UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF NEW BIO-LUBRICANT FOR FRICTION AND WEAR REDUCTION IN AUTOMOTIVE APPLICATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirement for the degree of Bachelor of Engineering Technology Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) (Hons.). The member of the supervisory is as follow:

……..

(En. Nur Rashid Bin Mat Nuri @ Md Din)

ABSTRAK

Minyak pelincir adalah bahan yang digunakan untuk mengurangkan geseran antara permukaan pergerakan dua komponen. Pergerakan di dalam engine adalah sangat laju dan akan menghasilkan geseran yang amat tinggi. Pergeseran antara dua permukaan juga akan menghasilkan haba dan akan menyebabkan komponen itu haus. Minyak pelincir adalah penting untuk mengurangkan segala perkara tersebut. Sebuah minyak pelincir yang baru perlu di hasilkan kerana sumber minyak terhad dan akan berkurangan dalam masa beberapa tahun ini. Minyak pelincir berasaskan petroleum amat susah untuk di lupuskan dan akan menyebabkan pencemaran kepada alam sekitar. Minyak bio-pelincir daripada kelapa sawit dengan bahan ZDDP menjadi tumpuan dan focus untuk kertas kerja ini. Kajian untuk mengurangkan kadar geseran dan haus kepada komponen di dalam industri otomotif adalah di beri perhatian. Minyak bio-pelincir akan di uji di dalam makmal untuk di analisa ciri-ciri dan kesan minyak tersebut terhadap geseran dan kehausan komponen sebelum digunapakai di dalam perindustrian otomotif. Menggunakan kaedah ujian yang selalu digunakan, kelikatan minyak pelincir dan kesan terhadap geseran akan di analisa. Berdasarkan keputusan tersebut, barulah akan di tentukan sama ada minyak pelincir itu akan diguna pakai di dalam perindustrian otomotif.

ABSTRACT

Lubricant is a substance to reduce the friction between two moving component surfaces. The movement of components in internal combustion engine of vehicle is at high velocity and may cause a highly friction. The friction between two surfaces may cause the heat and also wear and tear to the component. As the lubricant is an important to reduce all of these effect, the new kind of bio-lubricant is needed to create as the resources of petroleum is limited and will become shortage in the next few years. The petroleum based lubricant also is hard to dispose and may harm to the environment. The bio-lubricant made of palm oil with ZDDP addictive is focused on this project. The study to reduce the friction and wear on the automotive application is been highlighted. The bio-lubricant will be tested in laboratory to analyse its characteristics and effects on the friction and wear before can be implemented in the automotive industries. With the common testing method used, the results of the viscosity and its effect on friction will be discussed before can be implemented in automotive industries.

DEDICATION

To my beloved parents that always at supported and motivated me. 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 strengths and courage to finish up this project. This research project would not have been possible to finish without the support from many people surround me.

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I also would like to express my gratitude to my supervisor, En. Nur Rashid Bin Mat Nuri @ Md Din, who is has graciously contributed his time, patience, and guidance in helping me completing my project even though he always been busy with his works. His experience in this related topic has also given me a boost of confidence in conducting my experimental work. Without him, I would never achieve what I have meant to complete.

Finally, I would like to thanks to all my friends who help and guide me discussed about my project. Without their moral support, I can't finish this project. Hopefully, this report will be used as guidance and reference for the future studies.

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mm	-	millimetre
N	-	Newton
℃	-	Degree Celsius
ZDDP	-	Zinc Dialkly Dithiophosphate
%	-	percent
Rpm	-	rotational per minute
g	-	gram
cSt	-	centistoke
µ	-	micron

CHAPTER 1

INTRODUCTION

1.0 Introduction

This paper is about the study to develop a new bio-lubricant and the effects of its friction and wear in automotive applications. Nowadays, the lubricant based on natural resources is more focused to overcome the rising of petroleum based oil and to make more friendly environmental lubricant. In this project, the lubricant is more focus on the palm oil. The palm oil was chosen because Malaysia is one of the major producer palm oil in the south East Asian. The palm oil will add on additive called Zinc Dialkyl Dithiophosphate (ZDDP) as an agent to reduce the friction and wear on the component will be tested and analyse. In this chapter the subtopic as a guideline for this study will be explain such as problem statement, objective and the scope of this project.

