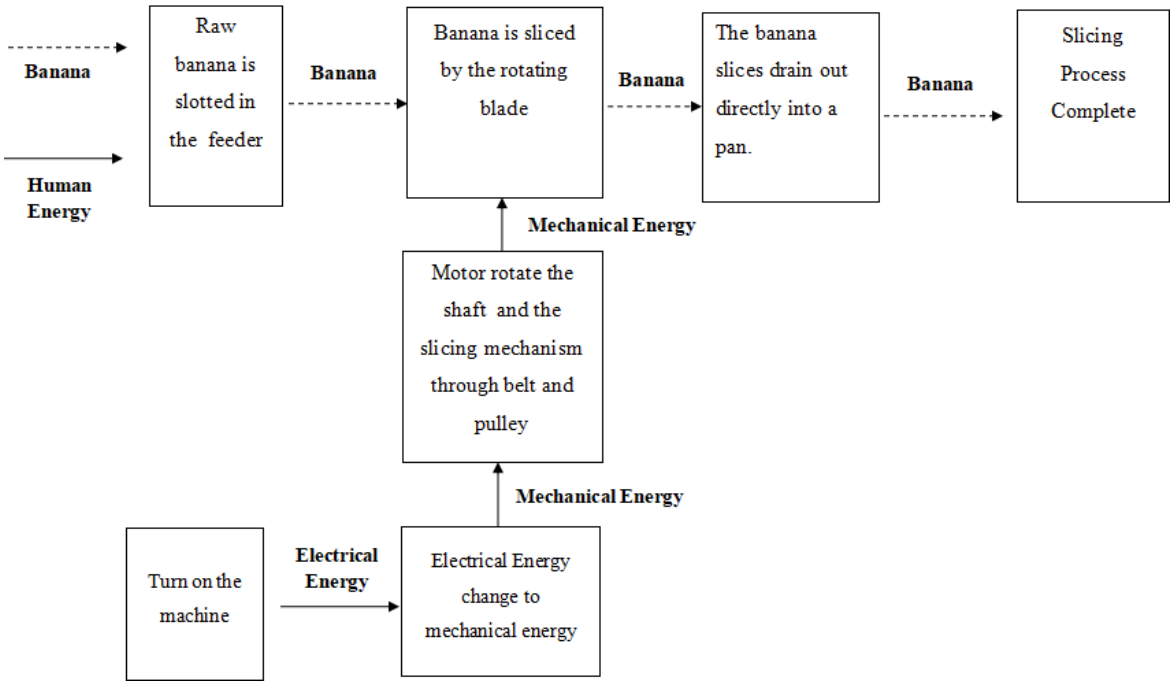

Figure 4: Function Structure

3.3 Concept Evaluation and Concept selection

From a morphological chart, weighted decision matrix was used to examine and evaluate the variety of concepts by ranking the design criteria with a weighting factor obtained from the objective tree questionnaire. This method was allowed the author to find the best concepts that can fulfil the important criteria that customers need. After evaluating the concept, the concept with the highest rating will be selected to proceed on the next stage. Table 3 shows the concept selection for the machine.

Table 3: Concept Selection of the machine

No	Function	Specification
1	Power Source	Electricity
2	Switch	Eliminate Rocker
3	Speed Control	Rotate Controller
4	Body Material	Stainless Steel
5	Frame Type	Hollow Bar
6	Power Transmission	Belt System
7	Movement Mechanism	Wheel
8	Motor Type	Electric Motor

3.4 Product Architecture

Product architecture is the arranging of a product's physical parts to accomplish the desired function. It connected to the function structure. However, it does not need the properties to be balanced. Besides, once a design concept has been selected, it is chosen to determine the best functional success of the system. The architecture of products included Schematic of the product and Geometric Layout. Figures 5 and 6 show the schematic product and the geometric layout respectively.

