



**UNIVERSITI PUTRA MALAYSIA**

***VIBRATION ATTENUATION STUDY IN AXIAL-LATERAL ROTARY  
CUTTER FOR OIL PALM FROND CHOPPING***

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CUTTER FOR OIL PALM FROND CHOPPING**

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This project report here to entitle “VIBRATION ATTENUATION STUDY IN AXIAL-LATERAL ROTARY CUTTER FOR OIL PALM FROND CHOPPING” was prepared and submitted by SYED ABDULLAH KHAIED BIN SYED IDROS in partial fulfillment of the requirement for the degree of Bachelor of Engineering (Agricultural and Biosystems) is hereby accepted.

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## ABSTRACT

The oil palm fronds chopping machine is one of the most important mechanism in agriculture sector in Malaysia. The machine was used widely over the world in order to provide high quality livestock feed, thus the vibration issue is a main concern for the industry since a high level of vibration on the machine may affect the production and give some negative effects to the labour. The main factor that contribute to the vibration of the chopping machine is on the development of the machine itself. Also, the vibration behaviour of the machine should be recognize or identify first in order to analyse the performance of the machine during run the operation. Oil palm fronds chopping machine have been assembling well with all of their compartment to ensure that the chopping process could be done smoothly. The specimen were freshly collected from field and prepared within the dimension before starting the chopping process. Once the vibration sensor have been attached to the machine at the certain points, the oil palm fronds were ready to be chopped. During run the operation, the data on the overall vibration of the machine at the bearing and the body have been recorded and analysed by the sensor. From the results obtained, the vibration level ( $\text{ms}^{-2}$ ) produce on the bearing during the chopping process by the machine that implemented with four axial blade is 17.6 compared to seven axial blade which is 23.9. While, the vibration level ( $\text{ms}^{-2}$ ) produce on the body for four axial blade is 28.6 compared to seven axial blade which is 44.5. The result gained from the experiments conclude that the most efficient implement should be applied to the machine is the knife with four axial blade as it produce the minimum vibration level on the machine.

## ABSTRAK

Mesin pemotong daun kelapa sawit merupakan salah satu mekanisma yang paling penting dalam sektor pertanian di Malaysia. Mesin ini digunakan secara meluas di seluruh dunia untuk menyediakan makanan ternakan yang berkualiti tinggi, oleh itu isu getaran merupakan kebimbangan utama bagi industri kerana tahap getaran tinggi pada mesin boleh menjejaskan pengeluaran dan memberi kesan negatif kepada tenaga kerja. Faktor utama yang menyumbang kepada getaran mesin pencincang adalah pada pembentukan mesin itu sendiri. Juga, kelakuan getaran mesin harus dikesan atau dikenal pasti terlebih dahulu untuk menganalisis prestasi mesin semasa menjalankan operasi. Mesin pemotong daun kelapa sawit telah dipasang dengan baik dan sempurna untuk memastikan proses pemotongan dapat dilakukan dengan lancar. Spesimen baru dikumpulkan dari lapangan dan disediakan dalam dimensi yang ditetapkan sebelum memulakan proses pemotongan. Setelah sensor getaran dipasang pada mesin pada titik-titik tertentu, daun kelapa sawit sedia dicincang. Semasa menjalankan operasi, data mengenai getaran keseluruhan mesin pada bearing dan badan telah direkodkan dan dianalisis oleh sensor. Dari keputusan yang diperolehi, tahap getaran ( $ms^{-2}$ ) dihasilkan pada bearing semasa proses pemotongan oleh mesin yang dilaksanakan dengan empat pisau paksi ialah 17.6 berbanding dengan tujuh pisau paksi iaitu 23.9. Walaupun, tahap getaran ( $ms^{-2}$ ) dihasilkan pada badan untuk empat pisau paksi ialah 28.6 berbanding dengan tujuh pisau paksi yang 44.5. Keputusan yang diperolehi dari eksperimen menyimpulkan bahawa pelaksanaan paling berkesan harus digunakan pada mesin adalah pisau dengan pisau empat paksi kerana menghasilkan tingkat getaran minimum pada mesin.

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# CHAPTER 1

## INTRODUCTION

Oil palm trees cultivation can produce one of the most important by-product which called as oil palm fronds. Malaysia is known as one of the most rapid develop of the palm oil industry since 1990s in South-East Asia. Therefore, the rapidly develop of palm oil industry of this country lead the output wastes derived from oil palm trees to be increase every day. Based on the statistic from my research, it is stated that oil palm fronds production can be produce up to 100 kg/ha daily (Ishida and Abu Hassan, 1997). From the worldwide statistic, it is estimated that there were 164 million t DM oil palm fronds to be produced every year.

There are several type of method in order to decompose the oil palm fronds such as burning, leaving on the ground, and shredding. Shredding method is the best way to decompose OPF compare to the other method because it have higher efficiency and do not affected environmental system. The mechanical machine which call oil palm fronds shredder have been invented with purpose to facilitate the decomposition process and decrease the period for the OPF to be decompose because oil palm fronds can take up to 50 years to decompose on their own. In order to speed up the process, oil palm fronds also could be combine with moisture and other plant material that decompose more quickly.

Based on the research, the decomposing method for oil palm fronds using shredding process is to be done with medium mechanical machine. Raw OPF have been collected from the plantation and were brought to the shredding section in order

to do the shredding process by using the chopping machine. Then, sieving process was done to classify the different particle sizes of the output as the shredded feedstock obtained from the shredding process were not in uniform sizes. After shredding and sieving operation were done, the proper shredded feedstock of OPF were collected and gathered. There are two stages involve in the sieving process which are conducted with two different sieve size. At the first stage, the 10mm sieve to be poured with shredded OPF. Then, the process was repeated by using smaller scale of sieve which is 5mm. Briquette was formed from the mixture of the diced type OPF, OPF fibre and OPF sawdust. The briquette process was done in two batches. In the first batch, paper, leaflet, sawdust and fibre were used. While in the second batch of briquette, diced OPF was used in order to replace the uses of paper and a fibre as mentioned at the first batch. Lastly, in order to blend well the mixture, approximated 4-5 liters of water was added to the mixture to form the soupy slurry (Sulaiman et al., 2017).

Vibration issue was a main concerned in shredding process. The various form of vibration can be sensed by touching, seeing and so on where they were concerned about the vibration of machine or its parts. The perception of human being varied between each other, some person finds that particular vibration were bad for the proper working of machine and some person may find it useful. In certain condition, some vibration were over the range of human attention. Therefore, many new technologies invented in order to analyse and measure the same. In addition, vibration was inversely related to the lifetime of the machine, as the vibration level of the machine was low, it indicated a low vibratory forces. When the machines performance deteriorates, the dynamic forces generated by the machine would increase intensity which causing increasing in machine vibration. There four factors that determine the characteristic of

vibration which are stiffness of vibrating system, mass of vibrating system, exciting force and damping characteristics of the vibrating system.

### **1.1 Problem Statement**

In agriculture sector, most operations required the uses of machinery either simple or heavy machine. Oil palm fronds chopper can be categorize as one of the simple machine in agriculture industry. Even though this machine have been used since a long time ago, but there are some flaws that have been not fixed yet especially on the vibration mechanism. Therefore, the agriculture engineer should figure out and suggest the best way to attenuate the vibration on the machine.

### **1.2 Objectives**

The main goal of the project is to study the vibration mechanism of the cutter for oil palm frond chopping and determine the best way in to attenuate the vibration of the machine. To achieve the goals, there are a few specific objectives that emphasized are listed as follows:

- i. To improve the development of oil palm fronds chopping machine.
- ii. To analyse how cutter can affect the vibration of the machine.
- iii. To identify the main source that contribute the vibration of the machine,

### 1.3 Scope of Study

The scope of the study is limited to the oil palm fronds chopper that have been used in agricultural industry of Malaysia. There are a few types of oil palm chopping machine developed in this country which have differential in term of design, size and capability, the specimen were taken from the local plantation in order to observe the capability of the machine to be used in the industry.



