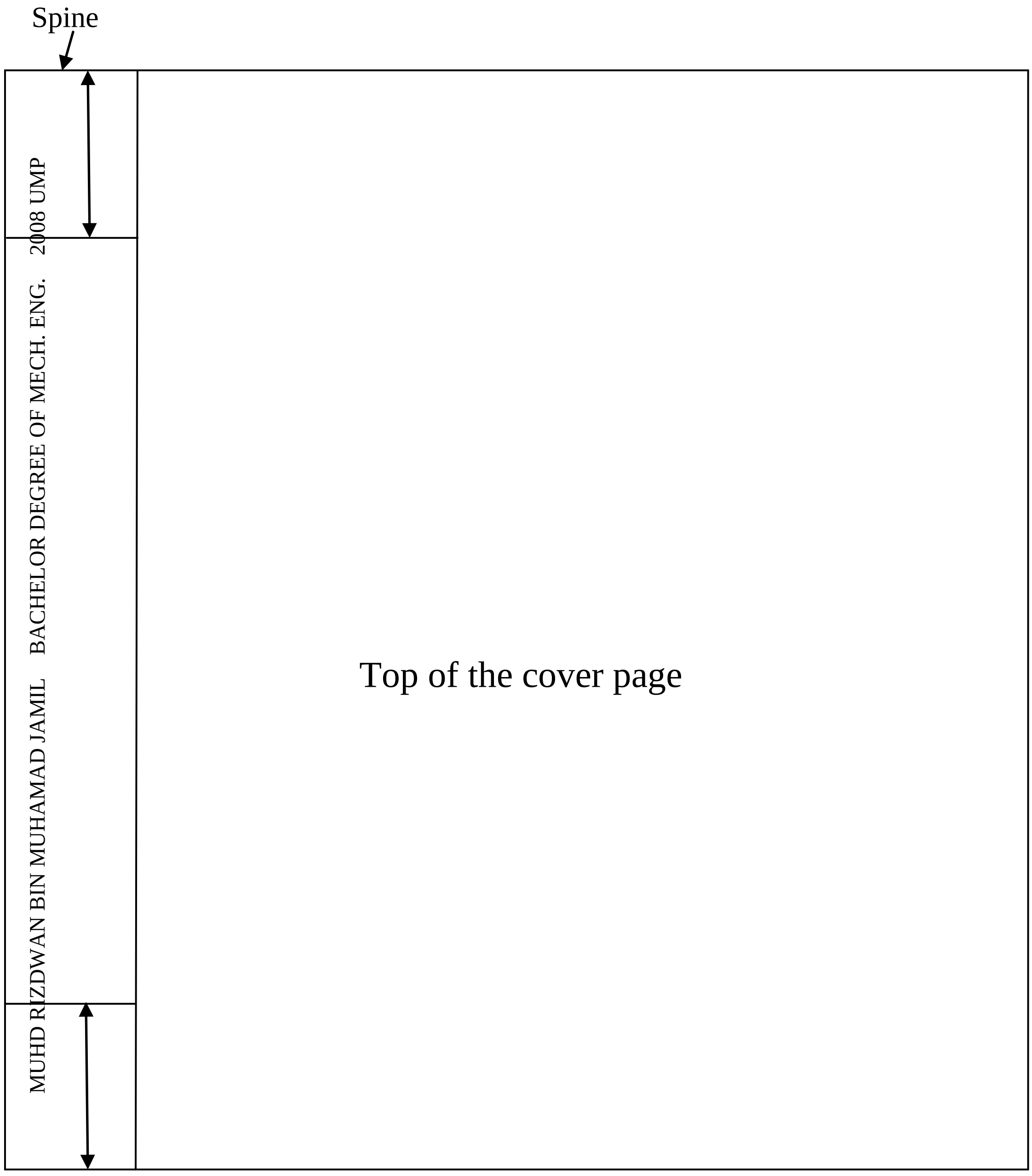
DESIGN AND FABRICATE THE PROTOTYPE OF A MOTORIZED CUTTER FOR HARVESTING PALM FRUIT

MUHD RIZDWAN BIN MUHAMAD JAMIL

UNIVERSITI MALAYSIA PAHANG

APPENDIX A2

SAMPLE OF THE SPINE



MUHD RIZDWAN BIN MUHAMAD JAMIL

BACHELOR DEGREE OF MECHANICAL ENGINEERING

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DESIGN AND FABRICATE THE PROTOTYPE OF A MOTORIZED CUTTER FOR HARVESTING PALM FRUIT

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A report submitted in partial fulfillment of the requirements

of the award of the degree of

Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

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NOVEMBER 2008

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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Name of Supervisor : …………………………………………………

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Position : ………………………………………………….

Date : ………………………………………………….

CANDIDATE'S DECLARATION

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

Signature : ………………………………………………

Name : MUHD RIZDWAN BIN MUHAMD JAMIL

ID Number : MA06110

Date : ………………………….

DEDICATION

To my beloved mother and father

Muhamad Jamil Bin Afandi

Saripah Bte Ramin

To my beloved family and friends

ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor Mr. Zamzuri Bin Hamedon for his germinal ideas, invaluable guidance and continuous encouragement. I appreciate his consistent support from the first day I applied to graduate program to these concluding moments. I am truly grateful for his progressive vision about my training in this thesis, his tolerance of my naïve mistakes, and his commitment to my future career.

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ABSTRACT

Nowadays, agriculture especially palm fruit have some problem such as how to increase the productivity and profit, how to reduce the cost and how to solve the problem come from foreign workers. A new motorized cutter specifically designed for palm trees was designed and developed. It comprises three criterions, easy to fabricate, low cost and light weight. By using design and fabricate the mechanical cutter, the entire problem can solved easily. There are some procedures to solve this problem such as design using several concepts, sketching and modeling the design, fabricate the prototype using suitable material and test the functioning of this machine. So the objectives are to design and fabricate the prototype of motorized cutter for a harvesting palm fruit.

ABSTRAK

Pada masa sekaranag, agrikultur terutama kelapa sawit mengalami beberapa masalah seperti bagaimana untuk meningkatkan pengeluaran dan keuntungan, bagaimana untuk mengurangkan kos dan bagaimana untuk menanggani masalah yang berpunca daripada pekerja asing. Pemotong bermotor yang baru telah direka dan dibangunkan untuk pokok kelapa sawit. Ia merangkumi tiga ciri iaitu mudah direka, kos yang murah dan beban yang ringan. Dengan merencana dan mereka pemotong bermotor, segala masalah di atas dapat diselesaikan dengan mudah. Dengan beberapa prosedur untuk menyelesaikan masalah seperti merencana menggunakan beberapa konsep, lakaran dan permodelan, mereka model menggunakan bahan yang sesuai dan menguji kelancaran mesin ini. Oleh itu, objektifnya adalah merencana dan mereka model pemotong bermotor untuk menuai buah kelapa sawit.

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LIST OF SYMBOLS

%	Percent
ϕ	Diameter
°C	Degree Celsius
j_p	Total number of primary joints
j_h	Total number of higher order joints
θ	Angle
γ	Angle
Δ	Difference of range
mm	Millimeter
cm	Centimeter
kg	Kilogram
min	Minute
sec	Second
K	Kelvin

LIST OF ABBREVIATIONS

MPOB	Malaysian Palm Oil Board
RMK 9	Rancangan Malaysia Ke-9
SRC	Single Rope-and-Cutlass
DRC	Double Rope-and-Cutlass
BPK	Bamboo Pole and Knife
APK	Aluminum Pole and Knife
CAD	Computer Advance Drawing
rpm	Revolution per hour
FAMA	Federal Agriculture Marketing Authority
MARA	Majlis Amanah Rakyat
MARDI	Malaysian Agricultural Research and Development Institute
FELDA	Federal Land Development Authority
FELCRA	Federal Land Consolidation and Rehabilitation Authority

CHAPTER 1

INTRODUCTION

1.1 Background

Argriculture can define as the science, art, and business of cultivating soil, producing crops, and raising livestock or farming. Nowadays, agriculture are the new field that can give many advantages and benefits to our life especially to our economy, politics and social. There are many parts in agriculture such as coconut fruit, pineaplle, palm fruit, livestock and farming. For the new focus is on palm fruit which is Malaysia want to produce own bio-chemical that can use for fuel and any application for the consumer. Now, production in petroleum are decrease. Beside that, from BBC News on September 2008, Malaysian price for 1 litre petrol is RM 2.30 [5]. That why Malaysia focus on this palm fruit because many researchers from this country and outside believe this fruit is usefull which is can use as a fuel and can take place from petroleum.

In agriculture, there are two major input especially palm fruit which are machinery and labour (MPOB Information Series June 2007) [3]. The main objective from this input is maximizing the profit, productivity must increase and the cost must reduce. From that, the conclusion is machinery can maximizing the profit, increase productivity and reduce cost. One of the important activities in palm fruit cultivation is harvesting. Harvesting is the act of removing a crop from where it was growing and moving it to a more secure location for processing, consumption or storage. The major factor to determine the time of harvest is the maturity of the crop. The other factor is weather, availability of harvest equipment, picker, packing and storage facilities also transport which is important consideration [7].

From MPOB Information Series June 2007, this harvesting operation requires 60% of total labour for the crop which constitutes about 50% of the total production cost [3]. It is well known that the agriculture sector in Malaysia in general and the palm fruit industry in particular depends very much on labour especially foreign labour to function in production. From this foreign labour, our country can get many problem such as social problem deu to reduction of foreign labour and much of money draining out to other country [1]. Data from the Satistics and Labour Departmentrevealed 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 (MPOB webpage)[10]. 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 important ones is safety to the operator.

The main objective for this project is to design and fabricate the suitable mechanical cutter for harvesting. To achieve this objective there are several machines such as mechanical ladder, mini crawlers harvester and telescopic crane (manufacture and developed by MPOB and outside researcher)[11]. But all this machine have their own problem such as high cost and still use many workers. But there are two version machine that can use as reference to achieve the objective for this project. But this reference machine must developed by this project to solve the problem. The problem for this reference machine is high cost which is RM5000 per unit (MPOB Information June 2007)[3] and not flexible to high and low harvesting. So the new design for this mechanical cutter must in term of low cost which is below RM1500 and flexible to high and low harvesting.

There is the two reference machine for harvesting. The first version of mechanical cutter develope by Abdul Razak Jelani et al. His mechanical cutter have been follow several criteria such as the cutter should be easy to handle and effiecient and should improve productivity. It must be able to minimize fatique to the worker during the cutting operation. The usual criteria for harvesting from palm of more than 3 meters high is attached a sickle into a pole. Many effort have been expanded in developing various type of cutting devices but the manual method still remains as the most effective way of harvesting. The sickle with its curve design could effectively get access to the fronds as well as the bunch stalks during the harvesting process. In this invention, the sickle is still used as the cutting device however the cutting operation is executed mechanically [9].

For harvesting, the vibrating action method can be adopted to this new design of mechanical cutter. Whereby the vibrating action is transferred to a vertical direction so that the cutting operation can be performed vertically. A vibrating mechanism has been selected and can vibrate at high speed in the longitudinal direction of the pole's axis. The vibration is developed by an oscillating mechanism which is a pair of bevel gears. The rotational movement from the engine is trasmitted by a cable to these bevel gears to create the rapid vibration of the sickle along the pole's axis. The speed of vibration can reach up to 3000 cycle per minutes (MPOB Information Series June 2003)[3].

A special cutter has been designed and developed to fit into the vibrating mechanism for efficient cutting. To minimize vibration transfer to the operater is at the centre of cutting at the cutter was made in line with the axis of the vibrating mechanism. This mechanical hand-held cutter consists of a special cutter, a pole and a petrol engine of 23.6 cc which is two stroke. Its light weight of only 5.5 kg makes it easy to be carried and handled. Most of the component are mae of aluminum alloy that contributes to its lightweight [9].

The second version of the cutter also developed by the same person. This new mechanical cutter is for taller palm of 8 meter height. The machine employs similar to the first version with same cutting head and engine. A curve sickle is still used together with the specially designed vibrating mechanism for the sickle to cut. The only difference is it has a 5.60 meter composite pole which is lighter than the aluminum pole. There are two consideration in design the new cutter which is weight and stiffness. A good cutter must be light weight and have a stiff pole for easier handling and control especially when harvesting tall palms of above 6 meter. A weight of more 10 kg would be heavy and difficult to lift. Similarly with flexibility of the pole which is too flexible would make handling difficult [14].

For the new design, the chainsaw engine is use as a source for vibrating mechanism. The chainsaw engine is selected because the price for 1 unit engine is about RM800. From the source, the same concept like movement of piston and crank shaft in car engine is use to transmitted the rotational movement from the engine to the sickle. The rotational movement from the engine is trasmitted by a two cranks which connected with a small pin. These pin will connected to the lower section of shaft. The shaft can be devided into 3 parts which are lower and upper section and the transferred shaft. The lower section contains a pin connected to the crank and the set of linear bearing which allowed the movement in longitudinal direction of the pole’s axis. Also for the upper section contains a set of linear bearing and the sickle connected with the screw. This linear motion make the rapid vibration of sickle along the pole’s axis. From this new design, hopefully the problem such as high cost and flexible can be solve easily.

1.2 Problem Statement

In Rancangan Malaysia Ke-9 (RM9) where agriculture becomes the new focus which can give many advantages and benefits especially to our economy, politics and social. Palm fruit is one of the new targets in agriculture where still not much researchers and manufactures participate in this field. From that there are some problems arise such as how to maximizing the profit, how to increase productivity and how to reduce the cost. One of the important activities in palm fruit is harvesting. This harvesting operation requires 60% of total labor where some of the workers are foreign Labour. The problems with foreign labor are increase the social problem in our society and increase the money draining out to other country. So the ideas to reduce the dependent on workers in this harvesting, this project comes to solve all this problems where the new invention for machinery in harvesting which able to reduce the workers. By using the tools like machinery, the dependent on the foreign worker can be reduce, productivity can be increase, the cost can be reduce and the profit can be increase. From that, the main objective for this project is to design and fabricate the prototype of a motorized cutter to harvest palm fruit for commercial used can achieve.

1.3 Objectives

1.3.1 To design the prototype of the Motorized Cutter for Harvesting Palm Fruit.

1.3.2 To fabricate the prototype of the Motorized Cutter for Harvesting Palm Fruit.

1.4 Scope of Study

1.4.1 Literature study/ review

i. Make the review about other research and study relevance to the title.

1.4.2 Design

ii. Design the prototype of motorized cutter for a harvesting palm fruit using some criteria such as low cost.

1.4.3 Material Selection

iii. Select suitable material, components and parts for this new invention.

1.4.4 Fabrication

iv. Fabricate the prototype of motorized cutter for a harvesting palm fruit using suitable process and concept.

1.4.5 Documentation

v. Preparing a report for the project.

1.5 Significant of Study

This study is to design and fabricate machinery which can reduce dependent to workers especially to foreign worker which give many effect to our country such as social problem and much of money draining out to other country. To design and fabricate this machine, there are several criterion are selected such as easy to fabricate, low cost in long term, and can harvest high and low palm fruit.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Agriculture is the art and science of crop and livestock production. In its broadest sense, agriculture comprises the entire range of technologies associated with the production of useful products from plants and animals, including soil cultivation, crop and livestock management, and the activities of processing and marketing. Many different factors influence the kind of agriculture practiced in a particular area. Among these are climate, soil, and water availability, topography, nearness to markets, transportation facilities, land costs, and general economic level. The primary agricultural products consist of crop plants for human food and animal feed and livestock products. Nowadays, palm fruit is part of the famous agriculture which can product a lot of product from it. For example like oil, soap, butter, cream and cheese.

2.2 Palm Fruit

The palm fruit is a tree without branches but with many wide leaves at its top. It has become the world's number one fruit crop because of its unparalleled productivity. Generally, for fruit crops, the majority of the mechanical harvesting systems utilized today are shake-catch systems. Each tree is visited for harvesting every 10 – 15 days as fruit bunches ripen throughout the whole year. The stalks of the palm fronds underlying a bunch are first cut, after that the stalk of the bunch is cut and it is allowed to fall freely onto the ground. Harvesting schedule will depend on the ripening of fruits as observed on plantations. When a fruit is fully ripe, it loosens itself from the bunch and drops on the ground or it becomes easily detachable (C. Nwajiuba et al) [6].

Figure 2.1 Palm Fruit Tree and the Parts of Palm Fruit

Source: http://www.answers.com/topic/oil-palm

2.3 Harvesting

In agriculture, harvesting is the process of gathering mature crops from the fields. Reaping is the harvesting of grain crops. The harvest marks the end of the growing season, or the growing cycle for a particular crop. Harvesting in general usage includes an immediate post-harvest handling, all of the actions taken immediately after removing the crop—cooling, sorting, cleaning, packing—up to the point of further on-farm processing, or shipping to the wholesale or consumer market.

2.4 Previous Method of Harvesting

The previous method to harvesting, the criteria of design and the recommended design are the issues frequently mentioned in the literature (D.A. Adetan, L.O. Adekoya and K. A. Oladejo Department of Mechanical Engineering) [7].

Locally, short trees within arm-reach are harvested using either the cutlass or the chisel to cut the bunches and fronds. On the other hand, very tall trees above 9 m in height are harvested using high technology machinery. There are two methods in harvesting which is the single rope-and-cutlass (SRC) or the double rope-and-cutlass (DRC) method. The SRC method is more common because it is relatively much faster though less safe. In this method, the harvester manually climbs the tree by the use of a rope tied around the tree and his torso. When arm-reach of the crown, the harvester uses a cutlass to cut the fronds and bunches. Medium-height trees beyond arm-reach up to a height of about 9 m are harvested using the bamboo pole and knife (BPK) method [12]. In this method, a Malaysian knife, which is a curved knife with the sharp edge along its convex side, is attached to the end of a bamboo pole. The length of the pole depends on the average height of the trees on the plantation plot to be harvested. The harvester stands on the ground while the pole and knife are raised to the tree crown in order to harvest the bunches.

Yet another method is the Aluminum pole and knife (APK) method. In this method, a 40 mm diameter aluminum tube replaces the bamboo pole of the BPK method. It works very well and even faster than the BPK method for trees of height below 5.5 meter. Above this height, bending of long harvesting poles that carry relatively heavier cutting knives on top constitutes a very serious problem as it becomes very difficult to engage the stalks of palm fronds and bunches. Indeed, a lot of time and energy (and therefore production cost) goes into oil palm harvesting. Such an enormous amount of energy is required for harvesting oil palm that even cutting a single frond alone, using the sickle cutter (the Malaysian knife), could require the exertion of a force as much as 18,048 N for the most matured frond (Jelani et al., 1999) [2].

Harvesting from the older trees took more man-days. The situation, most likely, has not changed today because harvesting is still being done manually. Many attempts have been made to reduce the drudgery of the harvesting of oil palms. Webb (1976) worked on an oil palm tree climbing cycle. Test results showed that the cycle was not efficient for palm trees and it was not comfortable for the harvester to use. A lot of energy and time was required by the method. Pierce and Cavalieri (2002) opined that improving Labour productivity, health and safety represents a major opportunity for reducing production costs. Also, the report by Adetan and Adekoya (1995) [7] further established that because climbing before cutting substantially reduced the SRC harvesting rate and that much risk (including fatal falls) is involved in climbing, the pole-and-knife method is both faster (more productive) and safer than the rope and-cutlass method. Thus the report recommended that research effort should preferably be directed towards improving the pole-and-knife method by redesigning the harvesting pole to reduce its weight, minimize bending and increase the ease of its transportation.

2.5 References Machines

2.5.1 Mechanical Ladder (Three Wheeler Ladder)

Figure 2.2 Mechanical Ladder

Source: MPOB webpage, http://mpob.gov.my/

This machine can reach up to 6m height palm fruit tree. After harvest the palm fruit will falls to ground to be collected manually. The productivity for this machine is about 5-7 ton/day. There is some advantage for this machine which is can harvest near the fruit which we can choose the fruit. Beside that, the disadvantages for this machine are still using human energy and high cost and heavy.