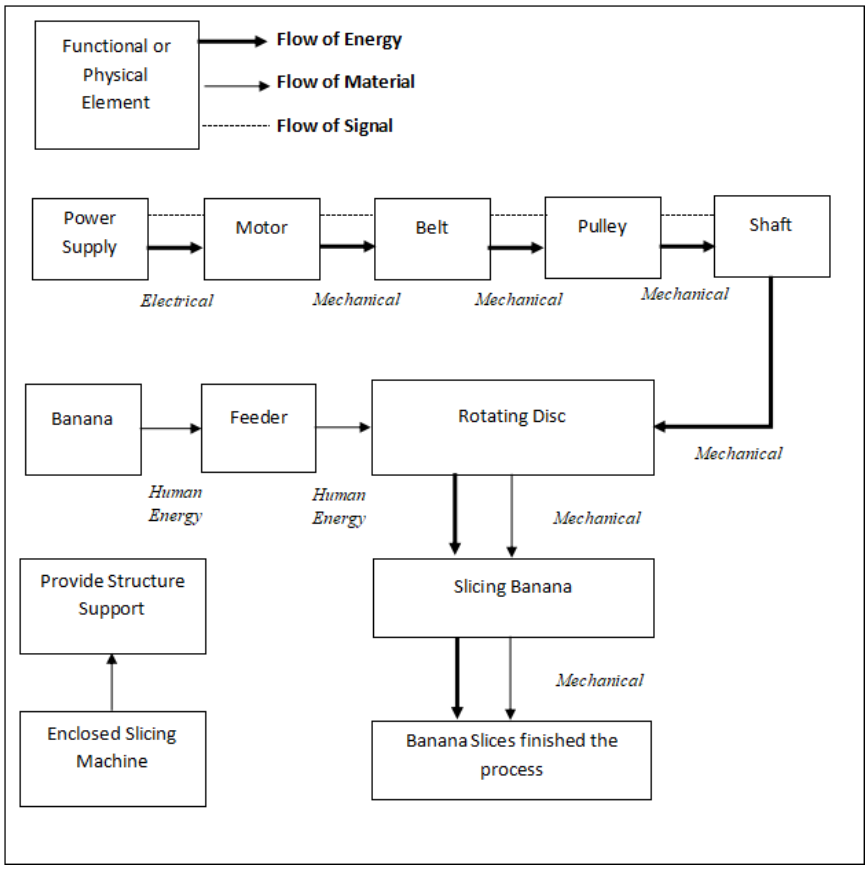

Figure 5: Product Schematic

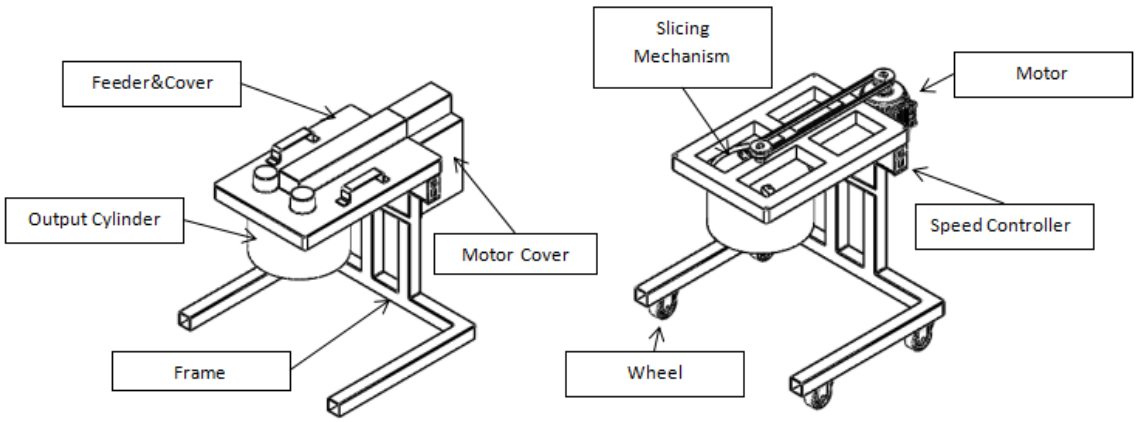

Figure 6: Geometric layout

3.5 Modelling

Concept of the banana slicing machine was drawn by using Solidwork Software. All component that are drawn will be assembled to form the overall structure of banana slicing machine. Figure 7 shows the full assembly of the banana slicing machine.

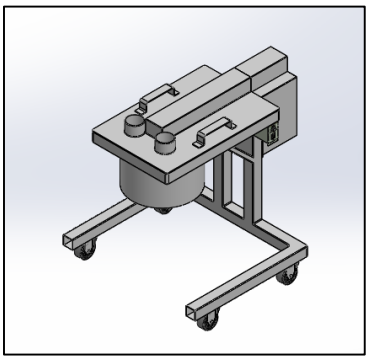

Figure 7: Full Assembly of Banana Slicing Machine

3.6 Machine Process Flow

Before starting slicing process, the machine will be placed which the output cylinder position is on the top of frying pan. It is to make sure that the banana slices will fall directly into the boiling oil in the pan. Figure 8 shows the position of the machine.

