UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHARACTERIZATION OF USED-ENGINE OIL ENHANCE BY USING ZIRCONIA NANO-PARTICLES

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

MOHD AHASSOLEHIN BIN MOHD AHADLIN

B071310806

920126-13-5157

FACULTY OF ENGINEERING TECHNOLOGY

2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Characterization of Used-Engine Oil Enhance by Using Zirconia Nano-Particles

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

Saya MOHD AHASSOLEHIN BIN MOHD AHADLIN

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

_____ _____

Alamat Tetap:
No. 35, TU 19,
Taman Tasik Utama,
Ayer Keroh, Melaka

Cop Rasmi:

Tarikh: _____ Tarikh: _____

`** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Characterization of used-engine oil enhance by using zirconia nano-particles" is the results of my own research except as cited in references.

Signature : ……

Author's Name : ……

Date : ……

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 Degree of Engineering Technology Bachelor of Mechanical Engineering Technology (Maintenance Technology) With Honours. The member of the supervisory is as follow:

……

(Dr. Muhammad Ilman Hakimi Chua bin Abdullah)

ABSTRAK

Kajian ini tertumpu kepada perincian minyak enjin terpakai bagi meningkatkan kualiti minyak pelincir dengan menggunakan nanopartikel zirkonia. Tujuan kajian ini adalah untuk menghasilkan minyak pelincir nano zirkonia dari minyak pelincir enjin yang terpakai dan ciri-ciri sifat physco-kimia yang baru penghasilan minyak pelincir nano zirkonia. Ini kerana masalah bekalan minyak pelincir dan pelupusan sisa minyak menjadi isu besar kepada alam sekitar berikutan jumlah kenderaan telah meningkat pada masa kini. Penghasilan pelincir baru daripada sumber yang boleh diperbaharui seperti dari polyalphaolefins (PAO) menjadi satu perkara penting pada masa kini dalam penghasilan minyak pelincir. Daripada kajian ini, gabungan diantara minyak pelincir terpakai dan partikel nano menjanjikan potensi kualiti yang lebih baik. Bagi mencapai objektif ini, minyak enjin SAE SN 0W20 yang terpakai telah ditapis dengan penapis minyak enjin berdasarkan ASTM D7317-06. Serbuk zirconia telah ditambah ke dalam minyak enjin yang telah dibersihkan dan sampel akan disebatikan dengan menggunakan ultrasonik homogenizer. Sampel diperincikan berdasarkan sifat-sifat physco-kimia dengan menggunakan ujian kelikatan, ujian takat kilat, ujian jumlah bilangan asid dan pengesahan sebatian kimia, (FTIR). Keputusan menunjukkan penambahan nanopartikel zirkonia dalam minyak engin yang terpakai boleh meningkatkan minyak baru yang dihasilkan. Tambahan pula, penambahan nanopartikel zirkonia dalam minyak engin yang terpakai mengurangkan ujian kelikatan, meningkatkan takat kilat, mengurangkan jumlah bilangan asid dan mengenalpasti komponen kimia yang ada pada minyak baru nona-zirkonia.

ABSTRACT

This study focused on characterization of used engine oil enhance by using zirconia nanoparticles. The purpose of this study are to develop zirconia nano-oil from used engine oil and characterize the physco-chemical properties of the newly develop zirconia nano-oil. This is because the problem of the lubricant supply and disposal of waste oil become a big issue in the environment because of the vehicle numbers has increase nowadays. The development of a new lubricant came from renewable sources such as from polyalphaolefins (PAO) has become an importance matter currently in lubricant development. From this study, the combination between the newly develop lubricant enhance by nano-particles potentially promising for better lubricant characteristics. In order to achieve this objective, used engine oil of SAE SN 0W20 was filtered by filtering unit according to ASTM D7317-06. Zirconia powder was added into purify used engine oil and the sample will homogenized by using ultrasonic homogenizer. The sample was characterized based on the physco-chemical properties by using viscosity test, flash point test, total acid number test and chemical compound verification, (FTiR). The result shows the addition of zirconia nanoparticles into used engine oil can improve the performance of the newly develop of the lubricant. In addition, addition of zirconia into used engine oil had reduced the kinematic viscosity, increased the flash point, decreased the value of total acid number and defined the chemical compound in the newly develop zirconia nano-oil.

DEDICATION

To my beloved parents.

