UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FRICTION AND WEAR PREVENTIVE CHARACTERISTIC OF BIOLUBRICANT DERIVED FROM WASTE COOKING OIL

This report submitted in accordance with requirement of the UniversitiTeknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Bachelor of Mechanical Engineering Technology Maintenance Technology) (Honours)

By

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FACULTY OF ENGINEERING TECHNOLOGY

2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **FRICTION AND WEAR PREVENTIVE CHARACTERISTIC OF BIOLUBRICANT DERIVED FROM WASTE COOKING OIL**

SESI PENGAJIAN: **2016/17 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

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(DR ABDUL MUNIR HIDAYAT SYAH LUBIS)

ABSTRAK

Keperluan pelincir boleh diperbaharui dan mesra alam telah menjadi kebimbangan kepada alam sekitar untuk menggantikan pelincir berasaskan mineral. Ini adalah disebabkan oleh kesan buruk minyak berasaskan mineral terhadap alam sekitar membuat kesan penggantian ini untuk menjadi penting. Kajian ini memberi tumpuan kepada minyak pelincir bio yang diperolehi daripada sisa minyak masak dan mengkaji kehausan dan geseran ciri pencegahan minyak pelincir bio. Untuk menjalankan kajian ini, sisa minyak masak telah menjalani proses transesterifikasi untuk menghasilkan pelincir bio. Ciri pencegahan kehausan dan geseran minyak pelincir bio diperolehi dengan menggunakan kaedah empat bola penguji (ASTM D4172) dengan beban (147N, 392N dan 736N) dan kelajuan (600 rpm, 1200 rpm dan 1600 rpm) yang berbeza. Diameter parut geseran bola diukur menggunakan mikroskop optik dan mekanisme kehausan juga telah dikaji. Proses transesterifikasi telah mengurangkan asid lemak beban dalam sisa minyak masak dan menghasilkan ciri-ciri pencegahan geseran dan keupayaan kehausan yang lebih baik. Hasil keputusan keupayaan geseran minyak pelincir bio ini untuk 600 rpm bagi beban 147N ialah 0.0296, 392N ialah 0.0639 dan 736N ialah 0.0795. Manakala untuk 1200 rpm bagi beban 147N ialah 0.0878, 392N ialah 0.0795 dan 736N ialah 0.0795. Untuk 1600 rpm bagi beban 147N ialah 0.0402, 392N ialah 0.0680 dan 736N ialah 0.0771. Hasil keputusan untuk diameter parut kehausan untuk 600 rpm bagi beban 147N ialah 0.1750mm, 392N ialah 0.2187mm dan 736N ialah 0.2548mm. Manakala untuk 1200 rpm bagi beban 147N ialah 0.2209mm, 392N ialah 0.2230mmm dan 736N ialah 0.2618mm. Untuk 1600 rpm bagi beban 147N ialah 0.2276mm, 392N ialah 0.2400mm dan 736N ialah 0.2747mm. Kajian ini menunjukkan bahawa pekali geseran minyak pelincir bio telah meningkat apabila kelajuan dan beban meningkat dalam sempadan pelinciran rejim. Minyak pelincir bio ini berpotensi digunakan dalam enjin bukan pembakaran seperti pemampat dan pam empar.

ABSTRACT

The needs of renewable and biodegradable lubricant had become the most environmental concern issues nowadays to replace the mineral based lubricant. This is due to the environment effect imposes by mineral based oil making the effect of substitution to be essential. This study is focused on developed bio lubricant derived from waste cooking oil and study the wear and friction preventive characteristic of the bio lubricant. In order to conduct this study, the waste cooking oil had to undergo transesterification process to produce the bio lubricant. The wear and friction preventive characteristic of the oil were acquired by using four ball tester methods (ASTM D4172) with different load and speed. The wear scar diameter of the balls was measured using optical microscope and the wear mechanism also had been studied. The coefficient of friction of the bio lubricant at 600 rpm with load 147N is 0.0296, 392N is 0.0639 and 736N is 0.0795. While at 1200 rpm with load 147N is 0.0878, 392N is 0.0795 and 736N is 0.0726. At 1600 rpm with load 147N is 0.0402, 392N is 0.0680 and 736N is 0.0771. The measurement for the wear scar diameter at 600 rpm with load 147N is 0.1750mm, 392N is 0.2187mm and 736N is 0.2548mm. While at 1200 rpm with load 147N is 0.2209mm, 392N is 0.02230mm and 736N is 0.2618mm. At 1600 rpm with load 147N is 0.2276mm, 392N is 0.2400mm and 736N is 0.2747mm. It was found that the transesterification process has reduce the free fatty acid in the waste cooking oil and produce a better friction and wear preventive ability. The test show that the bio lubricant coefficient of friction increase as the speed and load increase in boundary lubrication regime. The bio lubricant potential application is in non-combustion engine such as compressor and centrifugal pump.