## CHAPTER 2

### LITERATURE REVIEW

Briefly, this chapter will cover up the studies or researches on the vibration of the oil palm fronds chopping that had been done by other researchers, publications and journal relevant to the current study.

#### 2.1 Background of Study

Oil palm can be define as *Elaeis guinensis*, is one of the most important crop in Malaysia or some other tropical countries. As there were rapidly expanded on the palm oil production, so it could be one of the important contribution to the national income. Based on the statistic, in peninsular Malaysia, there were increases on the area of the oil palm planted from 96 900 in 1965 to 2.05 million hectares in 2000. Also, the planted area of oil palm in Sabah increases from 38 433 hectares in 1970 to 1 000 777 hectares in 2000 following to the rapid expansion. In Sarawak, from 1970 to 2000, the planted area rose from 975 hectares to 330,387 hectares respectively (Wan Zahari et al., 2003). The private estate sector occupied the largest area, amounting about 53.1% of the total area. The rest of the estates were government and state-owned (29.7% and 8.0% respectively) and smallholdings (9.2%). The overall growth from 1991- 2020 is forecast to be at 2.2%.

The Malaysian palm oil industry produce about 17,730,000 tonnes of palm oil and 2, 130,000 of palm kernel oil have been produced from about 4 490 000 hectares of land (Ferdous Alam et al., 2015). Therefore, it conducted the industry to be primarily export-oriented. There are several by-products of oil-palm and these include

palm press fibre (PPF), palm kernel cake (PKC), oil palm trunk (OPT), palm oil mill effluent (POME), empty fruit bunches (EFB), and oil palm fronds (OPF). Production of these by-products were from both oil palm growing and palm oil processing.

Lately, oil palm has been given emphasis as OPF potentially to be utilized as a component in good feeding for ruminants or roughage source. There were a large population of ruminants locally, therefore, the industry should aware with the substantial of OPF supplied. This is one of the most important development of a domestic ruminant industry, especially as the country is only about 5% in milk, 20% self-sufficient in beef, and 6% in mutton. Currently, the total population of swamp buffaloes, dairy cattle, beef cattle, goat, and sheep in Malaysia are 100 000, 12 000, 660 000, 200 000, and 160 000 heads respectively (Wan Zahari et al., 2003). In order to sustain these expansion, some improvement should be made to accommodate increasing of local ruminant population and at the same time to expand feed resources to support these animals.

## 2.2 Oil palm wastes in Malaysia

The total land area in Malaysia amounts to 32.90 million hectares. The major agricultural crops grown in Malaysia are coconut (6.34%), rice (12.68%), oil palm (34.56%), rubber (39.67%), and cocoa (6.75%) which indicated that there are two main major production of the agricultural sector which are rubber and oil palm. However, by 1995 oil palm products have lead the production in the agricultural sector. Lignocellulosic biomass which is produced from the oil palm industries include shells, oil palm trunks (OPT), empty fruit bunches (EFB), and fronds.

The major characteristic similarity in production of agricultural and forestry sector is the large quantities of residues which have no beneficial or economic value other than energy generation. This phenomenon in recent years also has conducted to a major disposal problem due to the discouragement of open burning activities by the Department of Environment in Malaysia. Other than biomass from the plantations, the palm oil industry also produces other types of waste in large quantities mainly palm oil mill effluent (POME), PPF, EFB, and shell (Abdullah and Sulaiman, 2013).

Tropical grasses have been successfully replaced by oil palm fronds as the feed resources for ruminant, this method has been used widely by ruminant producers in Malaysia. Usually, the practices that have been applied in order to dispose PPF is burnt in the processing plant as fuel and the excess is disposed of in the plantations. The PPF and some palm shells have been mix together in the boiler and burnt to produce the power for running the mill (self-sufficient). The grate-type beds of boilers used in this process which are manufactured locally. Basically, palm oil mills use their own low pressure boilers in order to harness the energy from the shell and fibre. Normally, natural decomposition have been done at the plantation where oil palm trunk would

be left on the ground. This practice encourages the spread of diseases and insects like rhinoceros beetles The Oil Palm Wastes in Malaysia 87 and ganoderma that are harmful to the plantation and also disturbs the process of plantation due to the low decomposition rate. Besides, most of the technique practices at the plantations leads to the burning operation such as trunk-shredding and push-felling.

Generally, Malaysia is well known as one of the world's primary producers of palm oil and have done the adaptation on the promotion of renewable energy uses. The country's energy supply could be sustained strategically viable by the utilization of renewable energy resources in particular oil palm waste which minimize the negative impacts of energy generation on the environment. The higher efficiency used of oil palm biomass rather than the palm oil itself for food consumption give a big contribution to acquire more energy from oil palm plantations. Indirectly, this practice also could help agriculture industry to handle disposal problem in an eco-friendly manner while recovering energy and higher value chemicals for commercial applications like building products, bio-fuel, coal replacement and many others. In Malaysia, the principle that is currently adopted for electricity generation is the cost pass-through mechanism which also adopted for renewable power generation. As the result, it caused a little increment in term of electricity and consumer seem beneficial from the renewable energy generation revenues. Table 2.1 listed the breakdown of wastes from palm oil production in 2013.

*Table 2.1: Breakdown of wastes from palm oil production in 2013*

Wastes	Quantity (million tonnes)
Fronds	46.53
Empty fruit bunches (EFB)	22.43
Oil palm trunks (OPT)	6.63
Shell	5.61

### **2.3 Oil palm fronds (OPF)**

Oil palm fronds (OPF) are one of the main by-products of the oil palm industry in Malaysia. It contains about 38.5 % crude fibre with metabolisable energy, ME values of about 5.65 MJ/kg dry matter (Wan Zahari et al., 2003). OPF has great potential to be utilized as a roughage source or as a component in a complete feed for ruminant animals (Dahlan, 2000). This paper briefly reviews the availability of OPF in Malaysia and its importance in the local beef and dairy industry. About 26 million metric tonnes of OPF are produced on dry matter basis annually during pruning and replanting operations in the plantations. The nutritive value of OPF and studies to improve its feeding value is highlighted. The optimum level of inclusion for ruminant feeding is 30 % and improvement to intake and digestibility can be further enhanced with addition of other oil-palm by-products. Performances of beef and dairy cattle fed fresh OPF or as silage, pellets and cubes are shown. Good quality OPF silage can be produced without using any additive and the significant improvement on the rate of growth and milk yield were shown. With good formulations, OPF based diets can allow live weight gains of between 600-850 g/day and for local crossbred dairy

animals, milk yield of about 11.1 to 20.3 litre/day can be obtained. Pellet based on ground OPF seemed to be less well utilized for ruminant feeding due to its smaller particle size. OPF based cubes which have longer particle size is more suitable for beef and dairy cattle. Long-term feeding of OPF based feeds have been shown to produce good quality carcasses, and the meat is safe for consumption.

The average economic life-span of the oil palm is about 25 years. OPF is obtained during replanting and either during harvesting or pruning. On an annual basis, about 24 fronds are pruned per palm tree and the weight of fronds varies considerably with age of the palm, with an average annual pruning of 82.5 kg of fronds/palm/year. Most of the OPF are left rotting between the rows of palm trees, mainly for soil conservation, erosion control and ultimately for the long-term benefit of nutrient recycling.

The need to increase the net return per hectare, has resulted in fronds being exploited as starting resource material for paper pulp, extraction of vitamin E and animal feed. The large quantity of fronds produced by a plantation each year makes this biomass a very promising source of roughage feed for ruminants. It is estimated that about 26 million metric tonnes of OPF is produced on a dry matter basis annually during the pruning and replanting operations in the plantations.

