DEVELOPMENT OF PALM KERNEL OIL AS LUBRICATION UNDER EXTREME PRESSURE

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TO MY BELOVED....

Father (Misbah Bin Mohd Tap)
Mother (Hajar Binti Adam) and Family,

Thank You for Your Support!!

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"In the name of Allah with the Most Compassionate, the Most Merciful"

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ABSTRACT

Vegetable-based lubricants are more biodegradable compared to lubricants produced from mineral oil. Due to the increasing concern about environmental damage and health caused by mineral-oil based lubricants, there is a growing worldwide trend for promoting the use of vegetable oil as lubricants in industries. Nowadays, vegetable oil is viewed as having the potential to substitute the mineral-oil based oil due to its properties such as being biodegradable and non-toxic but the problem is performance at low temperature. In this research, palm kernel oil (PKO) blended with 6 w%, 8 wt% and 10 wt% of pour point depressant (PPD) is used as lubricants to evaluate tribological behaviours using fourball tribotester. The objectives of this research are to determine the friction value and wear characteristics of PKO blended with 6 w%, 8 wt% and 10 wt% of PPD using fourball tribotester and performance of low temperature ability of lubricant. In order to determine the lubricity trait, fourball tribotester machine are used and the experiment are comply with ASTM D4172 and ASTM D2783. Parameters which covers this research are low temperature performance ability of blended PKO, coefficient of friction (COF), wear scar diameter (WSD), surface roughness and worn surface. The result of the experiment show that for low temperature performance, PKO with 10 wt% PPD (PKO-10) show great performance which can withstand 13.6°C. While for the normal load condition test, PKO – 10 performance are far better than synthetic oil (SAE15W – 50) in term of COF. However, under extreme pressure test, the blended and unblended PKO becomes unstable thus show lower performances than synthetic oil (SAE15W – 50) COF and WSD. Hence from the result, PKO – 10 have promising lubricant trait and better low temperature condition performance to be used as lubricant.

ABSTRAK

Pelincir berasaskan sayuran adalah lebih mesra alam berbanding pelincir yang dihasilkan daripada minyak mineral. Berikutan kebimbangan yang semakin meningkat tentang kesihatan dan kerosakan alam sekitar yang disebabkan oleh minyak pelincir berasaskan galian, terdapat peningkatan satu trend di seluruh dunia untuk menggalakkan penggunaan minyak sayuran sebagai pelincir dalam industri. Pada masa kini, minyak sayuran dilihat mempunyai potensi untuk menggantikan minyak berasaskan galian kerana sifatnya lebih mesra alam dan tidak bertoksik tetapi masalahnya ialah prestasi pada suhu rendah. Dalam kajian ini, minyak isirong sawit (PKO) dicampur dengan 6 wt%, 8 wt% dan 10 wt% titik curah depresan (PPD) untuk digunakan sebagai minyak pelincir untuk menilai ciri – ciri tribologi dengan menggunakan mesin *fourball tribotester*. Objektif kajian ini adalah untuk menentukan nilai geseran dan ciri-ciri haus PKO dicampur dengan 6 w%, 8 wt% dan 10 wt% PPD menggunakan mesin *fourball tribotester* dan prestasi pelincir pada suhu rendah. Dalam usaha untuk menentukan sifat pelinciran, mesin *fourball tribotester* digunakan dan eksperimen adalah mematuhi ASTM D4172 dan ASTM D2783. Pembolehubah yang di ambil kira merangkumi prestasi suhu rendah dicampur dengan PKO, pekali geseran, diameter parut haus, kekasaran permukaan dan gambar permukaan haus. Keputusan eksperimen menunjukkan bahawa untuk prestasi suhu rendah, PKO dengan 10 wt% PPD (PKO – 10) menunjukkan prestasi yang hebat memboleh ia menahan suhu pada 13.6 °C. Manakala bagi keadaan bebanan normal, prestasi PKO – 10 adalah jauh lebih baik daripada minyak sintetik (SAE15W – 50) berdasarkan nilai pekali geseran. Walau bagaimana pun, di bawah ujian tekanan melampau, minyak isirong sawit campuran dan tidak dicampur dengan PPD menjadi tidak stabil dan menunjukkan prestasi lebih rendah berbanding minyak sintetik (SAE15W – 50) berdasarkan nilai pekali geseran and diameter parut haus. Oleh itu, PKO – 10 mempunyai potensi yang bagus dan prestasi suhu rendah ynag bagus untuk digunakan sebagai pelincir.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
ATF	Automatic transmission Fluid
CCD	Charge-Coupled Device
COF	Coefficient of Friction
DLC	Diamond Like Carbon
EP	Extreme Pressure
EC	Ethyl Cellulose
EVA	Ethylene-Vinyl Acetate
FFB	Fresh Fruit Brunch
HDEO	Heavy Duty Engine Oil
HOSO	High Oleic Sunflower Oil
MPOB	Malaysian Palm Oil Board
PAO	Poly Alpha Olefin
PKO	Palm Kernel Oil
PPD	Pour Point Depressant
RBD	Refined, Bleached and Deodorized
RPM	Revolution Per Minutes
SAE	Society of Automotive Engineers
SO	Sunflower
TMP	Trimethylolpropane
VI	Viscosity Index
WP	Wear Preventive
WSD	Wear Scar Diameter