ACKNOWLEDGEMENT

First of all, I was very grateful to Allah S.W.T because Allah S.W.T allowed me to finish this project after having all the challenge. Big thanks to Dr. Ilman Hakimi Chua Bin Abdullah for his guidance and his help for finishing this project. Big thanks to both my parents that always supports and motivates me since I was born until I am today. Thank you for always pray for me to finish this project. To my friends who always been a helpful, guide me and share idea knowledge about this system development. I hope my friends that I really appreciate will be bless by Allah S.W.T.

TABLE OF CONTENT

CHAPTER 3: METHODOLOGY

CHAPTER 4: RESULT AND DISCUSSION

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al_2O_3	-	Alumina
ASTM	-	American Society for Testing and Materials
Au	-	Gold
Cd	-	Cadmium
COF	-	Coefficient Of Friction
Cst	-	Centistokes
Cu	-	Copper
Cuo	-	Copper Oxide
EP	-	Extreme Pressure
Fe	-	Iron
FTiR	-	Fourier Transform Infrared Spectrocopy
HBN	-	Hexagonal Boron Nitride
KV	-	Kinematic Viscosity
MoS_2	-	Molybdenum Disulfide
P	-	Density
PAG	-	Polyalkylene Glycol
PAO	-	Polyalphaolefins
Pb	-	Plumbum
SAE	-	Society of Automotive Engineers
Sn	-	Tin
TAN	-	Total Acid Number
TiO_2	-	Titanium Dioxide
V	-	Volume
VI	-	Viscosity Index
WS_2	-	Tungsten (IV) Sulfide
ZDDP	-	Zinc Dithiophosphates
Zn	-	Zinc
ZrO_2	-	Zirconia Oxide

CHAPTER 1

INTRODUCTION

1.1 Introduction

Lubricant can be defined as a substance introduced between two surfaces in relative motion in order to reduce the friction between them. A 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. Besides, there are three type of lubricant which are liquid, solid and semi-liquid. Lubricating oils also known as liquid lubricants and further classified into three categories which are animal and vegetables oils, mineral based or petroleum oils and blended oils or Polyalpha-olefin (PAO).

The main function of a lubricant is to keep two metal surfaces wet thus minimizing friction and avoiding wear (Calhoun, 1960). Moreover, the function of a lubricant to reduce wear and tear of the surfaces by avoiding direct metal to metal contact between the rubbing surfaces. Besides that, the function of lubricant to reduce expansion of metal due to frictional heat and destruction of material. It also can acts as coolant of metal due to heat transfer media. According to Meena 2015, different mechanical systems need a variety of functional lubricants to decrease the friction and wear of contacting surfaces as well as to significantly reduce the total energy consumed by mechanical systems.

The characteristic of good lubricant oil are high boiling point, low freezing point, adequate viscosity for proper functioning in service, high resistance to oxidation and heat. Whilst the properties of lubricants consist of viscosity, flash point and fire point, cloud point and pour point, aniline point, corrosion stability.

The main function of the engine lubrication system are to maintain the operation of the engine system and continuous oil supply to the bearing. The pressure of the engine oil should be high enough to cause the oil flow that is needed for proper cooling (Haiderman & Mitchell, 2005). The recovery process of used lubricant is carry out by using filtration process is used to clean out all the contaminants. The filtration process consist of surface filter and depth filter. The process of surface filter usually known as screening process while depth filter will make the lubricant oil have a higher resistance to flow. Thus, the depth filter has a higher possibility to clean out more contaminants from the used lubrication oil.

The use of nanoparticles as additives infuse in the used engine oil would have a great impact on lubricating properties and environment protection. This is because nanoparticles are well-known as promising additives to minimizing friction and wear with respect to conventional oil. According to Abdullah et al, 2013, nanoparticles can be thought about as modern oil. They present major advantage over organic molecules that are now used as oil. Their nanometer size allows them to enter into the contact area like molecules. They are immediately even at the room's temperatures. Therefore, no induction period is necessary to get interesting tribological properties. Different types of Nano particles were used to prepare Nano oils, including polymers, metals, and organic and materials.

1.2 Problem Statement

The problem of the lubricant supply and disposal of waste oil become a big issue in the environment because of the vehicle numbers has increase nowadays. The used oil has been reported disposed improperly about 200 million gallons per year. As matter of fact, it takes 42 gallons of crude oil but only 1 gallon of used oil to produce 2.5 quarts of new and high-quality lubrication. According to Vadiraj et al, 2012, the loss is significant and about 15% of the total of energy and directly affects and ability to last of the engine.

According to Prasanna Raj Yadev et al., 2015, increasing of pollution levels by burning of oil and the increasing price of oil make the alternative sources more attractive. Increasing energy consumption and environmental deterioration drive human to finding out alternatives fuels for replacing petroleum fuels, especially for replacing diesel fuel which is widely used by commercial vehicles (Cheung et al., 2015). In Malaysia, the used oil will be disposed as scheduled waste oil. Used oil needs to be managed properly and carefully because if it is handled properly, it may affect the public health and the environment.