1.1 Problem Statement

In the automotive application, the function of lubricant is to reduce the friction between moving surfaces in the engine components. By reducing the friction of the components, the heat and wear particles also can be reduced. In the automotive industry nowadays requires high velocity movement of components in the internal combustion engine. With the high velocity may cause the components easy to wear and will easily broke. With the helps from the lubricant, the problems may be

reducing. The bio-lubricant become famous in researcher these day as its potential to replace the lubricant mineral oil based that already in the market. The shortage of resources of petroleum and the effect of the petroleum based oil to environment is the main factors to replace the mineral oil based lubricant to bio-lubricant. The mineral based oil also been hardly to disposed and harass the environment.

1.2 Objective

The objective of this project is the most important factor. The planning and flow of the activities to achieve the purpose of this project in the specific time is the fundamental for the project objective. For this project, the objective is to study and analyse the new bio-lubricant of palm oil with ZDDP (Zinc Dialkly Dithiophosphate) addictive. In this project, the study of the effect of friction and wear of palm oil with ZDDP (Zinc Dialklyl Dithiophosphate) addictive been applied.

1.3 Scope

This project is focus on the development of new bio-lubricant oil. The properties and characteristics of the new bio-lubricant are needed to be study. First of all, the study starting with the preparation of the lubricant. The experiment conducted to mix the solution of lubricant which palm based oil with ZDDP additive. After that, the oil will be analysing to determine its characterization on its cleanliness and particle count and size. Based on the ISO 4406, the standard of the lubricant can be observed. Then, the experiment of heated viscometer (ASTM D445) to determine the kinematic viscosity is conducted. The purpose of this experiment is to study the kinematics viscosity of the new bio-lubricant. Then, the oil will be tested using the wear and friction test by using pin on disc experiment method (ASTM G99).

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will focus on the information gained through the previous study. The previous research on bio-lubricant and related information of the study will be stated on this chapter. In this chapter also will be elaborate the advantages of bio-lubricant and the experiment commonly used to study the lubricant. The experiment and the study of the bio-lubricant effectiveness have been spread through all around the world in these few year as to overcome the problems with the resources of lubricant petroleum based is rapidly shortage nowadays. Many researchers around the world have been made experiment about the performance and efficiency of bio-lubricant based palm oil and majority, the researcher from Malaysia.

2.1 Oil Lubricant

Liquid lubricants have been practiced by humans for thousands of years. Initially, crude lubricants as simple as mud on an inclined plane were used. Art from ancient Egypt shows the Egyptians pouring a lubricant in front of a sled that is being perpetrated. (Williams, 1994). Later, animal and vegetable oils were used to lubricate items of war such as catapults and body armour. The improvement in mineral oil as well as artificial or synthetically oils in order to overcome the dilemmas make vegetable oils much less substantive. However, mineral oils plus some synthetic oils aren't eco-friendly whenever subjected to the environment. Likely the most essential present issues affecting to the biodiesel energy sources is actually their own reduced

oxidation stability compared to standard mineral oils. It is well recognized that the unsaturated fatty acids identified in common feedstock, such as corn and palm, are an excuse of this susceptibility. These unsaturated fatty acids may react with atmospheric oxygen, forming peroxides and lead in a variety of problematic degradation byproducts, including corrosive, low molecular weight acids and biopolymers. These byproducts are the main cause of sludge and lacquer in automotive injection systems and also fuel system corrosion. (Quigley, 2007).

Lubricants act as an antifriction media, easing smoother working, cutting down the risk of undesirable frequently encountered failures and maintaining authentic machine operation. Lubricants consist of a mixture of base oil with various additives, which can improves some of their properties. The basestocks may be of petroleum, vegetable or synthetic nature. The chief characteristic of a lubricant is its viscosity, since it prevents contact between surfaces.

Biolubricants are formulations made from vegetable based oils together with corresponding additives. Recently, increasing attention to enviromental issues has driven the lubricant industry toward ecofriendly product from renewable sources. The use of biodegrable and environmentally accepted lubricants from vegetable oil has increased over past 25 years (4). Biolubricant have been the most anticipating as the have unsuitable properties that make petroleum based lubricants the evident option. A lot of development and research is being done to vegetable oils to meliorate the physicochemical properties so that they may prove to be a cheap and good substitute of petroleum based lubricant.

