DESIGN AND FABRICATION OF MOTORIZED CUTTER PROTOTYPE

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Thesis submitted in partial fulfillment of the requirements for award of
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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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Name of Supervisor: Fadhlur Rahman Bin Mohd. Romlay

Position: Supervisor

Date: 25/06/2013

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This research focuses on the design and development of the motorized cutter for harvesting in agricultural industries. The design focuses on reducing the cost, the weight of the motorized cutter and to improve the performance of the cutter in term of productivity.to achieve the goals. All parts of this motorized cutter is studied and new improved cutter is designed. Three designs are made and the best design is chosen. Every part of the motorized cutter is fabricated and finally assembled. The static load analysis is done using Solidworks 3d software to determine the strength and the maximum deflection of the cutter. Also the new motorized cutter is tested to determine the performance of the product. The productivity, weight and the cost of the new cutter is tabulated and compared with the existing product. From the data, conclusions can be made that the new motorized cutter is more efficient, save cost and time compared to the existing product. In terms of cost the new motorized cutter is 25% cheaper compared to the existing product. The productivity of new motorized cutter has increased 30% from the existing product. The weight of this new cutter is also improved with only 3.2kg compared to another product which are heavier.

ABSTRAK

Kajian ini memberi tumpuan kepada reka bentuk dan pembangunan pemotong bermotor untuk menuai dalam industri pertanian. Reka bentuk ini memberi tumpuan kepada mengurangkan kos, berat pemotong bermotor dan untuk meningkatkan prestasi pemotong segi productiviti. Untuk mencapai matlamat, semua bahagian alat pemotong bermotor ini dikaji dan pemotong baru yang lebih baik direka. Tiga reka bentuk dibuat dan reka bentuk yang terbaik dipilih. Tiap-tiap bahagian pemotong bermotor direkabentuk dan akhirnya dipasang. Analisis beban statik dilakukan menggunakan perisian Solidworks 3d untuk menentukan kekuatan dan pesongan maksimum pemotong. Juga pemotong baru bermotor diuji untuk menentukan prestasi produk. Produktiviti, berat dan kos pemotong baru dijadualkan dan dibandingkan dengan produk yang sedia ada. Daripada data, kesimpulan yang boleh dibuat bahawa pemotong bermotor baru adalah lebih cekap, menjimatkan kos dan masa berbanding dengan produk yang sedia ada. Dari segi kos pemotong bermotor baru adalah 25% lebih murah berbanding dengan produk yang sedia ada. Produktiviti pemotong bermotor baru telah meningkat 30% daripada produk yang sedia ada. Berat pemotong baru ini lebih baik ringan 3.2kg sahaja berbanding dengan produk lain yang lebih berat.

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is one of the countries that rich with nature sources, especially in agriculture. There are many parts in agriculture such as coconut fruit, pineapple, palm fruit, rubber tree and farming. For the new focus is on palm fruit which is Malaysia want to produce own bio-chemical that can be used for fuel and any application for the consumer. Now, productions in petroleum are decreasing and the price of the fuel is increasing day by day. This is one of the causes why Malaysia focusing on this palm fruit because many researchers from this country and foreign believe this fruit is useful which is can be used as a fuel and replaces the petroleum. One of the important activities in oil palm cultivation is harvesting. It was estimated that the operation requires 60% of the total labour for the crop, which constitutes about 50% of the total production cost. It is well known that the agricultural sector in Malaysia in general, and the palm oil industry in particular, depend very much on foreign labour to function. The harvesting process is mostly done by the labour using a traditional palm fruit cutter. It need lots of workers, energy amd take quite long time to finish the process. Researches and improvement have been done to the cutter to improve the production in a short time and use less energy and workers.

1.2 Problem Statement

People usually used a lot of energy when using the traditional cutter to harvesting fruits brunches or pruning fronds because some of the rod cutters made from heavy materials and took a long time to harvesting fruits. Have higher possibility for getting hurt because of the unsafe condition during harvesting fruits manually which is the blade peel easily fall down to ground when it unstable cutting the fruit brunches for a long time. It is also easy to break and cannot used for a long term time period.

The existing motorized cutter in market are too expensive, not efficient and have a high maintenance cost. From that, the main objective for this project is to design and develop the prototype of a motorized cutter to harvest palm fruit for commercial use.

1.3 Objective of The Study

The objectives of this research are stated below:

i. To design and develop the motorized cutter for the palm tree.
ii. To reduce the weight and cost of the motorized cutter.
iii. To analyse the performance of the motorized cutter.

1.4 Scope of The Study

This study has been conducted based on the following scopes:

i. Doing literature review about the current cutter in the market.
ii. Analyse every part to know the advantages and disadvantages of the current products.
iii. Design and develop every part of the cutter. (motor, shaft, battery, casing, electrical and mechanical system) Stress load analysis is done to know the strength of the cutter.
iv. Fabricate the cutter according the schedule.
v. Integrate the system between the mechanical part of motorized cutter and the electro-mechanical part.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This literature review had been taken with reference from sources such as journal, books, thesis and internet in order to gather all information related to the title of this project. This chapter covers about the previous experiment doing by researcher and to go through the result by experimental and numerical.

2.2 MOTORIZED CUTTER

From Malaysian Palm Oil Board (MPOB) Information Series June 2007 stated that harvesting operation requires 60% of total labour for the crop which constitutes about 50% of the total production cost. It is well known that the agriculture sector in Malaysia in general and the palm fruit industry in Malaysia particularly depends on foreign labours to function in production. From this foreign labour, our country can get many problems such as social problem due to reduction of foreign labour and much of money draining out to other country. Data from the Statistics and Labour Department revealed that as at June 2006, the number of foreign workers in palm fruit industry was nearly 400 000 which is about 90% of its total labour. So the keyword to solve this problem is human or workers. Only human beings have the unique combination of eyes, brain and hands that permits the rapid identification and harvest of delicate and perishable material with minimal loss and bruising. But now is modern technology, there are many machinery that can help human to do this harvesting. Since 1982 many harvesting machines have been developed by industrial and agriculture machine manufacturer for harvesting palm fruit bunches. In developing the harvesting machine the most difficult part is to design a suitable cutter for harvesting and pruning. There are several factor were taken into consideration when developing the mechanical harvester such as ground pressure, light weight, technique to harvesting, able to both high and low harvesting, and the most important is the safety to the machine operator.

The main objective for this project is to design and fabricate the suitable mechanical cutter for harvesting. There are few cutter and motorized cutter designed and developed by MPOB and other designers, but there are still few problems with all these cutters such as high cost and still use many workers. But this reference machine must developed by this project to solve the problem. For example the Cantas7 motorized cutter machine is high in cost which is RM 5000 per unit (MPOB Information June 2007) and not flexible to high and low harvesting. So the new design for this mechanical cutter must in term of low cost and flexible to high and low harvesting.

2.2.1 Cantas 7

Figure 2.1: Cantas 7 motor and fuel tank

Source: MPOB 2007

Figure 2.2: Cantas 7 blade and shaft

Source: MPOB 2007

Cantas 7 is the motorized cutter that is produced by Malaysian Palm Oil Board. It is sold to the palm fruit farm owner to help them increase the productivity. Cantas 7 comprises a cutting head, a composite pole and a two-stroke petrol engine of 25.4 cc (1.3 horsepower). The length, weight and deflection of the cutter are 6.70 m, 9.50 kg and 0.08 m, respectively. The weight per meter run of the composite pole shaft is only 0.39 kg. It used fuel to run the motor and the fuel consumption is 0.2 liter per hour. The performance of this cutter is it is able to do double the productivity for harvesting. The price of this cutter is RM 5000 per unit.

2.2.2 Ckat Advanced 2

Figure 2.3: CKAT Advanced 2

Source: MPOB 2007

CKAT Advanced 2 is one more product by Malaysian Palm Oil Board. It uses rapid acceleration gear along with optimized transmission for best cutter performance. The blade used is a flat type and the total weight of the cutter is 6 kg. The length of this cutter is 2.1 meter and it can reach the tree within 1.2 meter to 2.4 meter. It only can be used for a low height tree and the net price of this cutter is RM 3990 per unit.

2.2.3 Cantas Advanced 2

Figure 2.4: Cantas Advanced 2

Source: MPOB 2007

Cantas advanced 2 uses 2-stroke petrol engine to operate the cutter. The maximum engine speed can run up to 10500 RPM. The working speed of the engine is 3000-5000 RPM. The fuel capacity of the tank is 440 cm^3. The maximum length of the cutter is 3.7meter (adjustable height) and the total weight is 7.2 kg. This cutter has a high power engine, the productivity is similar as the Cantas 7, but the cost for the fuel is higher.

2.3 MOTOR

Latest technology of the cutter is designed using motor to drive and cut the palm fruit, compared to manual cutter used before. From the survey, most of the motor is generated by fuel. There are 2 types of motor which are ac (alternating current) and dc (direct current).

