



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**PRELIMINARY STUDY OF THE AVAILABILITY OF
USING GEAR LUBE OIL BASED ON LOCAL PALM OIL
FOR TRANSMISSION APPLICATION**

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 fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with honors. The member of the supervisory is as follow:

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ABSTRACT

Vegetable oils are biodegradable lubricants which have been promoted because of the environmental friendly characteristics. The substitution of gear oil with palm oil as a base stock for an environment friendly lubricant in a transmission application is explored in this study without adding any additives. To determine the suitable composition for the lubrication, vegetable oil are mixed with the gear oil. In this report, palm oil was mixed in gear oil and its lubricating properties were tested. The mixing percentage of palm oil with the gear oil are 10%, 20%, 30%, 40%, 50% and also 100% for palm oil and gear oil. The testing was conducted using a four ball tribotester accordance with the American Society for Testing and Materials (ASTM) standard D4172 and the kinematic viscosity test. The results of kinematic viscosity shows that at 10% has the closest value to the gear oil concentration. On the other hand, by mixing a 40% of the coefficient of friction, frictional torque and the wear scar diameter reached the lowest value compared to the commercial lubricant oil. As a conclusion, the composition of palm oil with the gear oil has a better performance compared to the commercial lubricant or pure palm oil.

ABSTRAK

Minyak sayuran adalah pelincir mesra alam yang telah dikomersialkan kerana ciri-ciri yang mesra alam sekitar. Penggantian minyak gear dengan minyak kelapa sawit sebagai stok asas dengan pelincir mesra alam dalam aplikasi penghantaran telah diterokai di dalam kajian ini tanpa perlu menambah sebarang bahan tambahan. Untuk menentukan komposisi yang sesuai untuk pelinciran, minyak sayuran telah dicampurkan dengan minyak gear. Dalam laporan ini, minyak kelapa sawit telah digunakan untuk dicampurkan ke dalam minyak gear dan sifat-sifat pelincir telah diuji. Peratusan mencampurkan minyak sawit dengan minyak gear adalah 10%, 20%, 30%, 40%, 50% dan juga 100% bagi minyak kelapa sawit dan minyak gear. Ujian ini dijalankan menggunakan penguji empat bola dengan mengikut standard Persatuan Amerika untuk Ujian dan Bahan (ASTM) D4172 dan ujian kelikatan kinematik. Keputusan kelikatan kinematik menunjukkan bahawa pada 10% campuran minyak kelapa sawit dengan minyak gear mempunyai nilai yang kelikatan yang tinggi. Sebaliknya, dengan mencampurkan 40% campuran minyak kelapa sawit dengan minyak gear memperolehi nilai pekali geseran, tork geseran dan diameter memakai parut yang terendah berbanding minyak pelincir komersial. Kesimpulannya, komposisi minyak kelapa sawit dengan minyak gear mempunyai prestasi yang lebih baik berbanding dengan minyak pelincir komersial atau minyak kelapa sawit asli.

DEDICATION

A special thank you, to my parents for your unconditional support with my studies. I am honored to have you as my parents. Thank you for giving me a chance to prove and improve myself through all my life.

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LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	=	American Society for Testing and Materials
PFAD	=	Palm fatty acid distillate
FTP	=	Flash Temperature Parameter
TAN	=	Total Acid Number
WVO	=	Waste Vegetable Oil
TMP	=	Trimethylpropane
WSD	=	Wear Scar Diameter
COF	=	Coefficient of Friction
OL	=	Ordinary Lubrication
MOA	=	Multi Oil Analyzer
PTFE	=	Polytetrafluoroethylene
API	=	American Petroleum Institute
SAE	=	Society of Automation Engineer

CHAPTER 1

INTRODUCTION

1.0 Introduction of Lubricant

Lubricant is a substance that can reduce the friction, heat and wear between two moving surfaces. It also includes cleaning, improve sealing, reducing corrosion and cools up the engine. There have three types of lubricants which are liquids, solid and semi-liquid. The characteristic of a lubricant is it contains a substance that can reduce the friction and wear between two moving surfaces. Thus, the advantage of using the vegetable oil includes their relatively low viscosity-temperature characteristics, low volatility, biodegradable, non-toxic, renewable and environmentally friendly.

The level of viscosity index in the vegetable oils is higher than the petroleum oils. This is because of the viscosity of a high viscosity index oil changes less than a low viscosity index for a given temperature change (Aluyor et al. 2009). In addition, vegetable oil has a good combination of boundary friction lubricity and excellent protection from wear with the very low evaporation (Srivastava & Sahai 2013).

Fox & Stachowiak, (2007) reported that the mixture of vegetable oil shows many beneficial properties, which act as an attractive lubricants for various application. However, the disadvantage is having poor oxidation stability, but it can be improved with a correctly additive.

This research is focused on the mixing of local vegetable oil with the gear oil in a different amount of sample and using a different test which is four ball testers and heated viscometer. Then, the data will show a various result from a different concentration of oil after it mixes together. If the combination of both oils is successful, the local palm oil can be used in the transmission application.