An OPF is made up of three main components i.e. a petiole, rachis and leaflets. About 70 percent of the dry matter in the OPF is from the petiole and the rest from leaves and rachis. The leaves contain a higher percentage of crude protein (CP) and ether extract (EE) than the petioles. The dry matter content of OPF is about 31.0% and in vitro digestibility of dry matter of leaves and petioles was uniform throughout the length of the fronds with mean values of 35.6%. OPF also contains about 18.5%

hemicelluloses. The moisture content (%) of chopped fresh OPF, solar dried chopped OPF, steam dried ground OPF and OPF pellet were 58.6, 44.6, 12.7 and 14.7 respectively while the respective density values were 0.27, 0.08, 0.12 and 0.53. Rumen degradability is an appropriate assessment of the nutritive value of a fibrous feed for ruminants because it relates to the availability of nutrients. A degradability value of 40% or more at 48 h incubation indicated that OPF could be fed directly to ruminants. However, some improvement in terms of nutritive value is needed to increase the degradability level further.



## 2.4 OPF machine

A mobile machine, named OTOSIL, has been developed to produce OPF silage in a complete and improved mechanised process. OTOSIL is now made available to livestock producers. OTOSIL consists of three major components viz, a chopper, a hydraulic compactor and inoculant injector. The chopper is powered by an electric motor and produces fine OPF chips of 1-2 cm in length, considered to be most suitable for efficient fermentation and animal intake. After chopping, the chips are then blown through the chopper trunk to a cylindrical hopper equipped with an automatic sensor switch. The chips upon touching the sensor activate the injector unit which then sprays inoculants at measured amounts. A hydraulic compactor unit compacts the OPF chips into an awaiting PVC drum. The process continues intermittently until the PVC drum is fully filled with OPF chips. Finally the lid is installed on top of the PVC drum to complete the process. The OPF chips are then ensiled for 3-4 weeks before feeding to ruminants.

OTOSIL is very useful and practical to all types of livestock entrepreneurs. It is easily transportable to any location. Currently it is powered by an electric motor, but it can also be powered by a diesel engine. It also can be applied in-situ where processing and utilization can be made in oil palm estates. The invention of OTOSIL will assist the livestock producers and feed manufacturers to systemize silage production and feeding. Figure 2.1 shows OPF chopping machine applied in MARDI



*Figure 2.1. OPF machine used in MARDI*

## 2.5 Vibration mechanisms of OPF machine

In agricultural sector, it is common for the farmer to use or handle the machinery either heavy machinery or simple machinery. OPF chopper can be categorized as one of the simple machinery that have been used worldwide nowadays in the agricultural industry all over the world. So, when it is involve with the motorized machine, it will have the relationship with the vibration mechanism that have been produced by the machine itself.

For OPF frond chopper, vibration acceleration depends on the rotor drive shaft second stage of rotational speed. The results of the some experiments shows that at the rotation speed of 200 rpm, acceleration values of unladen and laden (loaded) cutter head bearing housing assembly vibrations are the same. However, the speed of rotation 600 rpm loaded rotor bearing housing assembly vibration acceleration value is more than twice lower than the unladen rotor bearing housing assembly vibration acceleration value. Therefore, it can be concluded that in order to determine the maximum cutter head unbalance induced bearing housing assembly vibration acceleration values, they would be measured for unladen cutter head (Smits and Kronbergs, 2015).

In addition, the vibration acceleration of the chopper could be measured by attach the vibration sensor to the machine. The sensor will read the vibration parameter while the machine started to do the chopping process. There are four main parameters that should be measured in order to analyse the vibration mechanism of the chopping machine which are rotor bearing housing assembly vibration acceleration (Acceleration), rotor bearing housing assembly vibration velocity (Velocity), rotor bearing housing vibration displacement node (Displacement), and rotor drive shaft rotational speed (Speed). All the parameters that have been measured displayed in Root Mean Square (RMS) values. Figure 2.2 shows example of the output displayed on the vibration sensor.

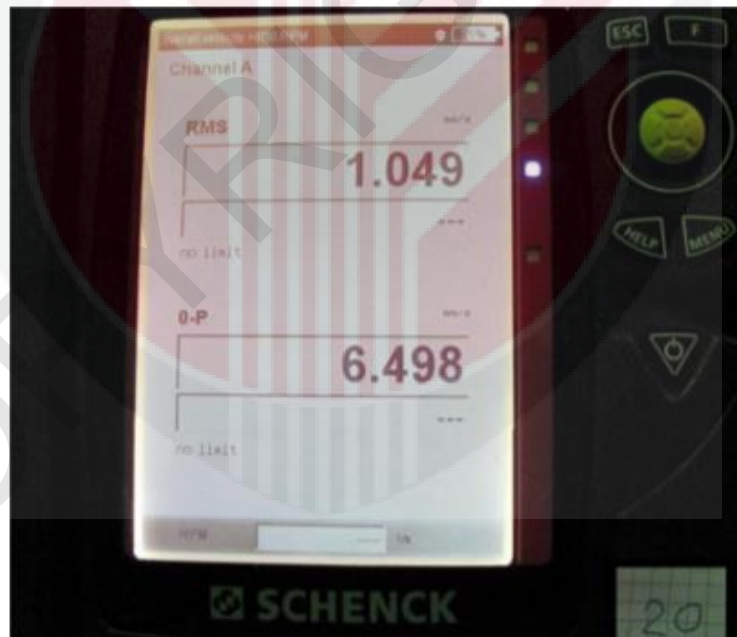


Figure 2.2: Example of vibration velocity (RMS) reading

## CHAPTER 3

### MATERIALS AND METHODS

#### 3.1 Overview

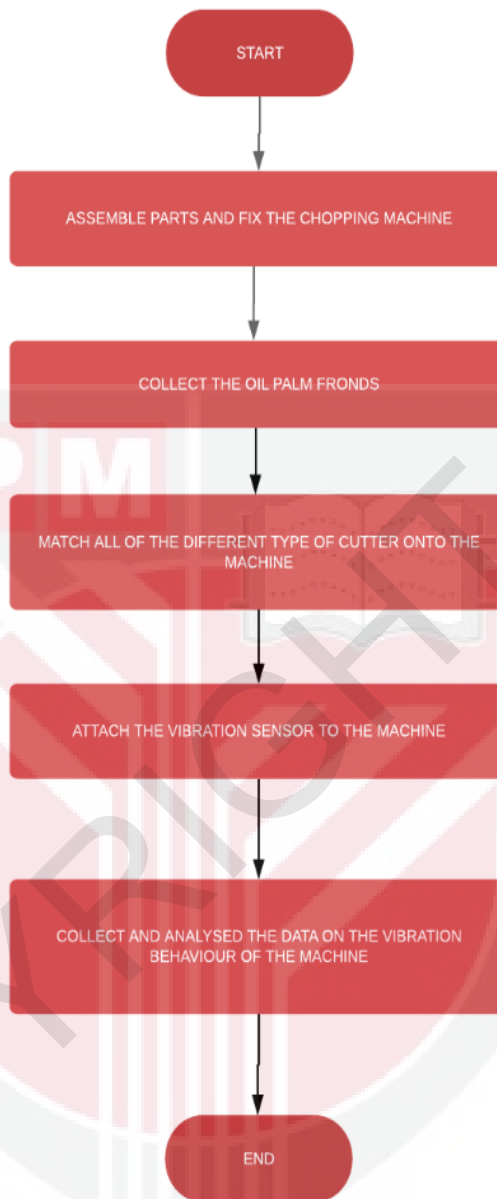
In this chapter, the materials and methods that involved through this project would be describe briefly following the order which are important in order to complete the project. It will describe all the methods and parameters that needed to be done in process of completing the project. The overview of this project will be displayed in a graphical diagram help the understanding and to ensure the project well success with the objectives or purposed that have been planned.

