SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive)."

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Date : 01/07/2015.

COMPARATIVE TRIBOLOGICAL INVESTIGATION OF BIO-LUBRICANT FORMULATED FROM COOKING PALM OIL

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This thesis is submitted in partial fulfillment of the requirement for Bachelor of Mechanical Engineering (Automotive) with honours

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : .....

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Date : 1 JULY 2015

Special for my
beloved father and mother

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ABSTRACT

The evaluation of friction and wear characteristic in lubrication is investigated by formulating a bio lubricant. The formulated bio lubricant is needed to acts as an alternative to reduce the usage of mineral oil that facing a depletion problem and also have a potential to bring harm to the human and environment. Cooking palm oil that act as a new source is used to reduce the dependence on mineral oil that commonly used in conventional lubricant. A portion of 10% to 40% of cooking palm oil ratio is blended with the base SAE 40 lubricant to produce a bio-lubricant and its properties data recorded. Four–ball tribo testing machine is used to conduct the friction and wear experiment to examine the formulated lubricants. Cooking palm oil also can represent as lubricant additive due to its ability to reduce friction very well. The addition of 30% cooking palm oil into the conventional lubricant shows the best result in every aspect.

ABSTRAK

Penilaian ciri-ciri geseran dan kehausan dalam pelinciran disiasat dengan menformulasi bio pelincir. Bio pelincir yang diformulakan perlu bertindak sebagai alternatif untuk mengurangkan penggunaan minyak mineral yang mempunyai masalah pengurangan sumber dan berpotensi untuk mendatangkan kemudaratan kepada manusia dan alam sekitar. Minyak masak kelapa sawit yang bertindak sebagai sumber baru untuk mengurangkan pergantungan kepada minyak mineral yang biasanya digunakan dalam minyak pelincir konvensional. Pembahagian sebanyak 10% kepada 40% daripada jumlah minyak masak kelapa sawit dicampur dengan pelincir asas SAE 40 untuk menghasilkan bio-pelincir dan data tentang sifat-sifatnya dicatat.Mesin Four Ball Tribotester digunakan untuk menjalankan eksperimen geseran dan kehausan untuk menguji pelincir yang diformulasi. Minyak masak kelapa sawit juga boleh bertindak sebagai bahan penambah kerana kemampuannya dalam mengurangkan geseran dengan berkesan. Campuran 30% minyak masak kelapa sawit ke dalam minyak pelincir asas adalah sampel yang memberi kesan yang paling bagus.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

An engine has friction that occurs in it that depends on lubricant to reduce that friction because the friction can cause wear and make the engine damage in a short time. Unfortunately the conventional lubricant nowadays based on mineral oil sources.

The consumption and the dependence of mineral oil are increasing day by day and the depletion of mineral oil reserves in the future that can cause the higher price of the oil nowadays. The mineral oil can produce many negative effects or impact to the human and environmental. Mineral oil is very toxic, not a renewable source and non-biodegradability. About 12 million tons of lubricants wastes are released into environment yearly that have been reported. Due to its increasing consumption with depletion of crude oil source and also the various negative effects on global climate and pollution like air pollution and acid rain produce to the environment have made concern, according to the use of this nonrenewable source based lubricant, thus, to find the

alternative lubricant sources to meet the future and green technology demand is an important issue.

Recently, the attention on environmental issues increases, which this driven the industry of lubricant toward eco-friendly products from renewable sources. Over the past 25 years, the use of vegetable oil that is biodegradable and environmentally friendly has rising. So, the designing bio-lubricant is one of the ways to fulfill the demand because plant based lubricant have more advantage which are non-toxic that contribute to the safety of the atmosphere and mankind, easy to dispose due to its biodegradability and can control the carbon cycle better than petroleum. This replacement is very worthy and alluring objective.

The reduction of pollution or greenhouse effect, the increasing the agriculture product are an attractive to many countries due to loss of depending on non-renewable sources and uses of vegetable oil. The palm oil is one of the vegetable oil that is now widely studied because of its benefits to the lubricant industry. So, the investigation about the edible oil source like cooking palm oil as a raw material to design the bio-lubricant to see its behaviors, characteristics and compatibility to the friction and wear base on application automotive in bio-lubricant is the main task in this study.