2.3.1 DC Motor

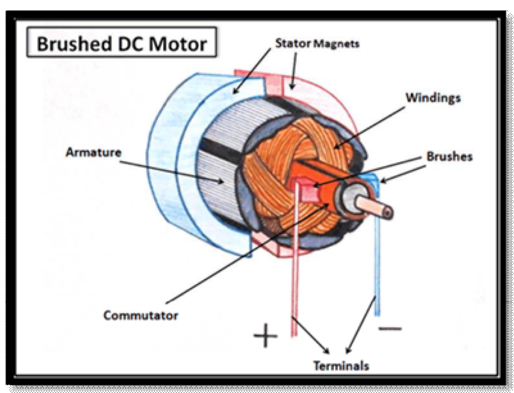

Figure 2.5: Brushed DC motor

Source: Zainal (2003)

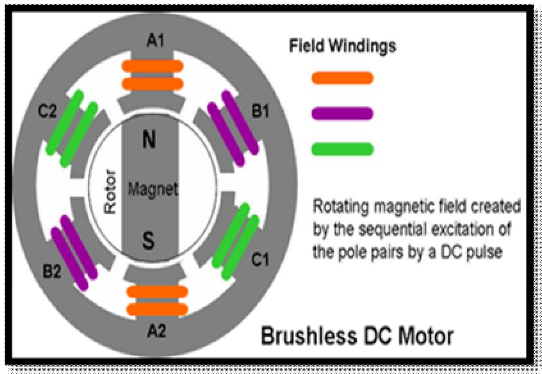

Figure 2.6: Brushless DC motor

Source: Zainal (2003)

DC motor is an electric motor that runs on direct current (DC) electricity. A DC motor works by converting electric power into mechanical work. This is accomplished by forcing current through a coil and producing a magnetic field that spins the motor. The simplest DC motor is a single coil apparatus, used here to discuss the DC motor theory. The voltage source forces voltage through the coil via sliding contacts or brushes that are connected to the DC source. These brushes are found on the end of the coil wires and make a temporary electrical connection with the voltage source. In this motor, the brushes will make a connection every 180 degrees and current will then flow through the coil wires. At 0 degrees, the brushes are in contact with the voltage source and current is flowing. The current that flows through wire segment C-D interacts with the magnetic field that is present and the result is an upward force on the segment.

The current that flows through segment A-B has the same interaction, but the force is in the downward direction. Both forces are of equal magnitude, but in opposing directions since the direction of current flow in the segments is reversed with respect to the magnetic field. At 180 degrees, the same phenomenon occurs, but segment A-B is forced up and C-D is forced down. At 90 and 270-degrees, the brushes are not in contact with the voltage source and no force is produced. In these two positions, the rotational kinetic energy of the motor keeps it spinning until the brushes regain contact.

The brushed DC motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary permanent magnets, and rotating electrical magnets. Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. The disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor.

Brushless DC motors use a rotating permanent magnet in the rotor, and stationary electrical magnets on the motor housing. A motor controller converts DC to AC. This design is simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. The disadvantages of this dc motor are high initial cost, and more complicated motor speed controllers.

2.3.2 AC Motor

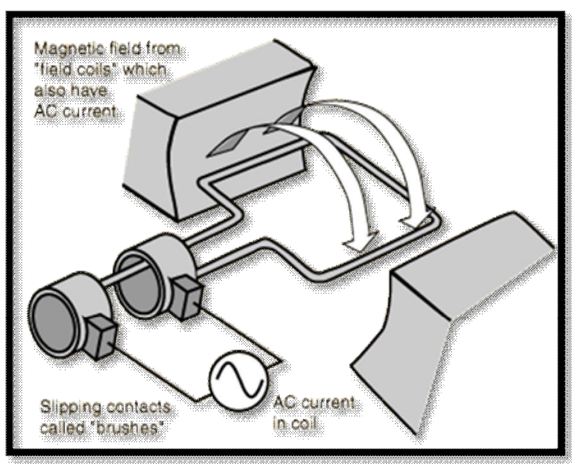

Figure 2.7: AC Motor

Source: Zainal (2003)

The principle of operation for all AC motors relies on the interaction of a revolving magnetic field created in the stator by AC current, with an opposing magnetic field either induced on the rotor or provided by a separate DC current source. The resulting interaction produces usable torque, which can be coupled to desired loads throughout the facility in a convenient manner. Basically it use a rotating magnetic field in the stator to induce a magnetic field in the rotor and hence a current to flow in the rotor's coils. The rotor coils actually just loop around on them. The induced field in the rotor tried to stay aligned with the rotating field of the stator, so it turns to chase the stator's field. Due to loads on the motor, the rotor's field is forced to rotate slightly slower than the stator's field (if it kept up exactly, there would be no difference in the fields and hence no torque).

Three phase induction motors are very common for industrial use because they are highly efficient and reliable. These same advantages apply for electric vehicle use, except for the added complication that a variable-speed inverter is required to control the AC motor from a DC power supply (the battery). These are a relatively expensive piece of hardware. Although they do include regenerative braking and are generally more efficient, AC systems currently cost about twice as much as series DC.

2.4 BATTERY

In electronics, a battery is a combination of two or more electrochemical cells which store chemical energy and make it available as electrical energy. It consists of a number of voltaic cells, each voltaic cell consists of two half-cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the electrode to which anions (negatively charged ions) the anode or negative electrode, the other half-cell includes electrolyte and the electrode to which cations (positively charged ions), the cathode or positive electrode. In the redox reaction that powers the battery, cations are reduced (electrons are added) at the cathode, while anions are oxidized (electrons are removed) at the anode. The electrodes do not touch each other but are electrically connected by the electrolyte. Some cells use two half-cells with different electrolytes. A separator between half-cells allows ions to flow, but prevents mixing of the electrolytes.

There are two types of batteries which are primary batteries (disposable batteries), that are designed to be used once and discarded, and secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times. Batteries come in many sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centers.

2.4.1 Lithium Ion Battery

A lithium-ion battery is a family of rechargeable battery types in which lithium ions move from the negative electrode to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the electrode material, compared to the metallic lithium used in the non-rechargeable lithium battery.

Lithium-ion batteries are common in consumer electronics. They are one of the most popular types of rechargeable battery for portable electronics, with one of the best energy densities, no memory effect, and only a slow loss of charge when not in use.

2.4.2 Lithium Polymer Battery

Lithium Polymer batteries are usually composed of several identical secondary cells in parallel to increase the discharge current capability, and are often available in series packs to increase the total available voltage. This type has technologically evolved from lithium-ion batteries. The primary difference is that the lithium-salt electrolyte that is not held in an organic solvent but in a solid polymer composite such as polyethylene oxide or polyacrylonitrile. The advantages of Lithium polymer over the lithium ion design include lower cost of manufacture, adaptability to a wide variety of packaging shapes, reliability, and ruggedness, with the disadvantage of holding less charge. Lithium-ion polymer batteries started appearing in consumer electronics around 1995.

2.5 MECHANISM

Mechanism is the mechanical part of this mechanical part of this cutter. It will transfer the power generated from motor to the shaft and finally to the cutter blade. The motion that comes from the motor is rotational motion but when it comes to cutter, linear motion is needed. So a mechanism needed to convert the rotary motion to linear motion.

2.5.1 Cam Mechanism

A cam may be defined as a machine element having a curved outline or a curved groove, which, by its oscillation, rotation or reciprocating motion, gives a predetermined specified motion to another element called the follower. It is usually consists of a cam (the driver), the follower (the driven element), and the frame (the support for the cam and the follower).

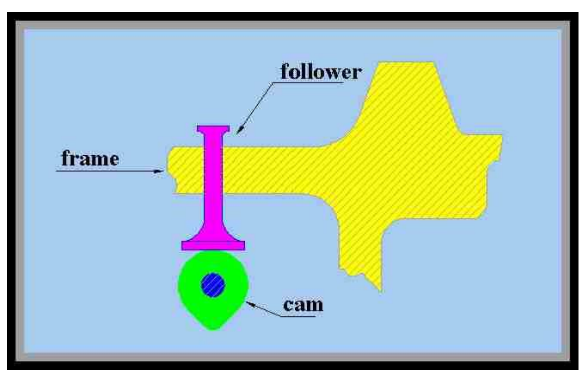

Figure 2.8: Parts of cam mechanism

Wue (2009)

Cams can be classified into three ways:

1. In terms of their shape, such as wedge, radial, cylindrical, globoidal, conical, spherical, or three-dimensional.

2. In terms of the follower motion, such as dwell-rise-dwell (DRD), dwell rise return dwell (DRRD), or rise-return-rise (RRR).

3. In terms of the follower constraint, this is accomplished by either positive drive or spring load as mentioned previously.

2.5.2 Bevel Gear Concept

Figure 2.9: Parts of cam mechanism

Wue (2009)

Bevel gears concept is the gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of bevel gears is a cone. It need a large space to allocate it and not suitable for high load application.

2.5.3 Cylindrical Cam

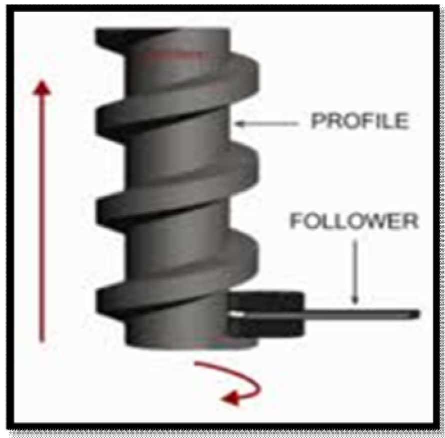

Figure 2.10: Parts of cam mechanism

Wue (2009)

This concept is similar with usual cam, but the cam is in cylinder shape attached to the follower. It needs a long shaft to make it works and not suitable for forced motor with stress application.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology is one of the most important elements to be considered in developing a research. Research methodology indicates procedures that are planned for the research. It is to ensure that the development of the research is smooth and get the expected result. It is also to avoid the research to alter course from the objectives that have been stated or in other words the project follow the guideline based on the objectives.

