UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PRELIMINARY STUDY OF THE CAPABILITY USING LUBE OIL BASED ON LOCAL VIRGIN COCONUT OIL FOR AUTOMOTIVE APPLICATIONS

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

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment 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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ABSTRAK

Pelincir dalam enjin adalah penting sebagai bahan yang akan digunakan untuk mengurangkan geseran dan haba di antara dua permukaan sentuhan melalui kesedaran tentang mesra alam sekitar akhir-akhir ini, minyak sayuran telah menjadi pilihan utama sebagai minyak asas untuk aplikasi pelincir. Minyak sayuran telah menjadi pilihan oleh kerana kelebihan sifatnya seperti mempunyai indeks kelikatan yang tinggi, kadar pelarut yang tinggi, sifat kemerosotan yang sangat baik dan kandungan toksin yang rendah. Tujuan kajian ini adalah untuk menentukan kebolehgunaan antara campuran minyak kelapa dara dengan minyak enjin. Melalui laporan ini, sifat-sifat pelincir minyak kelapa dara yang telah dicampur dengan minyak enjin dan telah dikaji. Peratusan komposisi campuran antara minyak kelapa dara dan minyak enjin adalah pada 10%, 20%, 30%, 40% dan 50% Selain itu, sifat-sifat fizikal antara minyak tulen 100% minyak kelapa dara dan 100% minyak enjin juga dibandingkan. Ujian telah dijalankan ke atas pekali geseran dengan menggunakan mesin –*four ball tester*" dengan berpandukan ASTM D4172, diameter kesan geseran dari bola keluli dikaji dengan menggunakan Mikroskop Imbasan Elektron dan kelikatan kinematik juga dikaji dengan menggunakan meter kelikatan. Hasil kajian menunjukkan bahawa, dengan mencampurkan 50% minyak kelapa dara, ia dapat memperbaiki pekali geseran dan prestasi geseran. Walau bagaimanapun, pada campuran 10% minyak kelapa dara, ia menunjukkan diameter kesan geseran yang paling kecil dan nilai tertinggi pada kelikatan kinematik diantara semua campuran. Kesimpulannya, dengan mencampurkan VCO dengan minyak enjin, ia menghasilkan prestasi yang lebih baik berbanding dengan minyak enjin tulen atau minyak kelapa dara tulen itu sendiri.

ABSTRACT

Lubricant inside an engine is important as a substance to be used in order to reduce friction, heat and wear between two contact surfaces. Due to the environmental friendly awareness lately, vegetable oil has become a primary choice as base oils for lubricant applications. Vegetable oil has favoured position on its properties such as high viscosity index, high solvency, excellent biodegradability and low toxicity. The purpose of this study is to determine the possibility composition of virgin coconut oil blend with engine oil. In this report, virgin coconut oil was blended with engine oil and its lubricating properties were investigated. The percentage of mixture composition between VCO and engine oil are at 10%, 20%, 30%, 40% and 50% of VCO. Besides that, pure oil of 100% VCO and 100% engine oil was also investigated on its physical properties to be compared together. The tests were conducted on its properties of coefficient of friction by using four ball testing machine with accordance of ASTM D4172, the wear scar diameter from the steel ball observed by using Scanning Electron Microscope on its wear performance and kinematic viscosity by using viscometer. The results showed that, by mixing 50% VCO, it improves on the coefficient of friction and wear performance. However, at composition 10% VCO, it shows the smallest wear scar diameter and highest value at kinematic viscosity between the mixtures. In conclusion, by mixing VCO with engine oil, it produces better performance compared with the pure engine oil or pure virgin coconut oil itself.

DEDICATION

A special gratitude to my parents for giving me endless support on my study from the very beginning until present. I am very grateful to have you both as my parents. Thank you for giving me this opportunity and chance to improve myself for my own future.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

VO	-	Vegetable Oil
SAE	-	Society of Automotive Engineers
SUV	-	Sport Utility Vehicle
RPM	-	Rotational per Minute
COF	-	Coefficient of Friction
VCO	-	Virgin Coconut Oil
USPS	-	U.S Postal Service
AISI	-	American Iron and Steel Institute
ASTM	-	American Society for Testing and Materials
ZDDP	-	Zinc Dialkyl Dihiophosphate
cSt	-	Centistoke
Li	-	Lithium
Na	-	Natrium
Ca	-	Calcium
Al	-	Aluminium
CO	-	Carbon Monoxide
HC	-	HydroCarbon
Cu	-	Copper
CO_2	-	Carbon Dioxide
NO_X	-	Nitrogen Oxide
CuO	-	Copper (II) Oxide
SiO_2	-	Silicon Dioxide
-OH	-	Hydroxide Ion
$-NO_2$	-	Nitrogen Dioxide
MoS_2	-	Molybdenum Disulphide
Al_2O_3	-	Aluminium Oxide
SEM	-	Scanning Electron Microscope

CHAPTER 1
INTRODUCTION

1.1 Introduction

Lubricant is a substance that usually used in order to smooth the friction between two mating surfaces. The other functions of lubricant are to help reducing heat and wear. Lubricant oil is also capable of cleaning the worn surface by transporting foreign particles, transmitting forces and heating or cooling the surfaces. There are three types of lubricant based which are solid, semi-solid and liquid. The application of lubricant is it can keep moving parts apart, reduce friction, transfer heat, carry away contaminants and debris, transmit power, protect against wear, prevents corrosion and sealing.