LIST OF NOMENCLATURE

SYMBOL	DESCRIPTION	UNIT
F_N	Normal Force	N
F_f	Frictional Force	N
F_g	Gravitational Force	N
F	Force Applied to System	N
r	Distance From The Centre Of Contact Surface On The Lower Balls To Axis Of Rotation	mm
T	Frictional Torque	Nm
W	Load Applied	kg
μ	Coefficient of Friction	-
R_a	Surface Roughness	-

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Vegetable oil is well known as usage for cooking oil purposes. There are a lot kind of vegetable oil such as palm oil, sun flower oil, nut oil and etc. Vegetable oils have been used widely not only as cooking oil, but as lubricant and become more expending into almost all are. They are mostly used in industries such as food processing as food machinery lubricants, agricultural machinery as hydraulic oil for tractor, cutting machinery as coolant and etc. In Malaysia, palm oil is mainly vegetable oil that being used as cooking oil and it is because of Malaysia one of the largest palm oil production in the world. Recently, palm oil not only being use as cooking oil but it also have been widely used as lubricant.

Palm oil can be categorize as one of edible oils that has been broadly developed to be used as lubricant. Oil palm or scientific name known as *Elaeis guinensis* is an ancient tropical plant from the West African tropical rainforest and palm oil were derived from the mesocarp of its fruits. The oil palm tree can be recognise by it apparent same as coconut tree, because of it come from palm tree family type. Palm oil is known as one of the highly-concentrated vegetable fats among their vegetable fats group. In room temperature it is in form of semi-solid because of it contain several saturated and unsaturated fats. From history, archaeological found evidence of palm oil trace in an earthenware jar back dated 5000 years ago in Egyptian tomb. The palm oil had been use as cooking oil at that time and continually being use until now. However, the turning point of usage palm oil from cooking oil to lubricant was during industrial revolution in 19^{th} century Europe and it is being sparked the international trade in palm oil when demand due to its use as lubricant in steam engine and other machinery.

Palm oil as lubricant for engine is new era of beginning toward adequate performance in a variety of applications, low cost, cleaner, renewable, biodegradable, non-toxic and environmental friendly. Moreover, palm oil also have lubricant properties such as high viscosity, good lubricity, high flash point and low evaporative loss make it suitable to be considered as lubricants for engine use.

1.2 Background of Research

Lubricant is a crucial element when there is moving surface between to metal to prevent friction, wear, reduce heat and etc. Lubricity of fluid property that reduces the friction and or wear in mechanical system. Besides, function of lubricants also to collect foreign particles such soot in combustion chamber or metal chip causes by fiction or wear and reduce engine from heat. Basically, there are several classification of lubricants such as mineral lubricants, synthetic lubricants, bio-lubricants and solid lubricants.

Lubricants can be categorised into two difference group of applications known as engine lubricants and non-engine lubricants. Table 1.1 shows the applications engine and non-engine lubricants in field of industries.

Table 1.1: Applications of the engine lubricants and non-lubricants [1]

Engine Lubricants	Non-Engine Lubricants
Gasoline engine oil	Transmission fluid
Diesel engine oil	Power steering fluids
Automotive diesel oil	Shock absorber fluids
Stationery diesel oil	Gear oils
Railroad diesel oil	Hydraulic Fluids
Marine diesel oil	tractor oils
Natural gas engine oil	Industrials metalworking fluids
Aviation engine oil	Greases

Basically, lubricants can be related to tribology which is a study of involving the wear, friction and lubrications in moving part that contact each other. The tribological fundamental normally used to control wear and friction by modifying the surface properties of solid moving components by using lubricants. Tribological plays significant important to ensure reliability and durability of the system. Tribology knowledge can help to understanding on how to minimise friction and wear inside engine. By studying tribology in term of engineering lubrication coating, friction and wear can be reducing and life span of components will be lengthen.

As Malaysia being second world largest palm oil production, it can contribute more to another application rather than being use as food purposes. From record of Malaysian Palm Oil Board (MPOB) in year 2014, Malaysia produce 19.7 million tonnes of crude palm oil and 4.8 million tonnes for palm kernel oil.

Palm oil undergo two stage of processing, first milling process from palm oil fresh fruit bunch to get crude palm oil. Then second stage is refinery process involving crystalizing and separation process to obtain solid and liquid fraction with numerous melting characteristic that can be separate according to their application. High demanding to the new application of palm oil as lubrication to substitute petroleum based lubricant, palm oil have been developed by alter the properties of original palm oil as to meet the requirement of lubricant.