2.5.2 Telescopic Crane

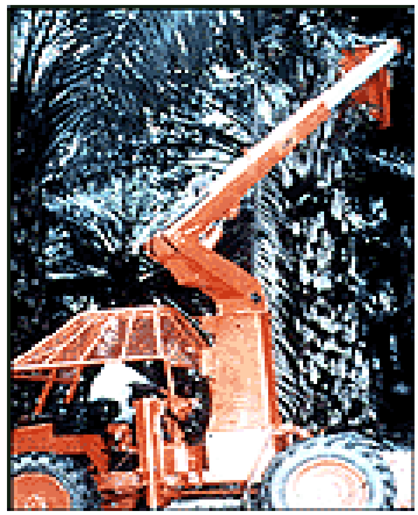


Figure 2.3 Telescopic Crane

Source: MPOB webpage, http://mpob.gov.my/

Telescopic crane fitted with a bucket at the end in which the cutter stands. The harvesting cutting is done manually. This machine fitted with stabilizers hence become slowly in operation. The productivity is about 5-8 ton/day. The advantages are heavy duty work environment and flexible to height and low tree and the disadvantages are still using manual harvest and high cost.

2.5.3 Omarv

Figure 2.4 Omarv

Source: MPOB webpage, http://mpob.gov.my/

This machine is an Italian design which a platform can enclose the palm trunk and can be raised up to 10m. A manual cutter stands on this platform using a cutting tool to cut the ripe bunch. The palm fruit will drop onto the platform. As the platform lowers to move to other palm tree, the palm fruit is then dropped into a container. The advantages are automatic collected and can enclose to the tree easily and the disadvantages is still using manual cutter and high cost.

2.5.4 Cantas

Figure 2.5 Cantas

Source: http://www.jariz.com.my/

This designed is for palms lower than 4.5 meter high. It employs a specially designed sickle. This machine use vibrating mechanism to perform the cutting operation mechanically. This machine powered by a 2-stroke petrol engine, it is equipped with a telescopic pole and a cutting head. The advantages are telescopic and less force needed to harvest and the disadvantages is high cost.

2.6 Selection of Criterion

To design and fabricate this mechanical cutter, there are some selection criterion which is easy to fabricate, low cost in long term and flexible to harvest high and low palm tree. The meaning of easy to fabricate is this design must selected the suitable fabricate activity which is simple and not take long time to produce 1 units of this machine.

The next criterion is low cost in long term. To produce this machine the important factor is about the cost. The machine available in the market has cost problem which the farmer in the estate is difficult to buy the machine which can help them to harvest the palm fruit. So to help this kind of farmer, the lower price for the mechanical cutter which can help this kind of farmer will produced.

The last criterion is flexible to harvest high and low palm tree. In Malaysia, the average palm tree height is about 4 to 8 meter. So, this machine must be flexible to harvest in this average height.

2.7 Advantages and Disadvantages of Harvesting with Machinery

This mechanical cutter can gives advantages to these 3 aspects which are to the worker, to the estate and to the country. The advantages to the workers are the workers can reduce the manual energy to harvest the palm fruit and can increase the income to the workers. Beside that, the workers also can increase the operational area to harvest and can improve the productivity.

The advantages to the estate are can improve the productivity and can reduce the labor requirement to this harvesting activity. The other advantages are can reduce the cost in production of this palm fruit and also can reduce the social problem due to reduction of foreign workers.

To the country, the advantages are can reduce the foreign labor in this country, can reduce the social problem that’s cause by foreign labors and can reduce money draining out to others country. Beside that, this machine also can introduce our country to the world in collaboration with foreign manufacture.

The disadvantage using this technologies in harvesting activity are the opportunities for the local workers become small and can increase the rate of unemployment people in Malaysia.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In order to complete a research, methodology is the one of the most important thing to be considered to make sure that the thesis run smooth and will get expected result which is needed. Methodologies also use to determine the research follow the objective that had been stated earlier or in the word to follow the guideline based on the objective.

In methodology, the structure of the research is a significant thing that should be considered. Methodology also can be described as a framework of the research that contains the element elements of work based on the scope of works and objectives. Frameworks also use to facilitate the supervisor to view the overall process of the research. Any mistaken or default can be correcting and adding the elements which lacking in the research.

This methodology contain the topics such as general flow chart, flow chart for PSM 1 and PSM 2, Gantt chart for PSM 1 and PSM 2, literature review about the title, design the motorized cutter, material selection which suitable to the design, fabrication the prototype of the motorized cutter, verification the prototype and documentation about the thesis.

3.2 Flow Chart

3.2.1 Flow Chart for PSM 1 (Refer Appendix A1)

3.2.2 Flow Chart for PSM 2 (Refer Appendix A2)

3.3 Gantt Chart

3.3.1 Gantt chart for PSM 1 (Refer Appendix A3)

3.3.2 Gantt chart for PSM 2 (Refer Appendix A4)

3.4 Flow in Methodology

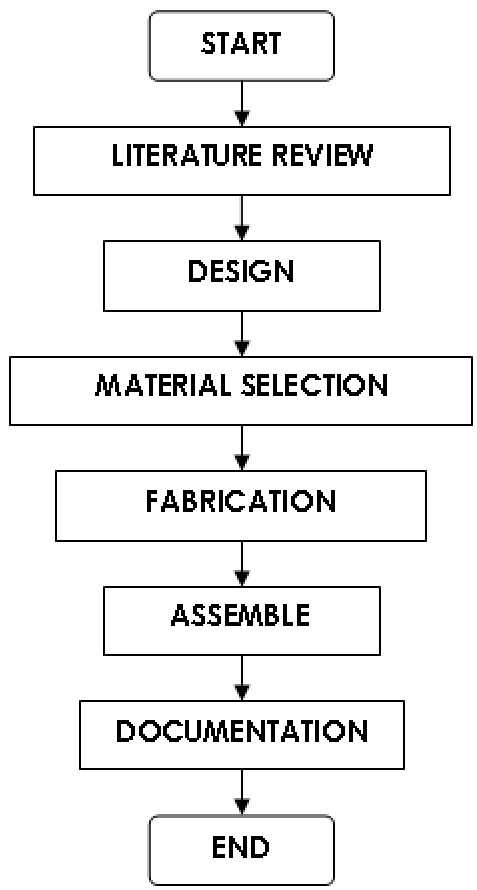


Figure 3.1 Flows in Methodology

3.4.1 Gathering the Literature Review

To start this project, it is important to understand the title of the project which is Design and Fabricate the Prototype of a Motorized Cutter for Harvesting Palm Fruit. The scope and the objective of this project also the important thing to consider and comprehend properly. So, in order to get the correct and precise information to complete this project it is important to get the right source of information in doing the literature review. The information which gets from the certain source must be accurate and useful to this project. There are the certain methods to get information in order to complete the literature review.

a) Browsing the internet
b) Books
c) Discussion with supervisor

i. Browsing the Internet

Internet is the one of the most important source to make the literature review and to complete this project. It became the main source due to the information regarding to this title widely spread at the internet. But not all the information from the internet is perfect information. To avoid this problem, the believe side such as internet journal from Science Direct is use to get the majority information to the literature review. For example website that being referred is MPOB website. From this website, the information about the palm fruit and related information can be founded easily.

ii. Reference Books

The related information about the title which is Design and Fabricate the Prototype of a Motorized Cutter for Harvesting Palm Fruit also getting from reference books. The information is getting from the references books is believable because the books is written by professional person such as professor outstanding researcher. For example title of book that being referred is Machines and Mechanism, 3rd Edition. From this book, the design consideration for this machine can be founded easily.

iii. Discussion with supervisor

Even the information is getting from the internet and the books is enough; discussion with the supervisor also important to make sure that the information which had gathered from the books and the internet is correct and useful to the project. Correct information is important because valid data come from the accurate information. Furthermore with the discussion can generate new ideas and exchange of thought about the research so that the title of the research can be more clear and understandable. To produce the perfect design, the information gathered from the internets and the books will be discussed with the supervisor.

3.4.2 Define Objectives

After getting the correct information from literature review, this title must define the main objective. From perfect information, knows that nowadays in agriculture especially palm fruit is depending on the workers to do some works. From these workers, the company can gain maximum profit and maximum productivity. Beside that, there are some problem come from this workers such increase the social problem. So, the objective is to reduce the workers but to reduce this problem, this project must achieve the main objective which is design and fabricate the prototype of a Motorized Cutter for a Harvesting Palm Fruit. From this main objective, this project can solve all the problems includes the workers problem, maximize the productivity and profit, and reduce the cost problem.

3.4.3 Design

To start the design for this prototype of a Motorized Cutter, this paper must define the suitable concept for this machine. The suitable concept for this machine can define from the accurate information in literature review before. This motorized cutter are selected several suitable concept for this prototype such as bevel gear concept, cam concept, cylindrical cam concept, and crank and piston concept. All of these concepts are the concept to transmit the rotational movement into linear movement. After selected several concept, this motorized cutter choose the suitable concept for this new invention using several factor such as simply, easy to fabricate, heavy duty and low cost. After select the suitable concept, these motorized cutters start to sketch the machine using selected concept and make the 3 Dimensional Models for the sketching model using Solid works software.

i. Conceptual Design

a. Bevel gear

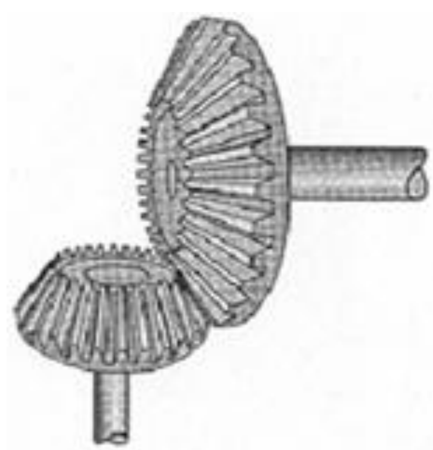


Figure 3.2 Bevel Gear

Source: Gear Manufacture webpage

Bevel gear (Figure 3.2) is a pair of gears with teeth surfaces cut so that they can connect unparallel gear shaft. Example application for this bevel gear is hand drill. As the handle of the drill is turned in a vertical direction, the bevel gear changes the rotation of the chuck to a horizontal rotation. For this project, the machine must get the linear movement from rotational movement. So that, combination bevel gear concept with piston and crank shaft concept can give the required movement for this machine. But this motorized cutter application needs enough force to cut the bunch of the palm fruit. So, this combination concept must in solid housing which can reduce the losses force from engine to the sickle. This idea is a perfect idea but the technical problem to manufacture the solid housing make this idea not suitable to this project.

b. Cam concept

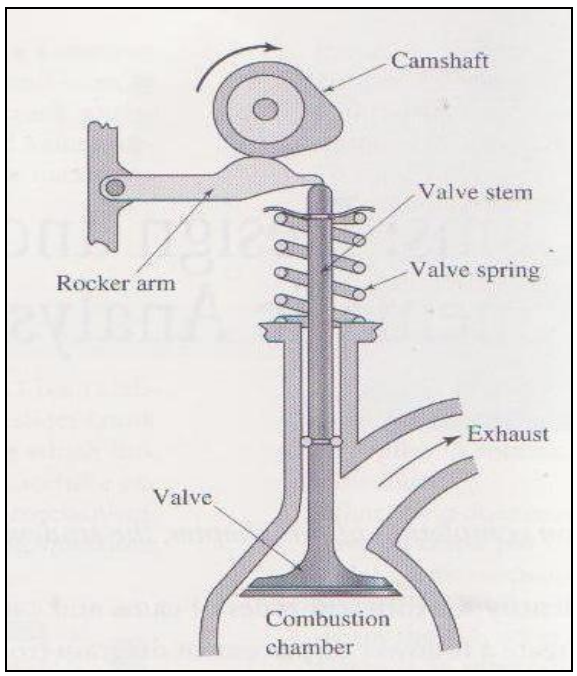


Figure 3.3 Cam concept

Source: Machines and Mechanism, 3rd Edition

A cam is a common mechanism element that drives a mating component known as a follower. The cam accepts an input motion similar to a crank and imparts a resultant motion to a follower. Example application for this concept is in valve train of an automotive engine (Figure 3.3). The camshaft is driven by the engine. As the cam rotates, a rocker arm drags on its oblong surface. Then, the valve can move on linear axis same like what this machine want which is linear movement from rotation movement. But the problem for this concept which is this concept is very simple and not suitable for this heavy duty harvesting activity.

c. Cylindrical cam concept

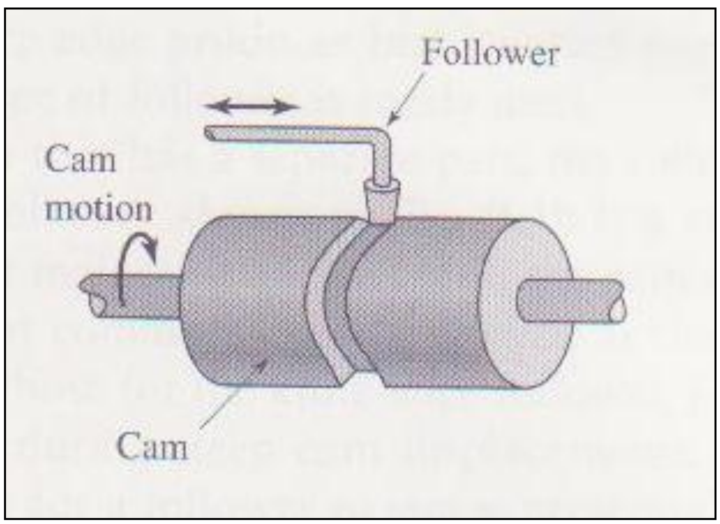
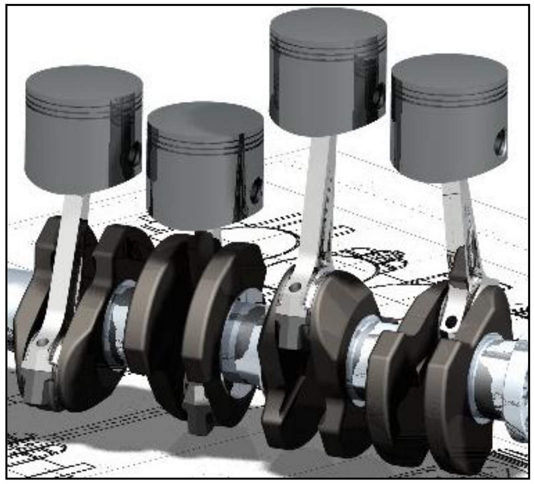


Figure 3.4 Cylindrical cam concept

Source: Machines and Mechanism, 3rd Edition

This type of concept is formed on a cylinder. A groove is cut into the cylinder which varies along the axis of rotation. Attaching a follower that rides in the groove gives the follower motion along the axis rotation. But the problem for this concept same like the problem comes from bevel gear concept which is difficult to manufacture.

d. Crank and piston concept



Source: http://auto.howstuffworks.com/engine_movement.htm

For this concept, this paper only use reverse concept with difference application. The movement at bottom crank shaft is rotation movement but the movement at the piston is linear movement. So that, the concept for this crank shaft and piston is adapted to this motorized cutter for harvesting palm fruit.

3.4.4 Decision

From all 4 concept which are bevel gear concept, cam concept, cylindrical cam concept, and crank and piston concept. The suitable concept which can adapt for the required movement for the motorized cutter is crank and piston concept. This machine choose this concept because this only this concept fulfill the criteria selection for this machine which is simple, low cost, heavy duty and easy to manufacture. Adaptation from this concept to the chain saw machine also make this new invention selected this concept.

3.4.5 Sketching

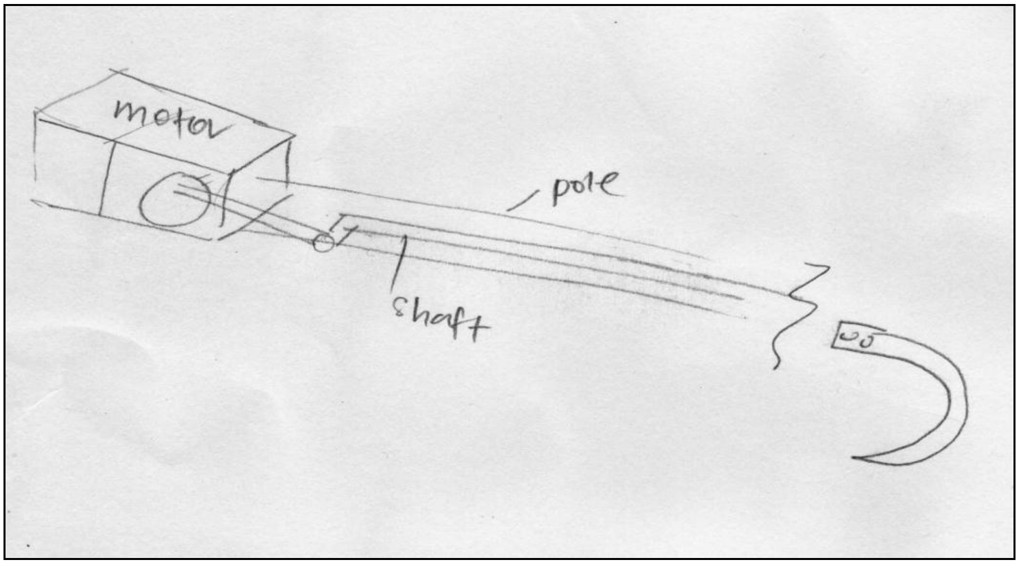


Figure 3.6 Machine Sketching

Firstly, identify the suitable engine and pole. From discussion with supervisor, the suitable engine for this harvesting activity is chainsaw engine. This machine chooses this engine because the price for this engine is less then the price for the engine which use in the reference machine. For the pole, this paper choose aluminum pole because this pole is easy to find and low cost. Base on this two main component which is the chain saw and the pole, the idea developed by sketching the new invention for this mechanical cutter. All the sketching for this machine is shown at the Appendix B

3.4.6 3D Modeling

After complete sketch for this new invention, the next stage is transferred the sketching in 3 Dimension Model using CAD software. Appendix B showed the 3D model and engineering drawing for this prototype of a Motorized Cutter for Harvesting Palm Fruit. All the 3D drawing for this machine is shown at the Appendix B.

3.4.7 Material Selection

There are three standard parts in this new invention of mechanical cutter which is sickle, chain saw and pole. These three standard parts selected because these parts is suitable to the selected concept which is movement of piston and crank shaft concept in car engine. This new invention of mechanical cutter choose the aluminum pole because this part is light in weight, easy to fabricate and widely available. The selected of chain saw as the source of this mechanical cutter and the sickle as a cutting tools is because this chain saw and the sickle can work in heavy duty environment.

3.4.8 Fabrication

In this process, suitable machining processes for all components are firstly defined. Then every machining process to be use in making all component must be learn before making any machining. This is to ensure safety and gather knowledge about every machine function and limitation. The training of the machine will be supervised for safety. After that every component will be machine according to suitable machining process. This process will guide by the engineering drawing. After all parts and component are ready, assembly process is next. Before that, the finishing process of the component is done. This to ensure the dimension is match with the engineering drawing. All the assembly is base on engineering drawing. The assembly start with the simple and small system before goes to bigger system. Then all system is assembling carefully.

3.4.9 Documentation

After all lengthy process, this is time to finalize the final report. All the activities will be document in thesis form. All the report material will be arranged neatly according to guideline gave by the University. This process includes the making of proposal, proposal presentation, final presentation and document all the report material to book form. This process includes the making of proposal, proposal presentation, final presentation and document all the report material to book form.