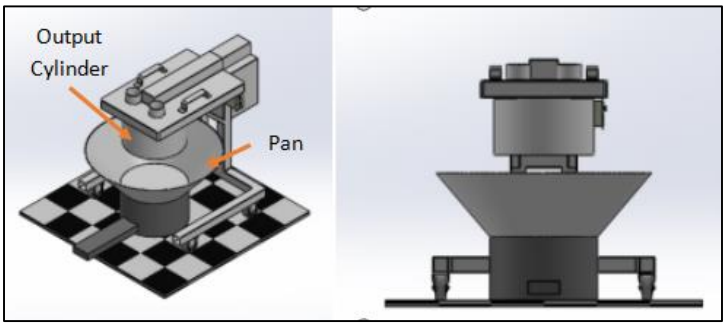

Figure 8: Position of the Machine

Once the switched is turned on the raw banana with diameter 40mm - 60mm will be slotted into the feeder and the rotating disc will slice the banana into 1mm thickness of banana slices. The slotting process will need a little human force to push the banana into the feeder. The slices will fall directly into the boiling oil in the pan. Figure 9 shows the slicing process.

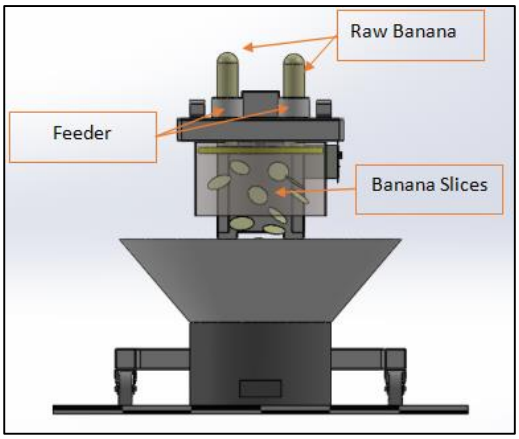

Figure 9: Slicing process

3.7 Engineering Analysis

In this analysis, calculation of the related parameter such as torque, power, and production rate were calculated. Based on the calculation it helps to choose a suitable specification of component that can avoid the failure of the product and reduce the overall cost of the product. From the analysis, the final product design specification can be obtained. Table 4 show the Final Product Design Specification for customer information.

Table 4: Final Product Design Specification

Product Specification	Description
Motor Specification	Power: 0.75 kW Voltage: 220 V Speed: 1400 RPM Frequency: 50Hz Phase: Single
Weight	57.16 kg
Dimension	700mm x 600mm x 755mm
Productivity	64.8kg/h
Power Consumption	307.87 Watt
Price	RM 4227.30

3.8 Body Structure Analysis

There are three analysis has been done to the body frame of the machine. It was stress analysis, displacement analysis and factor of safety. The maximum stress has a magnitude of 31.3 MPa which less than the material yield stress which is 205 MPa. Hence the body frame will not yield, and it will return to its initial state after removing the load. Figure 10 shows the result of stress analysis.

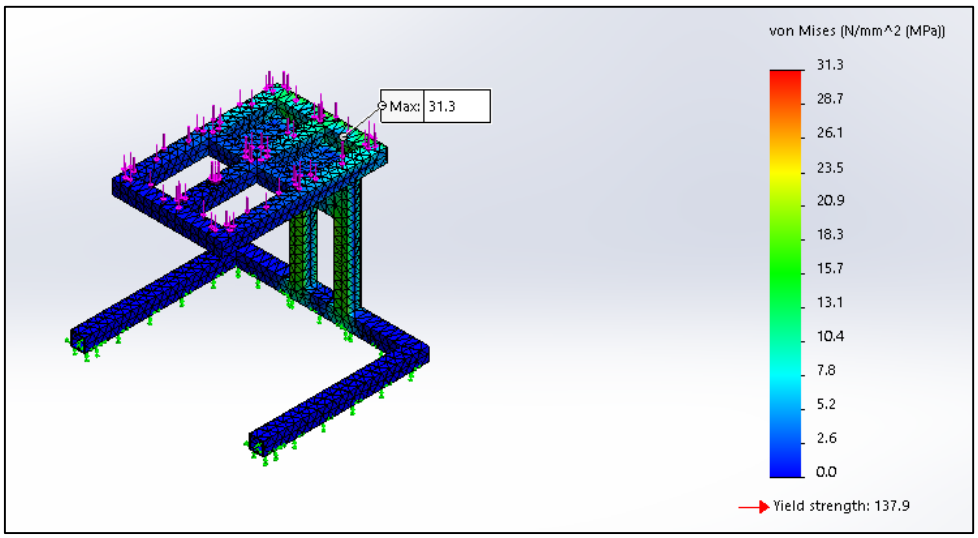

Figure 10: Result of Stress Analysis

Then, the maximum displacement is located at the front vertices of the frame with a magnitude of 1.6mm. This small value of displacement will not lead to any danger. Figure 11 shows the result of displacement analysis.