1.1 PROBLEM STATEMENT

The project is conducted because of several problem faces by industrial and environment. First, most of lubricant uses mineral oil as its sources which known have high toxicity and very harmful to the environment, atmosphere and human. The emission from the nonrenewable sources like air pollution problem can affect the human health by exposing them to many diseases such as respiratory disease, heart disease and stroke. The next problem is the depletion of the mineral oil reserve by time that contributes to the increase of its price in the world. The technology base on renewable

source is a high demand in the future so that this research acts as a measure to find alternative sources. Third, the mineral oil that is used in lubricant is not easy to dispose due to its non-biodegradability properties and this can give worse impact to the environment. Furthermore, the unknown characteristics of bio lubricant in term of wear, friction and wear scar diameter lead to this research. Due to all of these problems, this research will help in finding the suitability of cooking palm oil to replace or at least to reduce the uses of the conventional lubricant in the future based on its performance on wear scar diameter and friction.

1.2 OBJECTIVES

1. To investigate wear and friction behaviour in bio lubricant formulated from cooking palm oil.
2. To identify the amount of friction and wear scar diameter reduction when use cooking palm oil as bio lubricant source.

1.3 SCOPE OF STUDY

The scope of study focuses more on the method used to run friction and wear test using four ball tester machines to see the result produced by edible oil source which is cooking palm oil with the mixing of base oil. Before that, the study about how to blend the cooking palm oil with the base lubricant to formulate the bio-lubricant and also to find its properties is emphasized in this project. All the method need to concern about its preparation of apparatus and equipment with their method of use in order to get the

accurate result. The method required to be conducted and then the data need to be collected, recorded and make a proper analysis on it.

CHAPTER 2

LITRATURE REVIEW

2.0 FRICTION AND WEAR

The research on various lubricants has been extensively carried out due to present of friction and wear in industrial applications that cannot be avoided. Friction can be defined as the force that resists relative motion between two bodies in contact while wear is the action of causing deterioration. The responses of tribo-system are friction and wear.

Although a comprehensive, simple relationship should not be expected, both friction and wear need to be exactly related between each other in each state of contact in the system. Coefficient of friction and wear act as parameters that can be used to describe the state contact of bodies in a tribo-system. Both of them are not material constants of the bodies in contact and may be treated as material properties for technical conveniences with an engineering sense only in some special states of contact (Kato,2000).

2.1 LUBRICANT

Lubricant is a substance introduced between two moving surfaces that use to reduce friction between them, reduce wear and improve efficiency. Lubricant is essential for the lubrication, corrosion protection, power transmission and heat transfer. Wear and heat cannot be completely eliminated, but it can be reduced to acceptable levels. The conventional lubricant usually uses mineral oil as its base oil and with added of the small percentage of additive to increase its efficiency and performance by improving some of the base oil properties.

The base oils sometimes used vegetable oils or synthetic liquids such as hydrogenated polyolefin, esters, silicone, fluorocarbons and many others. Lubricant is widely used in the automotive industry like motor vehicle and powered equipment to protect the internal combustion engine. It can help to reduce friction like frictional horsepower and wear between two parts. Besides, it can act as a coolant in engine by carrying away the excess heat in it. The lubricant can help to remove debris or particles and send them to an oil filter to clean the engine.

Moreover, it produces seal between two parts and prevents compression gas escape into the crankcase area. Sometime, the lubricant oil can be contaminated and affect the lubricant efficiency where contaminants come from road dust and dirt, carbon an fuel soot, leaking of water in cooling system, fuel contaminant, oil oxidation and acids in the engine. The lubricant can be form in solid, semisolid, liquid and gaseous but mostly used in liquid. There are three important characteristics of the lubricant oil, which are viscosity, viscosity index, flash point, pour point and fire point.

2.0.1 Viscosity

The measure of resistance in flow and internal friction for moving fluid is known as viscosity. The viscosities of fluids can change as a function of temperature, pressure and other factors. In liquids and gases, the pressure is directly proportional to the viscosity. As the temperature rise, the liquid expands, causing the molecules move farther apart and the intermolecular forces decrease and consequently viscosity decrease. But, the different situation happens in gases. When the temperature increase, the velocity of molecules increases and the momentum transfer raised which results in increasing of viscosity (Wilard, 2014).

2.0.2 Viscosity Index

Viscosity index is an arbitrary measure of the change of viscosity with temperature. The calculating viscosity index from kinematic viscosity at 40 and 100˚C is to determine the standard viscosity

2.0.3 Flash point

The flash point of the liquid is the lowest temperature at which lubricant can vaporize to form an ignitable mixture in air

2.0.4 Pour point

The liquid pours point is the lowest temperature at which it becomes semisolid and loses its flow characteristics.

2.0.5 Fire point

The liquid fire point is the temperature at which it will continue to burn for at least 5seconds after ignition by an open flame.