A good methodology can described the structure of the research whereby it can be the guideline in managing the project. In other words the methodology can be described as the framework of the research where it contains the elements of work based on the objectives and scopes of the research.

For this chapter, all the details and related discussion on the process and methods involved in the project are described. The process flow and timeline of the project is illustrated using flow chart and Gant chart. Both charts are fundamental for this project as both charts explained every step to achieve the objective of the project. The project starts with working on literature review and end by submitting the complete report.

3.2 FLOW CHART DESCRIPTION

Figure 3.1 shows the flow chart of every process to complete this project. For the beginning, it starts with understanding the title propose, determining the project scopes and general background of projects.

Then, continued the study with the article review. It starts from download the entire related article with this title project from internet like sciencedirect.com and also, review from the books, journal and research from other project related. All the information from the previous research can be used to gain new idea and concept to be used during this project.

Next step continued the study for analysis all the information. Discussion, reading and research with supervisor and other friends are done to get the best idea for the product. The researchers are focus about reducing the cost, the weight of the cutter, reducing the maintenance cost and also design a product that will long last. Then 3 ideas of the motorize cutter is sketched and analysed to choose the best one.

Study is continued of methodology process. The final design is modelled using 3d solidwork software and the properties of the motorized cutter are defined. All the analysis is done using this software to make sure the cutter is strong enough to do the job without any defects. After that, the project continued with the fabrication of the motorized cutter. The fabrication process start with cutting the aluminium shaft according to the specification, joined with the blade. The motor attach t the mechanical converter, bearing and battery. The casing of the motor and battery is made by using cnc rapid prototyping machine. Finally all the parts are attached together and the motorized cutter is tested whether functioning or not.

The result was compared from the previous product to make conclusion. For the final step, all the information from this project was compiled and the complete report submitted as the thesis project.

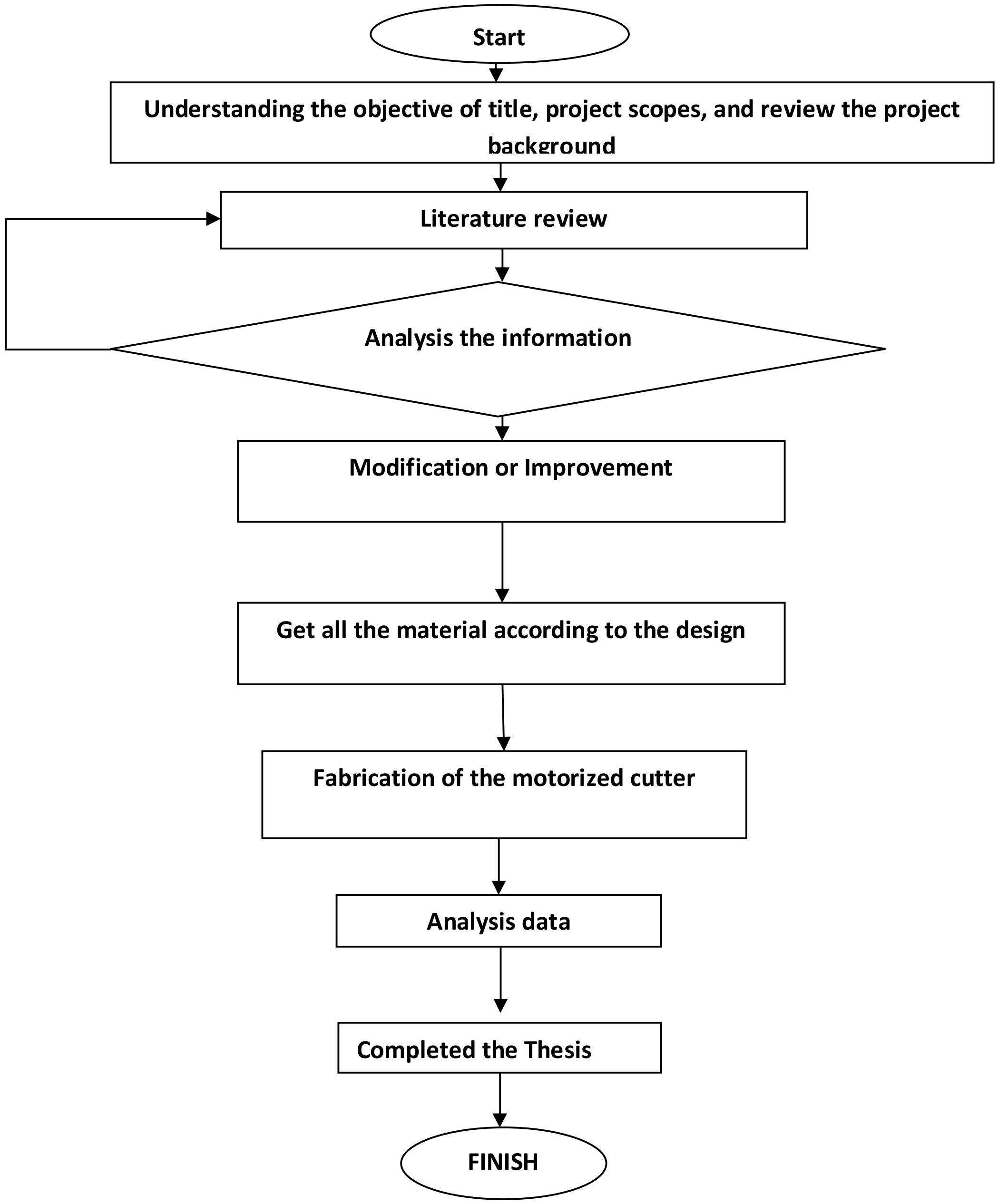

Figure 3.1: Flow chart of methodology

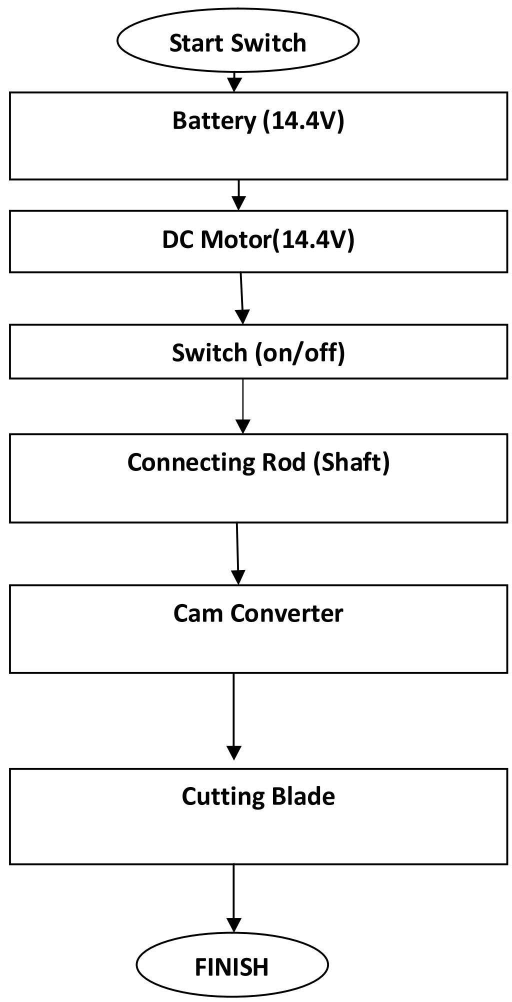

Figure 3.2: Flow chart of motorized cutter power flow

3.3 FABRICATION OF MOTORIZED CUTTER

3.3.1 Introduction

The first step to fabricate this motorized cutter is to make the designs, make comparisons part by part and choose the best deign as the final product. The suitable concept and design for this machine can be defined from the information we gathered from the literature review before. There are several parts and every part need a specific analysis to get a whole total better machine. For the casing of motor and battery, there are 3 designs made, comparisons done between those design and the best design is chosen as final design. For the motor the best efficient and cheapest motor that has a power that required running the cutter blade is chosen.

The shaft that has a good strength, low price, and light weight will the correct one for this motorized cutter. For battery that will generate the power to run the motor, most common rechargeable battery with long life span is given priority. The most important part is the mechanical concept that will transfer the power from the motor to the cutter blade. The bevel gear concept, the cam concept and the cylindrical cam concept are the mechanical concept to convert the rotational motion to linear motion. The selection criteria for this concept are it must be suitable concept, easy to fabricate and operate, simple design, heavy duty and cheap.