3.5 Significant in the Methodology

3.5.1 Design

In this chapter, the important part is in design because this machine must be compliance to several aspects. The design consideration must be done carefully so the design can be fabricated and the system functioning. The aspects that must be considered in designing the machine are:

i. Strength: The toughness of the cranks, shaft and support mechanism will be the most important criteria in designing the machine.
ii. Material: Material availability will be one of the challenges in the design consideration. The most important in material selection is easy to find and suitable to use.
iii. Cost: The cost of the whole machine must not exceeded budget given and must be reasonable. The design cost must also efficient and reduce waste and losses.
iv. Static dynamics: Since the machine is a moving thing, so the design of the system should also consider dynamic effect to the system. This will include all the force that will be acting on it and several others aspect.
v. Functionality: The machine function is an important aspect to make sure the palm fruit can harvest easily.
vi. Weight: weight is one more important aspect to consider in designing this machine so the machine can be easily move and easy to store it.

3.5.2 Material Selection

i. Bill Of Material

Table 3.1 Bill of Material

No	Part	Material	Dimension (mm)	Remark
1	Flywheel	Aluminum	ϕ 82 x 25	Fabricate
2	Base Plate	High Carbon Steel	300 x 115 x 10	Fabricate
3	First Crank	Aluminum	60 x 40 x 10	Fabricate
4	Second Crank	Aluminum	80 x 40 x10	Fabricate
5	Back Shaft	Aluminum	ϕ 32 x 100	Fabricate
6	Front Shaft	Aluminum	ϕ 32 x 200	Fabricate
7	Front Pole Holder	Aluminum	93 x 100 x 50	Fabricate
8	Back Pole Holder	Aluminum	93 x 100 x 20	Fabricate
9	Bearing Housing	Aluminum	ϕ 40 x 60	Fabricate
10	Chainsaw	-	-	Standard Part
11	Bearing	-	ϕ 8 x 5	Standard part
12	Linear Bearing	-	ϕ 21 x 2	Standard Part
13	Sickle	Steel	300 x 300	Standard Part
14	Pole	Aluminum	ϕ 43 x 500	Standard Part
15	Fasteners	Steel	Various Size	Standard Part
16	Thread Rod	Steel	M8 x 350	Standard Part

ii. Material Properties

a) Aluminum

- Aluminum is stable in air and resistant to corrosion by seawater and many aqueous solutions and other chemical agents.
- This is due to protection of the metal by a tough, impervious film of oxide.
- At a purity greater than 99.95%, aluminum resists attack by most acids but dissolves in aqua regia.
- Its oxide film dissolves in alkaline solution, and corrosion is rapid.
- Aluminum is amphoteric and can react with mineral acids to form soluble salts and to evolve hydrogen.
- Mechanical Properties:
    1. Density: 2600-2800 kg/m^3
    2. Melting Point: 660 °C
    3. Elastic Modulus: 70-79 GPa
    4. Poisson's Ratio: 0.33
    5. Tensile Strength: 230-570 MPa
    6. Yield Strength: 215-505 MPa
    7. Percent Elongation: 10-25%
    8. Thermal Expansion Coefficient: 20.4-25.0 × 10^{-6}/K

b) High Carbon Steel

- Also called plain carbon steel, is a metal alloy, a combination of two elements, iron and carbon, where other elements are present in quantities too small to affect the properties
- The only other alloying elements allowed in plain-carbon steel are manganese (1.65% max), silicon (0.60% max), and copper (0.60% max)
- Very strong, used for springs and high-strength wires.
- High-carbon steels typically have high wear resistance due to their superior surface hardness.

3.5.3 Fabrication Part

a) Part 1: Fabrication of Flywheel

Figure 3.7 show the picture of flywheel and the steps to fabricate the flywheel is stated on Table 3.2. The function for this flywheel is to rotate the crank and to move the shaft vertically. Then, below is detail parameter and manufacturing process for this flywheel.

Table 3.2 Steps to fabricate part 1

Step	Operation Description	Tools
Step 1	Lathe External Dimension into ϕ82	Lathe Machine
Step 2	Lathe Internal Dimension into ϕ72	Lathe Machine
Step 3	Cut into length 35 millimeter	Horizontal Bench saw
Step 4	Lathe back surface	Lathe Machine
Step 5	Thread	Thread M8

i. Selected raw material with dimension ϕ100.
ii. Cut the raw material into dimension ϕ100 x 50.
iii. Using lathe machine, make roughing and using vernier calipers, dimension the material.
iv. Lathe the outside diameter into ϕ84 and make finishing for the outside diameter about 2 millimeters.
v. Selected and secured properly the centre drill bit into lathe machine and make the centre drill at front surface.
vi. Selected and secured properly the drill bit size ϕ10 and drill on the centre of hole until 20 millimeters length.
vii. Change the drill bit into size ϕ20 and drill at same length.

viii. Using Boring tool and lathe inside diameter until the dimension is $\phi 74$.

ix. Finishing 2 millimeter for the inside diameter.

x. Roughing and finishing using same dimension like the front work piece at back surface.

xi. Using Horizontal Bench saw Machine cut the work piece into 35 millimeters from the front.

xii. Roughing and finishing the work piece until 25 millimeter using Lathe Machine.

xiii. At the spherical surface of work piece, drill $\phi 7$ for every 90 degree and make thread M8 for each hole.

xiv. Chamfer the sharp edge.

xv. Clean this flywheel.

Figure 3.7 Flywheel

b) Part 2: Fabrication of Base Plate

Figure 3.8 show the picture of base plate and the steps to fabricate the base plate is stated on Table 3.3. The function for this base plate is to support the pole which attach to the chainsaw. Then, below is detail parameter and manufacturing process for this base plate.

Table 3.3 Steps to fabricate part 2

Step	Operation Description	Tools
Step 1	Cut raw material into 300 x 115 x 10	Vertical Bench saw
Step 2	Mark centre holes	Height Gauge
Step 3	Punch centre holes	Puncher
Step 4	Drill $\phi 7$	Drill bit $\phi 7$
Step 6	Thread M8	M8
Step 7	Drill $\phi 10$	Drill bit $\phi 10$
Step 8	Drill $\phi 6$	Drill bit $\phi 6$
Step 9	Drill $\phi 4$	Drill bit $\phi 4$
Step 10	Cut $\phi 70$ hole	Wire EDM

i. To obtain the dimension of the entire centre of holes, reverse engineering using height gauge is used.
ii. Selected raw material with dimension 320 x 120 x 10.
iii. Using Vertical Bench saw machine cut the work piece into dimension 300 x 115 x 10.
iv. Referred to the reverse engineering, mark the entire centre of the drill using height gauge.
v. Punch with puncher to mark entire centre of drill.

vi. Secured properly the drill bit $\phi 7$ into drilling machine. Drill eight holes at specific mark and make thread for each hole with M8.

vii. Secured properly the drill bit $\phi 10$ into drill machine. Drill two holes at specific mark.

viii. Secured properly the drill bit $\phi 6$ into drill machine. Drill four holes at specific mark.

ix. Secured properly the drill bit $\phi 4$ into drill machine. Drill one hole at specific mark.

x. Using Wire Electrical Discharge Machine cut the big diameter which is $\phi 70$ to match with the flywheel. Drawing from AutoCAD software used to generate the programming for this cutting big hole.

xi. Chamfer the sharp edge.

xii. Clean this base plate.

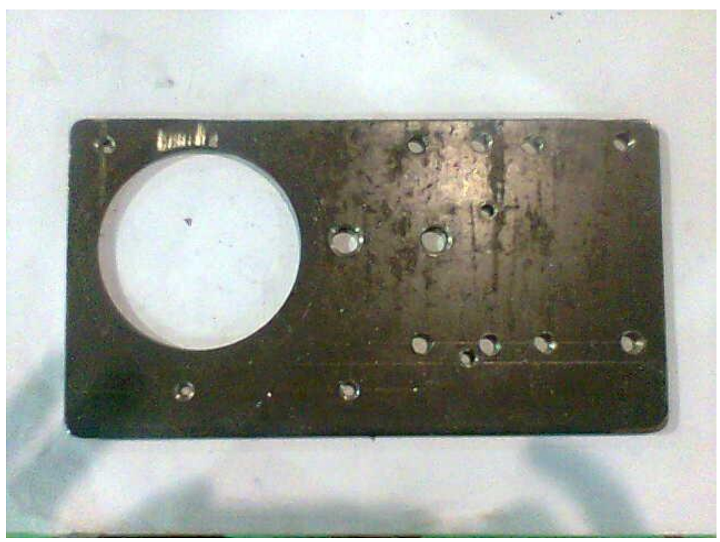


Figure 3.8 Base Plate

c) Part 3: Fabrication of first crank.

Figure 3.9 show the picture of first and second crank and the steps to fabricate the first crank is stated on Table 3.4. The function for this first crank is to make the rotation movement and transfer the toque to the second shaft. Then, below is detail parameter and manufacturing process for this first crank.

Table 3.4 Steps to fabricate part 3

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x 10	Horizontal Bench saw
Step 2	Cut into 60 x 40 x 10	Vertical Bench saw
Step 3	Mark and punch two centre of hole with distance 50 millimeter	Puncher
Step 4	Drill ϕ 10	Drill bit ϕ 10
Step 5	Drill ϕ 18	Drill bit ϕ 18
Step 6	Drill ϕ 20	Drill bit ϕ 20
Step 7	Bearing with inside diameter ϕ 8	Force fit

i. Selected raw material with dimension 100 x 100 x 10.
ii. Roughing and finishing about 2 millimeter each surface using Milling Machine.
iii. Cut the work piece into dimension 60 x 40 x 10 using Vertical Bench saw.
iv. Mark the centre of hole at both side of work piece which is 50 millimeters distance from each centre. Punch with puncher the centre of holes.
v. Secured properly the drill bit ϕ 10 into drill machine. Drill each mark.
vi. Secured properly the drill bit ϕ 18 into drill machine. Drill each holes.
vii. Secured properly the drill bit ϕ 20 into drill machine. Drill each holes.
viii. Force fit the bearing with internal diameter ϕ 8 into each hole.

ix. Chamfer the sharp edge.
x. Clean this first crank.

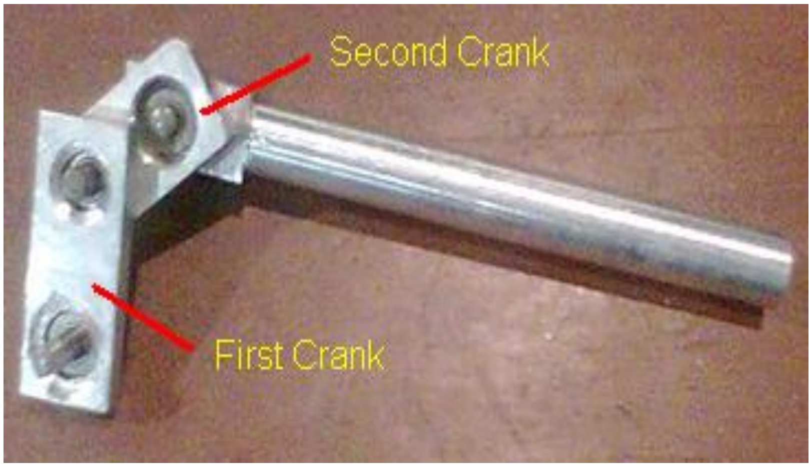


Figure 3.9 First and Second Crank

d) Part 4: Fabrication of second crank.

Figure 3.9 show the picture of first and second crank and the steps to fabricate the second crank is stated on Table 3.5. The function for this second crank is to guide the movement of the shaft. Then, below is detail parameter and manufacturing process for this second cranks.

Table 3.5 Steps to fabricate part 4

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x 10	Horizontal Bench saw
Step 2	Cut into 80 x 40 x 10	Vertical Bench saw
Step 3	Mark and punch two centre of hole with distance 50 millimeter	Puncher
Step 4	Drill ϕ 10	Drill bit ϕ 10

Step 5	Drill $\phi 18$	Drill bit $\phi 18$
Step 6	Drill $\phi 20$	Drill bit $\phi 20$
Step 7	Bearing with inside diameter $\phi 8$	Force fit

i. Selected raw material with dimension 100 x 100 x 10.
ii. Roughing and finishing about 2 millimeter each surface using Milling Machine.
iii. Cut raw material into dimension 80 x 40 x 10 using Vertical Bench saw.
iv. Mark the centre of hole at top and bottom work piece which is 50 millimeters distance each centre. Punch with puncher the centre of holes.
v. Secured properly the drill bit $\phi 10$ into drill machine. Drill each mark.
vi. Secured properly the drill bit $\phi 18$ into drill machine. Drill each holes.
vii. Secured properly the drill bit $\phi 20$ into drill machine. Drill each holes.
viii. Forces fit the bearing with internal diameter $\phi 8$ into each hole.
ix. Chamfer the sharp edge.
x. Clean this second crank.

e) Part 5: Fabrication of back shaft.

Figure 3.10 show the picture of back shaft and the steps to fabricate the back shaft is stated on Table 3.6. The function for this back shaft is to transfer the torque from the chainsaw to the sickle. Then, below is detail parameter and manufacturing process for this back shaft.

Table 3.6 Steps to fabricate part 5

Step	Operation Description	Tools
Step 1	Cut raw material $\phi 50$ x 150	Horizontal Bench saw
Step 2	Lathe until external diameter 20mm	Lathe Machine

Step 3	Cut into 100mm length	Horizontal Bench saw
Step 4	Milling both side	Milling Machine
Step 5	Drill $\phi 10$	Drill bit $\phi 10$
Step 6	Drill $\phi 18$	Drill Bit $\phi 18$
Step 7	Drill $\phi 20$	Drill Bit $\phi 20$
Step 8	Bearing with inside diameter $\phi 8$	Force fit
Step 9	Inside thread	Thread M8

i. Selected raw material with dimension $\phi 50$.
ii. Cut into 150 millimeter length using Horizontal Bench saw.
iii. Secure properly the work piece into Lathe Machine. Make external roughing and finishing about 2 millimeter.
iv. Dimension external diameter for the work piece with vernier caliper.
v. Lathe the work piece until the external diameter is 22 millimeter.
vi. Finishing for external diameter about 2 millimeters.
vii. Lathe the back surface of work piece until the external diameter is 22 millimeter.
viii. Finishing for external diameter about 2 millimeters.
ix. Cut the work piece with length 110 millimeter using Horizontal Bench saw.
x. Roughing and finishing until the length reach 100 millimeter using Milling machine.
xi. Using Milling machine and flyer cutter, mill the bottom part with length 40 millimeter from bottom edge.
xii. Mill the back surface at same length until the thickness reach 10 millimeter.
xiii. Mark and punch the centre of the hole which is 15 millimeter distance from bottom edge.
xiv. Secured properly the drill bit $\phi 10$ into drill machine. Drill the marking hole.
xv. Secured properly the drill bit $\phi 18$ into drill machine. Drill the holes.
xvi. Secured properly the drill bit $\phi 20$ into drill machine. Drill the holes.

xi. Forces fit the bearing with internal diameter $\phi 8$ into that hole.

xii. Make inside thread using M8 at the top surface.

xiii. Chamfer the sharp edge.

xvii. Clean this back shaft.

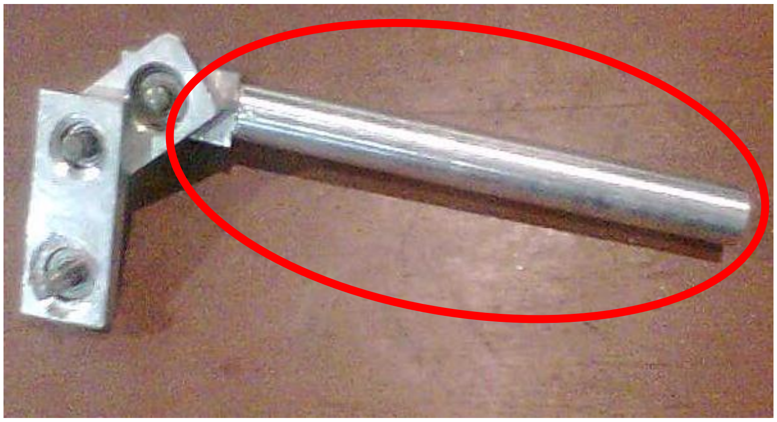


Figure 3.10 Back Shaft

f) Part 6: Fabrication of front shaft.

Figure 3.11 show the picture of front shaft and the steps to fabricate the front shaft is stated on Table 3.7. The function for this front shaft is receiving the torque from back shaft and transfer to the sickle. Then, below is detail parameter and manufacturing process for this front shaft.

Table 3.7 Steps to fabricate part 6

Step	Operation Description	Tools
Step 1	Cut raw material $\phi 50$ x 250	Horizontal Bench saw
Step 2	Lathe until external diameter 20mm	Lathe Machine
Step 3	Cut into 200mm length	Horizontal Bench saw
Step 4	Mill top surface	Milling Machine

Step 5	Drill $\phi 7$	Drill bit $\phi 7$
Step 6	Thread	M8

i. Selected raw material with dimension $\phi 50$.
ii. Cut into 250 millimeter length using Horizontal Bench saw.
iii. Roughing and finishing about 2 millimeter using Lathe Machine.
iv. Dimension external diameter for the work piece with vernier caliper.
v. Lathe the work piece until the external diameter is 22 millimeter.
vi. Make finishing for external diameter about 2 millimeters.
vii. Lathe back surface of the work piece until the external diameter is 22 millimeter.
viii. Make finishing for external diameter about 2 millimeters.
ix. Cut the work piece with length 210 millimeter using Horizontal Bench saw.
x. Roughing and finishing until the length reach 200 millimeter using Milling machine.
xi. From top, mark the length 120 millimeter and mill the spherical surface using Milling Machine that area until the centre of the work piece.
xii. Mark 3 centre of hole which is the distance of each hole is about 30 millimeter. The first centre, the distance is 40 millimeter from top edge.
xiii. Using Drill Machine and drill bit $\phi 7$, drill each marking until it through the other side. Make thread M8 for each hole.
xiv. Make inside thread using M8 at the top surface.
xv. Chamfer the sharp edge.
xvi. Clean this front shaft.

Figure 3.11 Front Shaft

g) Part 7: Fabrication of Front Pole Holder

Figure 3.12 show the picture of front pole holder and the steps to fabricate the front pole holder is stated on Table 3.8. The function for this front pole holder is support and holds the pole. Then, below is detail parameter and manufacturing process for this front pole holder.

Table 3.8 Steps to fabricate part 7

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x150	Horizontal Bench saw
Step 2	Mill until dimension 100 x 100 x 95	Milling Machine
Step 3	Cut C shape	Wire EDM
Step 4	Mill left and right side with dimension 25 mm from edge	Milling Machine
Step 5	Drill ϕ 7	Drill bit ϕ 7
Step 6	Thread	M8

i. Selected raw material with dimension 100 x 100.
ii. Cut into 150 millimeter length using Horizontal Bench saw.
iii. Roughing and finishing about 2 millimeter using Milling Machine.
iv. Dimension with vernier caliper and mill until the work piece dimension is 100 x 100 x 95.
v. Complicated profile of the front pole holder is produced using wire Electrical Discharge machine.
vi. Drawing C shape with diameter $\phi 43$. At both side of C shape make a straight line until the end of work piece.
vii. Drawing from AutoCAD software used to generate the programming and cutting operation performed by Wire Electrical Discharge machine.
viii. Using Milling machine, mill both side of work piece with dimension 25 millimeter from the edge until the thickness for that side reach 10 millimeter.
ix. Using Drill machine secured properly the drill bit $\phi 7$ and drill 4 holes at each side with distance 15 millimeter, 25 millimeter and 20 millimeter.
x. Using thread M8, make a thread at each hole which is 8 holes.
xi. Chamfer the sharp edge.
xii. Clean this front pole holder.

