INVESTIGATION OF TRIBOLOGICAL PERFORMANCE OF WASTE LUBRICATING OIL

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Report
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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials)"

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Date : 13.06.2014

DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged"

Signature : .....

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Date : 13/6/2017

DEDICATION

I would like to dedicate this research to my beloved parents, who always keep supporting and praying for my success.

ACKNOWLEDGEMENT

Glory to Allah S.W.T the most gracious and most merciful. All the worship belongs only to Allah. We seek refugee from the wickedness within evil and until I have completed the project. I also praised to Allah S.W.T for giving me courage, time, and knowledge in completing this report for my bachelor Degree project.

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ABSTRACT

The purpose of this study is to compare the lubricating oil before hazardous waste treatment and after hazardous waste treatment. Waste lubricant oil is harmful and dangerous to environment, human and animal. This study is to investigate tribological performance in terms of friction and wear. Four ball experiments were carried out to obtain results for coefficient of friction. After that, wear scars on balls were observed under inverted microscope to determine the wear scar diameter. All specifications used in this method were according to American Society for Testing and Materials (ASTM) D4172. Title for ASTM D4172 is Standard Test Method for Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method). Lubricant oil selected in this study is engine oil, gear oil, and coolant. Lubricant before hazardous waste treatment is waste lubricating oil which means oil that had been used and not yet be recycled or filtered. Lubricant oil after hazardous waste treatment is lubricating oil that had been recycled or filtered to remove particle contamination. Waste lubricating oil and recycle lubricating was collected at waste lubricating facility .Results shows that recycle lubricating oils have low wear scar diameter and low steady state coefficient of friction. For conclusion, recycle lubricating oil is acceptable to be used again as lubricating oil.

ABSTRAK

Tujuan kajian ini adalah untuk membandingkan minyak pelincir sebelum rawatan sisa berbahaya dan selepas rawatan sisa berbahaya. Minyak pelincir sisa berbahaya kepada alam sekitar, manusia dan haiwan. Kajian ini adalah untuk menyiasat prestasi tribological segi geseran dan haus. Empat uji kaji bola telah dijalankan untuk mendapatkan keputusan untuk pekali geseran. Selepas itu, memakai parut pada bola diperhatikan di bawah mikroskop terbalik untuk menentukan diameter memakai parut. Semua spesifikasi yang digunakan dalam kaedah ini adalah menurut Persatuan Amerika untuk Ujian dan Bahan (ASTM) D4172. Tajuk untuk ASTM D4172 adalah Ujian Kaedah Standard bagi Pakai Ciri-ciri Pencegahan Lubricating Fluid (Empat-Ball Method). minyak pelincir yang dipilih dalam kajian ini adalah minyak enjin, minyak gear, dan penyejuk. Pelincir sebelum rawatan sisa berbahaya sisa minyak pelincir yang bermaksud minyak yang telah digunakan dan belum dikitar semula atau ditapis. Pelincir minyak selepas rawatan sisa berbahaya adalah minyak pelincir yang telah dikitar semula atau ditapis untuk membuang pencemaran zarah. Buang minyak pelincir dan mengitar semula pelincir dikumpulkan di sisa pelincir kemudahan .results menunjukkan bahawa kitar semula minyak pelincir mempunyai diameter memakai parut rendah dan rendah pekali keadaan mantap geseran. Untuk kesimpulan, kitar semula minyak pelincir boleh diterima untuk digunakan semula sebagai minyak pelincir.

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LIST OF ABBEREVATIONS

ASTM	American Society for Testing and Materials
AISI	American Iron and Steel Institute
COF	Coefficient of Friction
SIRIM	Scientific and Industrial Research Institute of Malaysia
WSD	Wear Scar Diameter

CHAPTER 1

INTRODUCTION

1.1 Background

Sliding between clean solid surfaces is generally characterized by a high coefficient of friction and severe wear due to the specific properties of the surfaces, such as low hardness, high surface energy, reactivity, and mutual solubility. Clean surfaces readily adsorb traces of foreign substances, such as organic compounds, from the environment. The newly formed surfaces generally have a much lower coefficient of friction and wear than the clean surface. The presence of layer of foreign material at an interface cannot be guaranteed during a sliding process; therefore, lubricants are deliberately applies to produce low friction and wear. The term "lubrication" is applied to two different situations: solid lubrication and fluid (liquid or gaseous) film lubrication. (Bhushan, Introduction to Tribology, 2013)

In many industrial such as automotive industry, aeronautic industry and machinery industry, lubricant is one of the important aspects. Mainly, it is use to reduce friction and wear in mechanical contacts. Thus, in last decade, there are about 38 million metric tonnes per year of lubricants have been used, with the majority of these being petroleum based. (Quinchia, Delgado, Reddyhoff, Gallegos, & Spikes, 2014).