3.3.2 Casing for motor and battery.

Design 1

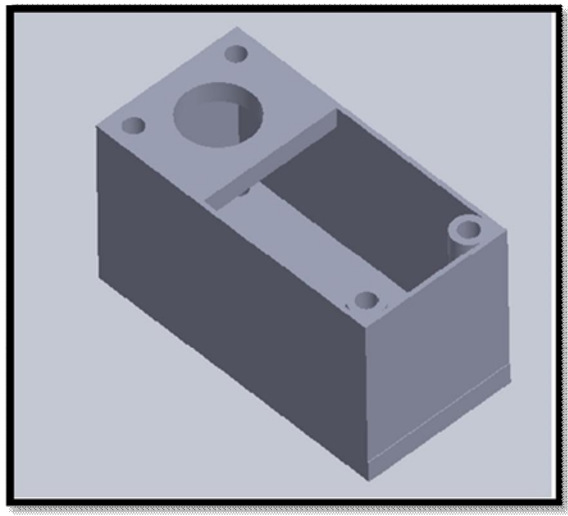

Figure 3.3: Bottom casing

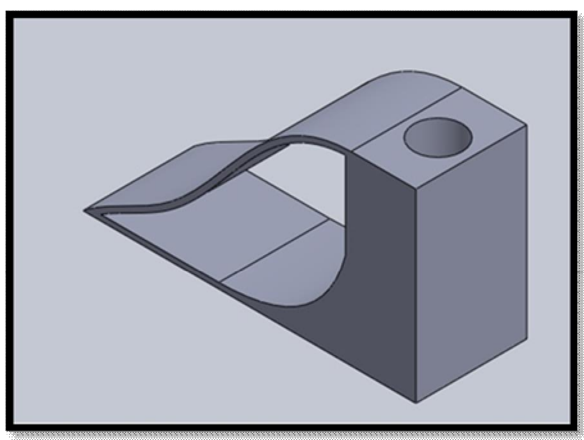

Figure 3.4: Top casing

Design 2

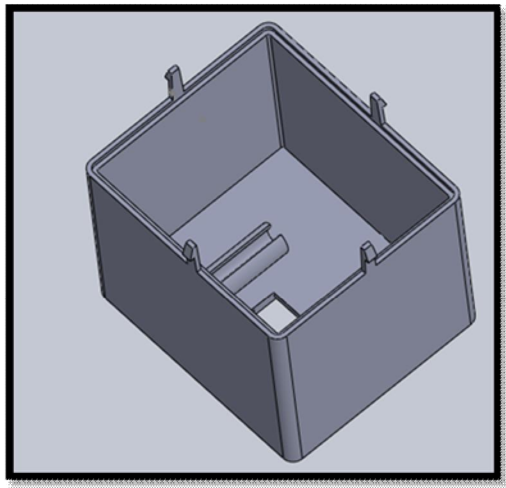

Figure 3.5: Bottom casing

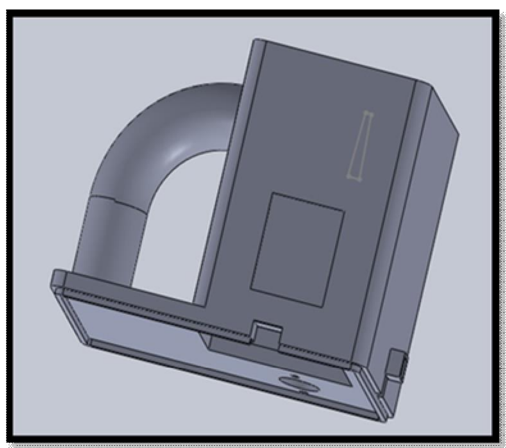

Figure 3.6: Top casing

Design 3

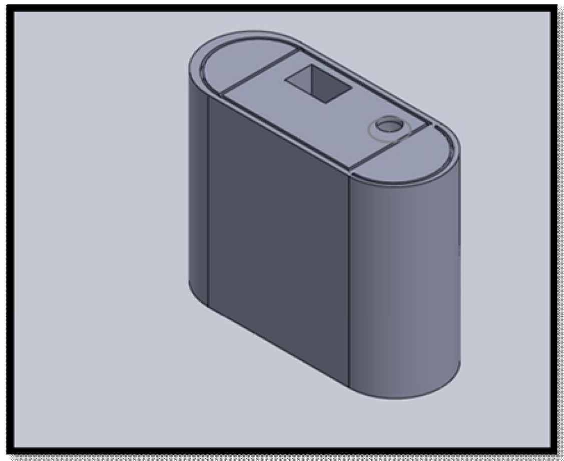

Figure 3.7: Bottom casing

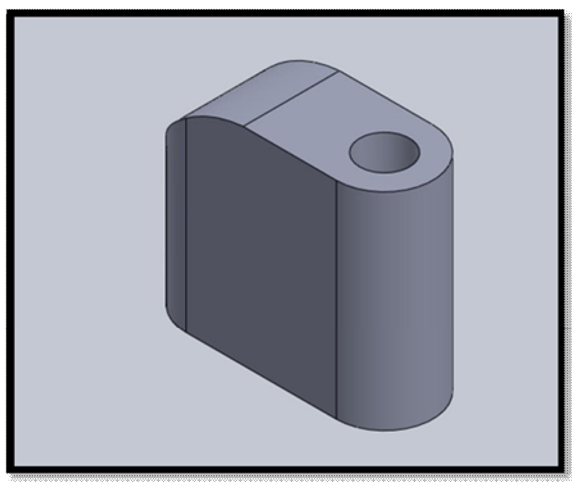

Figure 3.8: Top casing

These are the designs of three finalized casing for the battery and motor. The first and third design are using screw to connect the top and bottom casing, while the second design is more simpler cause it use snap fit concept to connect between the two parts. The final design chosen is design 3. The Solidworks 3d drawing then saved into .stl format and is fabricated by using 3d printing rapid prototype machine.

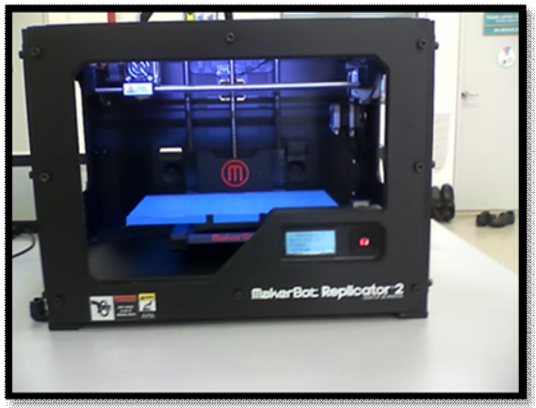

Figure 3.9: Rapid prototype machine

3.3.3 Shaft

Figure 3.10: Aluminium shaft with rubber grip

The dimensions of the aluminium shaft are:

1) 1182 mm x Ø 45 mm x 1 mm

2) 1115 mm x Ø 26 mm x 1 mm

The Second shaft (inner shaft) is attached with 30 mm spring. The two different diameter shafts are connected by an adjustable connecter. Along 91 mm outer shaft is covered by rubber grip.

3.3.4 Motor

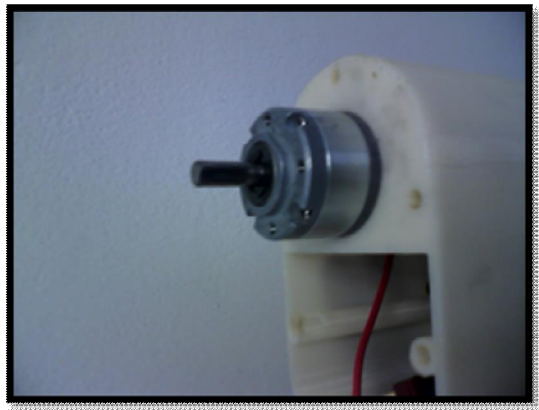

Figure 3.11: DC motor

Brushless DC motor is the compatible and suitable motor to empower this motorized cutter. These are the specification of the DC motor used with the motorized cutter:

- Voltage : 14.4 V DC motor
- Torque, maximum without load : 60 Nm
- Torque, maximum with load : 45 Nm
- Speed : 500 rpm- 3000 rpm
- Drill spindle thread : 12 mm
- Dimension : 72 mm x Ø 36 mm

3.3.5 Battery

The previous motorized cutters that exist at the market use petrol fuel to generate the power to runs the motor or engine. The difference with this new design is it uses rechargeable lithium polymer battery to generate the power for run the motor. With full recharge it will give the output voltage 14.4 V and can runs the motor for 3 hours. So for one day usage (about 6 hours cutting time) 2batteries will be used to operate the motorized cutter.

Figure 3.12: Lithium polymer 14.4 V battery

3.3.6 Cam mechanism

The power from the motor will create a rotational motion, to convert it becomes a linear motion and transfer the power to C-sickle cutter, a cam mechanism is used. A shaft from the motor is attached to Ø 50 mm cam, and then the other side is connected to linear square rod that attached to C-sickle cutter at the end. The cam mechanism is attached on the 260 mm x 120 mm x 30 mm steel casing.

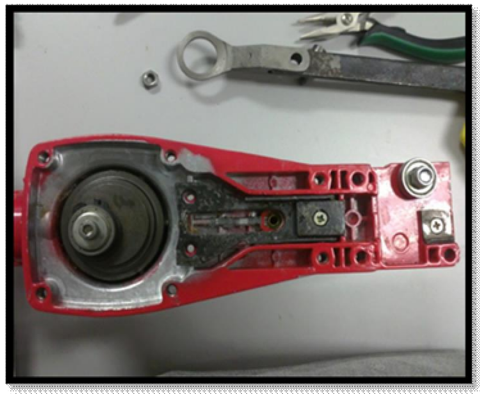

Figure 3.13: Cam mechanism

3.3.7 C-Sickle Cutter

The most important part of the motorized cutter to harvest the palm fruit is the cutter blade. C-sickle type blade cutter is chosen to be used in this design because this is the most common design used and easy to harvest the food especially the palm fruit. The dimension of this cutter is Ø 300 mm x 5 mm and the material of the cutter is stainless steel.

Figure 3.14: C-sickle cutting blade

3.3.8 The motorized cutter

This is the full assembly of the motorized cutter. The total height of this cutter is 2.47 meter.