Figure 3.12 Front Pole Holders

h) Part 8: Fabrication of Back Pole Holder

Figure 3.13 show the picture of back pole holder and the steps to fabricate the back pole holder is stated on Table 3.9. The function for this back pole holder is support and holds the pole. Then, below is detail parameter and manufacturing process for this back pole holder.

Table 3.9 Steps to fabricate part 8

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x150	Horizontal Bench saw
Step 2	Mill until dimension 100 x 100 x 95	Milling Machine
Step 3	Drill $\phi 7$	Drill bit $\phi 7$
Step 4	Thread	Thread M8

i. Selected raw material with dimension 100 x 100.
ii. Cut into 150 millimeter length using Horizontal Bench saw.
iii. Roughing and finishing about 2 millimeter using milling machine.
iv. Dimension with vernier caliper and mill until the work piece dimension is 100 x 100 x 95.
v. Using Drill machine, secured properly the drill bit $\phi 7$ and drill at the surface with 10 millimeter.
vi. Drill 4 holes at each side with distance 15 millimeter, 25 millimeter and 20 millimeter.
vii. Using thread M8, make a thread at each hole which is 8 holes.
viii. Chamfer the sharp edge.
ix. Clean this back pole holder.

Figure 3.13 Back Pole Holder

i) Part 9: Fabricate of Bearing Housing

Figure 3.14 show the picture of bearing housing and the steps to fabricate the bearing housing is stated on Table 3.10. The function for this bearing housing is match the bearing and the pole. Then, below is detail parameter and manufacturing process for this bearing housing.

Table 3.10 Steps to fabricate part 9

Step	Operation Description	Tools
Step 1	Cut raw material ϕ50 x 150	Horizontal Bench saw
Step 2	Lathe until dimension ϕ40	Lathe Machine
Step 3	Drill centre drill	Centre Drill
Step 4	Drill ϕ10	Drill Bit ϕ10
Step 5	Drill ϕ20	Drill Bit ϕ20
Step 6	Boring ϕ35	Boring
Step 7	Cut into 60 mm length	Horizontal Bench saw

i. Selected raw material with dimension $\phi 50$.

ii. Cut into 150 millimeter length using Horizontal Bench saw.

iii. Secured properly the work piece into Lathe Machine. Make 2 millimeter roughing and finishing.

iv. Dimension with vernier caliper and mill outside surface until the work piece dimension is $\phi 40$.

v. Secured properly the centre drill into lathe machine and make the centre drill at front surface.

vi. Take and put drilling tool size $\phi 10$ and drill the material until the drill through at other side.

vii. Change the drilling tool into size $\phi 20$ and drill at same dimension.

viii. Lathe inside diameter until the dimension is $\phi 37$ using boring tool.

ix. Finishing the inside diameter about 2 millimeters.

x. Roughing and finishing back surface of work piece using same dimension for the front work piece.

xi. Cut the material into 30 millimeter using Horizontal Bench saw Machine.

xii. Chamfer the sharp edge.

xiii. Clean this bearing housing.

Figure 3.14 Bearing Housing

j) Standard Part

Figure 3.15, 3.16, 3.17, and 3.18 shows the picture of standard part. It's includes the chainsaw, bearing, linear bearing, sickle, aluminum pole and the fasteners. Then, below is the parameter and the part description for this standard part.

Table 3.11 Standard Part

No	Part	Remark
1	Chainsaw	Standard Part
2	Bearing	Standard Part
3	Linear Bearing	Standard Part
4	Sickle	Standard Part
5	Pole	Standard Part
6	Bolt and Nut	Standard Part
7	Tread Rod	Standard Part

a) Standard Part 1: Chainsaw.
- Power : 1.3 hp (25-26cc)
- Max. engine speed : 10500rpm
- Working Speed : 3000 – 5000 rpm
- Fuel Capacity : 440cm^3
- Weight : 8 kg

b) Standard Part 2: Bearing.
- Inner size: $\phi 8$
- Supplier: SKF

c) Standard Part 3: Linear Bearing.
- Inner size: $\phi 20$
- Supplier: SKF

d) Standard Part 4: Sickle.

- Material: Steel
- Dimension: 300 x 300.

e) Standard Part 5: Pole.

- Material: Aluminum
- Dimension: ϕ43 x 500

f) Standard Part 6: Bolt and Nut.

- Stud Screw: ϕ8.
- Bolt and Nut: ϕ8.
- Screw: ϕ8 and ϕ6.

g) Standard part 7: Thread Rod

- Dimension ϕ8 x 350
- Thread M8

Figure 3.15 Chain Saw

Figure 3.16 Sickle

Figure 3.17 Bearing

Figure 3.18 Aluminum Pole

3.5.4 Assembly

i. Front Subassembly (Refer Appendix C1)

The front subassembly consists of front shaft, sickle, 3 units of bolts and 3 units of nuts. Next, take all this parts. Assemble the front shaft and the sickle with the bolts and nuts. Then, make sure the fasteners secured properly. Use washer as a mechanism to avoid this bond loose.

ii. Middle Subassembly (Refer Appendix C2)

The middle subassembly consists of aluminum pole, 2 units of linear bearing, thread rod and 2 unit of bearing housing. Firstly, lubricant the linear bearing which is to make the bearing move smoothly. Then, take 2 unit of bearing and 2 unit of housing bearing. Using force fit insert the bearing into bearing housing. After that, make sure the bearing position is in the middle of the bearing housing. Last, insert that subassembly into the pole. The position of 1 unit of subassembly is at the top of the pole and the other 1 unit at the bottom of the pole.

iii. Back Subassembly (Refer Appendix C3)

The back subassembly consists of chainsaw, base plate, 2 units of crank, 5 units of bearing, back shaft, and fasteners. First assemble the chainsaw and the base plate using screw. Second assemble the flywheel and the chainsaw using stud screw. Make sure the fasteners are secured properly. Use washer as a mechanism to avoid this bond loose. Third assemble first crank and second crank using shaft $\phi 8$. Use lubricant to make sure the movements of bearing are smoothly. Fourth assemble the sub assemble of crank and the back shaft with $\phi 8$ shaft and last assemble the crank and the flywheel using shaft $\phi 8$.

iv. Fully Assemble (Refer Appendix C4)

The fully assemble consists of front pole holder, back pole holder, middle subassembly, front subassembly, back subassembly, bolts, and nuts. First assemble back subassembly with the thread rod. Make sure the bond is secured properly. Second assemble the middle subassembly with that subassembly. Third take front pole holder and back pole holder. Assemble into the pole with the bolts and nuts. Make sure the bolts and nuts are secured properly Use washer as a mechanism to avoid this bond loose. Fourth assemble the thread rod with the front subassembly. Make sure the bond is tight. Then, the machine has been complete assembly and ready to next process which is testing process but before testing, make sure all the screw, bolt and nuts are secured properly.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Result for this fabrication can be divided into two which is completely fabricate the motorized cutter for harvesting palm fruit using several criteria and analysis about the performance of this machine. Figure 4.1 shown the complete motorized cutter and this machine has been analysis with several aspect. Analysis is the study of such constituent parts and their interrelationships in making up this machine. Analysis is one of the important parts because from analysis, the function and the strength of this machine can be analyzed and confirmed. The verification of function for this machine can see with the eye but the analysis such as velocity, acceleration and the strength of this machine must be done with experimental.

Figure 4.1 Complete Motorized Cutters

4.2 Mechanism Design

Mechanism is the links, joins and other part related to this machine which is in mechanical environment. From this mechanism, there are 2 aspects which are Four-Bar Mechanism and Close-Form Position. Using these 2 aspects, the analysis for this machine has been done. The analysis includes analysis about displacement, velocity and acceleration.

4.2.1 Four-Bar Mechanism

For this machine, it will transfer into four-bar mechanism which is simple and most common linkage. It is a combination of four links, one being designated as the frame and connected by four pin joints. Because the four-bar mechanism has one degree of freedom, it is constrained or fully operated with one driver. The pivoted link that is connected to the driver or power source is called the input link. The other pivoted link that is attached to the frame is designated the output link of follower. The couple or connecting arm couples the motion of the input link to the output link. [7].

An important property in mechanism analysis is the number of degrees of freedom of the mechanism. The number of degrees of freedom of a mechanism is called the mobility, F. When the configuration of a mechanism is completely defined by positioning one link, so system has one degree of freedom. Using Gruebler's Equation [7]:

$$F = Degree\,of\ Freedom = 3(n-1) - 2j_p - j_h$$

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)

Mechanism with one degree freedom is termed constrained mechanism. Mechanism with zero or negative degrees is termed locked mechanism; mechanism that unable to move a form a structure. Mechanism with more than one degree of freedom is termed unconstrained mechanism; mechanism that need more than one driver to precisely operate them. By this equation, the mechanism for the cleaning machine can be classified [7].

4.2.2 The Closed-Form Position Equation For Four-Bar Linkage

The Closed-Form Position Equations for a Four-Bar Linkage involve determining the interior joint angle ($\theta 3, \theta 4$ *and* γ) for known links (L_1, L_2, L_3, and L_4) at a certain crank angle ($\theta 2$). Specifically, the interior joints angles ($\theta 3, \theta 4$ *and* γ) must be determined. A, B, C and D are the primary joints for the mechanism like Figure 3.2 [7].

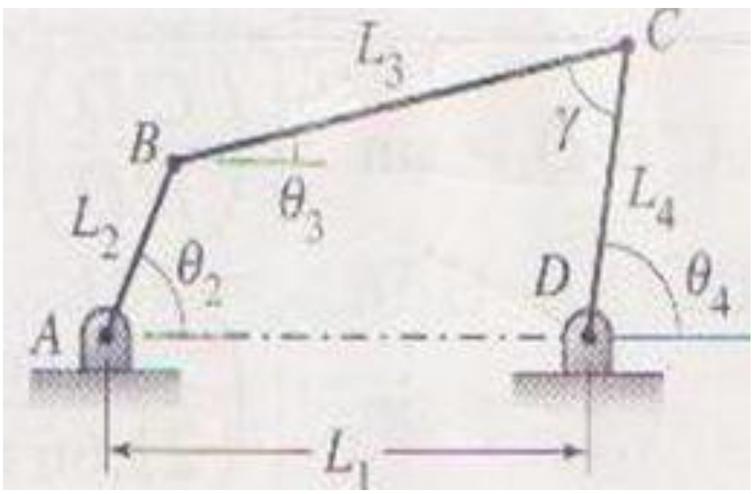


Figure 4.2 The Four-Bar Mechanism

Source: Machines and Mechanism, 3rd Edition

The related equations for this Four-Bar Linkage are [7]:

$$BD = \sqrt{[L_1^2 + L_2^2 - 2(L_1)(L_2)\cos\phi_2]}$$

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

$$\gamma = 180° - \cos^{-1}\left[\frac{(L_1^2)-(L_2^2)+(BD)^2}{2(L_1)(BD)}\right] - \cos^{-1}\left[\frac{(L_4^2)-(L_2^2)+(BD)^2}{2(L_4)(BD)}\right]$$

$$\phi_3 = \phi_4 - \gamma$$

Equation to calculate the velocity of machine [7]:

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

Equation to calculate the acceleration of machine [7]:

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

4.3 Theoretical Calculation

The values calculated in the spreadsheet and tabulated in Table 4.1 were plotted in Figure 4.2, Figure 4.3 and Figure 4.4.

Table 4.1 Displacement, Velocity and Acceleration Analysis

Crank Angle (degree)	Time (sec)	Displacement (mm)	Velocity (mm/s)	Acceleration (mm/s^2)
0	0.0000	0.0000	0.0000	0.1681
30	0.0017	13.8765	6.8327	0.3326
60	0.0033	29.1724	10.3363	0.0057
90	0.0050	47.0850	8.9183	-0.2217
120	0.0067	69.1724	4.8731	-0.2561
150	0.0083	77.7995	1.5329	-0.1271
180	0.0100	80.0000	0.0000	-0.0944
210	0.0117	77.7995	-2.7055	0.1558
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

Table 4.1 shows the displacement, velocity and acceleration of the machine. All the value inside the table has been calculated using all the equations above. After calculated for all value, this value will be shown in the below graphs which are Displacement Curve, Velocity Curve and Acceleration Curve graph.

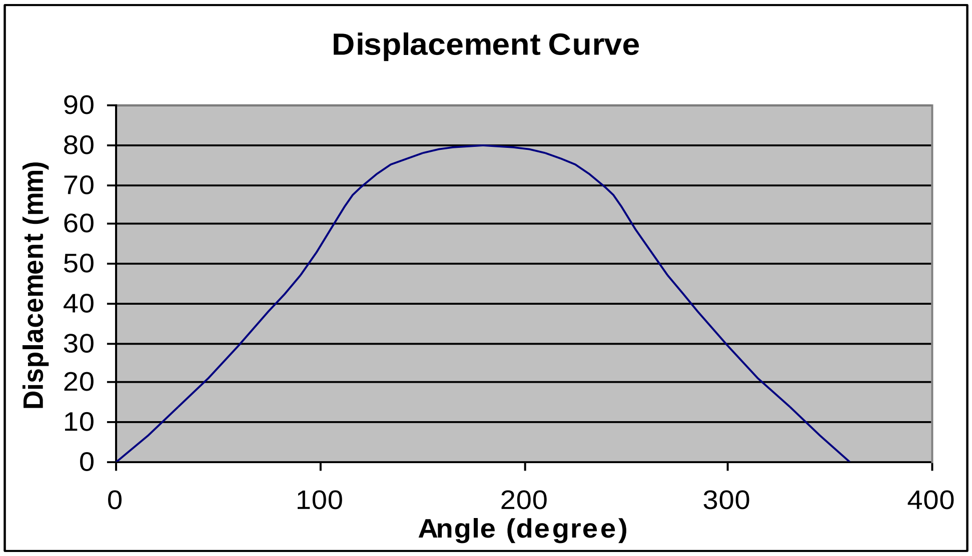


Figure 4.3 Displacement Curve

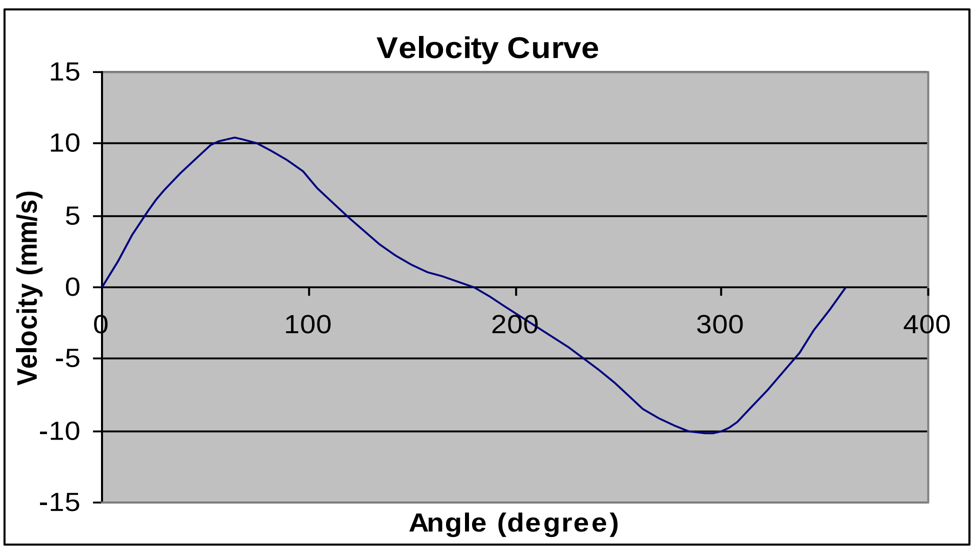


Figure 4.4 Velocity Curve

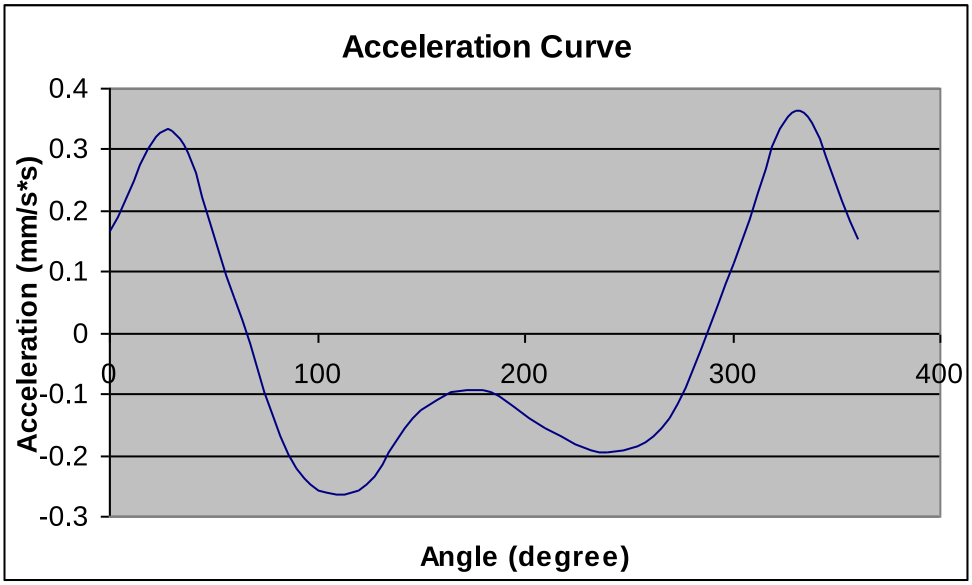


Figure 4.5 Acceleration Curve

Figure 4.3 is Displacement Curve graph, the maximum distance that can sickle move is about 80 millimeter. At maximum distance, the angle of crank is about 60 degree. After it reaches the maximum distance, the sickle will moved to the initial position which is at angle 360 degree. This movement will repeat follow the movement of the machine and the angle of the cranks.

Figure 4.4 is Velocity Curve graph, the maximum velocity that can sickle move is about 10 millimeter per second. The sickle will achieve the maximum velocity when the crank angle is 60 degree. This situation greatly needed to harvest the palm fruit because the factor in harvesting is initial velocity to cut the fronds. So this value is enough to cut the fronds.

Figure 4.5 is Acceleration Curve graph, the maximum acceleration ensued after the sickle fully harvests the palm fruit. For this machine, the maximum acceleration which is about 0.3647 millimeter per second square happens when the angle of crank is about 330 degree.

