TRIBOLOGICAL PROPERTIES INVESTIGATION FOR NANOPARTICLE ENHANCED NATURAL OIL-BASED LUBRICANT

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This report is submitted
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DECLARATION

I declare that this project report entitled "Tribological properties investigation for nanoparticle enhanced natural oil-based lubricant" is the result of my own work except as cited in the references.

Signature :.....

Name :.....

Date :.....

APPROVAL

I hereby declare that I have read this project report 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 (Thermal-Fluid).

Signature :. .....

Name of Supervisor : .....

Date : .....

DEDICATION

To my beloved mother, father and siblings

ABSTRACT

Friction and wear are one of the main factors that affect the efficiency, performance, quality and life span of machinery system. The purpose of this study is to determine tribological properties of nanoparticles enhanced natural oil-based lubricants which consist of Refined Glycerine and Oleic Methyl Ester. Four ball tester experiments are carried out based on ASTM standard to evaluate the tribology properties of lubricants. The flash point and viscosity are taken at the lubricants to obtain the characteristics of these lubricants. The measurements of Coefficient of Friction and Wear Scar Diameter are taken at bearing ball for different types of lubricants. The difference in coefficient of friction and wear scar diameter for lubricant without and with additive are being investigated. The results obtained for coefficient of friction and wear scar diameter of lubricants are then compared with difference concentration of additive. The average coefficient of friction obtained from analysis for refined glycerine without and with additive show lower reading than oleic methyl ester. Lubricant with Carbon Nano Tube as additive show more preferred results compared to lubricant without additive in term of coefficient of friction. With increase the concentration of additive, all lubricants which is refined glycerine and oleic methyl ester only up to 3%wt of additive to get better result. More than 3%wt of additive, they continue increase the coefficient of friction. It happens during the homogenizing process, the lubricant cannot dissolve sufficiently with higher amount of additive. For wear scar diameter, refined glycerine with additive show the smallest reading compare to other. Based on the result, recommendations and suggestions are made to improve the accuracy of tribology test and tribology properties of lubricants.

ABSTRAK

Geseran dan haus adalah salah satu faktor utama yang memberi kesan kepada kecekapan, prestasi, kualiti dan jangka hayat sistem jentera. Tujuan kajian ini adalah untuk menentukan sifat tribological nanopartikel dipertingkatkan pelincir berasaskan minyak semula jadi yang terdiri daripada glyserol mentah dan oleik methyl ester. Empat uji kaji bola tester dijalankan berdasarkan standard ASTM untuk menilai sifat-sifat tribologi pelincir. Titik kilat dan kelikatan diambil pada pelincir untuk mendapatkan ciri-ciri pelincir ini. Ukuran pekali geseran dan diameter haus parut diambil pada bearing bola untuk pelbagai jenis pelincir. Perbezaan dalam pekali geseran dan haus diameter parut untuk pelincir tanpa dan dengan tambahan sedang disiasat. Keputusan yang diperolehi daripada ukuran fizikal dan analisis berbanding dengan pekali geseran dan memakai parut diameter pelincir dengan kepekatan perbezaan tambahan. Pekali geseran purata yang diperolehi daripada analisis untuk gliserol mentah tanpa dan dengan tambahan menunjukkan bacaan yang lebih rendah berbanding oleik methyl ester. Pelincir dengan Karbon Nano Tiub sebagai persembahan bahan tambahan keputusan lebih diutamakan berbanding pelincir tanpa bahan tambahan dari segi pekali geseran. Dengan meningkatkan kepekatan bahan tambahan, semua minyak pelincir yang ditapis gliserin dan oleik methyl ester hanya sehingga 3% berat bahan tambahan untuk mendapatkan hasil yang lebih baik. Lebih daripada 3% berat bahan tambahan, mereka terus meningkatkan pekali geseran. Ia berlaku disebabkan oleh semasa proses larutan minyak, minyak pelincir tidak boleh larut cukup dengan jumlah yang lebih tinggi bahan tambahan. Untuk diameter haus parut, gliserol mentah dengan bahan tambahan menunjukkan bacaan yang paling kecil berbanding dengan yang lain. Berdasarkan kepada keputusan, cadangan dan cadangan dibuat untuk meningkatkan ketepatan ujian tribologi dan sifat-sifat tribologi pelincir.