Inside the engine, combustion gases contain a high level of water, which is one major factor lead to the corrosion on the engine component. The engine parts must be protected from corrosion and that is why lubricating oil is enquired (Blaine, 2013). According to Blaine 2013, added that heat not only tears oil apart chemically, it increases the rate of degradation reactions that occur within the oil, such as viscosity change, oxidation, and additive removal.

According to Shahabuddin et al. 2013, vegetable oil played an important role as a substitute to the petroleum lubricant as it acquire various advantages over base lubricant such as its renewability, environmentally-friendly, biodegradability and less toxicity. The advantage of coconut oil is by the existence of high saturated fatty acids, good thermal and oxidative resistance, to be compared with other vegetable oils and most likely become subject of interest for the different lubricant applications (Jagadeesh et al., 2012).

In other words, this research will be focusing on blending virgin coconut oil with engine oil. After mixing both types of oil, the properties of this oil can be obtained after two different tests were taken. The tests will be using four ball tester according to ASTM 4172 and kinematic viscosity using viscometer. At the end of the tests, the observation on the data and properties comparison can be made. If there any positive outcome of the combination of both oil, the virgin coconut oil can be used in automotive application for engine.

1.2 Problem Statement

Lately, the usage of green innovation has been generally embraced far and wide. This demonstrates the significance of protection and preservation of the earth for future eras. The utilization of unrefined petroleum on the planet is in a disturbing rate when the raw petroleum itself is diminished, there are different issues that emerge concerning the utilization of crude oil and that is the utilization of unrefined petroleum that cannot be reused after usage. Despite that, the existing mineral-based oil is not environmentally friendly.

Virgin coconut oil or coconut oil is edible oil that obtained from the kernel from mature coconuts of coconut palm. Lately, coconut oil has been a common substance used in the health applications. Virgin coconut oil also can be implemented to be used as fuel. With the environmental concern among the researchers lately, people keep inventing new alternative to overcome this problem by replacing the oil with a new medium. R. Early et al. 2005, state that the use of coconut oil is not brand-new, it was used since back then during Second World War in Philippines when diesel was short of supply. Unfortunately after the war is ended, during the time there is a wide availability of diesel throughout the world which caused the development and improvement of coconut oil as lubricating oil became slower.

According to Shahabuddin et al. 2013, state that, various types of lubricants are available all over the world including mineral oils, synthetic oils, re-refined oils and vegetable oils. Most of the lubricants which are available in the market are based

on mineral oil that resource from petroleum oil which is not adaptable with the environment because of its toxicity and non-biodegradability. Due to the awareness of this matter, an alternative lubricant need to develop to meet the future demand is important to reduce the dependency on petroleum fuel.

1.3 Objectives of Research

From the background and the problem statement that have been stated, the objectives of the research are as below:

- To determine the suitable composition of engine lube oil mixing with virgin coconut oil.
- To test and characterize the capability of engine lube oil mixing with virgin coconut oil

1.4 Scope of Research

In order to achieve the objective of the research study, several work scope have been sketched:

- Determine the composition of virgin coconut oil that is suitable to be mixing with engine lube oil in order to form a new lubricant
- Test the newly develop lubricant using a four ball tester methods (ASTM D4172) and viscometer.

CHAPTER 2
LITERATURE REVIEW

2.1 Lubricant

In any type of machineries, there are moving surfaces either sliding or rolling that rub against each other. For example, the internal combustion inside an engine system obviously there is friction between the surfaces due to the mutual rubbing of one part to another that may cause power loss, that why the usage of lubricants are important. The functions of lubricants are to reduce wear and tear in order to prevent direct contact between two surfaces. Lubricant also helps reducing the expansion of the metals due to frictional heat. In addition, lubricant also works as a coolant to the metal to transfer heat. Lubricant also helps to avoid any unsmooth relative motions. The major factor when owning any machineries or facilities are due to involvement of high cost for maintenance, as solution lubricant helps a lot in reducing maintenance costs. Lubricant can be divided into few categories which respect to different type of characteristic. Types of common use lubricant are solid lubricant, semi-solid lubricant, and liquid lubricant. The difference between these three types is the based oil used in producing the lubricant. The properties of these lubricants on its viscosity, flash point, cloud point and corrosion stability are also differ with each other.