4.4 Motorized Machine Calculation

The mobility of the machine can be calculated with four links and four primary joints. Therefore,

$$n = 4, j_p = 4, j_h = 0$$

$$F = Degree\, of\ Freedom = 3(n-1) - 2j_p - j_h$$

$$= 3(4-1) - 2(4) - 0 = 1(constrained\ mechanism)$$

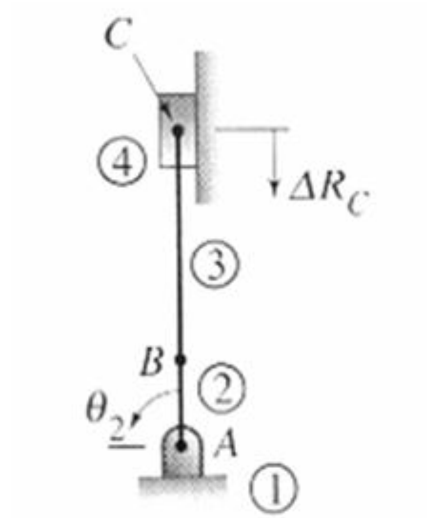


Figure 4.6 Mechanism Diagram

Source: Machines and Mechanism, 3rd Edition

Dimension: AB = 60mm, BC = 80mm, N = 3000rpm

Calculation for data at row 2:

$$\Delta\theta = \theta\left(\frac{1rev}{360°}\right) = 30°\left(\frac{1rev}{360°}\right) = 0.08333\,\text{rev}$$

$$\Delta t = \frac{\Delta\theta}{\omega} = \frac{0.08333}{3000}(60) = 0.001667\,\text{sec}$$

$$\theta_1 = \sin^{-1}\left(\frac{AB\sin\theta}{BC}\right) = \sin^{-1}\left(\frac{60\sin 30°}{80}\right) = 22.0243°$$

$$\theta_3 = 180° - (\theta + \theta_1) = 180° - (30° - 22.0243°) = 127.9757°$$

$$R_c = \sqrt{[L_1^2 + L_2^2 - 2(L_1)(L_2)\cos\phi_2]}$$

$$= \sqrt{[80^2 + 60^2 - 2(80)(60)\cos 127.9759°]} = 126.1235\text{mm}$$

Velocity, v, of the machine can be calculated as;

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

$$= \left[\frac{29.1724 - 0}{2(0.0033)}\right] - \left[\frac{47.0850 - 2(29.1724) + 2(0) - 0}{12(0.005)}\right] = 6.832722\,\text{mm/s}$$

Acceleration, a, of the machine can be calculated as;

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

$$= \left[\frac{10.33633 - 0}{2(0.0033)}\right] - \left[\frac{8.91835 - 2(10.33633) + 2(0) - 0}{12(0.005)}\right] = 0.3326\text{mm/s}^2$$

4.5 Discussion

The motorized cutter for harvesting palm fruit has been fabricated successfully without any major problems and follows several identified criterion such as easy to fabricate and low cost in long term. The process to fabricate this prototype of motorized cutter has been done on the time. After verification section there are several technical problems such as machines use problems, the weight of machine and the parts assembly problems. But after problem solving section, all the problems can solve easily and the performance of this machine can be increase. Detail cause and solution for this technical problem will discuss below.

The first problem is the performance of the chainsaw. This type of chainsaw only can produced 3000 rpm working speed. But in harvesting palm fruit, this kind of speed cannot support this kind of activity. So, to solve this performance problem the machine with higher speed will take place of this chainsaw machine.

The second problem arises after testing section is the weight of this motorized cutter. Expected weight for this motorized cutter is below that 10 kilogram but the weight result for this complete machine is about 15 kilogram. So, the changers to reduce this weight is at the pole, if the composite pole take the place of the aluminum pole, this machine become light weight. The light machine will produce the easier handling of the machine. So the harvesting activity becomes easier.

Last technical problem arise is the part matching problem in assembly section. After problem solving section, there is some reason that is a cause for this problem. The major causes for this problem come from fabrication of that part. The parameter and the tolerance of that part must be explain clearly and detail because small error will give big effect to that part. The other cause is come from machinery which is cutting tool and technique to fabricate this part. To fabricate the accurate part, detail tolerance, the suitable machine, cutting tool and technique must be select correctly.

The conclusion for this discussion is the important factors to design and fabricate the perfect prototype of a motorized cutter base on the functional are in selection of material and in fabrication section. The suitable material, corrects parameters with detail tolerance and correct technique in fabrication will cause the motorized cutter going well without any problem. If no problem arises the motorized cutter would function smoothly and easily.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

As the conclusion, this project has been successfully and the problems arise can solve easily. Below are the summary about this motorized cutter and the expected result from this motorized cutter. The machine that has been developed is able to meet the requirements of the harvesting process because the consideration for this design machine has been done with several factors such as the concept and the fabrication. So, from this machine the problems such as how to reduce the dependent on the foreign worker, increase the productivity, reduce the cost and increase the profit can solve completely. To make the machine functions smoothly there were some of the factors that should be taken into consideration. For example in fabrication, the tolerance and the parameter need to be explained clearly. The technique and machine use in fabrication also need to consider. After the machine function smoothly, the objective which is design and fabricate the prototype of a motorized cutter for harvesting palm fruit will achieve completely.

5.1 Recommendation objective

The important thing in this research is how to make the motorized cutter function smoothly and can harvest pal fruit easily. To achieve that goal, there are several recommendations to make sure the machine can function efficiently. First the weight of the machine, the light machine will produce the easier handling of the machine and the harvesting activity becomes easier. The changer to reduce the weight is at the pole, if the composite pole takes the place of the aluminum pole. The weight of machine can be reducing.

Second the fabrication accuracy, it's important in assembly section. The accurate part fabrication will produced the accurate assembly. So the machine will function as expected before. Last, about the performance of the chainsaw. This type of chainsaw only can produced 3000 rpm working speed. But in harvesting palm fruit, this kind of speed cannot support this kind of activity. So, for future plan, the performance of source which produced the speed must be developed and increase.

Other change that enables the machine going well is reducing the vibration of machine. The step to reduce the vibration is use spring washer at all fasteners or use design of 'C sickle' (Figure 5.1) as the cutting tools in the motorized cutter. This design also can increase the cutting efficiency in harvesting palm fruit.

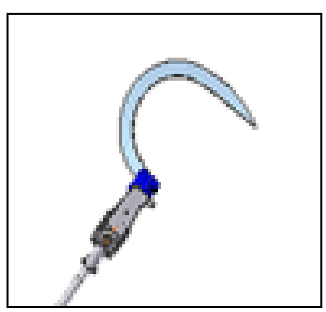


Figure 5.1 Design of 'C sickle'

After this machine completely function as expected before, it’s could be commercialized but to start the mass production for this machine, it needs higher cost. As recommendation, high cost can be acquired from scholarship or loan from FAMA, MARA or FELDA. Next step after commercialized is to promote that motorized cutter. In that case supply the machine to MARDI, FELCRA or FELDA and ask that organization to promote this machine to others organization. Then, this machine is ready to compete with other design of motorized cutter.

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Design and Fabricate the Prototype of a Motorized Cutter for Harvesting Palm Fruit

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Abstract

Nowadays, agriculture especially palm fruit have some problem such as how to increase the productivity and profit, how to reduce the cost and how to solve the problem come from foreign workers. By using design and fabricate the mechanical cutter, the entire problem can solved easily. There are some procedures to solve this problem such as design using several concepts, sketching and modeling the design, fabricate the prototype using suitable material and test the functioning of this machine. So the objectives are to design and fabricate the prototype of motorized cutter for a harvesting palm fruit.

Keyword: agriculture, productivity, cost, mechanical cutter

1.0 INTRODUCTION

The palm fruit is a tree without branches but with many wide leaves at its top. It has become the world's number one fruit crop because of its unparalleled productivity. Generally, for fruit crops, the majority of the mechanical harvesting systems utilized today are shake-catch systems. Each tree is visited for harvesting every 10–15 days as fruit bunches ripen throughout the whole year.

Harvesting schedule will depend on the ripening of fruits as observed on plantations. The stalks of the palm fronds underlying a bunch are first cut, after that the stalk of the bunch is cut and it is allowed to fall freely onto the ground. When a fruit is fully ripe, it loosens itself from the bunch and drops on the ground or it becomes easily detachable. From this information, this study comes to take the advantages for this new potential field which can give effect to our country especially to our economy, politics and social.

2.0 METHODOLOGY

i. Design

- Design the prototype of motorized cutter for a harvesting palm and fruit using some criteria such as low cost and flexible application.
- There are several concept which used in this design:
  - Bevel Gear Concept
  - Cam Concept
  - Cylindrical Cam Concept
  - Piston and Crank Shaft Concept

ii. Material Selection

- Select suitable material, component and parts for this new invention.
- Below is Bill of Material (BOM) for this machine:

Table 1: Bill of Material

Part	Material	Dimension (mm)	Remark
Flywheel	Aluminum	ϕ 82 x 25	Fabricate
Base Plate	High Carbon Steel	300 x 115 x 10	Fabricate
First Crank	Aluminum	60 x 40 x 10	Fabricate
Second Crank	Aluminum	80 x 40 x10	Fabricate
Back Shaft	Aluminum	ϕ 32 x 100	Fabricate
Front Shaft	Aluminum	ϕ 32 x 200	Fabricate
Front Pole Holder	Aluminum	93 x 100 x 50	Fabricate
Back Pole Holder	Aluminum	93 x 100 x 20	Fabricate
Bearing Housing	Aluminum	ϕ 40 x 60	Fabricate
Chainsaw	-	-	Standard Part
Bearing	-	ϕ 8 x 5	Standard part
Linear Bearing	-	ϕ 21 x 2	Standard Part
Sickle	Steel	300 x 300	Standard Part
Pole	Aluminum	ϕ 43 x 500	Standard Part
Bolt and Nut	Steel	Various Size	Standard Part
Thread Rod	Steel	ϕ 8 x 350	Standard Part

iii. Fabrication

- Fabricate the prototype of motorized cutter for a harvesting palm using suitable process.

3.0 FABRICATION PART

i. Part 1: Fabrication of Flywheel

Table 2 Steps to fabricate part 1

Step	Operation Description	Tools
Step 1	Lathe External Dimension into ϕ 82	Lathe Machine
Step 2	Lathe Internal Dimension into ϕ 72	Lathe Machine
Step 3	Cut into length 35 millimeter	Horizontal Bench saw
Step 4	Lathe back face	Lathe Machine
Step 5	Thread	Thread M8

Select raw material with dimension ϕ 100. Then, cut into 50 mm of length. Using lathe machine, lathe the work piece into ϕ 82 x 50 mm. Drill front surface until diameter 20mm. Then, lathe using boring bit until the internal diameter ϕ 72.

Make same process for the other flat surface. Then, make thread M8 at side surface. Last process is chamfering the sharp edge.

Figure 1 Flywheel

b) Part 2: Fabrication of Base Plate

Table 3 Steps to fabricate part 2

Step	Operation Description	Tools
Step 1	Cut raw material into 300 x 115 x 10	Vertical Bench saw
Step 2	Mark centre holes	Height Gauge
Step 3	Punch centre holes	Puncher
Step 4	Drill 8 x ϕ7	Drill bit ϕ7
Step 6	Thread 8 x M8	M8
Step 7	Drill ϕ10	Drill bit ϕ10
Step 8	Drill ϕ6	Drill bit ϕ6
Step 9	Drill ϕ4	Drill bit ϕ4
Step 10	Cut circle ϕ70	Wire EDM

Select raw material with dimension 320 x 120 x 10. Cut the material into 300 x 115 x 10. To obtain the dimension of the entire centre of holes, reverse engineering using height gauge is used. Then, mark each centre of holes. Drill using drill bit ϕ4, ϕ6, ϕ7 and ϕ10. For hole ϕ7, make thread using tool M8. Then, cut circle ϕ70 using Wire EDM. Drawing from AutoCAD software used to generate the programming for this cutting hole. Last process is chamfering the sharp edge.

Figure 2 Base Plate

c) Part 3: Fabrication of first crank.

Table 4 Steps to fabricate part 3

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x 10	Horizontal Bench saw
Step 2	Cut into 60 x 40 x 10	Vertical Bench saw
Step 3	Mark and punch two centre of hole with distance 50mm	Puncher
Step 4	Drill ϕ10	Drill bit ϕ10
Step 5	Drill ϕ18	Drill bit ϕ18
Step 6	Drill ϕ20	Drill bit ϕ20
Step 7	Inside bearing	Forces fit

Select raw material with dimension 100 x 100 x 10. Using Vertical Bench saw, cut the raw material into dimension 60 x 40 x 10. Then, mark and punch the centre of hole at both side of the work piece. Using drill bit ϕ10, ϕ18 and ϕ20, drill through that mark. Force fit the bearing with internal size ϕ8 into each hole. Last process is chamfering the sharp edge.

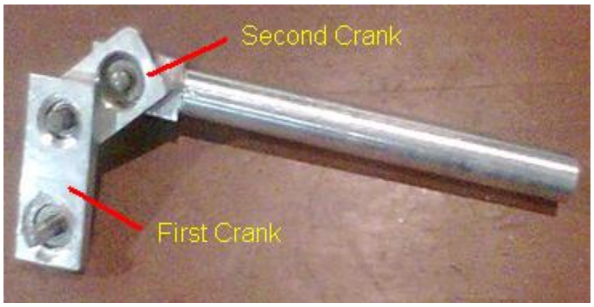

Figure 3 First Crank

d) Part 4: Fabrication of second crank.

Table 5 Steps to fabricate part 4

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x 10	Horizontal Bench saw
Step 2	Cut into 80 x 40 x 10	Vertical Bench saw
Step 3	Mark and punch two centre of hole with distance 50mm	Puncher
Step 4	Drill ϕ10	Drill bit ϕ10
Step 5	Drill ϕ18	Drill bit ϕ18
Step 6	Drill ϕ20	Drill bit ϕ20
Step 7	Inside bearing ϕ8	Force fit

Select raw material with dimension 100 x 100 x 10. Using Vertical Bench saw cut the raw material into dimension 80 x 40 x 10. Then, mark and punch the centre of hole at both side of the work piece. Using drill bit ϕ10, ϕ18 and ϕ20, drill through that mark. Force fit the bearing with internal size ϕ8 into each hole. Last process is chamfering blunt the sharp edge.

e) Part 5: Fabrication of back shaft.

Table 6 Steps to fabricate part 5

Step	Operation Description	Tools
Step 1	Cut raw material ϕ50 x 150	Horizontal Bench saw
Step 2	Lathe until external diameter 20mm	Lathe Machine
Step 3	Mark and punch centre of hole with distance 15mm	Puncher
Step 4	Drill ϕ10	Drill bit ϕ10
Step 5	Drill ϕ18	Drill bit ϕ18
Step 6	Drill ϕ20	Drill bit ϕ20
Step 7	Inside bearing ϕ8	Force fit
Step 8	Inside thread	Thread M8

Select raw material with dimension ϕ50 and cut into 100 millimeter length. Lathe the work piece until dimension ϕ20 x 100mm. Then, mill the bottom side of the work piece until both side is flat. Next, drill the flat surface until diameter ϕ20. Then, drill top surface using drill bit ϕ7 and make thread using

M8. Last process is chamfering the sharp edge.

Figure 4 Back Shaft

f) Part 6: Fabrication of front shaft.

Table 7 Steps to fabricate part 6

Step	Operation Description	Tools
Step 1	Cut raw material ϕ 50 x 250	Horizontal Bench saw
Step 2	Lathe until external diameter 20mm	Lathe Machine
Step 3	Mark and punch centre of hole with distance 15mm	Puncher
Step 4	Drill ϕ 10	Drill bit ϕ 10
Step 5	Drill ϕ 18	Drill bit ϕ 18
Step 6	Drill ϕ 20	Drill bit ϕ 20
Step 7	Bearing with inside size ϕ 8	Force fit

The fabrication for this part same like back shaft but there are some addition process which is mark 3 centre of holes and drill with drill bit ϕ 7. Then, thread that hole using M8. Last process is chamfering the sharp edge.

Figure 5 Front Shaft

g) Part 7: Fabrication of Front Pole Holder

Table 8 Steps to fabricate part 7

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x150	Horizontal Bench saw
Step 2	Mill until dimension 100 x 100 x 95	Milling Machine
Step 3	Cut C shape	Wire EDM
Step 4	Mill with dimension 25 mm	Milling Machine
Step 5	Drill ϕ 7	Drill bit ϕ 7
Step 6	Thread	Thread M8

Select raw material with dimension 100 x 100 x150. Mill the work piece until dimension 100 x 100 x 95. Complicated profile of the front pole holder is produced using wire Electrical Discharge machine. Last process is chamfering the sharp edge.

Figure 6 Front Pole Holders

h) Part 8: Fabrication of Back Pole Holder

Table 9 Steps to fabricate part 8

Step	Operation Description	Tools
Step 1	Cut raw material 100 x 100 x150	Horizontal Bench saw
Step 2	Mill until dimension 100 x 100 x 95	Milling Machine
Step 3	Drill ϕ 7	Drill bit ϕ 7
Step 4	Thread	Thread ϕ 8

Select raw material with dimension 100 x 100 x 150. Mill the work piece until dimension 100 x 100 x 95. Then, using drill bit ϕ7, drill 4 holes at each side with distance 15 millimeter, 25 millimeter and 20 millimeter. Then, thread entire holes using M8. Last process is chamfering the sharp edge.

Figure 7 Back Pole Holder

i) Part 9: Fabricate of Bearing Housing

Table 10 Steps to fabricate part 9

Step	Operation Description	Tools
Step 1	Cut raw material ϕ 50 x 150	Horizontal Bench saw
Step 2	Lathe until dimension ϕ 40	Lathe Machine
Step 3	Drill centre drill	Centre Drill
Step 4	Drill ϕ 10	Drill Bit ϕ 10
Step 5	Drill ϕ 20	Drill Bit ϕ 20
Step 6	Boring ϕ 35	Boring
Step 8	Cut with dimension 60 mm	Horizontal Bench saw

Select raw material with dimension ϕ50 x 150. Then, lathe the work piece until ϕ40. Then, drill and boring centre of front surface until dimension is about ϕ35. Then, cut the work piece into 30mm length. Last process is chamfering the sharp edge.

Figure 8 Bearing Housing

j) Standard Part

Table 11 Standard Part

No	Part	Remark
1	Chainsaw	Standard Part
2	Bearing	Standard Part
3	Linear Bearing	Standard Part
4	Sickle	Standard Part
5	Pole	Standard Part
6	Bolt and Nut	Standard Part
7	Thread Rod	Standard Part

Figure 9 Chain Saw

Figure 10 Sickle

Figure 11 Bearing

Figure 12 Aluminum Pole

4.0 ASSEMBLY

i. Front Subassembly

The front subassembly consists of front shaft, sickle, 3 units of bolts and 3 units of nuts. Next, take all this parts. Assemble the front shaft and the sickle with the bolts and nuts. Then, make sure the fasteners secured properly. Use washer as a mechanism to avoid this bond loose.

ii. Middle Subassembly

The middle subassembly consists of aluminum pole, 2 units of linear bearing, thread rod and 2 unit of bearing housing. Firstly, lubricant the linear bearing which is to make the bearing move smoothly. Then, take 2 unit of bearing and 2 unit of housing bearing. Using force fit insert the bearing into bearing housing. After that, make sure the bearing position is in the middle of the bearing housing. Last, insert that subassembly into the pole. The position of 1 unit of subassembly is at the top of the pole and the other 1 unit at the bottom of the pole.

iii. Back Subassembly

The back subassembly consists of chainsaw, base plate, 2 units of crank, 5 units of bearing, back shaft, and fasteners. First assemble the chainsaw and the base plate using screw. Second assemble the flywheel and the chainsaw using stud screw. Make sure the fasteners are secured properly. Use washer as a mechanism to avoid this bond loose. Third assemble first crank and second crank using shaft $\phi 8$. Use lubricant to make sure the movements of bearing are smoothly. Fourth assemble the sub assemble of crank and the back shaft with $\phi 8$ shaft and last assemble the crank and the flywheel using shaft $\phi 8$.

iv. Fully Assemble (Refer Appendix C4)

The fully assemble consists of front pole holder, back pole holder, middle subassembly, front subassembly, back subassembly, bolts, and nuts. First assemble back subassembly with the thread rod. Make sure the bond is secured properly. Second assemble the middle subassembly with that subassembly. Third take front pole holder and back pole holder. Assemble into the pole with the bolts and nuts. Make sure the bolts and nuts are secured properly Use washer as a mechanism to avoid this bond loose. Fourth assemble the thread rod with the front subassembly. Make sure the bond is tight. Then, the machine has been complete assembly and ready to next process which is testing process but before testing, make sure all the screw, bolt and nuts are secured properly.

5.0 MACHINE CALCULATION

Below is the analysis for this machne which is analysis about the displacemnt, velocity and the acceleration.