The production of new oil needs a lot of cost. The re-used of the used oil can reduce the cost of the production to make a new oil. It also can save oil extracted from the ground supply. The recycle of the used oil can make the used oil become reusable. Used oil should be going through the filtration process to make it reliable again. An effort must be done in order to reduce disposal of used oil. Filtration process is one of the effective approach to make used oil as a renewable sources.

1.3 Objective

From the problem statement that have been stated, the purpose of this research is:

1. To develop zirconia nano-oil from used engine oil.

2. To characterize the physco-chemical properties of the newly develop zirconia nano-oil.

1.4 Scope

In order to achieve the objectives of the study, several scopes have been identified:

1. Developing a new purify engine oil with addition of zirconia nano-particles.

2. Characterizing the newly develop zirconia nano-oil by using viscosity test, total acid number (TAN), flash point and chemical compound verification (FTIR).

CHAPTER 2

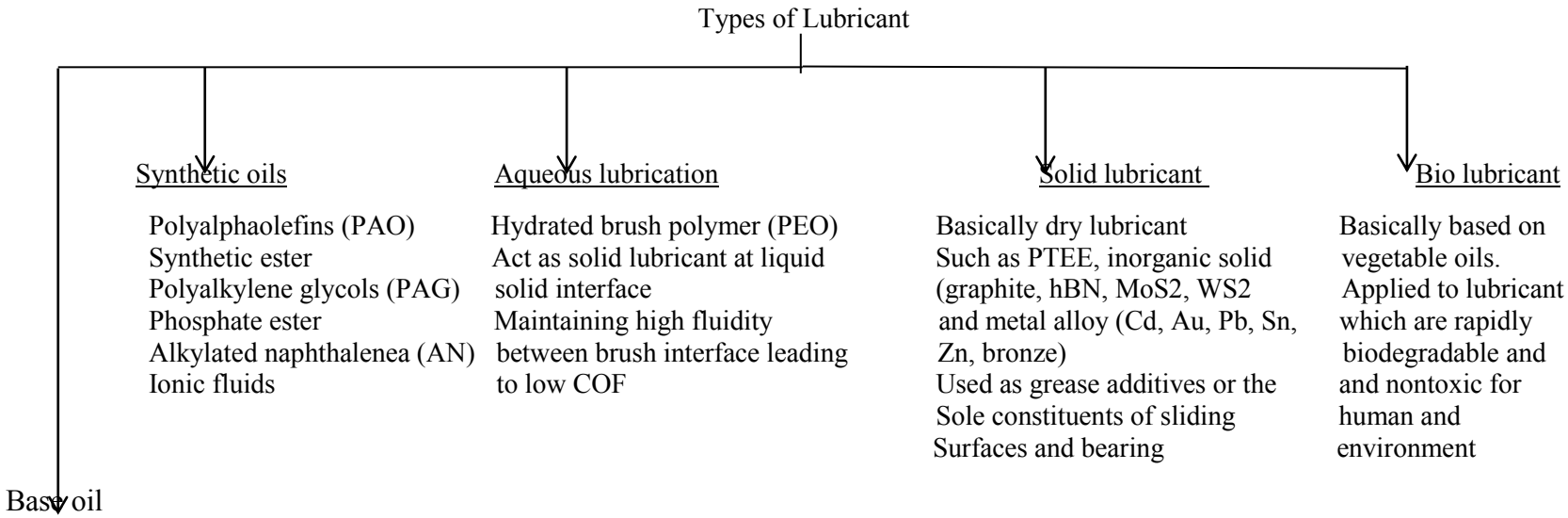
LITERATURE REVIEW

2.1 Lubricant

There are three classification of lubricant which is solid, semi-solid and liquid and also divided into two major groups. The first group is automotive lubricant and the second group is industrial lubricant. The industrial lubricant can be in the formed of industrial oils or industrial specialties. Greases, metalworking lubricant and lubricants films are examples of industrial specialties. (Mang et al, 2013). The prime function of lubricant is to reduce the frictional and wearing of the specified equipment or machine. There are different type of lubricant use for some machine vehicle, industrial gearbox, compressor, turbines and liquid related system. The most important function of lubricants is to secure all the machineries and engines lubricants to operate effectively. Without lubricants, the part of the engine will not run properly. In addition, a good quality of lubricants can prevent from corrosion.