The replacement of petroleum based lubricant with lubricants derived from vegetable oils is very worthy and alluring objective. The lessening of dependence on non-renewable resources, reduction of greenhouse gases and increase in market rof agricultural products these all outcomes are attractive to many countries. Vegetables oil are chemically triglycerides of fatty acids, vegetable oil are known to have

superior inherit qualities like excellent biodegrability and lubricity, much higher viscosity and viscosity index, enhanced flash and fire points and lower toxicity. Lubricity of vegetable oils is attributed to their ability to absorb to the metallic surfaces and to form a tenacious monoplayer, with the polar head adhering to the metallic surfaces and the hydrocarbon chains orienting in near normal directions to the surface.

The effect a lubricant has on its environment depends on several lubricant properties including biodegradability, toxicity and the products of biodegradation. Synthetic oils have been the primary lubricant utilized where environmental concerns are considered (Miller, 2009). Recent studies have examined the possibility of using a vegetable oil based lubricant. There four main types of lubrication which is:

I. Hydrodynamic lubrication.
II. Hydrostatic lubrication.
III. Elastohydrodynamic lubrication.
IV. Boundary lubrication.
V. Solid film lubrication.

Hydrodynamic (or full-film) lubrication happen when the surfaces are separated by a relatively thick film of lubricant (to prevent metal to metal contact). The film pressure is created by the moving surface forcing the lubricant into a wedge-shaped zone, therefore creating a pressure that separates the sliding surfaces. For hydrostatic lubrication, the lubricant is forced into the bearing at a pressure high enough to separate the surfaces (relative motion of the surfaces is not involved in this case). Elastohydrodynamic lubrication is type where the lubricant is introduced between surfaces that are in rolling contact for example:

I. Mating gears.
II. Rolling bearings.

Boundary lubrication is a special type of hydrodynamic lubrication where the film thickness is reduced to be “very fragile”. This may occur because of increased load, reduced lubricant supply, reduced rotational speed, reduced viscosity and so much more possible causes. And lastly solid-film lubrication is a self-lubricating solid materials such as graphite are used in the bearing. This is used when bearings must operate at very high temperature (Budynas & Nisbett, 2011).

Lubricant oil is a substance that known as a medium that used to reduce friction between contact moving surfaces. The characteristic of lubricant that reducing friction also known as lubricity or slipperiness. A function of lubricant also can transport the foreign particles in machine or engine. William A. Glaeser(2001) was said the main requirements for lubricants are that they are able to:

I. As a cooling agent - removing the heat which is produced by friction or from other sources such as external sources.
II. Protection of surface - protect the surface of part during operation from the attach of aggressive product
III. Cleaning and dirt holding capacity - during the operation, the oil should become cleaning and dirt capacity which is can remove residue and debris that occur in operation.
IV. Reducing friction agent - keep the surface separate under all loads, temperatures and speed, it will minimising friction and optimizes the wear.

Typically lubricant oil consists of 90% base oil and 10% of additives. The most base oil from petroleum fraction that called minerals oils. Another example used for base oil is a vegetable oils and synthetic liquids such as silicones, esters and more. The non –liquid lubricant is grease. Good lubricant oil must have some characteristic such as:

I. High boiling point
II. Low freezing point
III. High viscosity index

IV. Thermal stability
V. Hydraulic stability
VI. Demulsibility
VII. Corrosion prevention

2.2 Contaminant

Engine liquid circuit (lubricant, fuel and coolant) have different design in every types of engine. It comes in all shapes and sizes, simple and complex design. They all need protection and to avoid more damage, the contaminants need to be removed as it will give effect on the engine efficiency. These contaminant may lead to more friction occurs and wear to the engine component.

Figure 2.1 : Close up of new (left) and worn (right) fuel injector nozzles.

Types of Contaminant

There are various types of contaminant may exist and lead to causing problems. Below is some of the type of contaminant may be present in engine fluids.

I. Particulate (dust, dirt, sand, rust, fibers, elastomers)
II. Wear metals, silicon and excessive additives (aluminium, chromium copper, iron, lead, tin, zinc, phosphorous)
III. Water
IV. Sealant (Teflon tape, plasters)
V. Sludge, oxidation, and other corrosion products
VI. Acids and other chemicals

Where Contamination Comes From

I. New Fluids – Adding new fluid can be a source of contamination. Even though the oil is taken fresh from the drum, it came from various cleanliness levels coming out of the pump. (human eye can only observe particle size of about 40µm.).