In addition, every steps of generating project requires the labour of every individual and the measures taken are described in detail from the beginning until the end of the project. Therefore, all the work flow could be done smoothly and wisely in order to ensure the goals of this project would be achieved. Besides, the materials and methods also include the action plan, development of the machine, collecting of specimen and analysing of data.

### 3.2 Action Plan

The whole procedures of the project should be planned wisely in order to ensure the smooth implementation of the project before starting the project. It is important to do this process as a guideline and to estimate the timeline for this project to be finished. Also, the consideration of the possible error or constraint should be identify to ensure the problems that may face could be handled well. These plans can give a lot of advantages such as saving time, labour and cost of the project. Furthermore, the plans were outlined to avoid failure while working on this project according to the work flow chart based on the implementation of the project.

In this project, the materials and method have been done within the procedure. Firstly, the chopping machine have been fixed and all the parts were assembled. Then, raw oil palm fronds have been collected from Taman Pertanian Universiti, (TPU). Both of the cutter have been matched onto the chopping machine before doing the chopping test. Next, the vibration sensor (ADASH VA2 Pro II) have been attached to the chopping machine within two points which are at bearing and body of the machine. Lastly, the vibration level of the chopping machine have been collected and analysed. Figure 3.1 shows work flowchart of this project.



*Figure 3.1: work flowchart*

### 3.3 Assembling parts of the chopping machine

The chopping machine that would be used have been developed well in term of structure, design and system. Therefore, it is important to recognize and identify all the compartments of the machine were ready to be used or run. Firstly, all the parts of the machine that have been loosen up were assembled and fix to the machine. After all the compartments of the machine were fully setup, the testing on the machine have been done in order to ensure the chopping machine is on best performance to do the chopping process on the oil palm fronds. Figure 3.2 all the parts have been assembled and fixed to the machine.



*Figure 3.2: Assembling chopping machine parts*

### 3.4 Collecting the specimen

In this process, the specimen that should be used are oil palm fronds that are collected from the local plantation. The fronds should be collected fresh from the plantation which were harvested not more two days before done the experiment in order to maintain its strength and physical. Therefore, the specimen were collected from Taman Pertanian Universiti (TPU), UPM. The application form should be filled up first in order to get permission from TPU officer to take the specimen for this project.

After collecting the specimen, it have been brought back to the lab in faculty of engineering where the chopping machine was setup. Then, the fronds have been cut within the dimension that are suitable for the fronds to be chopped. There are two sets of sample that have prepared in this experiment. The dimension of the fronds that should be prepared before doing the chopping process is 70 cm in length and 10 cm in width. Figure 3.3 shows oil palm fronds that have been collected from TPU.



*Figure 3.3: Raw specimen collected from TPU*

### **3.5 Matching the cutter onto the chopping machine**

The implement that have been applied to this machine are axial-lateral blade type. The blade were designed with compound knife with axial blade. There are two type of cutter that would be testing in this project differing only on the number of axial blade on each lateral. The distance of the cutter with 4 axial blade and 7 axial blade are 5 cm and 3 cm respectively. Both of the cutter should be match to the machine in order to observe the different vibration performance of the machine once it was attached with different cutter. Each type of cutter should be done with chopping test in order to determine the different vibration production and to compare which cutter contribute minimum vibration to the machine. Figure 3.4 shows implements used on the machine.



*Figure 3.4: Type of implement used on the machine*

### **3.6 Attach vibration sensor to the machine**

This sensor would collect all the data on the vibration which are used in the analysing process. Therefore, the vibration sensor that have been used in this experiment is ADASH VA2 Pro II. The main component of this sensor is the accelerometer that should be attached to the point where the vibration want to be measured.

Acceleration sensor used in ADASH VA2 Pro II was a piezoelectric type acceleration sensor with 100 mV/g sensitivity. Piezoelectric crystal was generate the electric charge when it is deformed. Then, electric charge was transferred into the

electronics of the sensor where the electric charge was converted to voltage. This voltage was then transferred into the vibration analyser through sensor connector and cable. In conclusion, while the sensor shaking on the chopping machine, preloaded mass was deforming the piezoelectric crystal and generated voltage signal on the output of the sensor.



Vibration analyser is used in order to assess the machine's axis of rotation. The measurement could be obtained by certain parameters such as vibration displacement, vibration acceleration and vibration velocity. In this experiment, there were two point which are the sensor are attach to the machine which are at the bearing and the body of the machine itself. So, there were two different result could be displayed on the sensor which can see how the vibration applied to each point. The vibration sensor used in chopping test have been shown in Figure 3.5 and table 3.1 tabulated the technical specification of the sensor.



*Figure 3.5: Vibration sensor attached on the machine*

Table 3.1: Technical specification of ADASH VA2 Pro II.

<b>Input channels</b>	- 4 x AC, ICP® power supply on/off - 4 x DC for process values
<b>Input range</b>	- AC +/- 12 V peak-peak - DC +/- 24V
<b>AD conversion</b>	24 bit, 64 bit internal signal processing
<b>Dynamic range S/N</b>	120 dB
<b>Frequency ranges</b>	- Maximum range: 0.35 Hz - 25 kHz (4 Ch, 64 kHz sampling) - Minimum range: 0.35 Hz - 25 Hz (4 Ch, 64 Hz sampling)
<b>Sampling mode</b>	Fully simultaneous for 4 channels
<b>FFT resolution</b>	- Min. 100 lines - Max. 3 276 800 lines
<b>Unit modes</b>	- Analyzer - analytical measurements - Data collector - route measurements - Balancer - 1 and 2 plane on site balancing - Run up - run up and coast down measurements - Recorder - raw signal recording for later post analysis - Stethoscope - listening of the - -bearing/machine noise - Bump test - measurement of natural frequencies - Ultrasound - measurement of ultrasound in 30 - 50 kHz range
<b>Display</b>	Colour 1140 x 800 pixels, LCD
<b>Processor</b>	Intel Atom 1.9 GHz
<b>Memory route</b>	64 GB, max. 16 GB for one route, number of routes is limited by free memory only
<b>Data processing</b>	- Real time FFT - DEMOD - ENVELOPE analysis - ACMT - low speed bearing analysis - Order analysis - RPM measurement - DC measurement - Orbit measurement
<b>Raw signal recorder</b>	- 64 kHz sampling frequency - 4 Ch memory consumption 3 GB/hour - 4 Ch total recording - 20 hours
<b>Interface</b>	USB 3.0, 2.0 compatible
<b>Operating temperature range</b>	-10°C to +50°C
<b>Power</b>	Battery 8 hours of operation, AC 230 V
<b>Case</b>	Aluminium heavy duty
<b>Size &amp; Weight</b>	280 x 205 x 55 mm, 2200 g

### 3.7 Data collection and data analysis

At the final stage, the collection and analysing of the data have to be done with purpose to identify what are the main factor that contribute to the vibration behaviour of the machine. Once the machine was fully setup and the vibration sensor was attached to the machine, the chopping would be run in order to collect the data. There are two type of testing should be done in the experiment which involve the two types of cutter. Each set of testing required the chopping machine to run for three times which are on the free run, with application of the absorber, and while chopping the fronds. Therefore, data was taken in four seconds that have been set in the sensor while the machine was in progress.