Figure 3.15: Motorized cutter full assembly

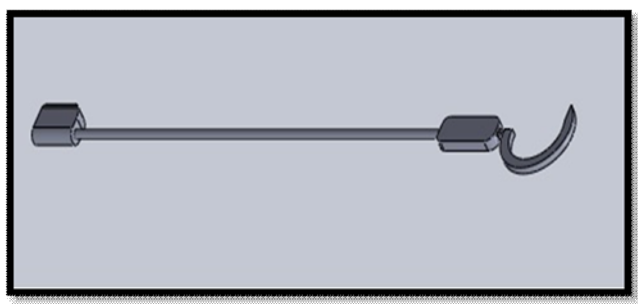

Figure 3.16: Motorized cutter 3d drawing

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter presents result of this project and later on, the result will be discussed in details. The aims of this chapter are to analyze the result of the project, which includes the static stress analysis of the design structure, the performance efficiency analysis which been compared to other current products. Also the concept calculations are done to determine the velocity, displacement and acceleration of the system.

4.2 STATIC LOAD ANALYSIS

This experiment is for analysis to determine the strength of the full assembly of this motorized cutter. A Static load of 200 N is applied on top of the cutter because the force will exerted at this point. 200 N is still a large amount of force, because the average weight of the palm fruit is only 20 kg but it is hanging on the tree, the weight will be lighter than the real weight.

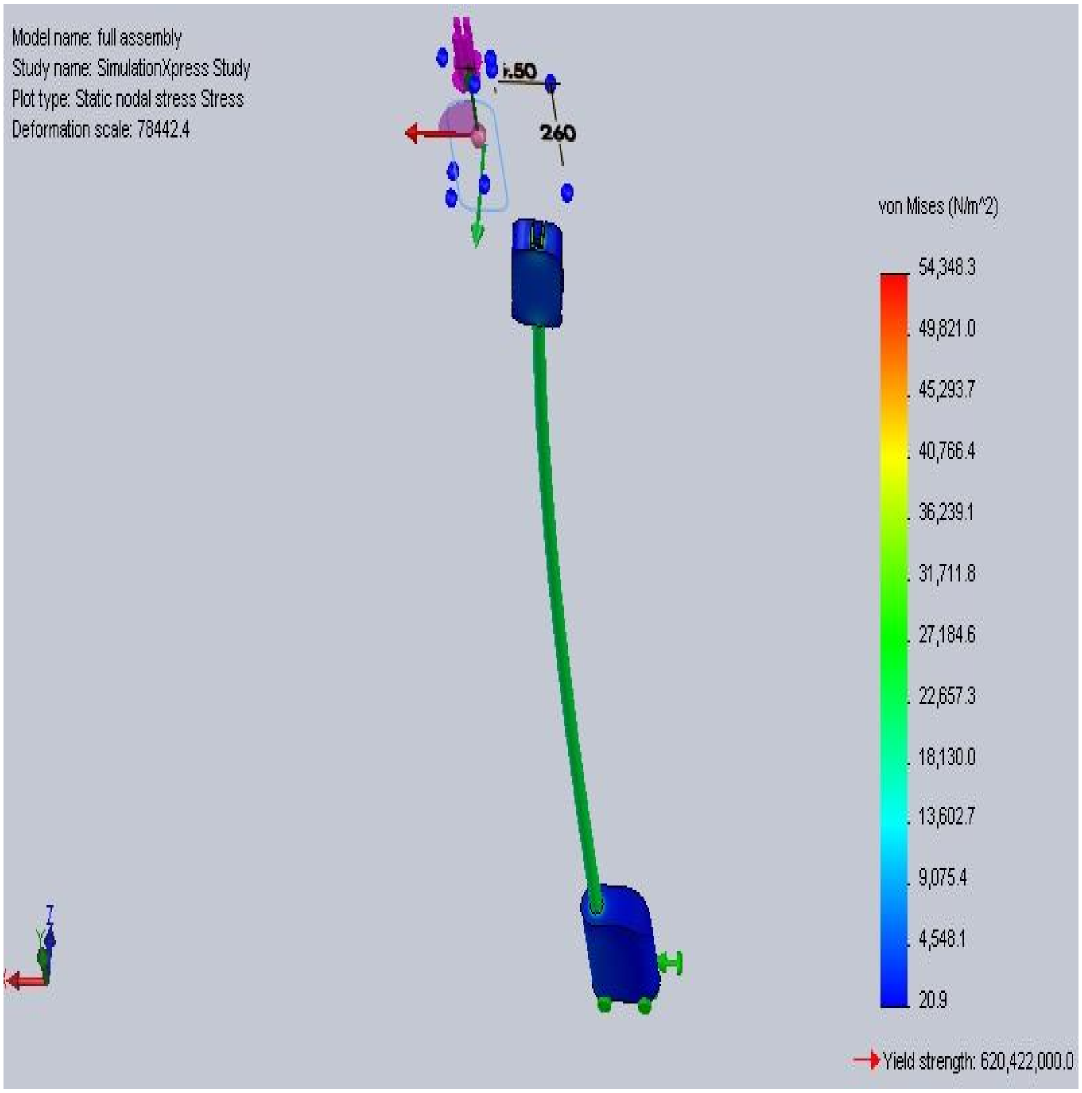

Figure 4.1: Stress analysis

This is the result of the static load analysis, when a 200 N of load is applied on the top part. The maximum critical point is at the center of the shaft and the yield strength of the cutter is about 620 MN/m^2.

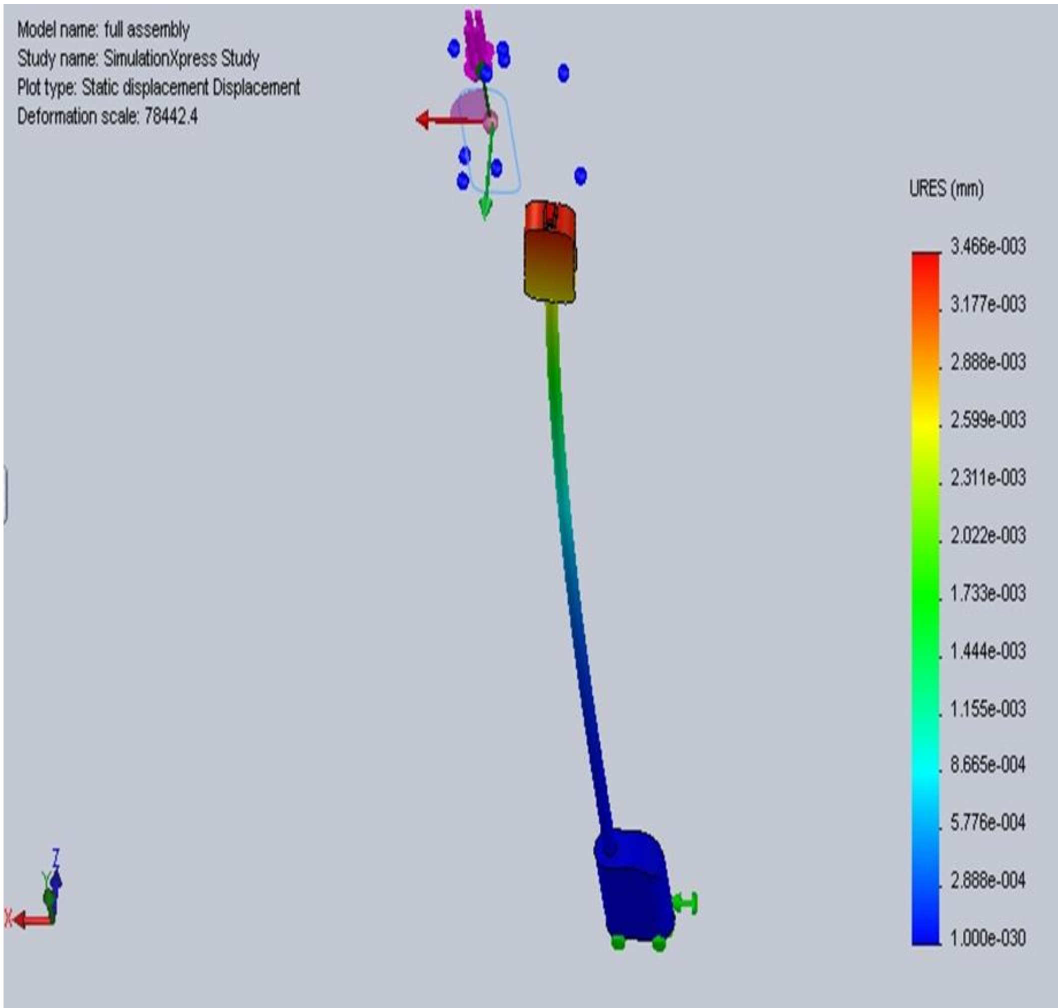

Figure 4.2: Displacement analysis

This figure shows the displacement of the motorized cutter when exerted 200 N forces on it. The maximum displacement is at the top which is nearly 0.346 x 10^2 mm.