DEDICATION

To my beloved parents that always at supported and motivated me. To all my friends that give support. To my project supervisor and my academic advisor who always patiently give me guidance.

ACKNOWLEDGEMENT

First of all, I would like to recite Alhamdulillah and thanks to Allah for providing me strength and courage to finish up this project. This research project would not have been possible to finish without support from many people surround me. Special thanks to my supervisor, Dr. Abdul Munir Hidayat Syah Lubis, for his guidance and support through this case study. His experience in this related topic has given me a boost of confidence in conducting my experimental work. Another thanks to Puan Rusni binti Hassan for the help in the product production. Appreciation to my parents and family for their cooperation, encouragement, constructive suggestion and full of support for the report completion, from the beginning till the end. Finally, I would like to thanks to my entire friends who help and support thorough my project and writing this report.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCULTURE

PAO	-	Polyalphaolefines
PTFE	-	Polytetrafluoroethylene
TMP	-	Trimethylpropane
VI	-	Viscosity Index
%	-	Percent
°C	-	Degree Celsius
FA	-	Fatty Acid
TAG	-	Triacylglycerol
OOL	-	Oleic Oleic Linoleic
OLL	-	Oleic Linoleic Linoleic
cSt	-	Centistokes
COF	-	Coefficient of Friction
ASTM	-	American Standard for Testing and Material
CEC	-	The Coordinating Europian Council
WSD	-	Wear Scar Diameter
SAE	-	Society of Automotive Engineering
C_2H_6O	-	Ethanol
KOH	-	Potassium Hydroxide
FAAE	-	Fatty Acid Alkyl Ester

$C_{16}H_{32}O_2$	-	Palmitic Acid
Mm	-	Millimetre
N	-	Newton
Rpm	-	Rotation per Minute
±	-	Plus/Minus
X	-	Times
mm	-	Millimetre

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The major function of the lubricant is to reduce friction and wear that destroy the surface due to friction that goes on between the parts. Besides that, lubricant also used to clean, improves sealing, reduces corrosion and avoids the engine heating extremely. In some way, the purposes of the lubricant in an engine are to extend the lifespan of the engine (Syahrullail, et al., 2012). The thin layers of a lubricant between two surfaces are generally used as a protector. It is because without a protector, it will cause the surface wear and damage due to the pressure that form between the devices in sliding motion (Guezmil et. al., 2014).

Currently, the demand of lubricant in industrial application is extremely huge especially in an automotive industry, but the mineral oil based lubricant cause pollution to the environment and non-bio degradable mineral. The needs of renewable and biodegradable lubricants had become the most environmental concern issue nowadays to replace the mineral based lubricant. As an alternative way to reduce the pollution, vegetable oil based lubricant were used to produce bio lubricant. The advantages of bio lubricant to the environment are its biodegradability, renewability resources and the performances in a variety application (Mobarak et al., 2014). Besides that, Syahrullail et al. (2011) stated that, vegetable oil based lubricant has low friction coefficients and good wear protection.

A bio lubricant is classified as biodegradable it is proved can be decay within 12 month, naturally (Whitby et al, 2005). When it is completely decay it means that the lubricant has necessity been back to its original place. This is to reduce the greenhouse effect that comes from lubricants. By doing this, the problem that comes from lubricant decomposition can be eliminate or decrease and keep the earth green (Silva et al., 2011).