II. Built-in - Metal filings, small burrs, dirt or sand of manufacturer, assembly and testing of engine components.

III. Ingressed – External contamination comes from surrounding the engine or vehicle. Dirt can enter the engine liquid supply through crank case breathers or fuel tank breathers and vent.

IV. Induced – Maintenance process also can be some of factors contaminant may exist. Opening the engine allows airborne particles to enter. Keep the engine system closed as much as possible.

V. In-Operation – the major sources of contamination are combustion by-products and oxidation of the fluids in the engine due to thermal stressing. Wear-generated contaminants are hazard during engine operation.

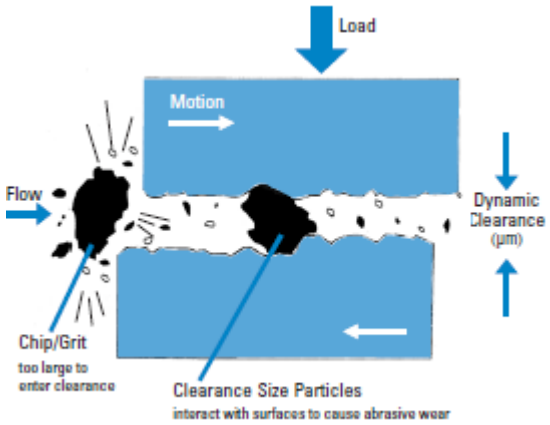

Figure 2.2 : Illustration in-operation of engine

2.3 Additive

Oil additives are chemical compounds that improve the lubricant performance of base oil (or oil "base stock"). (Liston, 1992).. Additives content up to 5% by weight of some oils. Oil additives are vital for the proper lubrication and extended use of motor oil in modern internal combustion engines. (Liston, 1992). Without many of these, the oil would become contaminated, break down, leak out, or not properly protect engine parts at all operating temperatures. (Gautam, Chitoor, Durbha, & Summers, 1999). Just as important are additives for oils used in gearboxes, automatic transmissions, and bearings.

There are several types of additives including detergent additives, dispersants additives, anti-wear agent additives, oxidation or rust inhibiting additives, friction modifier, antifoam agents, viscosity modifiers, pour point depressants and antioxidant and metal deactivators. (360ip, 2014) (Rudnick, 2009) (Mansfield, 2009) (Braun, 2007). This entire additive can be classified into three main branch functions which is:

I. Surface protection additives.

II. Oil property modification additives.

III. Base oil protection.

Some of the most important additives include those used for viscosity and lubricity, contaminant control, for the control of chemical breakdown, and for seal conditioning. Some additives permit lubricants to perform better under severe conditions, such as extreme pressures and temperatures and high levels of pollution.

Most modern lubricants require more than one additive to meet all performance requirements. In some instances, individual additives are blended directly into the base oil. In other instances, a group of additives is blended into an additive "package," which is subsequently incorporated into the base oil. Since most additives are active chemicals, they can interact with the package or in the lubricant to form new compounds. These interactions can decrease additive effectiveness and lead to insoluble or otherwise undesirable by-products. Additive functions frequently depend on their limited solubility in the lubricant. For example, Zinc Dithiophosphate must be able to leave the bulk of the lubricant and adhere to the machine surface to function as a wear inhibitor. When dispersion is used in the same lubricant, the dispersion can hold the zinc dithiophosphate in solution and prevent the latter from functioning. Many lubricants require both zinc dithiophosphate and dispersant. (Barnes, Bartle, & Thibon, 2001) Dispersants are frequently manufactured to minimize their ability to disperse zinc dithiophosphate. Moreover, zinc dithiophosphate for these applications are selected to perform in the presence of a dispersant. Surface active additives can also compete well each other. Both wear inhibitors and some rust inhibitors function by adsorbing on metal surfaces and they compete for the same surface. The wear inhibitor can displace the rust inhibitor on the surface and be detrimental to rust inhibition. Also, the rust inhibitor can displace the wear inhibitor. (O'Brien, 1983)