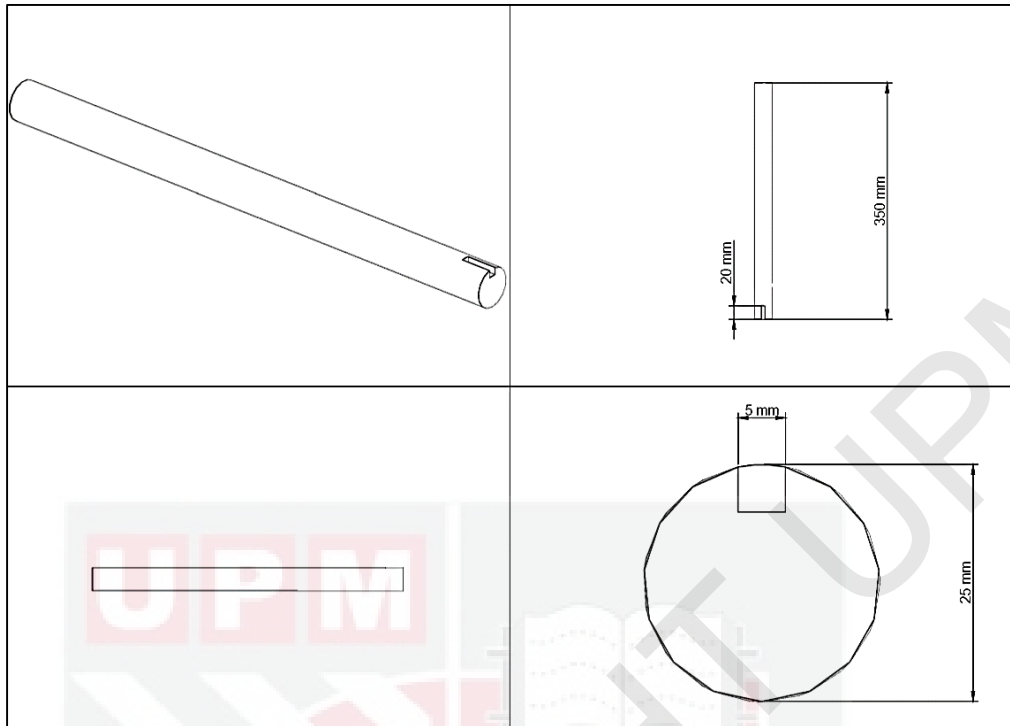
## CHAPTER 4

### RESULTS AND DISCUSSION

#### 4.1 Development of the OPF chopping machine

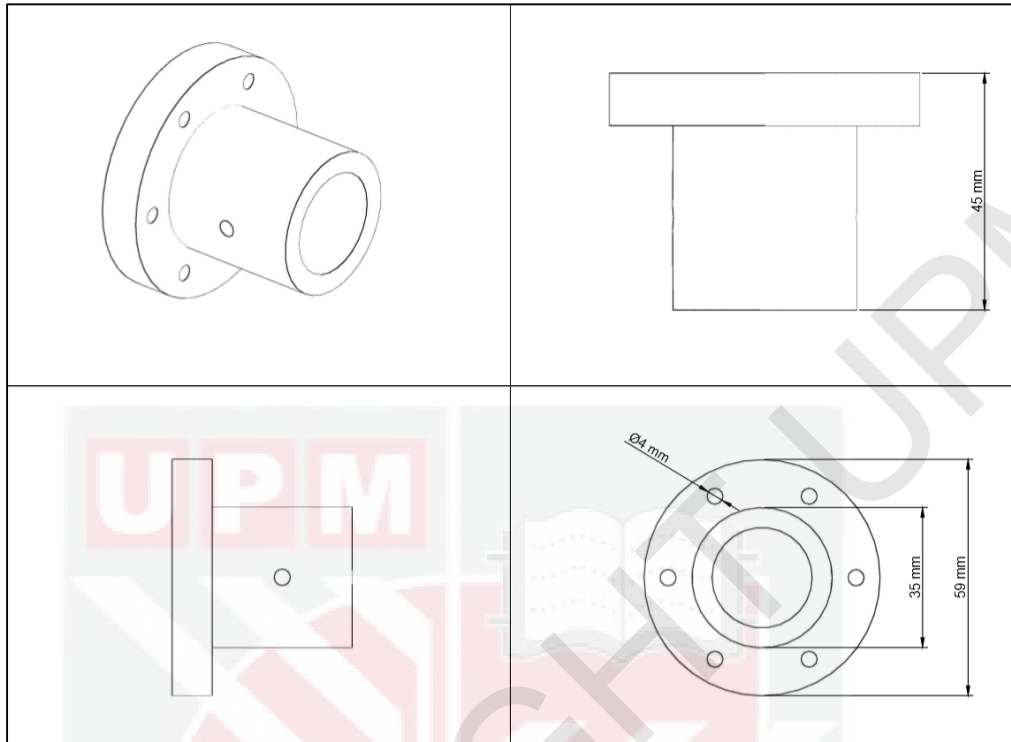
There are several type of chopping machine that have been developed in UPM. The machines have been designed differently as they have different functions according to the tasks that should be done. Therefore, it is important to choose the correct chopping machine following the specimen that want to be chopped.

The chopping machine that have been chosen was developed by previous researcher, but, there machine was not completely developed as there were some parts of the machine were loosen up and missing. So, process of assembling all the part should be done first before the machine are ready to be used or run. In addition, there were some parts or components that have to be redesign such as the shaft and connector in order to ensure the machine would be done properly without any problem. Figures 4.1 show the design of the shaft and the connector.