1.1 Problem Statement

Nowadays, lubricants oils was developed using mineral oil as a base fluid because of its cheap price and the durability. Besides that, mineral oil produce good tribology performance. The problem cause by mineral oil are it's hard to dispose and it's likely to pollute to the environment (Willing, et al., 2001). The most worrying issue is the limited resource of mineral oil. As the solution of this problem, vegetable oil based lubricant were produced. Vegetable oil based lubricant such as palm oil was used because it's biodegradability and good properties for lubricants. Besides that, waste cooking oil also share the same properties as vegetable oil and it advantages are it can reduce the waste cooking oil from being thrown away without any benefits.

1.2 Objective

- To develop bio lubricant oil derived from waste cooking oil.
- To study the friction preventive characteristic of bio lubricant derived from waste cooking oil.
- To study the wear preventive characteristic of bio lubricant derived from waste cooking oil.

1.3 Scope

In order to achieve the objective above, the following scopes of study have been drawn:

- Developed bio lubricant oil derived from waste cooking oil by using esterification process.
- Studied the wear preventive characteristic of bio lubricant derived from waste cooking oil.
- Studied the friction characteristic of bio lubricant derived from waste cooking oil.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Lubricant

Lubricant is a substance that is used to reduce friction and wear between two moving surfaces. A good lubricant will have the characteristics such as high boiling point, low freezing point, high viscosity index, high thermal stability, hydraulic stability, corrosion prevention and high resistance to oxidation. Lubricant also used to separates the moving parts in a system. So that it will reduce the friction and surface fatigue simultaneously reduces heat generation, vibration and operating noise. Other than that lubricant can reduces the expansion of by transferring the heat and can act as a coolant and it also can function like transporting foreign particles. In a commercial lubricants, usually there are 90% base oil and less than 10% additives. The additives work as friction and wear modifier, produce stable viscosity, give better viscosity index, avoid corrosion and oxidation, slow aging process, avoid contaminants etc. (Jeffrey, 2007).

Lubricants can be in liquid, solid and semi solid. Solid lubricant where the solid material that act as a layer which is composed of organic or inorganic compounds such as graphite, molybdenum disulphide, and cadmium disulphide. Next one is semi solid lubricant which is liquid are blended in a form of thickener and additives, like grease. Petroleum, vegetable, animal and synthetic oils are the example of liquid. Each of these has different base oil resources, for example natural oils that are derived from animal fats and vegetable oil. Lastly product reaction is liquid lubricant that is tailored per requirement such as ester, silicones and polyalphaolefines (Munack et al., 2001). There are several type of lubricant such as solid lubricant, semi-solid lubricant and liquid lubricant are discuss below.

2.1.1 Solid Lubricant

In severe service conditions such as high temperature or freezing, vacuum, radiation, and high load, solid lubricants is use to control friction and wear. The advantages of solid lubricant are it has excellent tribology characteristic for metal lubricants but less performance for most inorganic. It can stand high pressure besides than good wear preventive characteristic at slow speeds. Solid lubricants can be use in any condition to accomplish friction and wear under high load and/or high temperatures (Erdemir et. al., 2000). At sliding surfaces, solid lubricants sacrifice itself to reduce the friction and wear. Solid lubricant properties is shear easily to reduce friction and to avoid wear between the two moving surfaces. Examples of inorganic solid lubricant are molybdenum disulfide, graphite and hexagonal boron nitride. Besides that, soft metal such as lead, gold, silver, copper, indium, and zinc also used as solid lubricant.

The common solid lubricant use is graphite and molybdenum disulphide. Beside this boron nitride, tungsten disulphide and polytetrafluorethylene (PTFE) are the other solid lubricant solid lubricants are also used in form of dry powder or as constituents of coatings. All these type of crude oil product can only be used as long as the crude oil available to be distilled in distillation process. Although mineral commonly used in lubrication system there are side effect produce such as pollution in both aquatic and terrestrial ecosystem (Ssempebwa, 2009). Besides that, the combustion of mineral oil as a lubricant has been proven that it emit traces of metals, such as calcium, phosphorus, zinc, magnesium and iron nanoparticles(Miller et.al., 2007). Figure 2.1 show the structure of molybdenum and graphite.