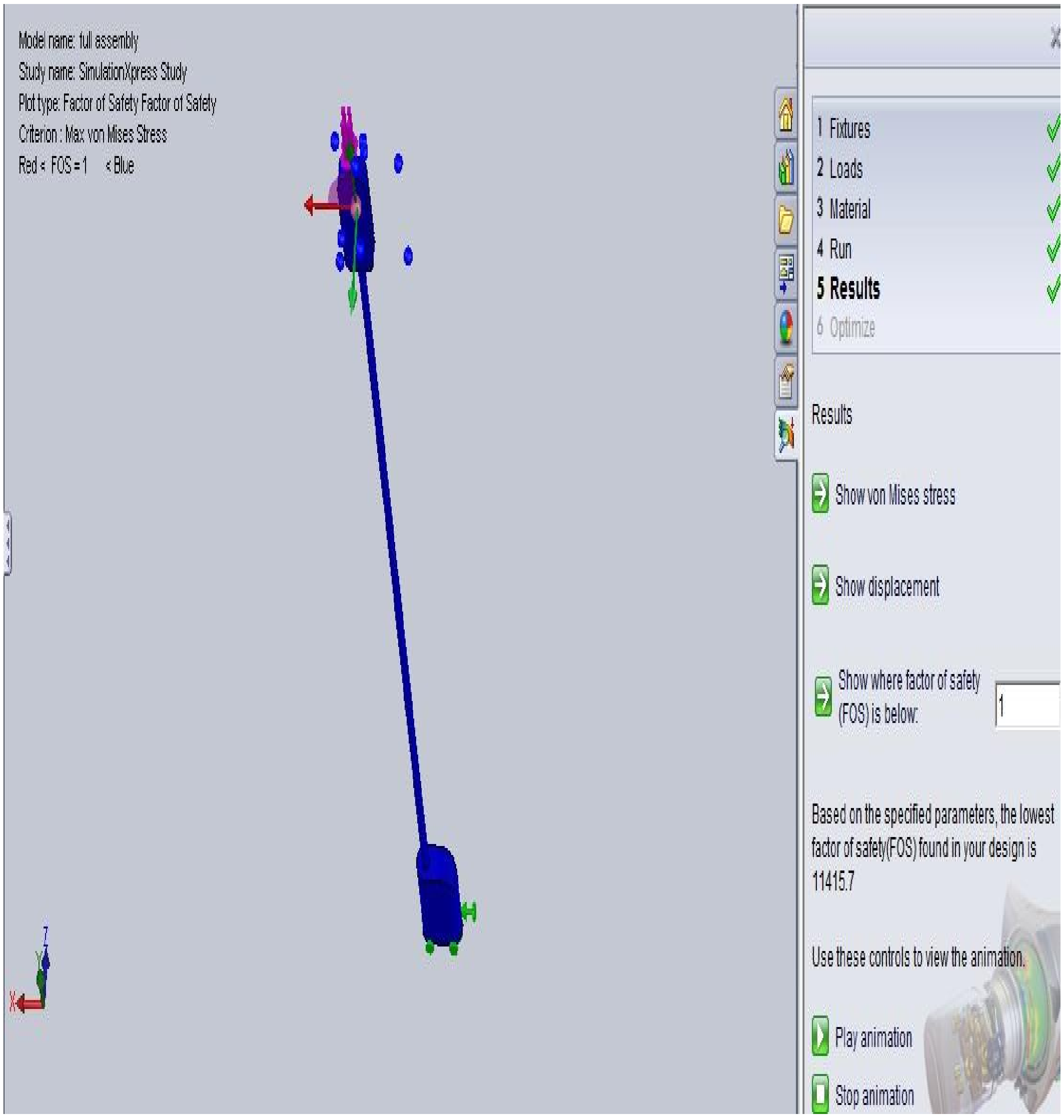

Figure 4.3: Factor of safety analysis

This is the analysis to find out the factor of safety of this motorized cutter. From the analysis, it shows that the factor of safety is 1 and there is no critical point at the cutter. So the design is strong enough for this motorized cutter.

4.3 PERFORMANCE ANALYSIS

The motorized cutter is designed using a cam mechanism system. The cam mechanism can be assumed as a 4 bar linkage mechanism. It is a combination of four links; one has been designated as the frame and connected by four pin joints. Because the four bar mechanism has one degree of freedom, it is constrained and fully operated with one driver. The pivoted or fixed link that is attached to the driver or power source is called the input link and the other pivoted link that attached to the frame is designated the output link follower. The couple or connecting arm couples the motion of the input link.

The number of degrees of freedom of this mechanism must be determined to make the analysis. The mobility (number of freedom) can be calculated by using this formula:

F = Degree of freedom = $3(n-1) - 2j_p - j_h$

Where:

n= total number of links in the mechanism

j_p = total number of primary joints(pins or sliding joints)

j_h= total number of higher order joints(cam or gear joints)

F= 3(4-1)-2(4)-0 = 1

So this mechanism system has 1 constrained degree of freedom. Mechanism with one degree of freedom is termed as constrained mechanism. Mechanism with zero or negative degrees is termed as locked mechanism, a mechanism that unable to move a form of structure. While mechanism with more than one degree of freedom is as unconstrained mechanism, it needs more than one driver to precisely operate them.

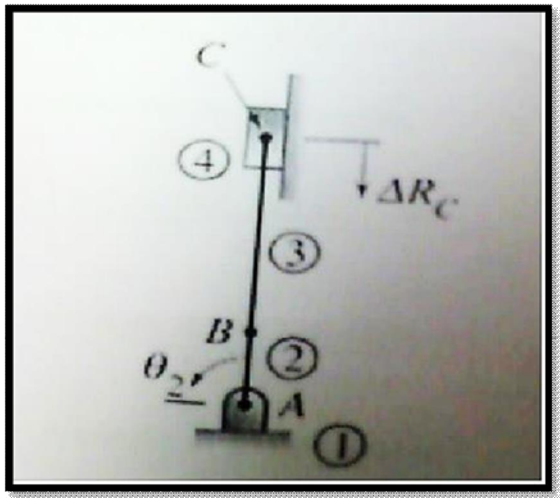

Figure 4.4: Mechanism diagram

Source: Myszka 2005

4.3.1 Four Bar Linkage Mechanism

The closed-form position equations for a four bar linkage involve determining the interior joint angle ($\varnothing_3$, $\varnothing_4$ and γ) for the known links L_1,L_2,L_3 and L_4. A,B,C and D are the primary joints for the mechanism shown in Figure 4.8

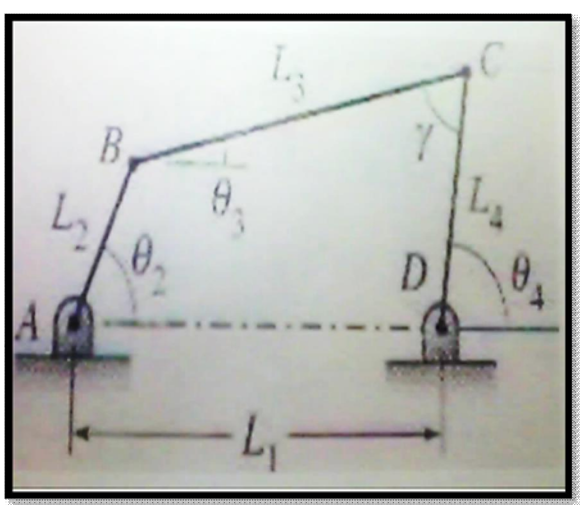

Figure 4.5: Four bar linkage mechanism

Source: Myszka 2005

Dimension for AB=60mm, BC=80mm and N=3000rpm

The related equations for this four bar linkage are:

$$BD = \sqrt{[L_1{}^2 + L_2{}^2 - 2(L_1)(L_2)\cos Ø_2\,]}$$

$$\gamma - \cos^{-1}[\frac{(L_3{}^2)+(L_4{}^2)-(BD^2)}{2(L_3)(L_4)}]$$

$$\gamma = 180^{\circ} - \cos^{-1}[\frac{(L_3{}^2)+(L_4{}^2)-(BD^2)}{2(L_3)(L_4)}] - \cos^{-1}[\frac{[(L_4{}^2)-(L_3{}^2)]+(BD^2)}{2(L_4)(BD)}]$$

$$Ø_3 = Ø_4 - \gamma$$

$$v_1 = [\frac{\Delta R_{i+1} - \Delta R_{i-1}}{2\Delta t}] - [\frac{\Delta R_{i+2} - 2\Delta R_{i+1} + 2\Delta R_{i-1} - \Delta R_{i-1}}{12\Delta t}]$$

$$Ŭ_i = = [\frac{\Delta v_{i+1} - \Delta v_{i-1}}{2\Delta t}] - [\frac{\Delta v_{i+2} - 2\Delta v_{i+1} + 2\Delta v_{i-1} - \Delta v_{i-1}}{12\Delta t}]$$

The calculations are done for each 30 angle increment, and these are the example of calculation for 30 degree angle.

$$\Delta Ø = Ø(1rev/360^{\circ})$$

= 30°(1rev/360°)

= 0.0833 rev

$\Delta t = \Delta Ø/\omega$

= 0.0833/3000

= 0.001667 sec

$\O_1$ = sin $^{-1}$ (AB sinØ/ BC)

= sin $^{-1}$ (60 sin 30°/80)

= 22.0243°

$\O_3$ = 180 °ï (Ø-$\O_1$)

= 180 °- (30 °-22.0243 °)