Basically, lubricants are used to enhance efficiency by reducing wear and friction. This is due to heat generation and formation of wear particles are reduced when it is less friction. Lubricant acts to keep the moving part apart to prevent wear from occur. It is a mixture of base oil and additives. The presence of additives in lubricants is to boost the lubricants performance and to enhance, add, or suppress the properties within the base oil. Examples of additives in used lubricating oil are detergents, antioxidants, detergents, anti-wear elements, metal deactivators, corrosion inhibitors, rust inhibitors, friction modifiers, extreme pressure withstanding elements, antifoaming agents, viscosity index improvers, demulsifying or emulsifying agents and stickiness improver. Commonly, lubricant consists of 90% base oil which is minerals oils and less than 10% additives. However, the amount of additives contain are depends on type of oil and its application.

Waste lubricating oils consist of the base oil, degraded additives, metallic debris, oxidation products and carbon soot. Additives in waste lubricating oils are decreases or lose their characteristic. Due to that, it loses their capability to enhance the performance of lubricants and rendering the lube oil non usable for lubrication purpose. In addition, during their use, the lubricating oils and the metal processing oils pick up fractions of various metals as a result of wearing out of components. The concentration of these impurities depends purely on the application to which the particular oil is put to. Some contaminants, such as chlorinated solvents, water, unburned fuel, carbon and dust are also picked up by the waste oil during use or during storage. (Diphare, Muzenda, Pilusa, & Mollage, 2013)

1.2 Problem Statement

Nowadays, the demand of fossil fuel increase from over a period of time. Every year, over 11 billion tons of oil in fossil fuels have been consumed for various function as fuel cars, power electricity plants, medicines, cosmetics, plastics, synthetic fibres and lubricants. On this rate, the remaining fossil fuels are not enough to accommodate for the future use. Oil wastage occurs when used oil are disposed or been throw away without knowing the properties whether the oil can still be used or not. Furthermore, waste lubricant oil is dangerous to environment, human, and animal. Waste lubricant oil contain harmful chemical that can give bad effect to environment pollution. Besides that, most of researches that have been done before were investigating about the oil that sold in market. The oils were mixed with other materials such as boron to enhance their performance. There is lack of literature review about the recycle waste oil to use as second grade oil. So, without knowing the capability of used oils, the oils are not use for suitable purposes.

1.3 Objectives

The overall aims of this study are:

i. To investigate physical tribological performance of waste lubricating oil before hazardous waste treatment.

ii. To investigate physical tribological performance of waste lubricating oil after hazardous waste treatment.

iii. To study the comparison of physical tribological performance between before and after hazardous waste treatment of lubricating oil.

1.4 Scope of Project

Based on the objectives mentioned above, the study is narrowed down to be more specified, in order to give a clearer view on the critical points. The scopes including in this study are:

i. This research investigates of tribological properties of waste lubricating oil.
ii. This research investigates of tribological properties of recycle lubricating oil.
iii. To study the comparison of physical tribological performance between before and after hazardous waste treatment of lubricating oil.

CHAPTER 2

LITERATURE REVIEW

2.1 Background

Tribology is the science and technology of interacting surfaces in relative motion and includes friction, wear and lubrication (Hutchings & Shipway, 1992). Tribology is a study focuses on friction, wear, and lubrication which defined in 1967 by a committee of the organization for Economic Cooperation and Development. The word Tribology comes from Greek word 'tribos'. 'Tribos' means rubbing or sliding. After an initial period of scepticism, the concept of tribology was accepted. However, concept of tribology still unclear to the wider community and humorous comparison with tribes or tribolites tend to persist as soon as the word tribology is mentioned (Stachowiak & Batchelor, 2014). Even though the name of tribology that is relatively new, some constituents parts of tribology is older than recorded history (Dawson, 1998).