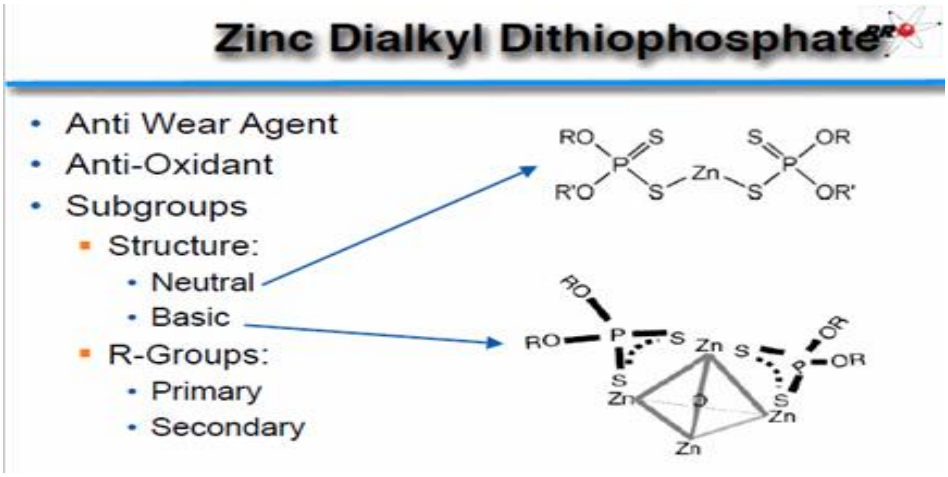

Figure 2.3 : ZDDP Structure

2.4 Viscosity

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress. In everyday term (and for fluid only), viscosity is "thickness" or "internal friction". Viscosity of lubricating oil is determined with the help of an apparatus known as Viscometer. In a viscometer a known volume of lubricant is allowed to flow, from a given height, through standard capillary tube under its own weight and the time of flow in second is recorded.

Fluid viscosity is the resistance to gradual deformation by shear stress or tensile stress. It corresponds to the informal concept of thickness of a fluid to flow. Fluid viscosity measured in centistokes (cSt). As fluid viscosity increases, the cSt rating increases. Higher viscosities also mean higher pressure drop because the thicker oil has a tougher time passing through. Viscosity is a property arising from collisions between neighbouring particles in a fluid that are moving at different velocities.

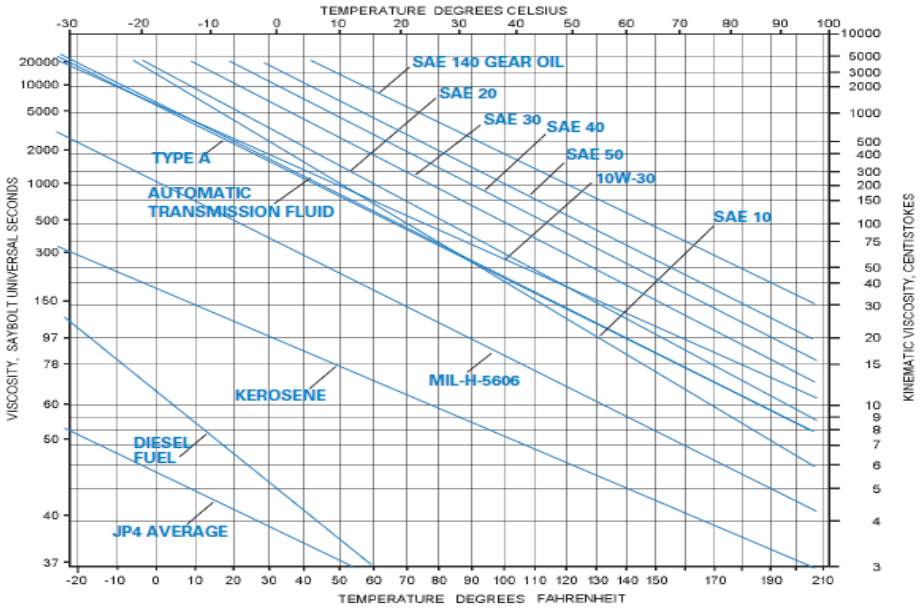

Figure 2.4 : Viscosity/ Temperature Chart