= 127.9757 °

R(BD) = $(L_1^2 + L_2^2 - 2(L_1)(L_2)\cos \O_2)^2$

= $(180^2 = 60^2 - 2(80)(60)\cos 127.9759°)^2$

= 126.1235mm

Velocity of the system for 30 degree angle

$$v_1 = [\frac{\Delta R_{i+1} - \Delta R_{i-1}}{2\Delta t}] - [\frac{\Delta R_{i+2} - 2\Delta R_{i+1} + 2\Delta R_{i-1} - \Delta R_{i-1}}{12\Delta t}]$$

$$v_1 = [\frac{29.1724 - 0}{2(0.0033)}] - [\frac{47.0850 - 2(29.1724) + 2(0) - 0}{12(0.005)}]$$

= 6.832 mm/s

Acceleration of the system

$$\breve{U}_1 = [\frac{\Delta v_{i+1} - \Delta v_{i-1}}{2\Delta t}] - [\frac{\Delta v_{i+2} - 2\Delta v_{i+1} + 2\Delta v_{i-1} - \Delta v_{i-1}}{12\Delta t}]$$

$$\breve{U}_1 = [\frac{10.33633 - 0}{2(0.0033)}] - [\frac{8.91835 - 2(10.33633) + 2(0) - 0}{12(0.005)}]$$

= 0.3326mm/s²

Table 4.1: Velocity and acceleration of the system

Cam Angle (degree)	**Time (sec)**	**Displacement (mm)**	**Velocity (mm/s²)**	**Acceleration (mm/s²)**
0	0.00	0.00	0.00	0.00
30	0.0017	13.8765	6.8327	0.3326
60	0.0033	29.1724	10.3363	0.0053
90	00.50	47.0850	8.9183	-0.2210
120	0.0067	69.1724	4.8731	-0.2561
150	0.0083	77.7995	1.5329	-.01273
180	0.0100	80.000	0.0000	-0.0940
210	0.0117	77.7995	-.27055	0.1557
240	0.0133	69.1724	-5.7237	0.1950
270	0.0150	47.0850	-9.1227	0.1393
300	0.0167	29.1724	-10.0156	0.1125
330	0.0183	13.8765	-5.9148	0.3647
360	0.0200	0.0000	0.0000	0.1537

4.3.2 Efficiency Analysis

Table 4.2: Efficiency analysis

	Manual	Cantas	Different
Total harvester (cutter + helper)	16	8	-8
Land : labour (ha)	1 : 18	1 : 37	+ 1 : 19
Average productivity (tonne/team)	4 : 19	11 : 60	+ 7.41
Harvesting cost (RM/tonne)	RM33	RM20	- RM13.00

The table 4.1 shows the analysis between the traditional harvesting method using manual manpower and using one of the most used devices, Cantas 7. The table plots the difference between these two methods. If we use manual harvesting process, we need about 16 workers to produce the same fruit but if using Cantas 7, its only need 8 workers. A worker using a manual harvesting method can take 18 hectares but if he uses Cantas 7, he will be able to finish 37 hectares at the same time. For the average productivity, using Cantas 7 it will able to gain profit with the rate of 7.41. For the cost per ton, using Cantas 7 we can save RM 13 per tonne compared to using traditional method.

Table 4.3: Productivity comparison between 3 types of cutter

	Tan/ hour	Cost	Efficiency
Manual	3.5- 4	Rm 50	Good
Cantas 7	8	Rm 54	Better
New Design	11	Rm 50	Most better

Three types of harvesting method are compared and plotted on the table. By using manual harvesting method, cost for a worker is RM 50 per day and will give the productivity from 3.5 to 4 tonne every day. By using current product existing at the market, Cantas 7, cost for a worker is RM 50 plus the cost for petrol oil is RM 3.80 for 2 liter per day. By using this CAntas 7 cutter, it can produce about 12 tonne of palm fruit per day. Using the latest design of this motorized cutter, it is able to produce 12 tonne of palm fruit per day by only costs RM 50 for a worker. Since a battery only will stand for 3hour, an extra battery needed.

The calculation for the production of the latest prototype model is:

6 second (cut 1 palm fruit) x 10(fruit per minute) x 60(fruit per hour) x 6 hour (2 battery) x

30 kg (average weight of one bundle palm fruit) = 10800 kg per day

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter will conclude all the process that have been done and achieved by the analysis of the final product. Also recommendation and suggestion are given for the improvement in future research to get a better results and performance.

5.2 CONCLUSION

This research is about to design and fabricate the motorized cutter to get a better product from the current product that already exist in the market. The best and simplest design is proposed and the fabrication process is done and finally the analysis is done to know the performance of this new motorized cutter. Each part of the motorized cutter is analyzed to know the suitable characteristics and better products. The first objective is to reduce the weight of the motorized cutter. The current products weights are 6 kg and 9.5 kg. The new motorized cutter prototype is only about 3.2 kg. So the first objective is achieved. The cost of the motorized cutter also is only RM1500 compared to Cantas 7 which is RM 5000 and CKAT Advanced 2 which is RM 3990. The performance and the efficiency of this new motorized cutter is improved from the current products. The total productivity is increased nearly 80% compared to the manual harvesting using traditional method. The total cost of new motorized cutter is also can be reduced about 70% from the manual harvesting using traditional method.

5.3 RECOMMENDATION

The most important things that must be considered in making this motorized cutter is to make sure its functioning smoothly and can harvest palm fruit easily. The cost and productivity is also must be considered. For the future research to achieve these goals, there are some recommendations that can be considered. The material for shaft and the cam mechanism cover can be improved to a stronger material tough the static load analysis result shows that there is some critical point at these parts. The casing of the motor is also act as a handle to hold the motorized cutter. The design of the casing can be improved to become more aesthetic and easy to grip to improve the handling the motorized cutter.

The current motor used having the operating speed 3000rpm. This speed is suitable for a low and average power requirement, to get a better performance a high speed motor will be more suitable. This new motorized cutter is design only for harvesting an average height of tree which is between 2 meter and 4.5 meter. An height adjustable cutter or a more height cutter will be more good so it can be used for multipurpose tree height cutting. Other changes that be made to enables the machine operating well is reducing the vibration at the cam mechanism and c-sickle cutter. Because of the vibration, there will be a power loss at the system and it will reduce the efficiency of the cutting productivity.

The battery of the system can be improved by using a battery that has a better lifespan and appropriate charger. Finally the prototype of this motorized cutter can be commercialized to be used in agriculture industry especially for harvesting the palm fruit.

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APPENDIX A: Motorized Cutter