Concept of tribology is one of the crucial concepts to modern machinery which uses sliding and rolling surfaces. Aim of this research is to minimize and eliminate loses resulting from friction and wear. This may happen at all level of technology when two or more surfaces are rubs. Examples of productive frictions are brakes, clutches, driving wheels on trains and automobiles, bolts, and nuts. Machining, shaving and polishing are the examples of productive wear. Writing with a pencil is also an example of productive wear as well. Examples of unproductive friction and wear are internal combustion and aircraft engines, gears, cams, bearings, and seals. Use of concept of tribology in research lead to greater plant efficiency, better performance, fewer breakdowns, and significant savings (Bhushan, Introduction to Tribology, 2013).

According to archaeologist finding, they discovered that the ability to manufacture or start a fire developed among humans sometime before 7000 B.C. People during that time making fire by using friction concept. They used fire drill which made from hardwood that pointed at one end and a slab of softer wood with a hole in it as shown in Figure 2.1. The point need to place in the cavity and rapidly twirled by rubbing between the palms, then, the softer wood will start smoulder. The shreds of dry tinder are placed in the smouldering cavity. Lastly, blow it carefully into flame (Gascoigne, 2001).

Figure 2.1: Illustration of people making fire by rubbing the stick

The study of friction, wear, and lubrication is a crucial study. This study is important to mechanical, electromechanical, and biological systems to have the right friction and wear values.

2.2 Friction In Tribology

Leonardo da Vinci (1452 – 1519) was an Italian Polymath. In 1508, he revealed the concept of a characteristics coefficient friction as the ratio of friction force to normal load. After industrial revolution begins, Guillaume Amotons (1663 - 1705) established the significance of a coefficient of frictions which was independent of the apparent area of contact (Khonsari & Boosed, 2008). He was a French engineer. He presented a paper about friction subject to French Academy in 1699. He said "indeed among all those who have written on the subject of moving forces, there is probably not a single one who has given sufficient attention to the effect of friction in machines

After that, the French physicist C.A.Coulomb (1785) was further distinguished between static, and kinetic frictions. These two frictional forces were independent with velocity. Mechanism to decrease friction and wear was by using soft coatings and adherent molecular and also lubricant surface layers were elucidated by Bowden and Tabor (1950) (Khonsari & Boosed, 2008).

Friction is the resistance to motion during sliding or rolling. It happened when one solid body moves tangentially over another with which it is in contact. There are two types of friction. The types are dry friction and fluid friction. Dry friction also known as Coulomb friction, is about the tangential components of the contact force when two dry surface move relatively to one another. Fluid friction is described about the tangential components of the contact force that exists between adjacent layers in fluid. The force are moving at different velocities relatives to each other as in liquid or gas between bearing surfaces (Bhushan, Principles and Applications to Tribology, 2013).