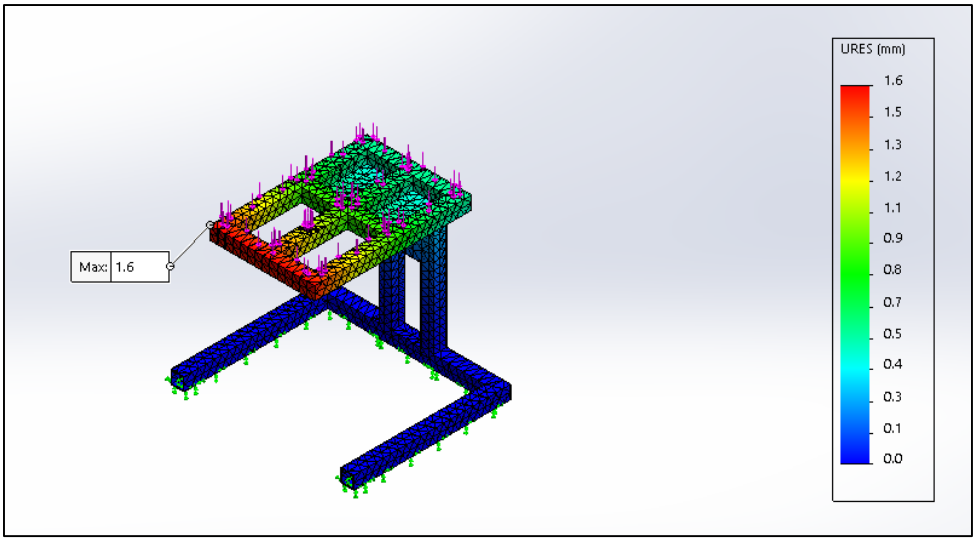

Figure 11: Result of Displacement Analysis

Lastly figure 12 Shows the result of the simulation for Factor of Safety Analysis of the body frame for banana slicing machine. The minimum safety factor for the frame is 4.4 which is above 1. thus, the structure of the frame is safe.

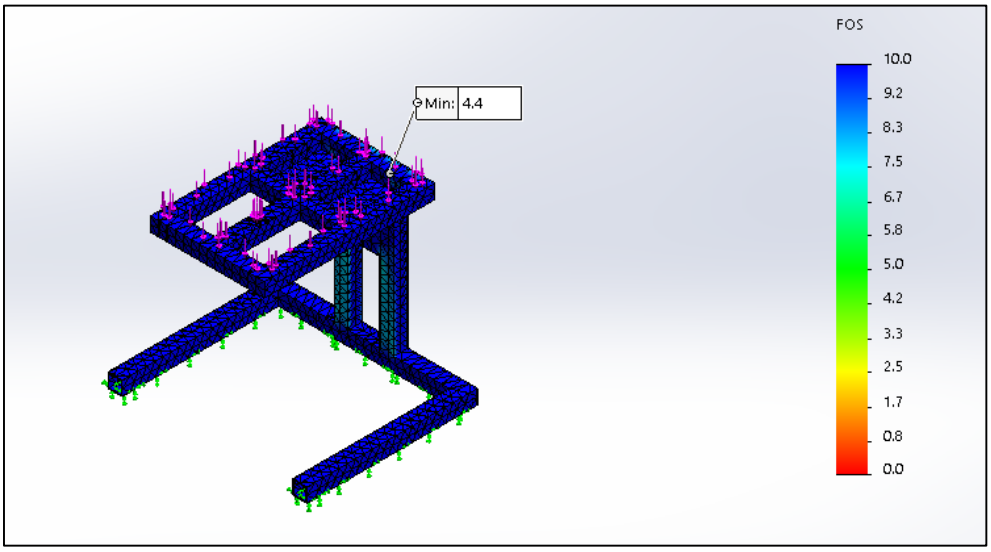

Figure 12: Result of the Factor of Safety Analysis

4. Conclusion

After completing this project, it can be concluded that this project is seen to have been successful by meeting all the objectives that have been set. As a result, a Banana Slicing Machine has been designed. The design was meeting the requirement from the IKS which is the machine was designed which the banana will be directly sliced into the pan. With the theoretical calculation and experimental result on the existing machine. This machine was able to produce 324kg slices of banana in a day which more than 100 kg a day. Lastly, with the analysis on cost this machine was able expected to be sell in range of below RM6000. Therefore, with this affordable design of machine, it will help the banana chips industries in Malaysia growth successfully.

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