According to Holweger.W, (2013), the functionality of lubricants was categorized by its physics and chemical structure. However due to a certain extent of modern understanding of lubrication technology, limitation to the construction of lubricant to its appropriate application is hard to be defined. Their physical properties with of full lubrication condition such as its viscosity, viscosity-temperature and viscosity properties usually dominating over the chemical structure. Under some circumstances, lubricant reduces the heat whereby it reacts as a cooling agent from two mating contact surface. It also functions as a cleaning agent as it protected the

surfaces from wear and debris. Holweger mentioned that, after at certain running time, some reaction layers of lubricant component or additives may be produced.

According to Taylor (2002), lubricant viscosity is fully dependent on the temperature, shear rate, and pressure. These factors are often been ignored in many simulations of engine components. Consumer assumed that the viscosity of lubricant will remain the same at the operate temperature. Figure 2.0 show the common behaviour of lubricant viscosity is differs with temperature and shear rate. The significance of key oil physical properties emphasis on how the decision of the right oil can help minimise the engine friction while preventing the engine from wear.

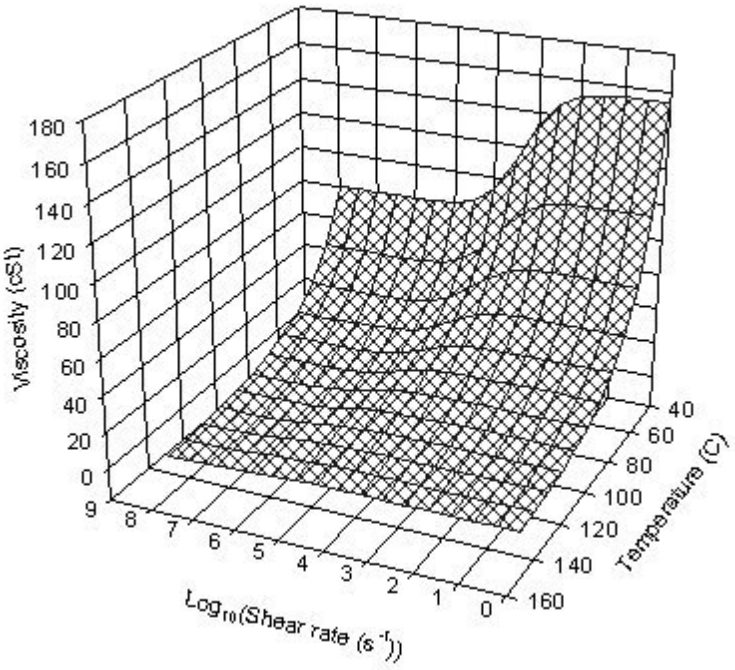

Figure 2.0: Variation of viscosity with shear rate for an SAE-10W/50 lubricant (R.I Taylor, 2002)

Table 2.0: The typical viscosity of common SAE's grades (R.I Taylor, 2002)

SAE grade	V_x40 (cSt)	V_x100 (cSt)	Vd (mPa.s) at – 20°C
20W/50	144.8	17.8	10,200
15W/40	114.3	14.9	4,800
10W/30	72.3	10.8	3,100
5W/30	57.4	9.9	1,900
0W/20	44.4	8.3	1,100
30	91.3	10.8	6,800

2.1.1 Solid Lubricant

The solid lubricant is an oil-based is prefers the working conditions that a lubricating film cannot be protected by the use of lubricating oil and grease. The solid lubricant cannot accept any contamination dust particles of lubricant oil and grease. According to Miyoshi, (1996) solid lubricant is generally defined as a material that provides lubrication, any under essentially dry conditions between two moving surfaces. Solid lubricant can withstand high operating temperature or high load even the grease remains in the position and any flammable lubricant must be avoided. The usage of solid lubricant is either in dry powder form or with binders in order to make it stick firmly to the metal surface whenever in use. This type of lubricant is also available as diffusion in non-volatile carriers such as soaps, flat, waxes and also as soft metal films.

The solid lubricant that commonly used is graphite, molybdenum disulphide, tungsten disulphide and zinc oxide. Solid lubricant can withstand the temperature up to 650°C. It also been used as additives to mineral oil-based lubricant and greases due to the increases of lubricant load carrying capacity.

Graphite solid lubricant is most widely used among all the other solid lubricant. It can be used either in powdered form or as suspension agent. This

material is non-flammable and can withstand up to 375^{o}C. The molecular structure of graphite is in flat-plate form with several layers bonding together by weak van der Waal's forces. Graphite is an effective structure layer because the parallel layer makes it easily to slide with one another. This layer has the impulse in absorbing oil.