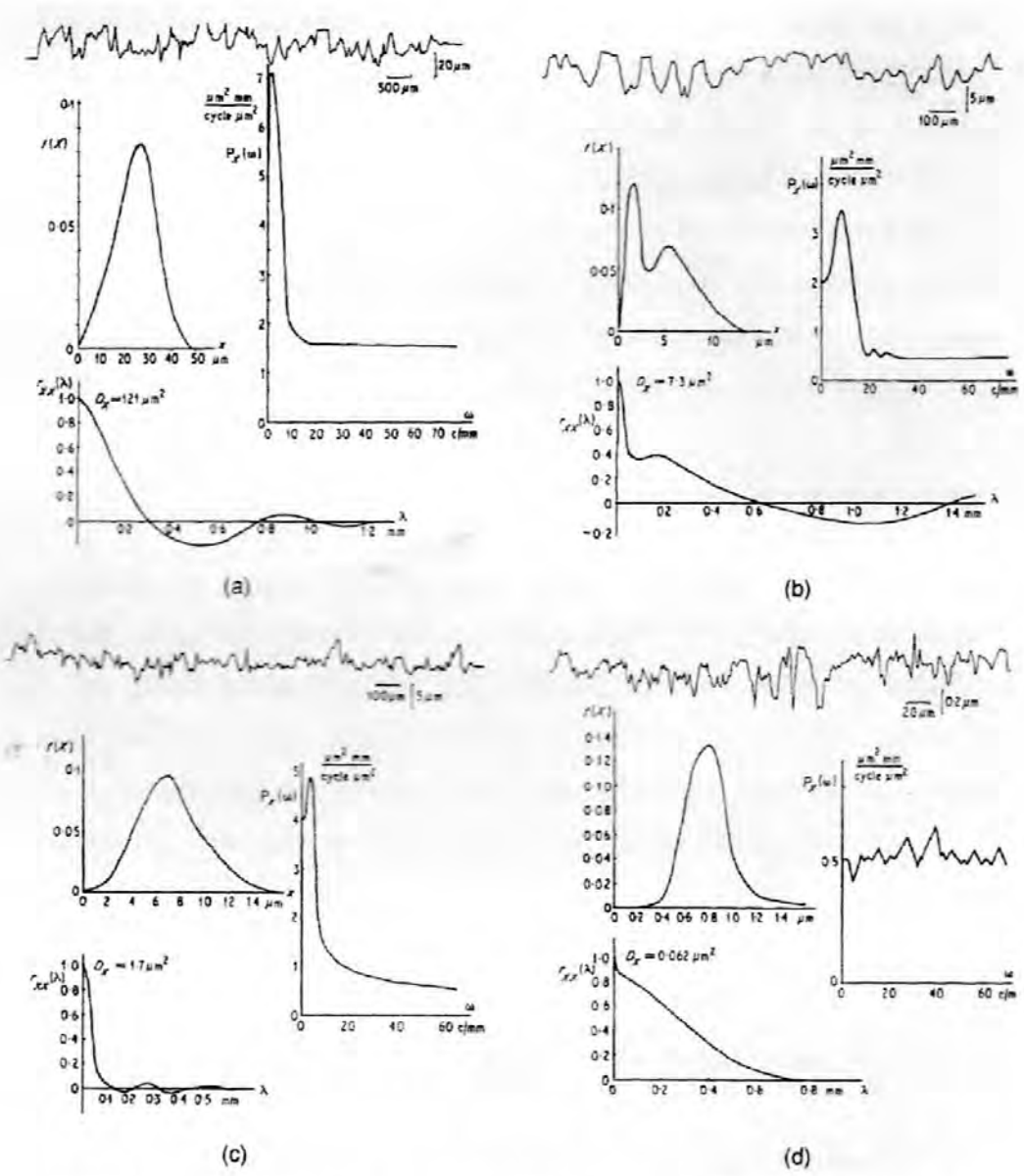

Figure 2.2: Examples of engineering surfaces (Reprinted by Council of the Institution of Mechanical Engineers from Peklenij, J. New developments in surface characterization and measurements by means of random process analysis, Proc. Inst. Mech. Engrs. 182,Pt.3K,108-126.1968).

Figure 2.2 is the examples of engineering surfaces for fine shaped (a), milled (b), surface ground (c), and super finished (d). Graphs show about distribution, autocorrelation, functions, and power spectra. There is friction in all machinery. Function of friction in machinery is to converts part of the useful kinetic energy to heat and decrease the overall efficiency of the machine. In automobile, about 30% of the power is wasted through friction (Hershey, 1996). In modern turbojet engine, about 1.5% is wasted through friction. One third to one half of the energy contributed to the world is consumed by fiction. This estimation was done by G. Vogelpohl in 1951 (Fuller, 1956).

Friction is a system response. High friction occur when two solid surface contacts with each other without chemical films and adsorbates. Solid contaminants or thin film affect friction. Friction and adhesion can be reduced by applying lubrication. However, apply a small quantity of liquid at the interface results in liquid-mediated adhesion will result a high friction especially between two smooth surfaces (Bhushan, Principles and Applications to Tribology, 2013).

There are two basic laws of friction:

i. Friction force F is proportional to the normal force W between surfaces.

ii. Friction force is independent of the (apparent) area of contact.

Laws of friction were first discovered by Leonardo da Vinci (1519). It was rediscovered again by Guillaume Amontons (1663-1705). Then, C.A.Coulomb (1785) proved these laws experimentally. He observed that "kinetic friction is nearly independent of the sliding speed" is at times referred to as the third law of friction.