2.1.1 Types of Lubricant

There are many differences of the lubricant depends on its function and purpose. Each type of lubricant is specialized only for certain situation. If lubricant is not applied in the right condition, the lubricant would has any beneficial, it only causes the part of the equipment.



	API designated	Saturated	VI SAE	Processing process	Remark
Mineral oil (Derived from Crude oil)	Group I	<90% and or Sulfur >0.03%	80~120	-Solvent extraction -Solvent or catalytic dewaxing -Hydro-fhinishing process	-common group -150 SN (solvent natural -500 SN and 150 BS (brightdtock)
	Group II	<90% and or Sulfur >0.03%	80~120	-Hydro-cracking -Solvent or catalytic dewaxing	-superior anti-oxidation -water white color
	Group III	<90% and or Sulfur >0.03%	>120	-isohydromerization	-can be manufacture from base oil or slax wax from dewaxing process
	Group IV	-	-	-	-polyalphaolefins (PAO)
	Group V	-	-	-	-all other not included group (I-IV) such as napthenics, PAO, esters

Figure 2.1: Summaries types of common lubricants (Abdulllah, 2015)

2.1.1.1 Solid Lubricant

Solid lubricant is a type of lubricant that managed to undergo extreme condition which the bearing surface in tribological contact separated effectively. According to Mang & Dresel (2013), graphite and molybdenum disulphide are widely used as solid lubricants. Bernal in 1924 suggested that the ideal structure of graphite is in plane hexagon with same lengths of side stacked. Moreover, the ideal structure with empty centres in any sheet are always overlaid of the next sheet by the atoms. However the structure of molybdenum disulphide is trigonal symmetry crystal that has six sides and sulphur atoms in a trigonal prism surrounded the molybdenum atom. MoS_2 is a very stable chemical and will be increase to radioactive radiation.

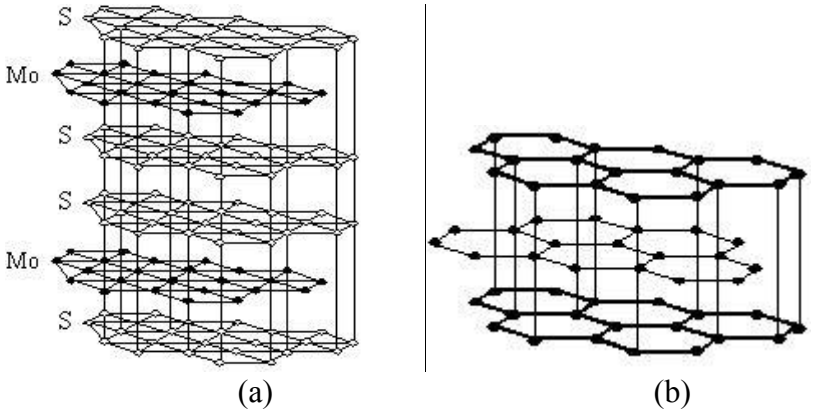


Figure 2.2: The structure of solid lubricants: (a) molybdenum disulphide (b) graphite (source: http://tinyurl.com/h8j8lsu)

In certain condition, solid lubricants used to overcome problems especially in edge and mixed frictional states where high particular loads being applied to sliding surfaces. This product is not only performing effectively at very low hydro dynamically effective speed, but also in critical applications. For example when the lubricant accomplished over a wide temperature range or under extreme temperature condition such as in aviation and in rocket technology.

This material can be found in dry powders that have an effective lubrication. Solid lubricants usually used for high temperature, outer space, nuclear radiation, vacuum and other

circumstances that not cover by liquid and semi-solid lubricants. Boron nitride, polytetrafluoroethylene (PTFE), cerium fluoride, talc, calcium fluoride and tungsten disulphide are the other substances that are usually use in solid lubricant.

2.1.1.2 Semi-solid lubricant

Greases is a product of lubricants from solid state to semi-fluid state when the thickening agent in the liquid lubricant spreads out. Usually, thickening agent in a metal soap contains more compounds to meet special properties. When the thickener is synthetic the term fully synthetic grease often used, for example the mixture of the salts of amid carboxylic acids with oligoureas. A semi-solid lubricant received by combining lubricating oil with thickening agents call as a grease. Generally, grease are widely used in bearings and gear systems (Khonsari & Booser, 2001). Grease also can operated under high-speed and lightly-loaded condition. The performance of using grease are better than using liquid lubricant because of grease can act as a seal, to provide protection against corrosion and to reduce noise and shock.