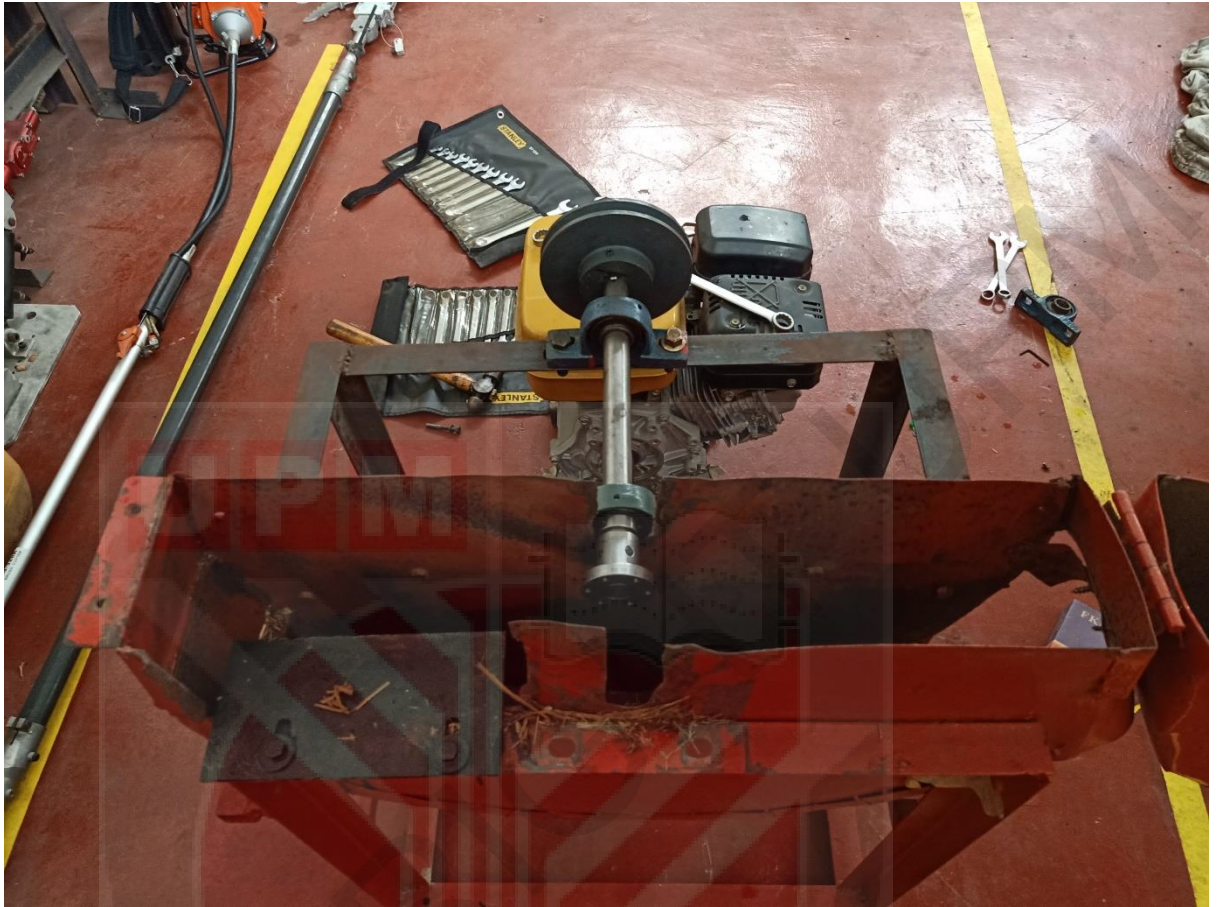
*Figure 4.1: Design of the shaft*

Based on the Figure 4.1, the shaft was designed according to the specification required by the machine. The shaft used to connect the pulley with the blade in the horizontal side which would ensure the pulley and blade were rotates at the same speed. The shaft was designed 350 mm in length and 25 mm in diameter. At one end of the shaft, the special slot have been made with the dimension of 5 mm in length and 5 mm in width in purpose to connect or lock the shaft with the pulley. It is important to ensure that all the dimension were correctly measured to avoid there were any problem to fix them with the machine. The material used to produce this shaft is mild steel as it have capability to accommodate the strength and force that applied by the engine.



*Figure 4.2: Design of the connector*

Figure 4.2 shows the design of the connector. The connector was designed based on the development of the shaft and the blade as it responsible to connect them. Therefore, it was designed 45 mm in length, 35 mm in inner width, 59 mm in outer width, 10 mm in inner thick, and 24 mm in outer thick. Also, it have been prepared with the six screw slots at the outer surface of the connector in order to connect it with the blade. The slots were been made with dimension of 4 mm in diameter. At the centre of the connector which is 22.5 mm from both ends, there were two holes that have been produce with dimension of 4 mm in diameter in order to lock it with the shaft. In addition, the material used for this component also same as the shaft which is mild steel. This is because, this connector should have high ability in order to hold the blade while running the chopping process. Figure 4.3 showed the shaft and connector developed have been connect to the chopping machine.



*Figure 4.3: The shaft and connector that have been connected to the chopping machine*

## 4.2 Vibration behaviour on the machine

Based on this research, there were two different cutter that could be matched with the chopping machine. Two compound knives were fabricated, differing only in the number of axial blade components, being 7 and 4 axial blades with between-blade distances of 30 mm and 50 mm respectively. As the result from my observation, the knife with 7 axial blades produce the minimum vibration on the machine, so it can conclude that the more axial blades on the knife, the less vibration produce on the machine. Figure 4.4 and Figure 4.5 show the results obtained from test by using four axial blade at the bearing and body respectively.