Figure 6.1: CKAT Advanced 2

Figure 6.2: Cantas Advanced 2

Figure 6.3: Cantas 7 motor and fuel tank

Figure 6.4: Cantas 7 blade and shaft

Figure 6.5: Motorized cutter full assembly

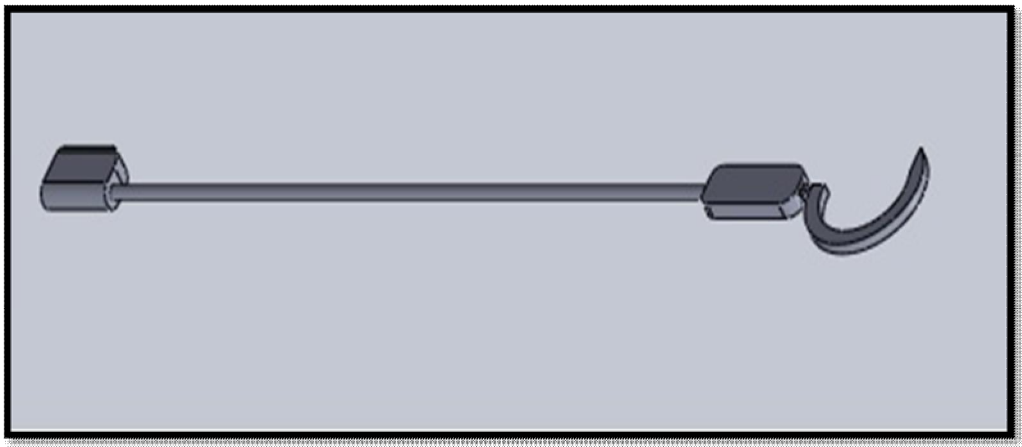

Figure 6.6: Motorized cutter 3d drawing

APPENDIX B: Analysis Data

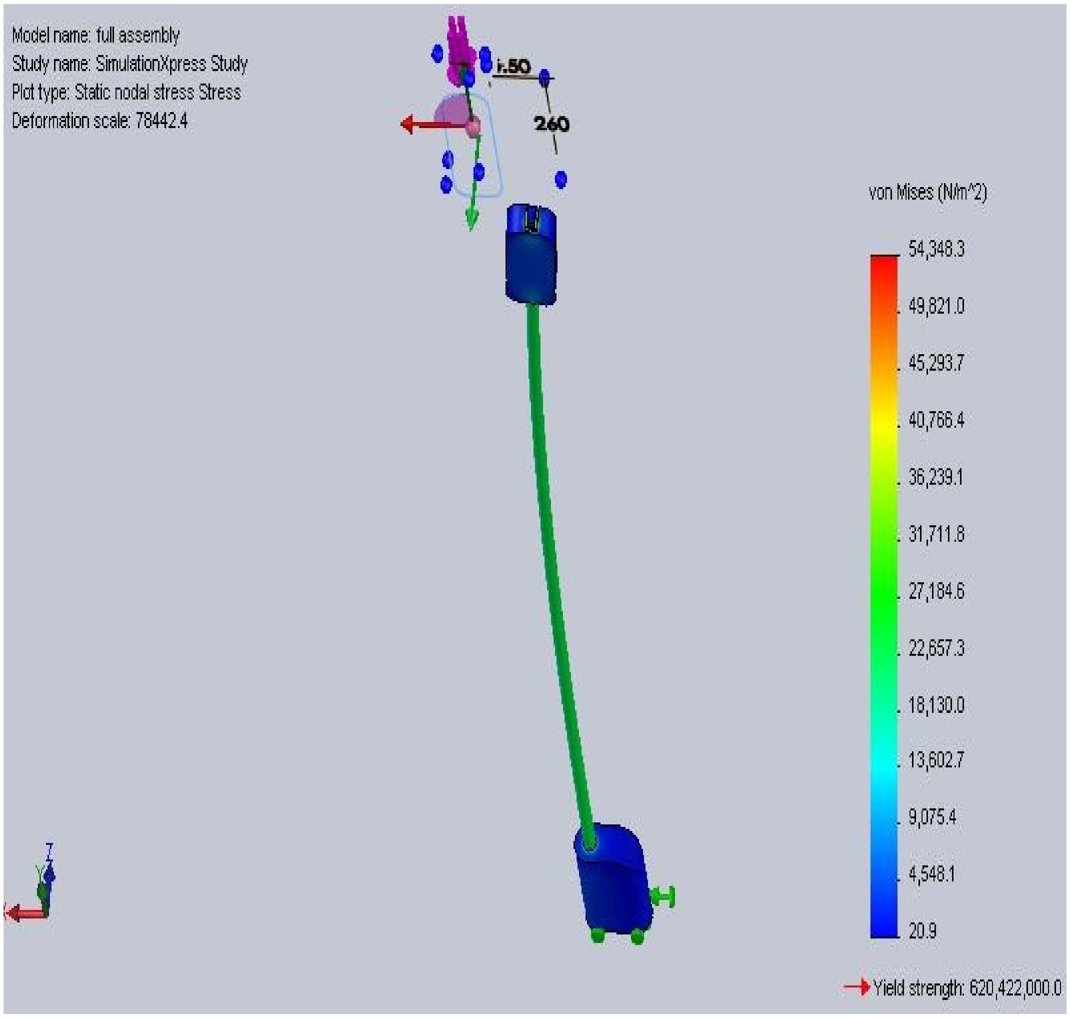

Figure 6.7: Stress analysis result

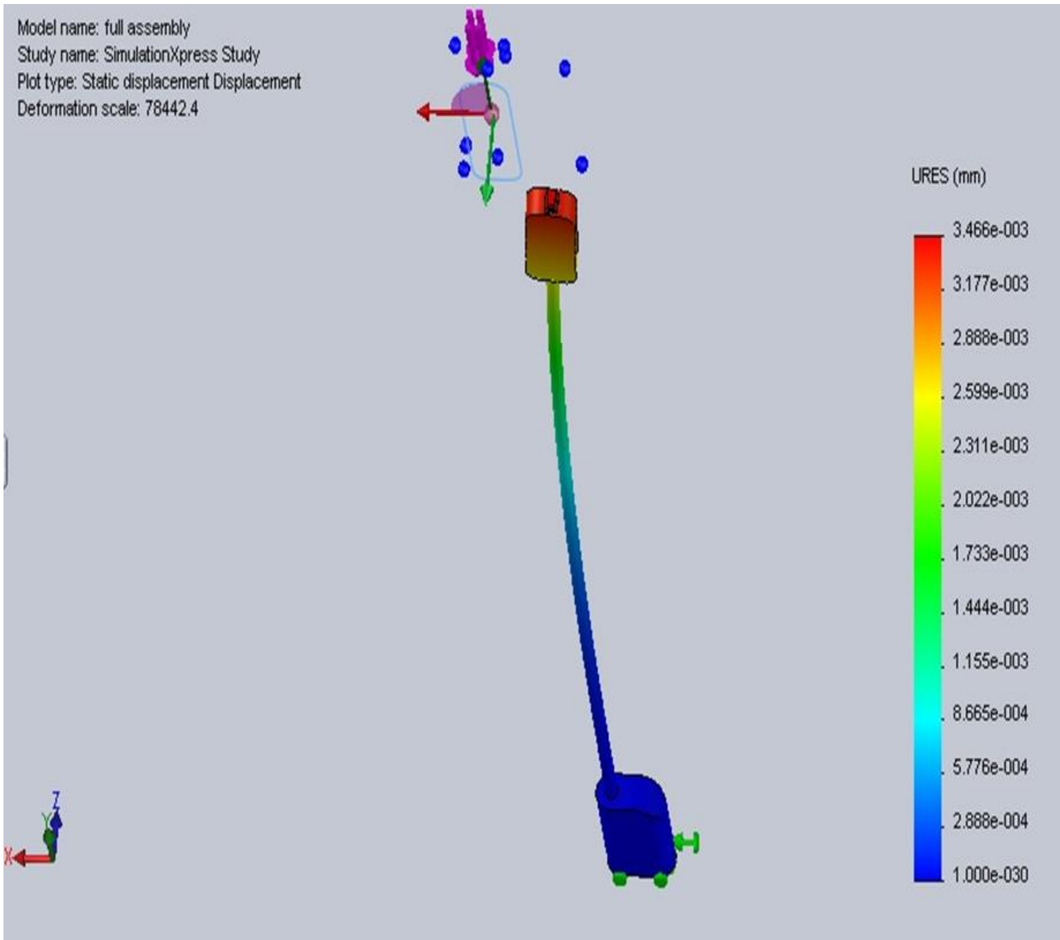

Figure 6.8: Displacement analysis result

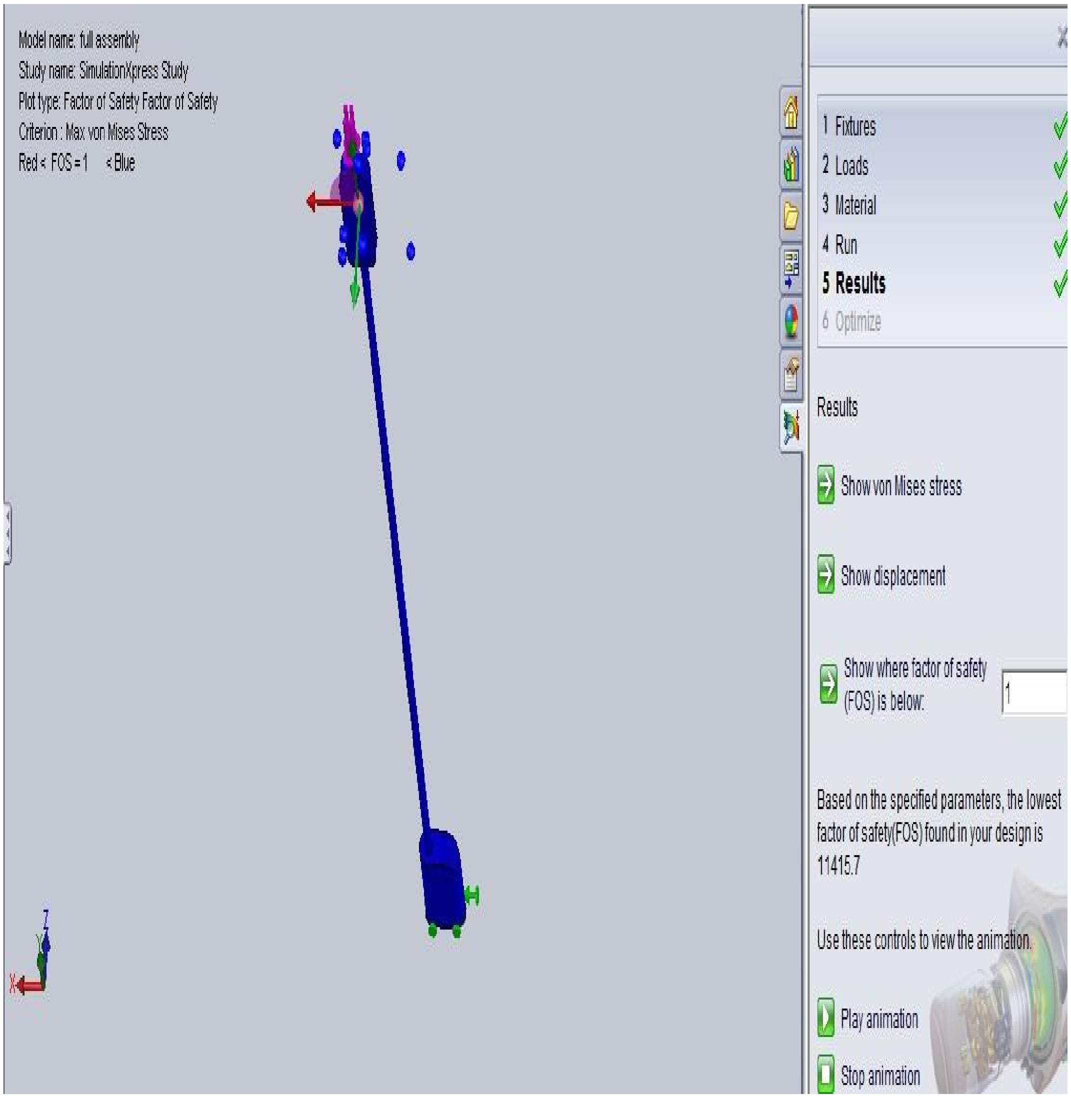

Figure 6.9: Factor of safety analysis

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