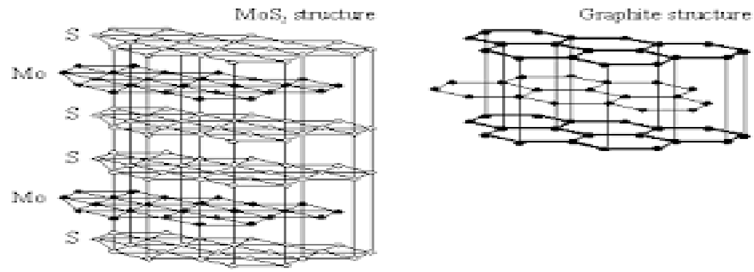

Figure 2.1: Molybdenum and Graphite Structure (Miller et al., 2007)

2.1.2 Semi Solid Lubricant

Semi solid lubricant is composed of calcium, sodium or lithium soap base emulsified with mineral or vegetable oils is known as grease. It is used in high load place and in condition where liquid lubricants cannot hold out. Greases are shear-thinning which undergo reduction in viscosity under shear. Greases are use at heavy pressures where oil drip is undesirable and place where contacting surfaces that are discontinuous and difficult to place lubricant oil at it (Varadarajan, 2014). The advantages of grease are its stick at application place and have a good bonding to surface, good for inclined/vertical shafts, prolong the life of worn parts, give a good mechanical lubrication absorber in extreme conditions such as shock loading, reversing operations, low speeds and high loads beside than reduce noise and vibration.

The grease properties depend on the type of oils used such as mineral, synthetic, vegetable or animal fat. Furthermore the additive also play important role in making a grease in order to enhance the grease properties like corrosion protection, anti-oxidation, extra pressure and etc. There are variety used of semi-solid lubricant such as roller bearings in railway car wheels, rolling mill bearings, steam turbines, spindles, jet engine bearings and other various machinery bearings. Grease can withstand heavy load at low speed. Besides that, grease experience higher internal resistance compared to lubricating oils. Therefore lubricant oil is more virtue compared to grease because grease are not efficiently spread heat from the bearings, thus it is only can be use at low temperature (Bijwe et al., 2016)

2.1.3 Liquid Lubricant

Liquid lubricant consists of a mixture of base oil and additives which are blended to a specific viscosity and it is designed to meet the performance needs of particular type of service (Eugene et. al. 2006). Liquid lubricants are generally composed of 90% base oil and less than 10% of additives to improve the performance. The type of lubricants oil are based on the type of base oil, the base oils produce the performance required of the lubrication oil. The addition of additives is made to modified friction and wear, give better viscosity and viscosity index, avoid corrosion and oxidation. The performances of liquid lubricant typically determined by the boiling and freezing point, viscosity index, thermal stability, corrosion prevention and resistance to oxidation (Syahrullail, et al., 2012).

Lubricant are highly toxic and the biodegradability are low (Horner et al., 2002)]. These factor will affect the environment and most important are losses to soil, water and contaminant that will threat plant, animal and human life (Sallimon et.al, 2010). The strong awareness of environmental and pollution encourage need of new renewable sources and biodegradable lubricant that are environmental friendly (Fox et al., 2007). For the past century, mineral oil have taken place in lubricant production and nowadays the greenhouse effect cause worries because of the mineral and synthetic oil are hard to disposed (Bartz et.al.,1998). Other than that, the mineral oil based lubricant are released into the environment during use, spills and disposal which cause the pollution (Schneider, 2006).

2.2 Liquid as Lubricant

There are various types of lubricant that are produced such as synthetic oil, mineral oil and vegetable oil. One of the most important factors in selecting base oil is the liquid's viscosity at various temperatures. Besides that, the viscosity and coefficient of friction is the important thing to be considered. Nowadays biodegradability being the significant thing to be considered because lubrication oil causes most of the environment problem (Syahrullail, et al., 2012).