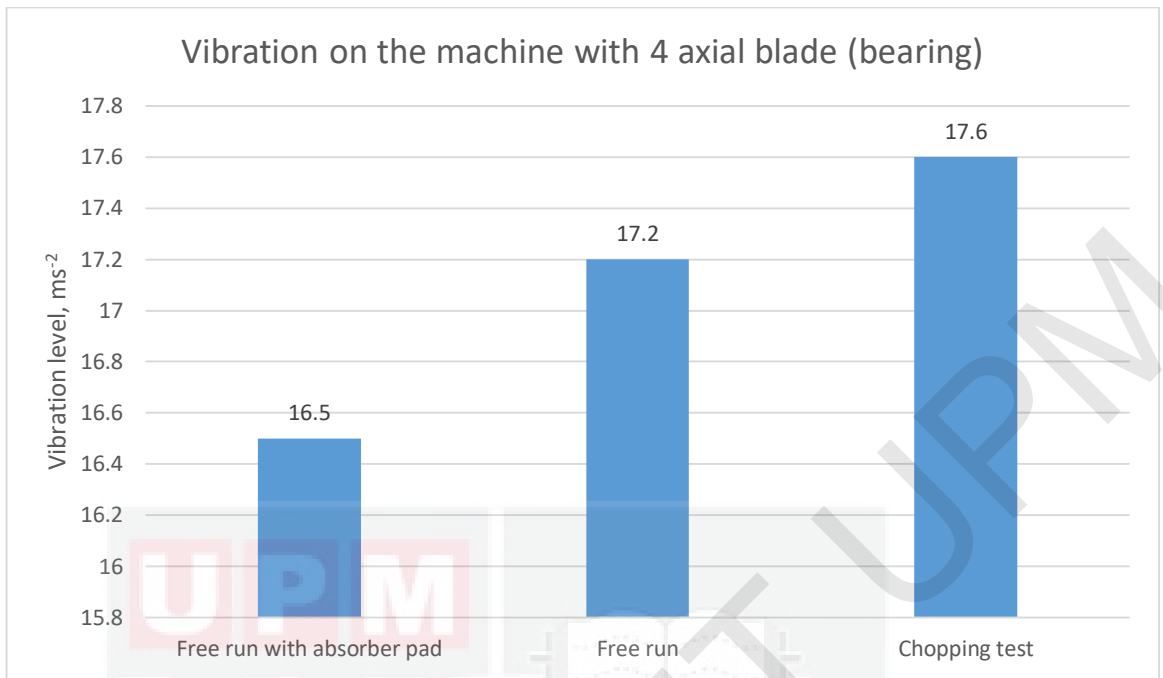


Figure 4.4: Graph on vibration level at bearing with 4 axial blade

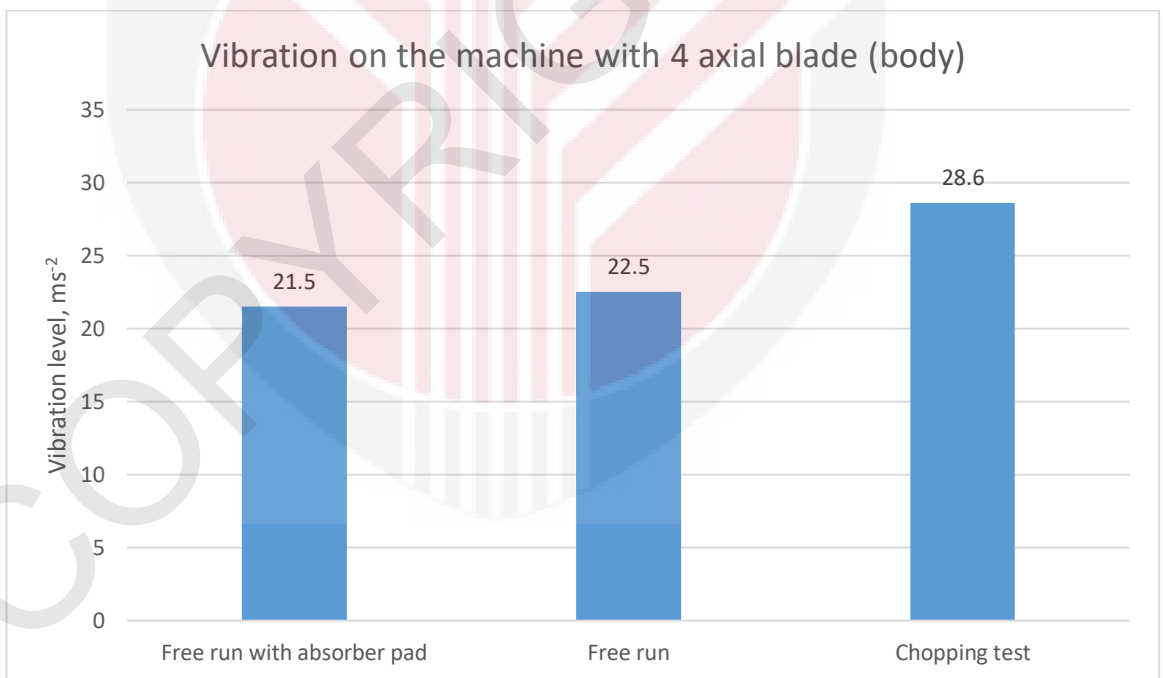


Figure 4.5: Graph on vibration level at body with 4 axial blade

Based on the Figure 4.4, it can be observed the behaviour of vibration on the bearing when four axial blade implemented on the machine. The experiment was run within three methods which are free run, free run with absorber pad and the chopping test with absorber pad. Each method displayed three different output as showed in the graph following the vibration applied on the machine. It shows that the vibration level ( $\text{ms}^{-2}$ ) at free run with absorber pad, free run and chopping test with absorber pad were 16.5, 17.2 and 17.6 respectively. From the observation, there were slightly increases on the vibration level starting from the test of the free run with absorber pad until the chopping test with absorber pad, it because as the resistance were increases, the vibration level increases. The test have been done five minutes for each method while the vibration sensor take only four seconds in order to collect the vibration data on the machine.

Then, the figure 4.5 indicated the vibration level taken by the accelerometer attach on the body of the machine. The test have been done simultaneously with the first test as there were two points have been taken in order to read the vibration level on the machine which are at the bearing and the body. Based on the graph, it showed that the vibration level ( $\text{ms}^{-2}$ ) taken by the sensor for each method which are free run with absorber pad, free run and chopping test with absorber pad were 21.5, 22.5 and 28.6 respectively. As it showed on the graph, the reading of the vibration level on the machine was increase when the absorber pad removed from the machine, while the reading of the vibration level ( $\text{ms}^{-2}$ ) on the chopping test with absorber pad was rapidly increases until 28.6. Therefore, it can conclude that highest value of the vibration level ( $\text{ms}^{-2}$ ) was when the chopping test with absorber pad were done. This is because, when the load were applied to the implement of the machine, the machine start to applied more force which is give more contribution to the vibration.

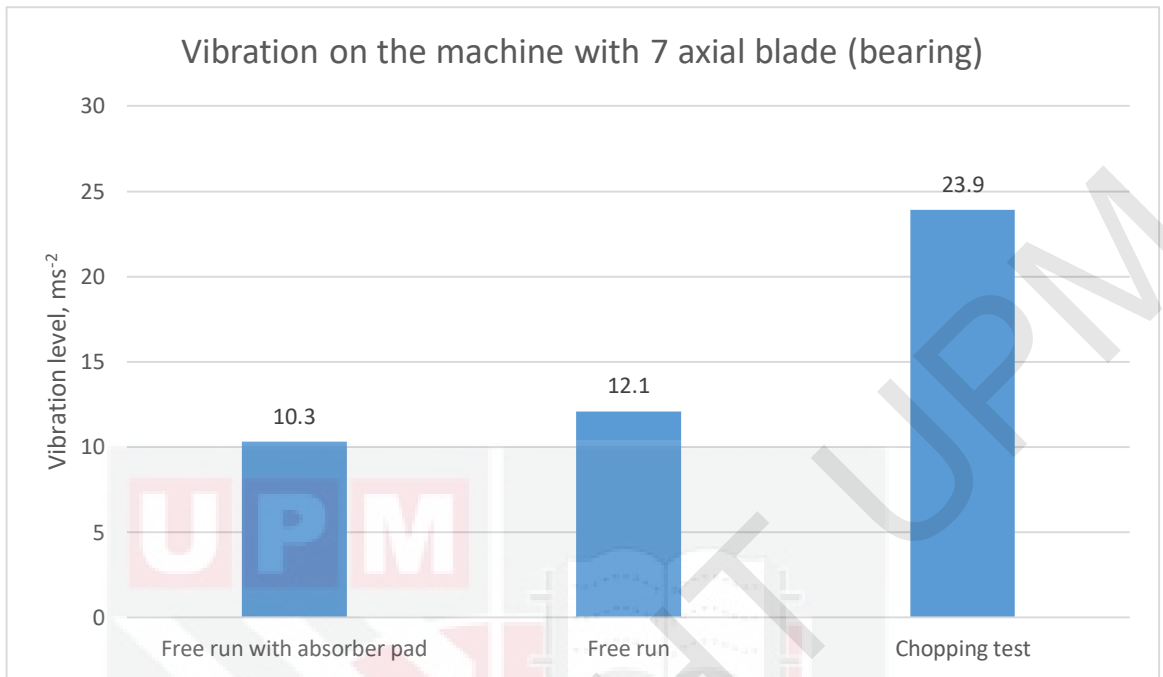


Figure 4.6: Graph on vibration level at bearing with 7 axial blade

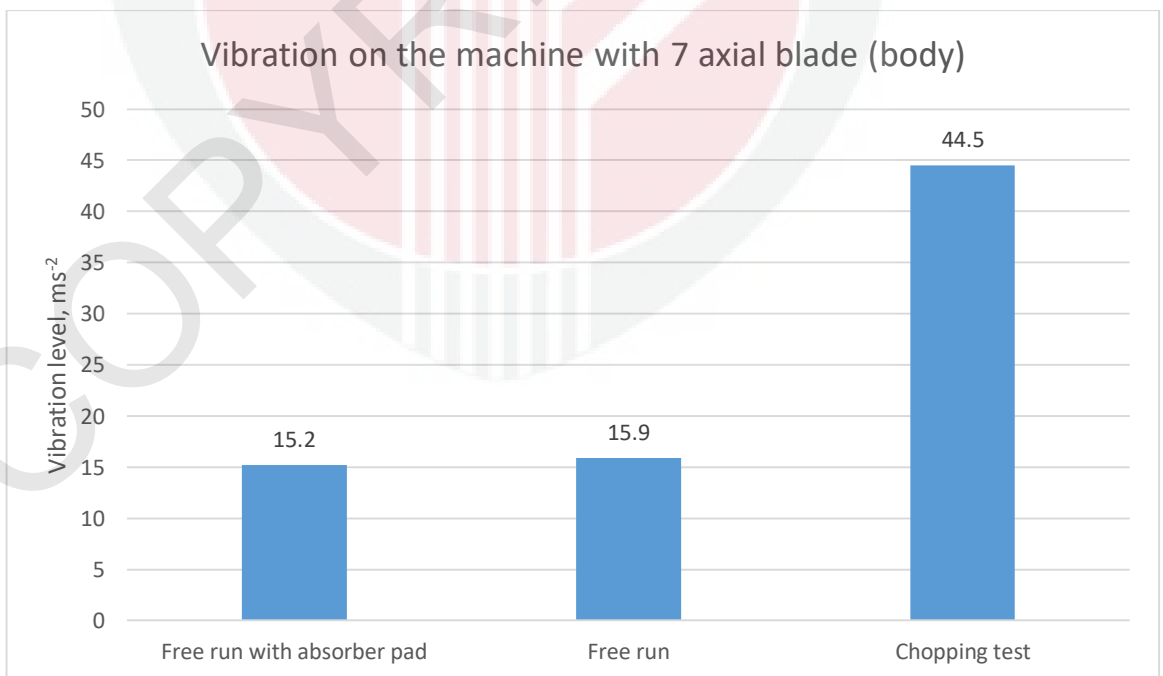


Figure 4.7: Graph on vibration level at body with 7 axial blade

Figure 4.6 and 4.7 show that the result obtained from the test which applied the seven axial blade by using the same methods as the first test. Also, the test was run within the same type of specimen and procedure only differ on type of the implement used. Based on the figure 4.6, the result obtained was on the vibration level at the bearing which was attached at the shaft that connect the pulley with the blade. It was observed that the reading of vibration level ( $\text{ms}^{-2}$ ) for the three methods which are free run with absorber, free run and chopping test with absorber pad were 10.3, 12.1 and 23.9 respectively. The pattern of the graph seemly same as the previous test as there was slightly increases from free run with absorber to the free run test without any absorber pad. Then, there were great increasing on the vibration level ( $\text{ms}^{-2}$ ) of the machine as there were load applied to the implement.