1.1 Problem statement

Crude oil is the main usage in the lubrication which is in industries or transmission application. This can cause the reduction of the world's crude oil reserve, rising crude oil market prices and other cases related to use bio-based materials. Unfortunately, it may cause harm to the environment such as evaporation, leakages, and the major problem for air pollution and on the effect of environmental health. As a renewable source, vegetable oils are used as an alternative lubricant for the industrial and transmission application. There have some advantages of using a vegetable oil as the feedstock in lubricants than the petroleum oil or crude oil and also has a good performance lubricant than the mineral oils (Srivastava & Sahai 2013).

During 19th century, the observation has been made on the usage of lubricant and their availability to meet a required performance. They found an essential solution to increase the production of petroleum which can reduce the price and the general problem which can lead to the greenhouse effect of global warming issues. So, the concerns of environment and insufficient of petroleum resources has promoted to use of biodegradable products. In addition, vegetable oil and animal oil can be used as the lubricant in mineral based oils (Ing et al. 2012).

According to Shahabuddin et al. (2013) there are many types of lubricants that are suitable to be used in the various application such as vegetable oils, mineral

oils, synthetic oils and refined oils. Usually mineral oil that derived from petroleum oil can be found in the market as a lubricant which is not environmentally friendly and renewable because of its toxicity and non-biodegradability. So that, they make an alternative to ensure that the usage of petroleum can be reduced as well as the reduction of crude oil to meet the future demand is an important case.

1.2 Objectives of Research

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

- i. To determine the suitable composition of gear lube oil mixed with palm oil.
- ii. To test and characterize the availability of using gear lube oil mixed with palm oil
- iii. To compare the mixture result with gear lube oil.

1.3 Scope of Research

In order to achieve the objective of the research study, several scopes have been drawn:

- i. Determining the composition of palm oil that suitable to be mixed with gear lube oil to form a lubricant.
- ii. Testing and characterizing the availability of using gear lube oil mixed with palm oil to form a lubricant using four ball tester methods and heated viscometer.

- iii. Comparing test result with the mixture and non-mixture of gear lube oil.

CHAPTER 2

LITERATURE REVIEW

2.0 Lubricant

Lubricants play vital roles in industries, especially when it comes to the use of machinery to operate and transmission application. These lubricants are used to keep the operating parts from failure and allow the freely of operation. There are some functions of lubricants which can be used to reduce friction, reduce wear, acts as a coolant to reduce heat that produced between two moving parts, and increases the efficiency of the machine by reducing the loss of energy. On top of that, lubrication also will make the operating parts move smoothly without any wear or noises.

Lubricant can be classified into three types based on their physical appearance which are solid, semi-solid and liquid. Each of the lubricant has their own specific performance. Lubricant is widely used in various applications such as in industrial and transmission lubrication. Lubricant can act as coolant because it reduces the production of heat, corrosion and the smoothness between two moving parts and reduce noise. In addition, it can reduce the wear and produce a high efficiency of the machine.

Solid lubricant can be found in dry powder which contains graphite and molybdenum disulfide as basic materials. This lubrication can be applied by rubbing

at the surface which can self-lubricate cages in ball bearing with a correct technique (Roberts, 1990). Semi-solid lubricant is a combination of lubricants oil with thickening agents which called grease. Usually grease is used as anti-friction of roller bearings and another industrial machine (Srivastava & Sahai, 2013). In addition, grease seemly used for low load application and low speed because it doesn't operate well and has a relatively poor coolant. Liquid lubricants are any kind of categories of fluid such as vegetable oil, mineral oil and others.

The most important of lubrication is to ensure all the machinery and engines operate effectively. Without them, all the operating parts cannot operate well and breakdown will happen.

In addition, a good characteristic of a lubricant is prevention of corrosion, high viscosity index, high boiling point and low freezing point. In lubricating, oil has been improved with the use of additives. This is because the additive will protect the lubricant in service by limiting the chemical change and deterioration and to protect the mechanism from harmful combustion products and malfunctioning lubricating oil. Addictive also will improve existing physical properties and to prepare new characteristics in the oil. The most important of additives are anti-oxidant that will reduce the rate of degradation, extreme pressure is usually used in gear lubricants and detergent or dispersion used in engine oils to prevent carbon deposits.

According to Robert (1990), there are many types of lubricant that depend on the gearing, operating speed and load, temperature and the method of lubricating application. The characteristics of the lubricant in gearbox include transferring heat generated and lubricate the teeth from the gear working. Moreover, it is important to find suitable properties of lubricant which have a good reliability to provide slip away power transmission at higher mechanical efficiency with low maintainability and long term service life. Surface failure occurs when the lubricant film on the gear wheel teeth is insufficient to protect the surfaces from the stress, resulting in pitting

forming in the contact region. If the lubricant film is not well maintained, a scratch might happen. Thus, the temperature will increase and may causing distress and wear of the material surface. By choosing the lubricant with a low viscosity, the reducing friction and churning can be minimizing. If the lubricant is too viscous, the excessive heat is generated.