Table 12 Machine Calculation

Crank Angle (degree)	Time (sec)	Displacement (mm)	Velocity (mm/s)	Acceleration (mm/s^2)
0	0	0	0	0.1681
30	0.0017	13.8765	6.8327	0.3326
60	0.0033	29.1724	10.3363	0.0057
90	0.005	47.085	8.9183	-0.2217
120	0.0067	69.1724	4.8731	-0.2561
150	0.0083	77.7995	1.5329	-0.1271
180	0.01	80	0	-0.0944
210	0.0117	77.7995	-2.7055	0.1558
240	0.0133	69.1724	-5.7237	0.195
270	0.015	47.085	-9.1227	0.1393
300	0.0167	29.1724	-10.0156	0.1125
330	0.0183	13.8765	-5.9148	0.3647
360	0.02	0	0	0.1537

The values calculated in the spreadsheet and tabulated in Table 12 were plotted in Figure 13, Figure 14 and Figure 15.

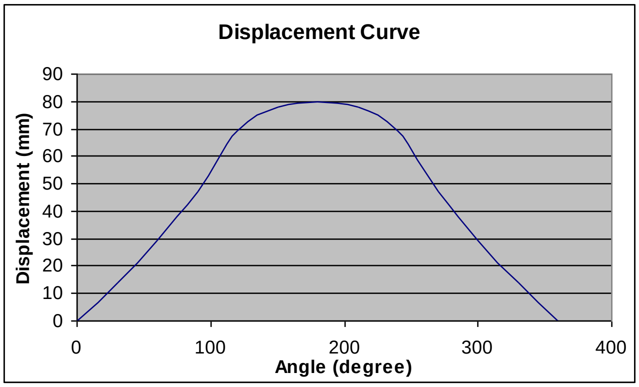

Figure 13 Displacement Curve

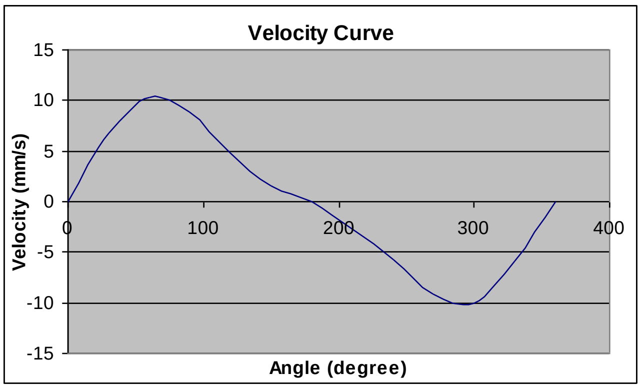

Figure 14 Velocity Curve

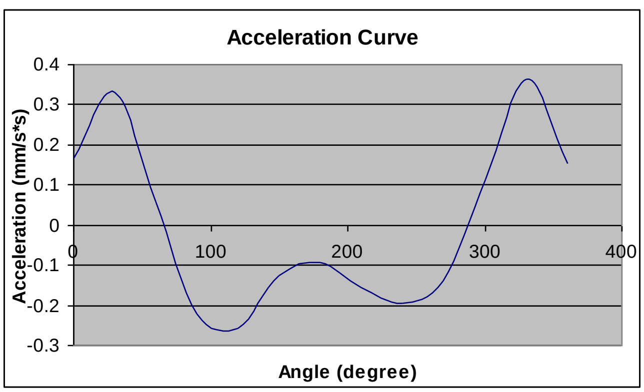

Figure 15 Acceleration Curve

Figure 13, 14 and 15 shown the displacement, velocity and acceleration curve. This figure wants to show the analysis about the function of the machine. For example, from velocity curVe, stated from that figure the maximum velocity for the machine is 10 mm/s. This result was fulfil the expected result base on the Journal of Oil Palm Fruit Research. [1]

6.0 THEORETICAL CALCULATION

The mobility of the machine can be calculated with four links and four primary joints. Therefore,

$$n = 4,\ j_p = 4,\ j_h = 0$$

$$F = Degree\ of\ Freedom = 3(n-1) - 2j_p - j_h$$
$$= 3(4-1) - 2(4) - 0 = 1(constrained\ mechanism)$$

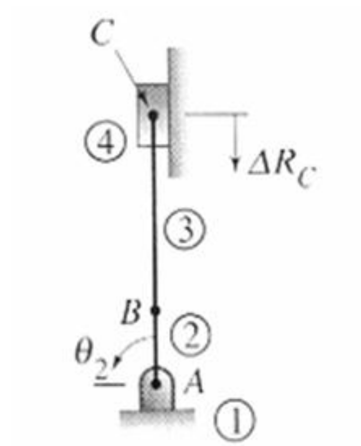

Figure 16 Mechanism Diagram

Dimension: AB = 60mm, BC = 80mm, N = 3000rpm]

Calculation for data at row 2:

$$\Delta\theta = \theta\left(\frac{1rev}{360°}\right) = 30°\left(\frac{1rev}{360°}\right) = 0.08333\,\text{rev}$$

$$\Delta t = \frac{\Delta\theta}{\omega} = \frac{0.08333}{3000}(60) = 0.001667\,\text{sec}$$

$$\theta_1 = \sin^{-1}\left(\frac{AB\sin\theta}{BC}\right) = \sin^{-1}\left(\frac{60\sin 30°}{80}\right)$$
$$= 22.0243°$$

$$\theta_3 = 180° - (\theta + \theta_1) = 180° - (30° - 22.0243°)$$
$$= 127.9757°$$
$$R_c = \sqrt{[L_1^2 + L_2^2 - 2(L_1)(L_2)\cos\phi_2]}$$
$$= \sqrt{[80^2 + 60^2 - 2(80)(60)\cos 127.9759°]}$$
$$= 126.1235\text{mm}$$

Velocity, v, of the machine can be calculated as;

$$v_i = \left[\frac{\Delta R_{i+1} - \Delta R_{i-1}}{2\Delta t}\right] - \left[\frac{\Delta R_{i+2} - 2\Delta R_{i+1} + 2\Delta R_{i-1} - \Delta R_{i-1}}{12\Delta t}\right]$$
$$= \left[\frac{29.1724 - 0}{2(0.0033)}\right] - \left[\frac{47.0850 - 2(29.1724) + 2(0) - 0}{12(0.005)}\right]$$
$$= 6.832722\ \text{mm/s}$$

Acceleration, a, of the machine can be calculated as;

$$a_i = \left[\frac{\Delta v_{i+1} - \Delta v_{i-1}}{2\Delta t}\right] - \left[\frac{\Delta v_{i+2} - 2\Delta v_{i+1} + 2\Delta v_{i-1} - \Delta v_{i-1}}{12\Delta t}\right]$$
$$= \left[\frac{10.33633 - 0}{2(0.0033)}\right] - \left[\frac{8.91835 - 2(10.33633) + 2(0) - 0}{12(0.005)}\right]$$
$$= 0.3326\text{mm/s}^2$$

7.0 CONCLUSION

As the conclusion, this project has been successfully and the problems arise can solve easily. Below are the summary about this motorized cutter and the expected result from this motorized cutter. The machine that has been developed is able to meet the requirements of the harvesting process because the consideration for this design machine has been done with several factors such as the concept and the fabrication. So, from this machine the problems such as how to reduce the dependent on the foreign worker, increase the productivity, reduce the cost and increase the profit can solve completely. To make the machine functions smoothly there were some of the factors that should be taken into consideration. For example in fabrication, the tolerance and the parameter need to be explained clearly. The technique and machine use in fabrication also need to consider. After the machine function smoothly, the objective which is design and fabricate the prototype of a motorized cutter for harvesting palm fruit will achieve completely.

8.0 RECOMANDATION

The important thing in this research is how to make the motorized cutter function smoothly and can harvest pal fruit easily. To achieve that goal, there are several recommendations to make sure the machine can function efficiently. First the weight of the machine, the light machine will produce the easier handling of the machine and the harvesting activity becomes easier. The changer to reduce the weight is at the pole, if the composite pole takes the place of the aluminum pole. The weight of machine can be reducing.

Second the fabrication accuracy, it's important in assembly section. The accurate part fabrication will produced the accurate assembly. So the machine will function as expected before. Last, about the performance of the chainsaw. This type of chainsaw only can produced 3000 rpm working speed. But in harvesting palm fruit, this kind of speed cannot support this kind of activity. So, for future plan, the performance of source which produced the speed must be developed and increase.

Other change that enables the machine going well is reducing the vibration of machine. The step to reduce the vibration is use spring washer at all fasteners or use design of 'C sickle' (Figure 5.1) as the cutting tools in the motorized cutter. This design also can increase the cutting efficiency in harvesting palm fruit.

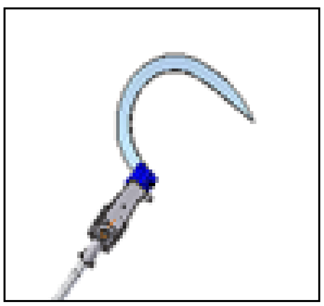

Figure 5.1 Design of 'C sickle'

After this machine completely function as expected before, it's could be commercialized but to start the mass production for this machine, it needs higher cost. As recommendation, high cost can be acquired from scholarship or loan from FAMA, MARA or FELDA. Next step after commercialized is to promote that motorized cutter. In that case supply the machine to MARDI, FELCRA or FELDA and ask that organization to promote this machine to others organization. Then, this machine is ready to compete with other design of motorized cutter.

9.0 REFERENCES

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APPENDIX

ATTACH THE SICKLE

MIDDLE PART

ATTACH THE ROD

ATTACH THE POLE

FIRST PART

SECOND PART

ASSEMBLY BACK PART 1

ASSEMBLY BACK PART 2

BACK PART

FRONT PART

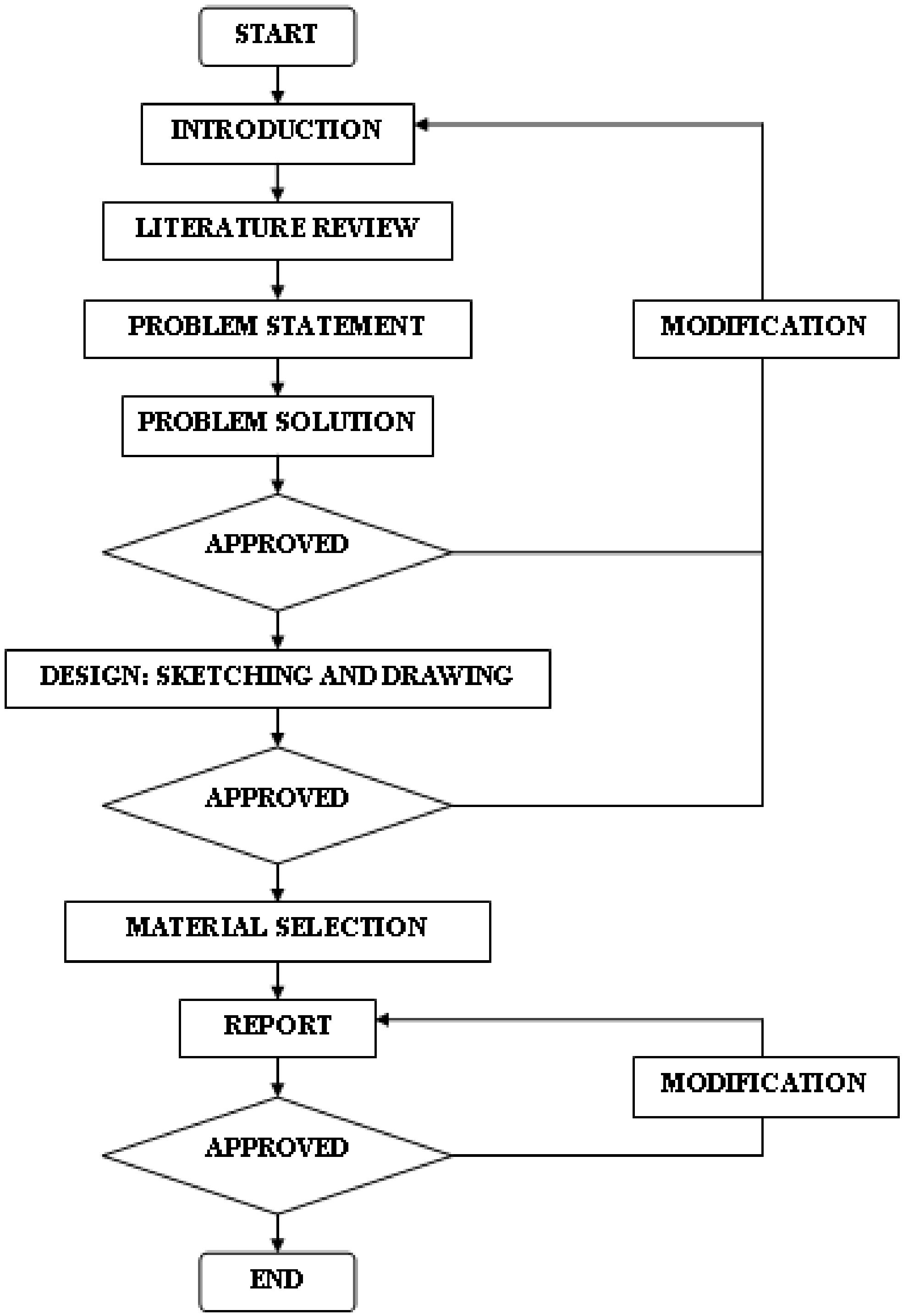
MIDDLE PART

APPENDIX A

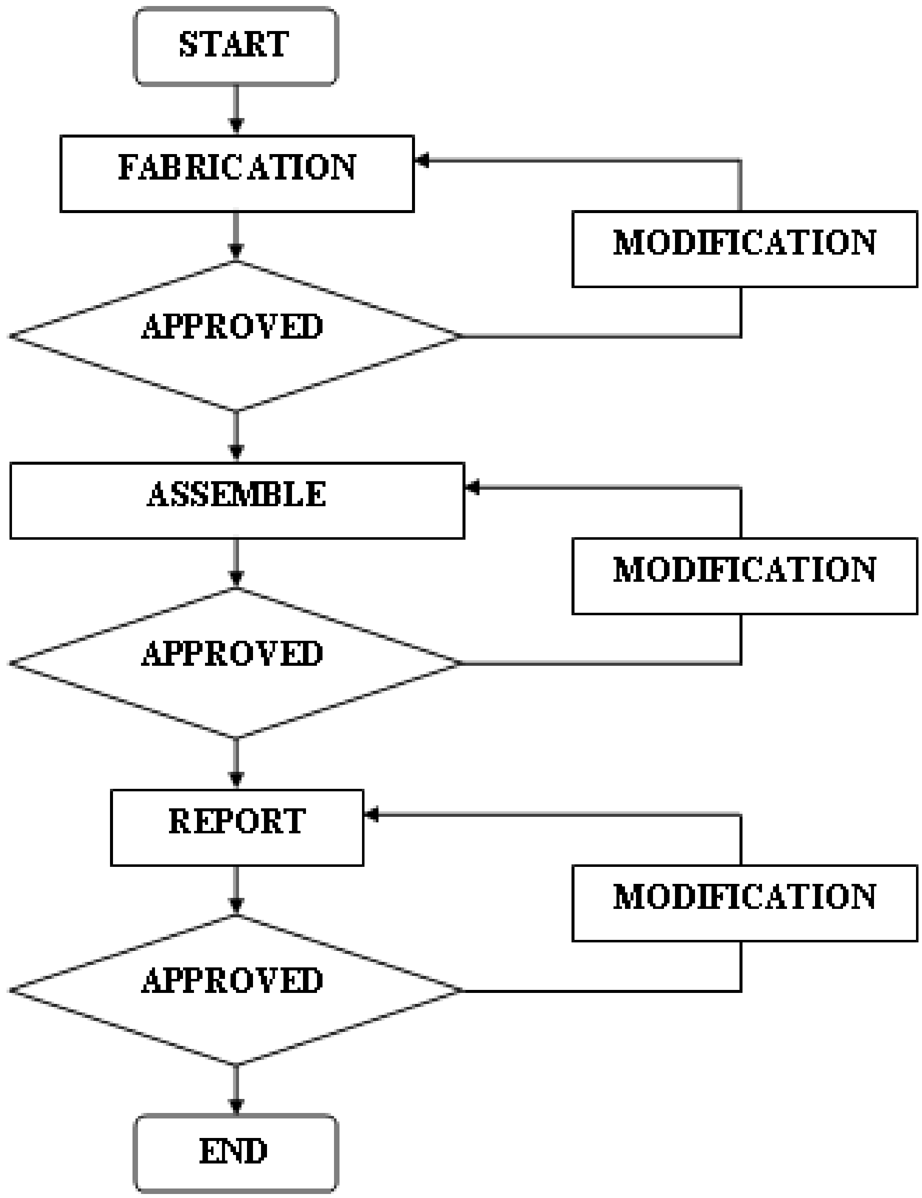
-Flow Chart PSM1 and PSM2-

-Gantt Chart PSM1 and PSM2-

APPENDIX A



-A1 Flow Chart PSM1-



-**A2** Flow Chart PSM2-

-A3 Gantt Chart PSM1-

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
INTRODUCTION														
Objective	X	X	X											
Project Scope and Project Background		X	X	X										
Gantt Chart and Flow Diagram			X	X	X									
Problem Statement														
LITERATURE REVIEW				X	X	X	X							
Gathering Information						X	X	X						
Refences Machine							X	X	X					
Conceptual Design							X	X	X					
New Design														
DESIGN								X	X					
Design and Sketch								X	X					
Full Dimension									X	X				
3D Drawing									X	X				
Detail Drawing									X	X				
Simulation									X	X	X			
MATERIAL SELECTION														
Gathering Information											X	X	X	
Decision											X	X	X	
PRESENTATION														
Final Presentation				X	X	X	X	X	X	X	X	X	X	X
REPORT														
Final Report				X	X	X	X	X	X	X	X	X	X	X

-A4 Gantt Chart PSM2-

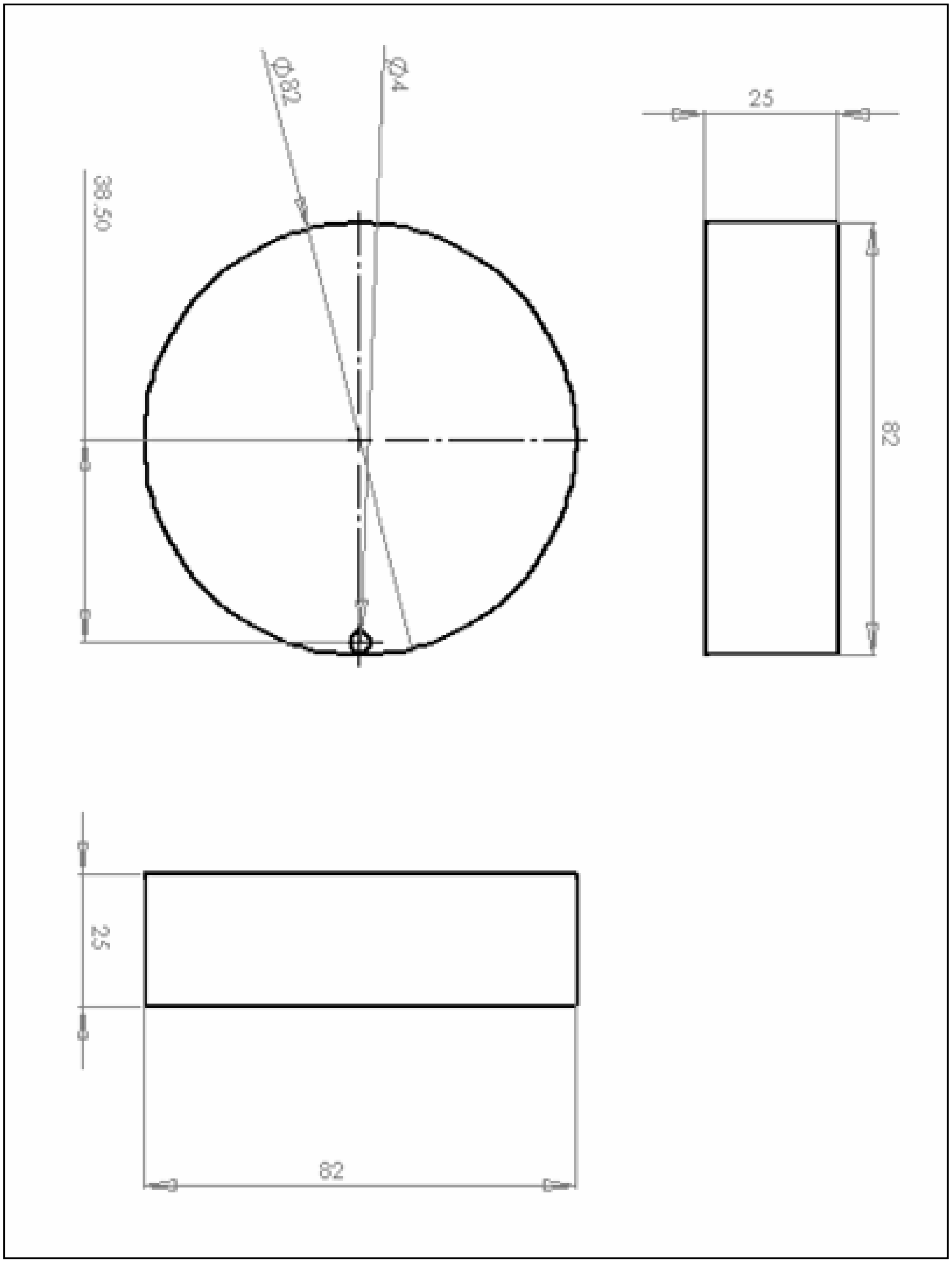
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
FABRICATION														
Flywheel	X	X												
Crank		X	X											
Rod			X	X										
Front Shaft				X	X									
Back Shaft					X	X								
Bearing Housng						X	X							
ASSEMBLE														
Front Part								X	X	X				
Middle Part										X	X	X		
Back Part												X	X	X
PRESENTATION														
Final Presentation							X	X	X	X	X	X	X	X
REPORT														
Final Report							X	X	X	X	X	X	X	X