Meanwhile, figure 4.7 shows the result obtained on the vibration level of the machine at the body itself. Before the test was started, there were two accelerometer as the sensor have been attached to the body and the bearing, so that it can be observed the differential of the vibration behaviour at both points. The absorber pad managed to reduce the vibration level ( $\text{ms}^{-2}$ ) as it displayed smaller value than the free run test without any absorber pad from 15.9 to 15.2. However, once the machine was applied with load the reading of the vibration level ( $\text{ms}^{-2}$ ) have increase rapidly to 44.5. Therefore, it can conclude that the load that have been chopped give a lot contribution to the vibration of the machine.

### 4.3 Analysing vibration behaviour on the machine

Vibration analysis can be defined as the process of measuring the parameter on the vibration levels which is used to determine the performance and health of the machine. In this study, a device called an accelerometer were used in order to generate a voltage signal that is proportional to the amount of vibration that produce by the machine during the operation. Also, the frequency of the vibration can be taken on how many time per second the vibration takes place. Furthermore, the vibration analysis used to identify or recognize the problems caused due to insufficient lubrication, improper shaft, improper installation, machining errors, loose bolting, bent shaft and much more.

In this experimental study, the test have been done by using two different blade which differs only on the number of the axial blade. There were two set of test have been run within this experiment which are each set of test represent the each blades. Each set of test includes three type of methods which are free run with absorber, free run without any absorber and the chopping test with absorber pad. Also, the sample prepared for each test have been ensured to be same on their physical and dimension. The sample have been collected freshly from TPU which were kept for two days after harvested in order to maintain its hardness and strength. Before doing the chopping test, the specimen have been cut into a smaller size which is 70 cm in length while 6 cm in width. Besides, the vibration analyser used in this experiment was ADASH VA2 Pro II which was equipped with accelerometer as a sensor. The accelerometer were located at two point of the machine which were at the bearing and the body.

Based on the result obtained in this study, the vibration level of the two set of test that have been done seem similar on the pattern of the graph which were increasing since the machine was applied with the absorber pad until the chopping test. The PVC absorber pads were located at four different points of the base of the machine. This is because, the absorber pad used to absorb mechanical energy that produce by the chopping machine during the operation which is good for overall system protection. As the result, the vibration level produce on the operation with absorber pads for each test smaller compared to the vibration level produce without applied the absorber pad.

In term of the chopping test with absorber pad, the vibration level of the machine have been compared by using the different of blades. Before ran the operation, the chopping machine were setup completely with the absorber pad, the same properties of sample and at constant speed. The engine that have been used in this experiment was 9.0hp Robin Petrol EX Engine with maximum output at 4000 rpm. The optimum speed have been applied in order to ensure the chopping process was smoothly run. Based on the output displayed on the vibration sensor, it showed that the implement with seven axial blade produce greater vibration level on the machine compared to four axial blade. This is because the area of surface to penetrate by the seven axial blade were greater compared to four axial blade which required the greater force to penetrate the load. This prove that the number of axial blade give a huge difference gap of vibration level within those two type of blades. It can be conclude that the implement with less number of axial blades produce a little vibration on the machine and more efficient to be used.

## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATION**

#### **5.1 Overview**

In this chapter, the conclusion and recommendation would be describe briefly to generate the better ideas for future research. There are many factor to be considered in order to ensure all the objectives in this project achieved such as development of the machine, utilization of sensor and type of specimen. All elements that involved in this project have their importance which are affected on the overall of the system. This chapter helps to overcome the problem and suggest improvement for this project in the future.

#### **5.2 Conclusion**

The main purpose of this project is to study the vibration behaviour on the chopping machine that have been developed in order to provide feed to the livestock in agricultural industry of Malaysia. This project able to determine the main factor that give the most contribution of the vibration on the machine which is on the design of the implement itself. Furthermore, the implements were designed with two sides of compound knife and each sides consist numbers of axial-lateral blade. During the chopping tests, the blade would bite into the frond and split into strips and have been cut one by one.

In addition, the result showed there was a great value of vibration level when seven axial blades used in the chopping process compared to four axial blade.

Therefore, it prove that the number of axial blade on the knife affect the vibration behaviour of the machine. So, it can conclude that the knife with four axial blade is the most suitable implement should be used for the chopping machine.

### **5.3 Recommendation**

Although this project have been done successfully, there are some recommendations could be made to improve the efficiency of this study. Firstly, calibration of sensors should be done before starting the experiment. This is important because it helps to improve the sensor performance by eliminating some errors that may reduce the accuracy of the reading. Therefore, it will display the most accurate result in term of precision, resolution and calibration.

Secondly, the chopping machine should be fixed to the ground in order to reduce the vibration that have been charged to the machine. When the machine is fix to the ground, the excessive vibration on the machine will be distribute to the ground, so that the vibration does not only rely on the body of the chopping machine. Also, while running the experiment, the machine tend to move away from original position. So, this will reduce the efficiency of the machine as well.

Lastly, the machine also should be applied with proper anti-vibration pad such as sorbothane vibration isolation pad, cone mounts, and rubber cushion pad. This is because the machine have produce too high vibration level which can give some negative effects to the labour or worker that work on this operation as it have been done manually which required man power. Besides, it is important for agricultural industry of Malaysia to put attention on these problems as it may effect on the agricultural production of the country.

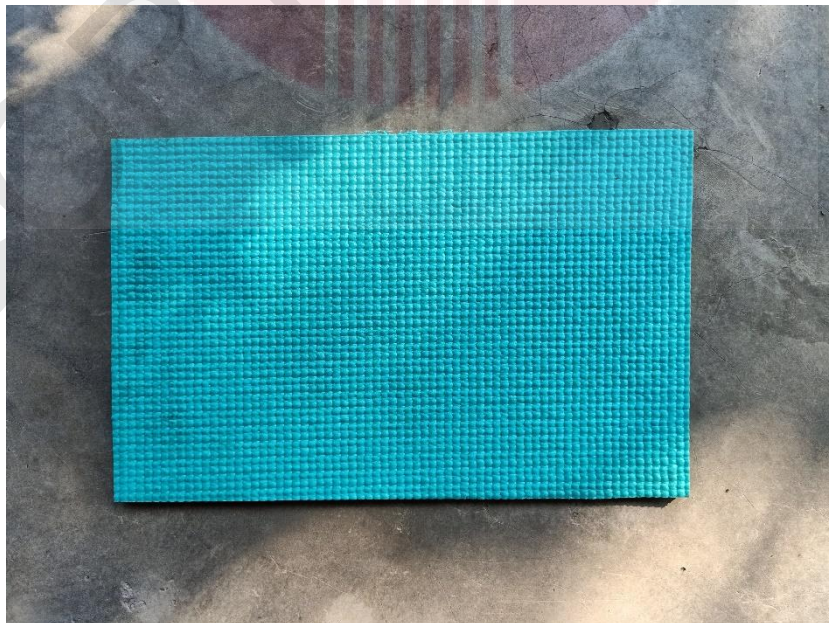
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## APPENDICES



*Figure 1: Chopping machine ready to be used*



*Figure 2: Absorber pad used to reduce vibration*



Figure 3: Output display on the sensor



Figure 4: Cutter attach to the body