Other than Graphite, Molybdenum Disulphide (MoS_2) has a sandwich-like structural. It contains a layer of molybdenum atoms in between two layers of sulphur atoms. Due to the poor attraction of inter-laminar, it helps those layers to slide easily to one another. This lubricant can withstand temperature up to 400^{o}C. Figure 2.1 shows the diagram of sandwich-like structure of molybdenum disulphide.

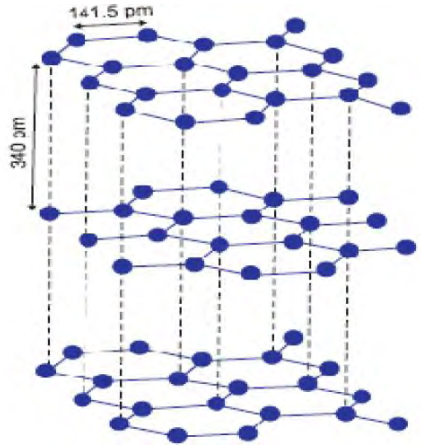

Figure 2.1: Sandwich-like structure of molybdenum disulphide
(source: http://cuiet.info)

2.1.2 Semi-solid lubricant

Semi-solid type of lubricant is combined types of lubricating oil which it has thickening agents that are termed as grease. Either petroleum or a synthetic hydrocarbon of low to high viscosity, lubricating oil is the principal component. There are few types of thickeners that are primary consists of special soaps such as Li, Na, Ca, Ba, Al and more. In additional, there is also a non-soap thickener such as carbon black, silica gel, polyureas and other synthetic polymers, clays and others. Grease can back much heavier load at lower speed. It is better to use oil over grease

due to the high internal resistance of grease. Grease cannot work at high temperature because it cannot dissipate heat from bearing as to be compared to lubricating oil, therefore, it is suggested to work the grease at a lower temperature.

2.1.3 Liquid lubricant

Other than a solid and semi-solid lubricant, lubricating oil is also known as a liquid lubricant. A liquid lubricant can be categorized by three and that is, animal or vegetable oil, mineral or petroleum oil and blended oils. Each of these lubricant categories is using a totally different oil-based in producing lubricating oil. And below is the type of engine oil for commercially used.

2.1.3.1 Types of engine oil

Engine oil can be divided into few types according to based-oil, which are synthetic oil, fully synthetic oil, high-mileage oil and conventional oil. Each types of engine oil have their own characteristic and properties reflect to each application. Synthetic engine oil is produced by laboratory synthesis whereby it is precisely composed ingredients that created by engineers, scientists, and chemists. When this oil is combined with a high-performance additive, the quality of this oil will increase that helps to protect the engine. Synthetic engine oil offers better protection at start-up, better-cleaning action and enhancing durability with better protection against high heat.

For synthetic blend oil, it uses a mixture of synthetic oil and conventional base oils in order to upgrade its resistance to oxidation to be compared with conventional oil. Synthetic blend oil also produces excellent low-temperature properties. Synthetic blend engine oil is usually used in cars, vans, SUVs which usually transport heavy loads with high operating RPMs. Vehicle with high-mileage is recommend to use synthetic engine oil. Synthetic engine oil has unique additives

and viscosity that will help to reduce oil burn-off and it helps in sealing oil leaks and improving combustion chamber sealing in order to restore engine compression.

In order to help meet the manufacturer needs and desired level of heat tolerance, breakdown resistance, and viscosity, conventional oil is enhanced by mixing with chemical additives. Drivers need to make sure they are using the correct engine oil for their vehicle based on the manuals given when they purchase their car because there is many products of engine oil sell in the market.

2.1.3.2 Mineral oil

Mineral oil or petroleum oils are basically consisted of lower molecular weight hydrocarbons with approximately 12 to 50 carbon atoms. The cost of mineral oil is cheaper as the availability of this oil is also abundant. Mineral oil is widely used all over the world due to the stability of the oil properties. The addition of any higher molecular weight compounds such as oleic and stearic acid will increase the oiliness of mineral oil.

According to Sheida et al. (2016), mineral oil properties are vary from the source of crude oil and the refining method applied. The factors that contributing the main differences observed in the mineral oil is its chemical structure, sulphur content, and viscosity. There are three basic chemical form that known as paraffinic, naphthenic and aromatic that is dependent towards the source of crude oil. Small amount of sulphur can induce oxidation to the lubrication properties regarding the quantity of the sulphur. The amount cannot exceed even one percent otherwise a rapid process of corrosion will occur on the seals. For mineral oil viscosity will be at the range within 5 cSt until 700 cSt at room temperature.