APPENDIX B

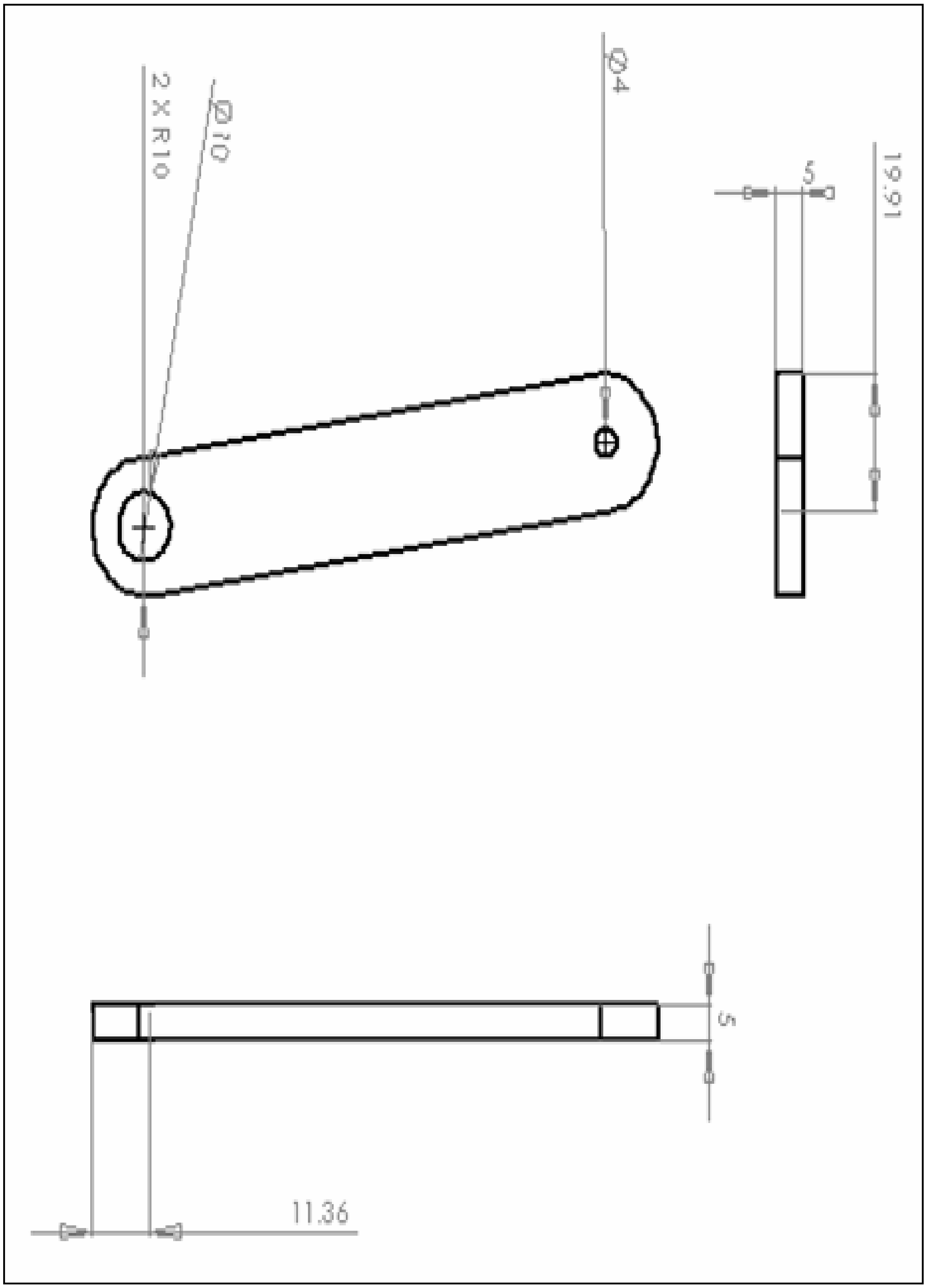
-Detail Drawing for Each Part-

-Sketching-

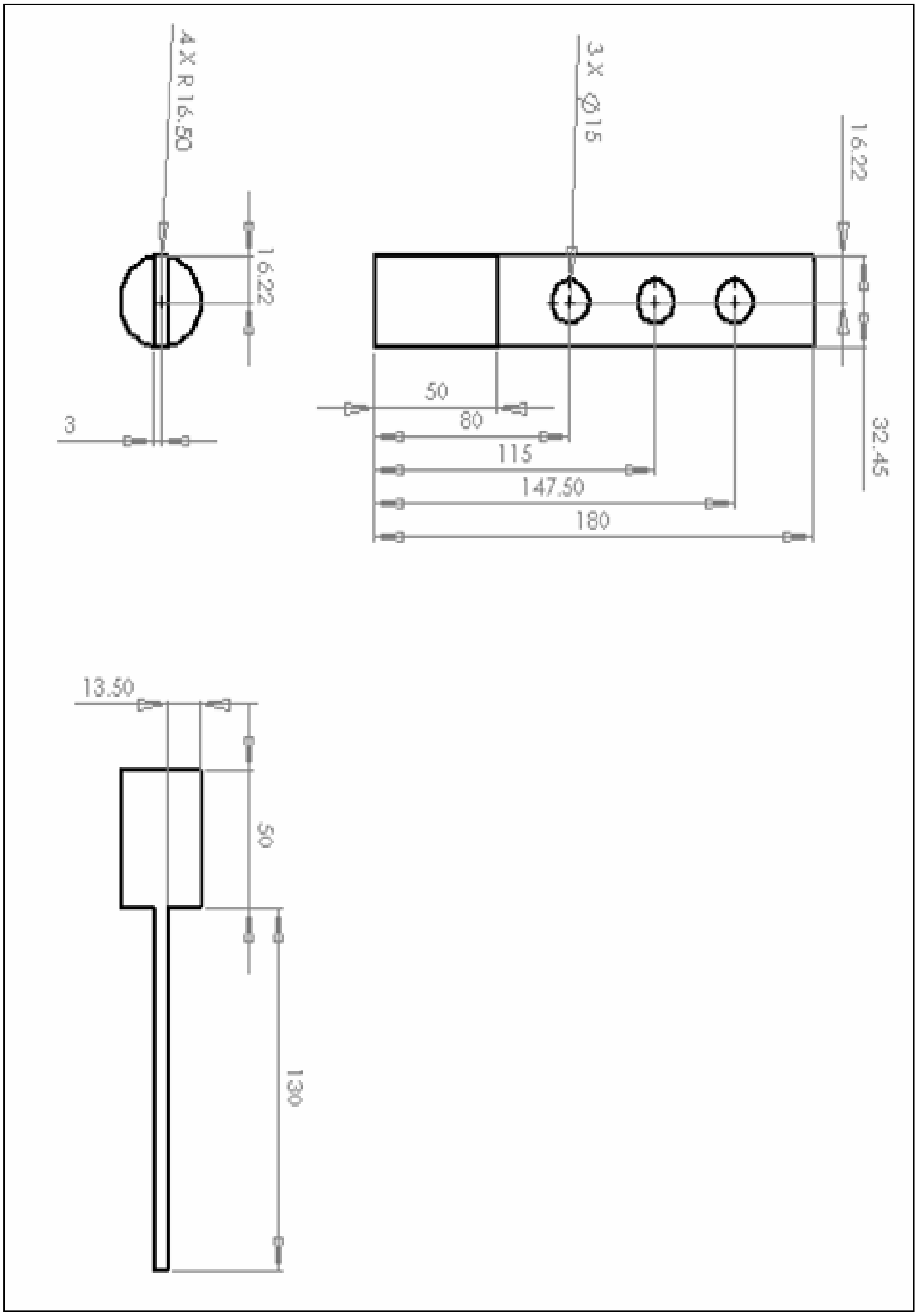
APPENDIX B



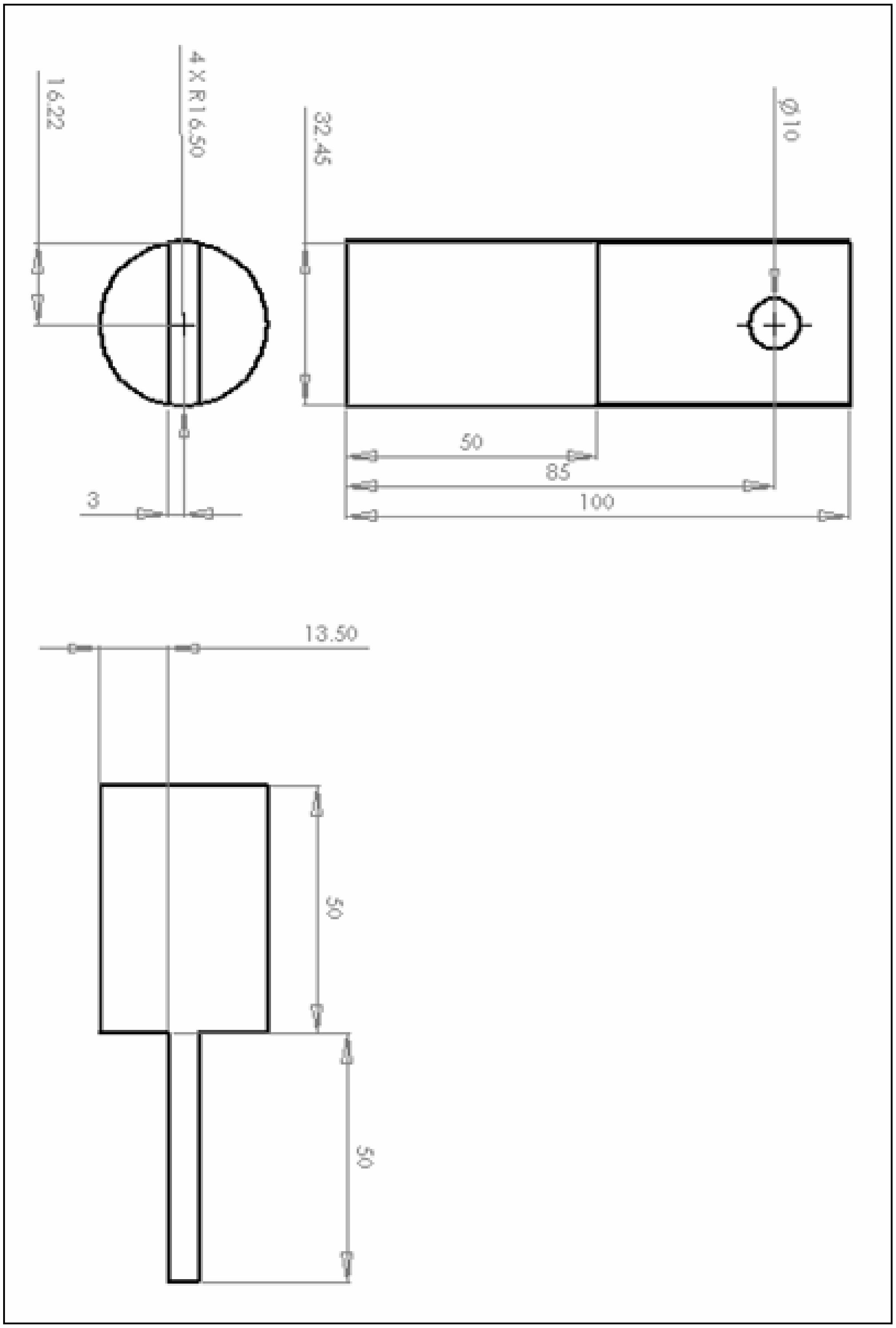
-B1 Flywheel Dimension**-**



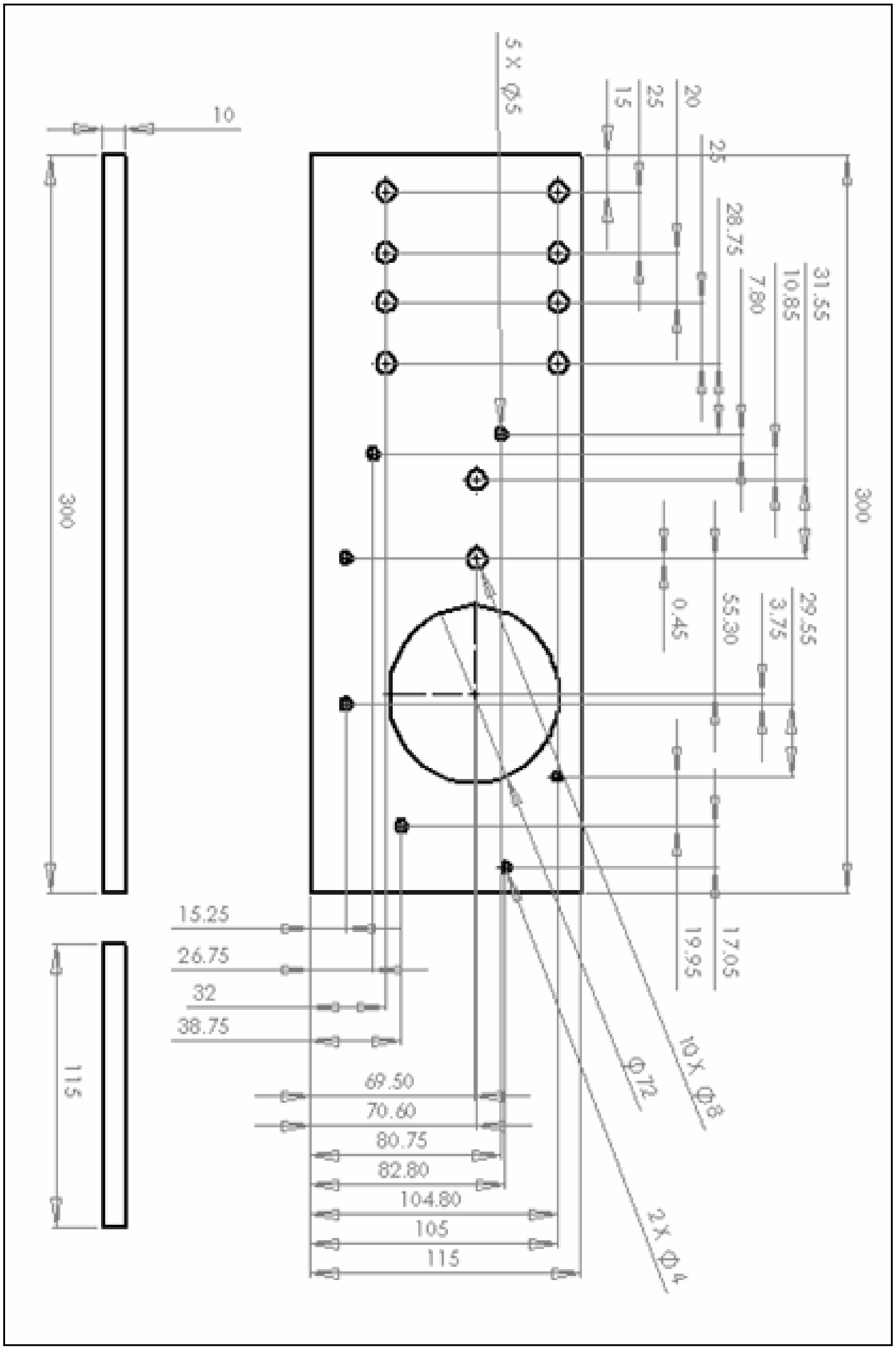
-B2 Crank Dimension**-**



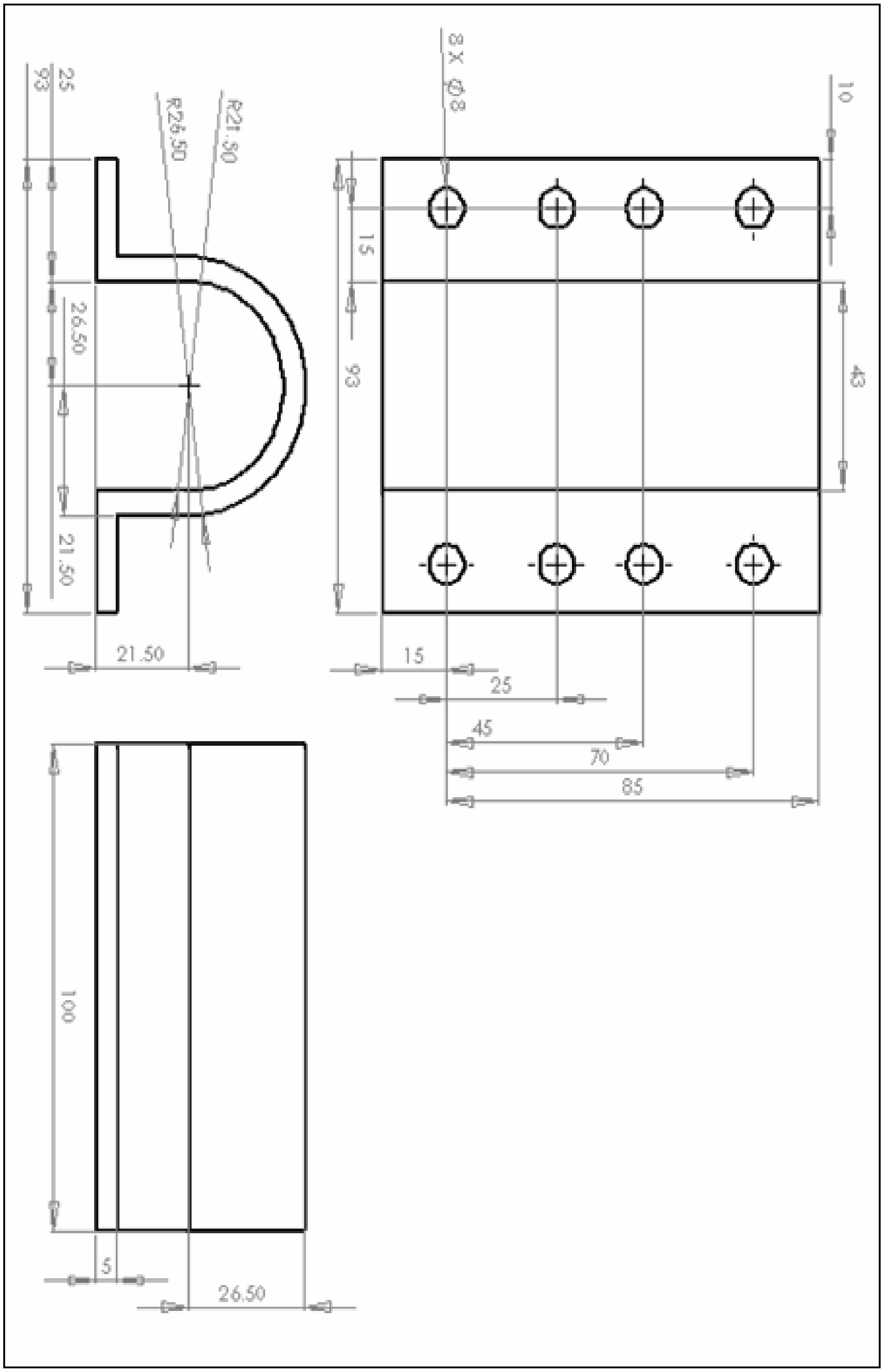
-B3 Front Shaft Dimension**-**



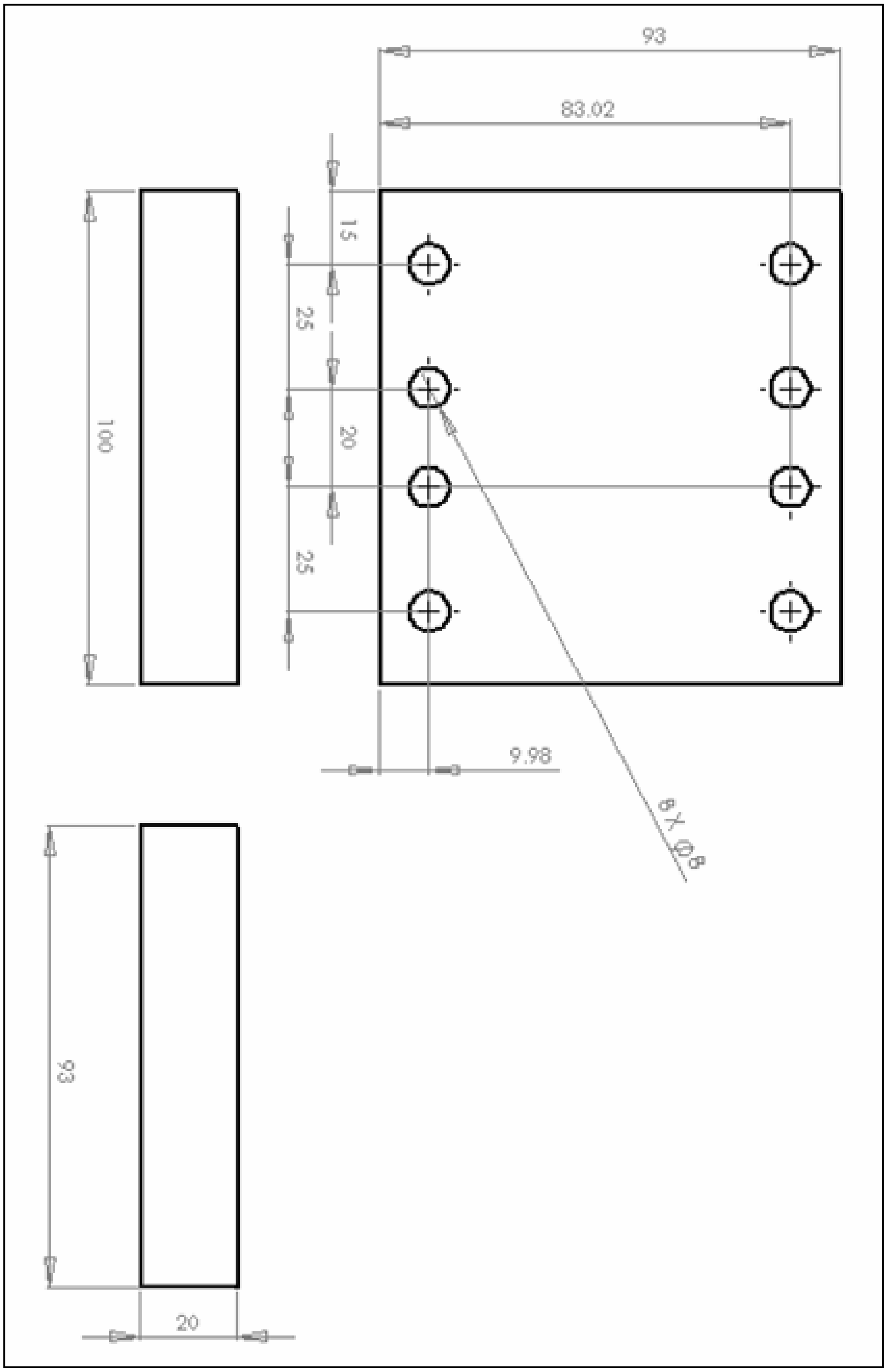
-B3 Back Shaft Dimension**-**



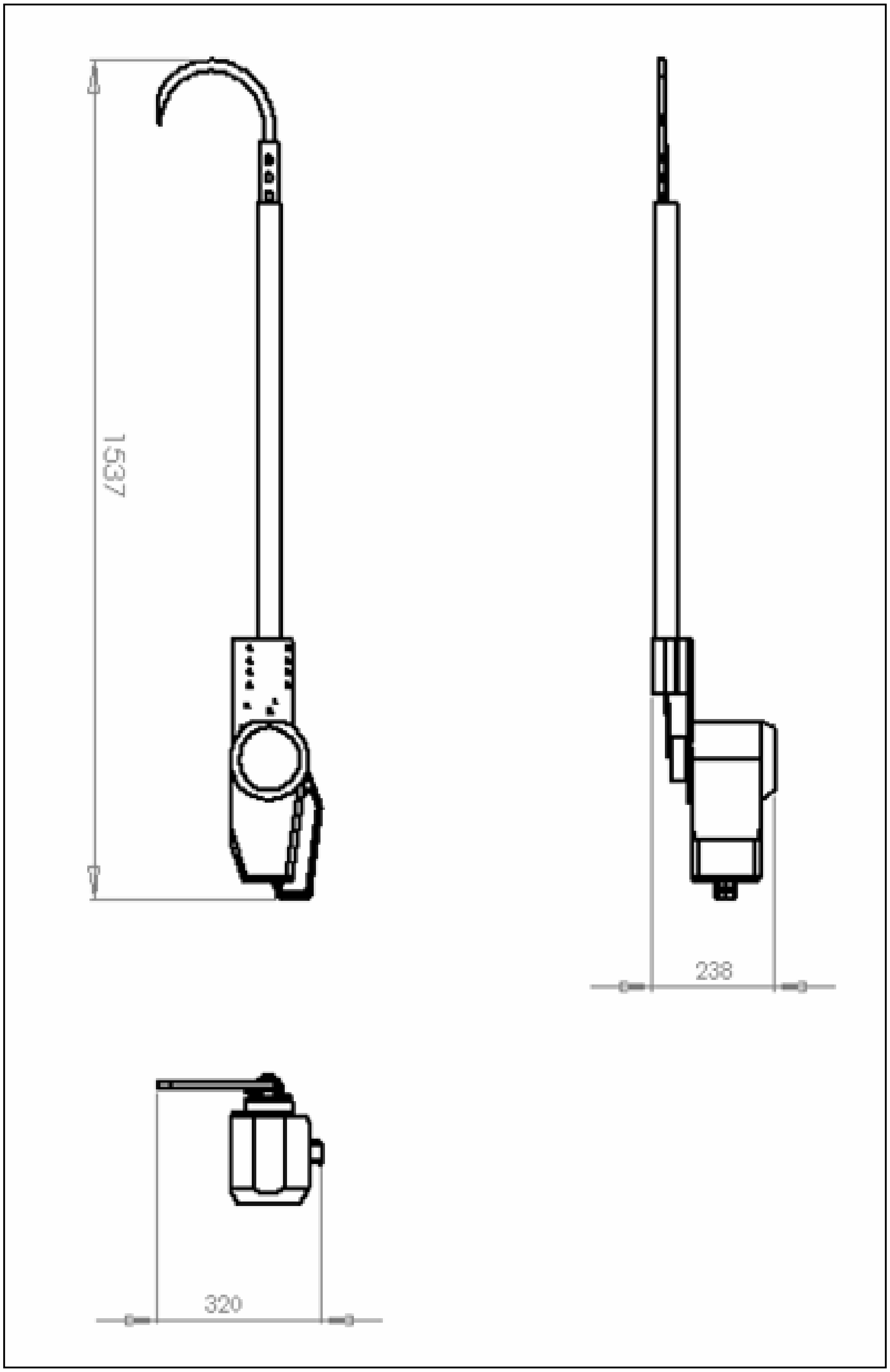
-B4 Base Plate Dimension**-**



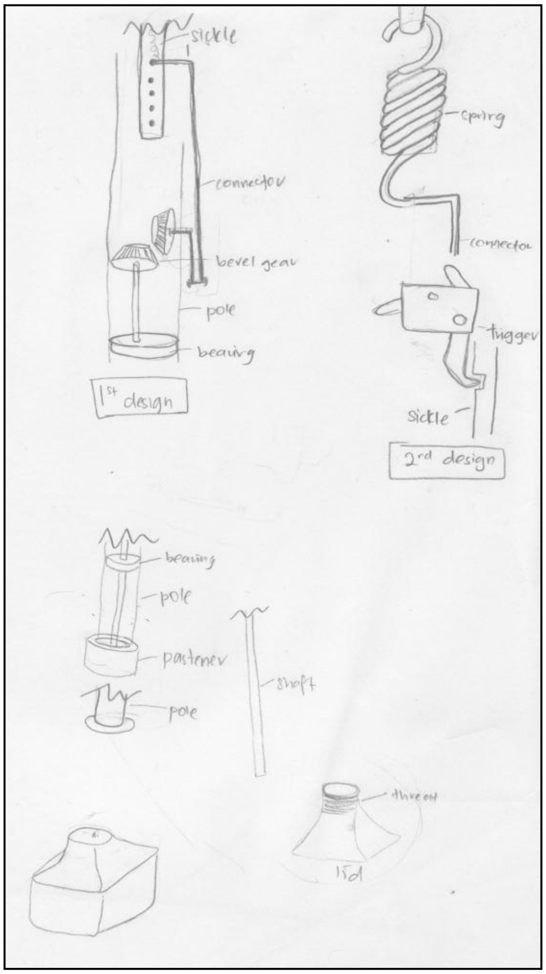
-B5 Front Pole Holder Dimension-

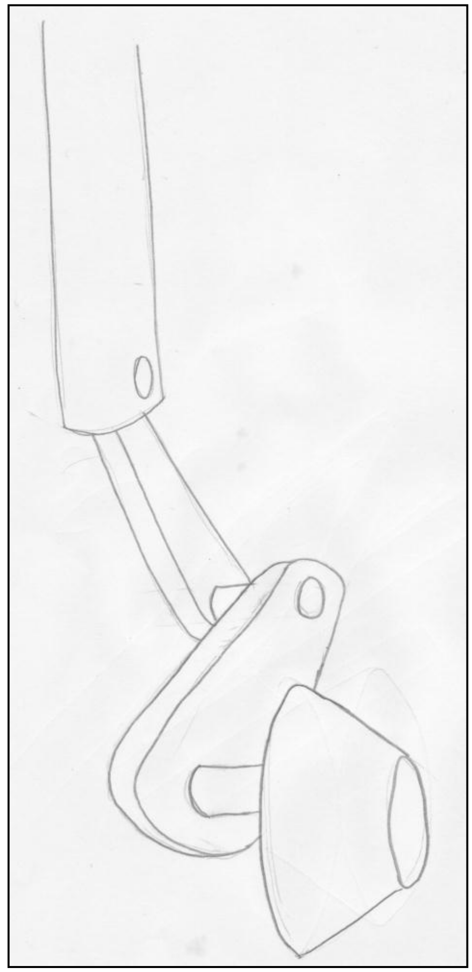


-B6 Back Pole Holder Dimension**-**

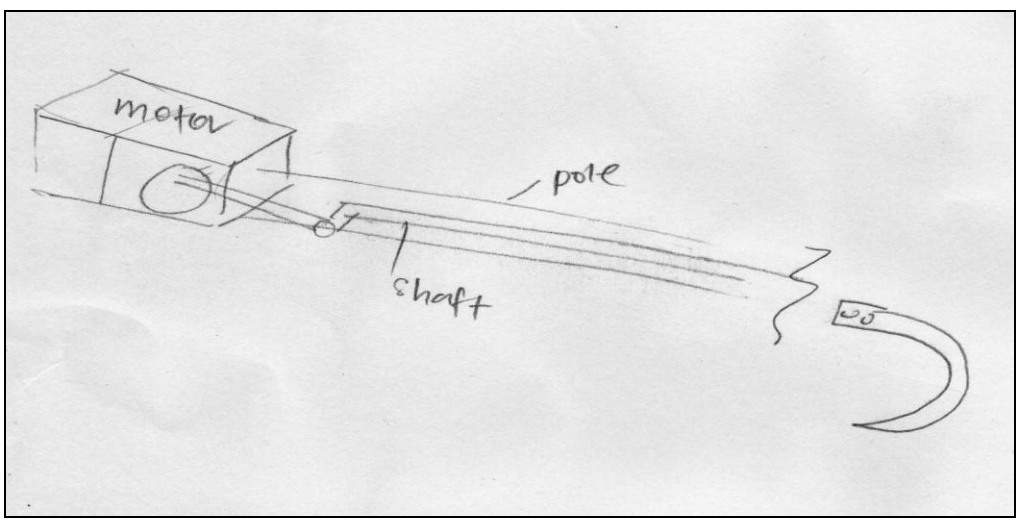


-B7 Full Assemble Dimension-



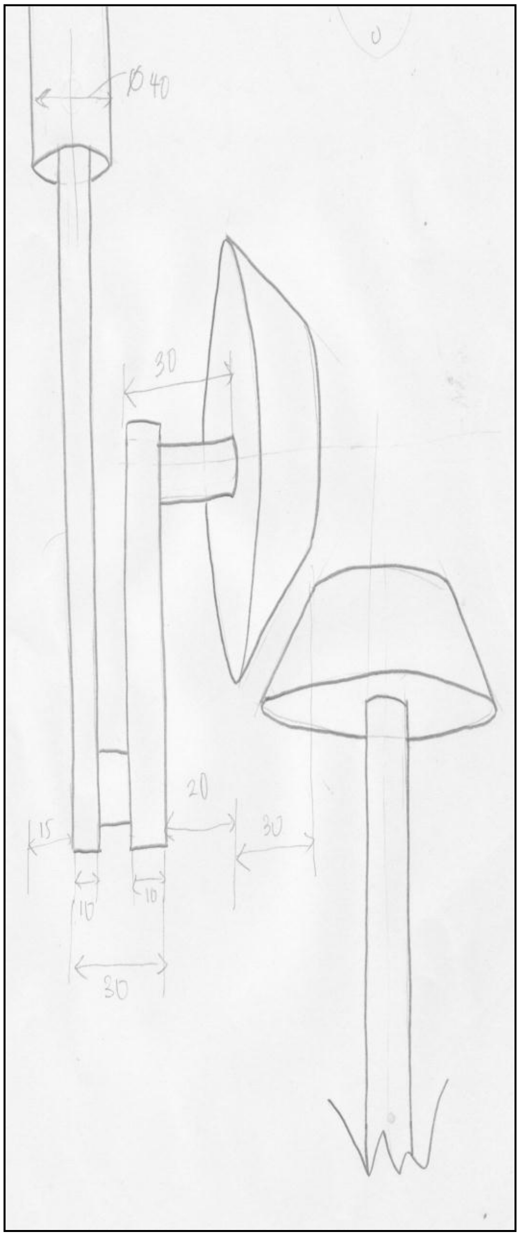


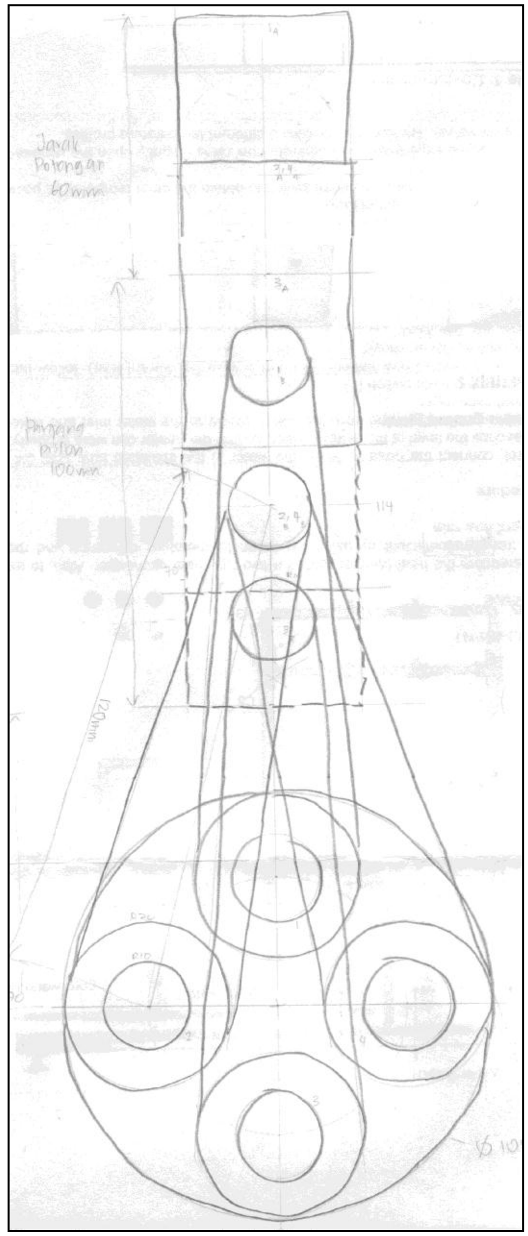
-Sketching using bevel gear and spring- -Sketching of crank connection-



-Full Assemble Sketching-

-B8 Sketching 1**-**





-Bevel Gear with Connection-　　　　　　-Movement of cranks-

-B9 Sketching 2**-**

APPENDIX C

-Front Subassembly-

-Middle Subassembly-

-Back Subassembly-

-Full Assemble-

APPENDIX C

-C1 Front Subassembly 1**-**

-C1 Front Subassembly 2**-**

-C2 Middle Subassembly **-**

-C3 Back Subassembly 1**-**

-C3 Back Subassembly 2**-**

-C3 Back Subassembly 3**-**

FRONT PART

MIDDLE PART

BACK PART

-C4 Full Assemble 1**-**

-Perspective of Back View-

-Perspective of Front View-

-C4 Full Assemble 2**-**

-Full Assembly in Perspective View 1 **-**

-Full Assembly in Perspective View 2**-**

-C4 Full Assemble 3**-**

APPENDIX D

-Machine Use-

APPENDIX D

Lathe Machine

Milling Machine

Wire EDM

Drilling Machine

-D1 Machine Use 1**-**

Horizontal Bench saw Machine

Vertical Bench saw Machine

-D2 Machine Use 2**-**

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL: DESIGN AND FABRICATE THE PROTOTYPE OF A MOTORIZED CUTTER FOR HARVESTING PALM FRUIT

SESI PENGAJIAN: 2007/2008

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