1.3 Statement of The Problem

As human tend to live in new modern world, a lot of damage and pollution human done the earth. The most concern one is environment pollution whether air or water pollution due to wide utilization of fossil fuel which is not only effected to human but also affected to another form of organisms such as animal, plant and aquatic life. Petroleum is a form of liquid that naturally occur from decomposition of animal and sea plant that buried underneath of thousand meter of silt, sand or mud. It takes millions of years to form. It consist complex mixture of element formed by hydrocarbons with trace other impurities such as sulphur.

The noxious waste produce from consuming or processing of petroleum product one of most contributing factor for environmental degradation in modern world. These hydrocarbon element are bring harmful to many living organisms including humans because of it highly toxic element. Petroleum that derived beneath earth not only contain useful element, it also contain trace of sulphur and nitrogen element. Resulting, these harmful element can create with environment and then create massive toxic element that affect all living creatures.

Conventional lubricant from petroleum based had been use widely for so long times ago as lubrication oil is known caused environmental pollution for being disposed to the environment without undergo any treatment. As earth becomes more polluted, human tend to increased their awareness regarding environmental and health issue, society put an extra effort to replace or reduce the usage of conventional petroleum based lubricant.

Vegetable oil is one of alternatives to be consider to substitute petroleum based lubricant for any application related such as automotive industries. Desirable properties of vegetable oil such as renewable, environmental friendly and biodegradable make it desirable to be choose as replacement for conventional lubricant. Furthermore, the most important aspect is vegetable oil can be consider non-toxic to human health. In Malaysia, richness of the palm oil has potential to develop and used it as alternative lubricant.

The problem vegetable oil faced now is the low temperature performance and stability. Some vegetable oil tend to solidify when goes below then room temperature and some of vegetable oil are readily in solid state even in room temperature. It became main issue and problem when down to the application. Lubricant need to be in liquid state when in application without being need to heated first when want to be used.

1.4 Purpose and Objective of Research

The main purpose of this research is to develop palm kernel oil as lubrication under extreme pressure and the objectives of this study are:

a) To investigate effect low temperature ability of palm kernel oil after blended with pour point depressant (PPD).
b) To determine friction coefficient and wear characteristic of palm kernel oil using fourball tribotester that following ASTM D4172 – 94 (2010).
c) To investigate the ability of palm kernel oil to run under extreme pressure following ASTM D2783 – 03 (2014).

1.5 Scope and Limitation of Research

Malaysia is can be consider as one of the largest palm oil producers around the world. Hence, the main purpose of this research is to explore the ability of palm oil as engine lubricant and low temperature performance of palm kernel oil. Following are the scope of the study and limitation in this research:

a) Palm kernel oil is used as lubricant in this research.
b) Pour point depressant (PPD) is used as to lower the pour point of palm kernel oil.

c) Research for normal load condition will follow ASTM D4172-94(2010) standard with normal load (40 kg to 120 kg), spindle speed (1200 RPM), operating lubricant temperature (75 ℃) and run for 60 minutes
d) Performance of palm kernel oil are tested under extreme pressure follow ASTM D2783-03 (2014) standard with load starting from 120 kg and increase until welding occur, operating lubricant temperature (35 ℃) and run for 10 second for each load.

1.6 Significant of Research

As earth becoming more polluted, human tend toward more environmental friendly stuff. Normally, half usage of lubricants turn out into environment because lack of awareness and high cost for proper disposal of lubricant. Mineral-based oil which come from petroleum fraction, now leading type of based oil are environmentally hazardous and poor degradability when released to the environment. Moreover, since government try to implement new policies to promote environmental friendly product, government and individuals put strong effort to follow government policies by provide biodegradable lubricants. They are put all effort in finding new resources that can substitute the mineral-based oil for gives similarity or better lubricity performance when compared with mineral-based oil.

The extant of enhanced lubrication contributed to the reducing of wear and friction problem that all moving part experience until now. Thus, modified vegetable oil selected as based oil for engine lubrication for keep the wear and friction at minimum level as possible. The development of advanced lubricants formulated based from vegetable oil and their great potential can be importance to nation, environment and also individual. Due to it outrage characteristics, performance and capability to reduce wear and friction, life span of moving components could be expand and also reduce the maintenance cost.

Palm kernel oil are being use in this research. As Malaysia is second world largest producers of palm oil now after Indonesia over the first ranking, the development of palm oil-based lubricant can help to reduce the oil contaminated pollution and hazard to environment. Currently, palm oil blended with additive has been studied to be use as biodiesel for combustion in diesel engine. Thus the development of palm oil as lubricant in moving mechanical system open new ways to create completely environmental friendly oil product.

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