2.1.1.3 Liquid lubricant

Liquid lubricant has been changed to fancy synthetics rather than the ordinary mineral-oil based and has been used for quite some time. The selection of a lubricant needs systematic approach where the evolutions of the base oil technology for ordinary lubricants will be discussed in detail. The key features the different of classes of synthetic-based specialty and high-temperature lubricant and also will be discussed.

The purpose of liquid lubricant can be used to transfer heat, minimize the friction and wear between mechanical parts which is in contact each other. The choice and application

method of liquid lubricant impose environmental impact, health issues and high cost. Thus, the minimum quantity of liquid lubricant is highly recommended.

2.2 Modern Liquid Lubricant

There are a many different kinds of modern lubricant categories such as mineral based oil, vegetable oil and polyalphaolefins (PAOs). All the liquid lubricant have a variation properties and usage.

2.2.1 Mineral Based Oil

According to A. Jackson, (1987), classify that mineral oil is derived petroleum and synthetic oil from petrochemical are mainly used as base oil in lubrication. Mineral oils are not pure chemicals, but contain various hydrocarbons of varying molecular weight and types. The fraction of a mineral oil is described whether the oil is extracted from the ground or of the based oil. Without great expense of the usual chemical practices, it is not possible to decide their exact structure. The processing of each fraction are reflected from the oil extracted from the ground which consist of thousands of single part. Therefore, it is always a goal to describe mineral oil to identify and quantitatively determine groups of parts with almost similar chemical character or also to help their technical properties.

The making of better pure method is either by using solvent or the hydro treating process. Both methods consist of a series of processes designed to remove undesirable part such

as smelly hydrocarbon, acid, sulphur compounds and wax. The method also improve desirable properties such as viscosity index, pour point and stability. (Bannister, 2001). Figure 2.3 shows the typical structure in mineral lubricating oils.

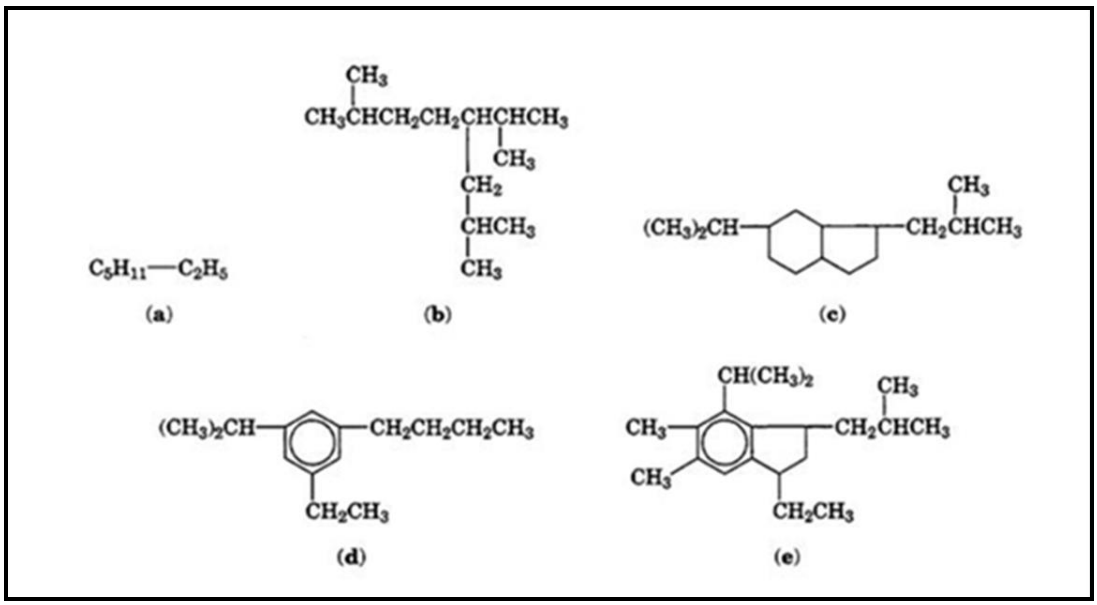


Figure 2.3: Typical structure in mineral lubricating oils: (a) n-paraffin, (b) isoparaffin, (c) cycloparaffin, (d) aromatic hydrocarcon, and (e) mixed aliphatic and aromatic ring. (Khonsari, 2008)

2.2.2 Vegetable oil

The vegetable oils as one of the renewable lubricants because these materials renewable possess good biodegradability, low water-based poisonous quality and environment friendly. Vegetable oils has lubrication properties where the triglycerides directly received from the plant, and the fatty acids directly received from the triglycerides. Furthermore due to their superior slipperiness, good corrosion, better viscosity-temperature and low evaporation loss, vegetable oil