2.1 Gear oil

Nowadays, gear lubricants are a part of machine component with specific utilities for transmission and gear. The purpose of using gear oils is to be a cooling agent if mixed with vegetable oil and remove the friction of heat generated between moving parts. Moreover, gear oil is a lubricant made specifically for transmission, transfer cases and differentials in automobiles, trucks and other machinery. It is of a higher viscosity to better protect the gears and usually is associated with a strong sulfur smell. The high viscosity ensures transfer of lubricant throughout the gear train, this is necessary since the devices needing this heavy oil do not pumps for transferring the oil with only portion of the lowermost gear bathed in an oil sump. There are many kinds of lubricant are used in the lubrication of gear and transmission such as synthetic hydrocarbons, mineral oils, esters and naphthenic oils. All the lubricants contain additive and base oil that fixed to the application and the base oil (Bartz, 1978).

According to Taiwo & David, (2014) in his research, to find a suitable property of vegetable oils for automatic transmission fluid there are three experiments can be determined such as the flash point, kinematic viscometer and the pour point. Basically, all the experiment was based on American Standard Test Material method. All the vegetable oils need to be tested to meet the requirement because of the automatic transmission fluid has the most complex of all lubrication fluids which need to prevent wear and allows at accepted level of friction.

2.1.1 American Petroleum Institute (API) Ratings

Gear oils are classified by the American Petroleum Institute using GL ratings. It has been provided by the American Petroleum Institute (API) in the API Publication 1560, 7th Edition, published in July, 1995. It is important to check the oil against the vehicle manufacture's specification to ensure it does not contain any aggressive chemicals that may attack yellow metal gear components such as phosphor bronze. Multi grade gear oils are becoming more common; while gear oil does not reach the temperatures of motor oil, it does warm up appreciably as the car is driven, due mostly to shear friction which with a small amount of heat conduction through the bell housing from the engine block. Fully synthetic gear oils are also used in many vehicles, and have a greater resistance to shear breakdown than mineral oils. The API classification divides automotive gear oils into a few performance level. The API classification has been described in Table 2.1.

Table 2.1 API service designations of automotive gear oils in current use, according to API Publication 1560

API service designation	Application and characteristics
GL-1	Manual transmissions operating under such mild conditions that straight petroleum or refined petroleum oil may be used satisfactorily. GL-1 contain oxidation and rust inhibitors, deformers and pour depressants. Friction modifiers and extreme pressure additives shall not be used.
GL-4	Axles with spiral bevel gears operating under moderate to severe conditions of speed and load or axles with hypoid gears operating under moderate speed and loads. GL-4 oils may be used in selected manual transmission and transaxle applications where MT-1 are unsuitable. GL-4 oils contain up to 4% of extreme pressure (EP) additives.

Table 2.1 API service designations of automotive gear oils in current use, according to API Publication 1560 (continued)

GL-5	Gears, particularly hypoid gears in axles operating under various combinations of high speed or shock load and low or high speed torque conditions. GL-5 oils contain up to 6.5% of extreme pressure (EP) additives.
MT-1	Non-synchronised manual transmissions used in buses and heavy-duty trucks. API MT-1 does not address the performance requirements of synchronized transmission and transaxles in passenger cars and heavy-duty application. API MT-1 oils provide protection against the combination of thermal degradation, component wear and oil-seal deterioration, which is not provided by lubricants in current use meeting only the requirements of API GL-1, 4 or 5.

2.1.2 Society of Automation Engineers (SAE) viscosity classification

This society of engineers of the American automobile industry presents an independent association taking responsibility for the standardization and classification in the American automobile construction. Besides, this classification is the SAE viscosity classification according to SAE J306:2005 standard. It divides automotive gear oils into 11 grades based on rheological properties. This standard shows the requirements of both a low temperature (SAE 80W) and a high temperature grade (SAE 90). Table 2.2 shows the automotive gear oil viscosity classification according SAE J306:2005.

Table 2.2: Automotive gear oil viscosity classification, according to SAE
J306:2005

SAE viscosity grade	Maximum temperature for viscosity of 150 000 cP, °C	Kinematic viscosity at 100°C, cSt (mm ² /s) Minimum	Kinematic viscosity at 100°C, cSt (mm ² /s) Maximum
70W	-55	4.1	-
75W	-40	4.1	-
80W	-26	7.0	-
85W	-12	11.0	-
80	-	7.0	<11.0
85	-	11.0	<13.5
90	-	13.5	<18.5
110	-	18.5	<24.0
140	-	24.0	<32.5
190	-	32.5	<41.0
250	-	41.0	-

2.1.2.1 Solid lubrication

Solid lubrication is made up from graphite and molybdenum disulfide (MoS₂). These materials can be found in dry powders that have an effective lubrication. Add an additive due to their fine layer that is alternating between different materials. This lubricants need to place in parallel on the surface between the directions of motion. Boron nitride, polytetrafluoroethylene (PTFE), cerium fluoride, talc, calcium fluoride and tungsten disulfide are the other substances that are useful in solid lubrication.