2.2 BIO LUBRICANT

Further study of Bio-lubricant is made because it is an alternative way or a solution to the uses of mineral oil, the nonrenewable sources that uses in conventional lubricant because of their widespread sources. Bio lubricant is formulated from vegetable base oils together with the base oil. This lubricant also can be made from petroleum oils and synthetic esters that satisfy established toxicity and biodegradability criteria (Shahabuddin et al, 2013).

Generally, bio lubricant can be considered as high biodegradability lubricant as well as low environmental and human toxicity. It has very useful physicochemical properties, but it also has the properties that are unsuitable which make crude oil lubricant based sources evident option. So, many research and development have done

to improve the physicochemical properties of the vegetable oil to make it cheap and good enough compare to petroleum.

The bio lubricant types of feedstock may differ from every country and mostly depend on geographical locations. More than 350 oil-bearing crops are known is used to make bio lubricant. Among of them are palm, sunflower, soybean, coconut, peanuts, cottonseed and rapeseed oils which have a great potential alternative bio lubricant.

In Malaysia, palm oil is the main feedstock for biodiesel and bio lubricant because it has shown promise in both technologies with its eco-friendly characteristic and has high production rate, which could fulfill the demand for a vegetable base lubricating oil and biodiesel. Moreover, other non-edible oils like Karanja, Neem and Jatropha have received worldwide interest. The **Table 2.1** below shows some of non-edible and edible seed with their oil content statistic (Mobarak et al, 2014).

Table 2.1: Oil content statistics of some non-edible and edible oil seeds

Sl. No.	Non-edible species	Oil content (% of volume)	Edible species	Oil content (% of volume
1	Jatropha	40-60	Rapeseed	38-46
2	Neem	30-50	Palm	30-60
3	Karanja	30-50	Peanut	45-55
4	Castor	45-60	Olive	45-70
5	Mahua	35-50	Corn	48
6	Linseed	35-45	Coconut	63-65
7	Moringa	20-30	-	-

In addition, the lubricants are satisfactory for low pressure and low speed application. When oil viscosity is insufficient to prevent surface contact, the boundary of lubrication will occurs. To reduce wear, anti-wear additives provide a defensive film at the surface of contact. The vegetable oil-based bio lubricants have better anti-wear properties than mineral oil by formation of tribo film on the material's surface (Abdullah et al, 2013).

Bio lubricant has its advantages that make it very suitable as an excellent technology in mechanical industry and disadvantages that become an obstacle that the researcher should overcome in order to apply it in this industry (Mobarak et al 2014)

2.2.1 Advantage of bio-lubricant

1. The bio-lubricant produce less emission because of its high boiling temperature and this benefit the designing of lubricants which it can be used over a wide temperature during designing the lubricant.
2. Bio-lubricant has more excellent lubricity than petroleum based corresponding lubricants where this lubricant can substantially increase thin film strength by enhanced with the polar nature of lubricants and also enhance affinity towards the surface of metal. This tendency of wetting reducing the friction and save energy of the equipment of operation in the range of 5 to 15%.
3. This lubricant also more suitable for high temperature application about 250°C and above because its viscosity index is very high and it does not vary with the temperature as much as mineral oil.
4. Less maintenance, which can reduce costs due to longer interval to re-lubricate
5. The uses of the bio-lubricant can decrease the uses of mineral consumption. The better manage of the carbon cycle that can contribute to the reducing of environment and human negative impacts are one of the benefits when this renewable source more applied in this world.

6. Due to the bio-lubricant higher flash or fire points and lower volatility, less vapor emission and oil mist and constant viscosity, the lubricant cause better lubricant.
7. Bio-lubricant can minimize metal surface corrosion and toxicity.
8. It exhibits a less dermatological problem and better skin compatibility.
9. It is biodegradability that can be easy to dispose, reduce cost of disposal and make it eco-friendly

2.2.2 Disadvantages

1. When contaminant present in bio-lubricant, some bad odors produced
2. Bio-lubricant lacks oxidation stability and will have high pour point if not treated.
3. To eliminate stability issues that relate to the extreme high and low temperature in plant-based lubricants, an additive has designed specifically.
4. It has high viscosity even at low temperature.
5. At high temperature, it has poor oxidative stability.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This chapter showed the process of conducting this PSM project by a simple flow chart and followed by the methodology that has been used to make sure the objectives above achieved and produce accurate results. The explanations about the sample that prepared, the method for blending, finding of sample properties and the procedure that needed to conduct of the experiment with the apparatus and equipment used are focused through this chapter. Besides, the expecting result is also mentioned as a guide to run the methods.