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ASTM	American Society for Testing of Materials
CNT	Carbon Nanotube
TGA	Thermogravimetric analysis
N2	Nitrogen
COF	Coefficient Of Friction
POME	Palm oil methyl ester
CL	Commercial lubricant
WSD	Wear Scar Diameter
RBD	Refined Bleached Deodorised
FYP	Final Year Project
VI	Viscosity Index
ANSI	American National Standards Institute
PMO	Paraffinic Mineral Oil
PS	Palm Stearin
FTP	Flash Temperature Parameter
MWSD	Mean Wear Scar Diameter
CNF	Carbon Nano Fiber

CHAPTER 1

INTRODUCTION

1.1 Background Study

The tribology study of metal processing has been emphasized nowadays due to the trend towards machinery world. To increase the life span of machinery system, lubricant is needed. Global environmental awareness encouraged the replacement of mineral lubricant with renewable, sustainability, high biodegradability and eco-friendly lubricant. Palm oil based lubricant constitute as one of the natural oil-based lubricant and as alternative lubricant for industrial processes.

Pure natural oils have been known to be good lubricants since ancient times in lowering friction and preventing wear. The advent of petroleum of petroleum-based oils produced rapid advances in lubrication technology that quickly dominated other oils, such as natural oils in the lubricant industry. A thermogravimetric analysis and variable-temperature viscosity analysis were conducted to study the thermal response of the lubricants in a high temperature environment. (Reeves. 2014)

1.2 Problem Statement

Tribological properties such as wear, viscosity, flash temperature of resulting nanoparticle enhanced lubricant will be evaluated and compared with selected lubricants. But the uses of mineral oil lubricants can pollute the environment either during or after use. Hence, natural oil-based lubricant which has high biodegradability compared to mineral oil is applied to provide an alternative to replace the mineral oil as lubricant. In this project, we use natural oil from plant because they are non-toxic, biodegradable and renewable. Natural oil-based lubricants have a higher lubricity, lower volatility, higher shear stability, higher viscosity index, higher load carrying capacity and superior detergency when compared to mineral oils. (Syahrullail et al. 2011).

The tribology properties and effectiveness of the natural oil-based lubricant can be evaluated by using four-ball tester, seta flash series 2 and viscometer to determine the friction and wear of ball bearing which is carry out the properties of lubricant, flash temperature and viscosity for difference type of lubricants respectively. This project aimed to investigate the tribological properties of nanoparticles enhanced natural oil-based lubricant at difference concentration of additive and make comparison with selected lubricants. Measuring of tribological properties of lubricant can be done by using four-ball tester, seta flash series 3 and viscometer.

1.3 Objective

The objectives of this project are as follows:

1. To investigate the tribological properties of nanoparticles enhanced natural oil-based lubricants which consist of Refined Glycerine and Oleic Methyl Ester.
2. To compare the properties between the selected lubricants.

1.4 Scope of Project

The scopes of this project are:

The project will conduct tribology tests on two types of natural oil-based lubricants which are Refined Glycerine and Oleic Methyl Ester. The lubricants will be mixed with carbon nanotubes at 0.5%wt, 1%wt, 2%wt, 3%wt, 4%wt and 5%wt.

1.5 General Methodology

List of method that will be done to achieve the objectives of this project are as follows:

1. Literature Review

   Journal, the standard document or whatever type of reference that can provide as references.

2. Experiments Conducted

   The experiment will be conducted according to the given guidelines by ASTM standard.

3. Measurement

   Measured the mixing of lubricant with carbon nanotube (CNT). The mixture are measured by using digital mass measurement instrument.

4. Analysis

   Analysis will be performed on different type of lubricants and parameters such as different composition and with and without addictive.

5. Writing report

   The report on this project will be completed at the end of the study.

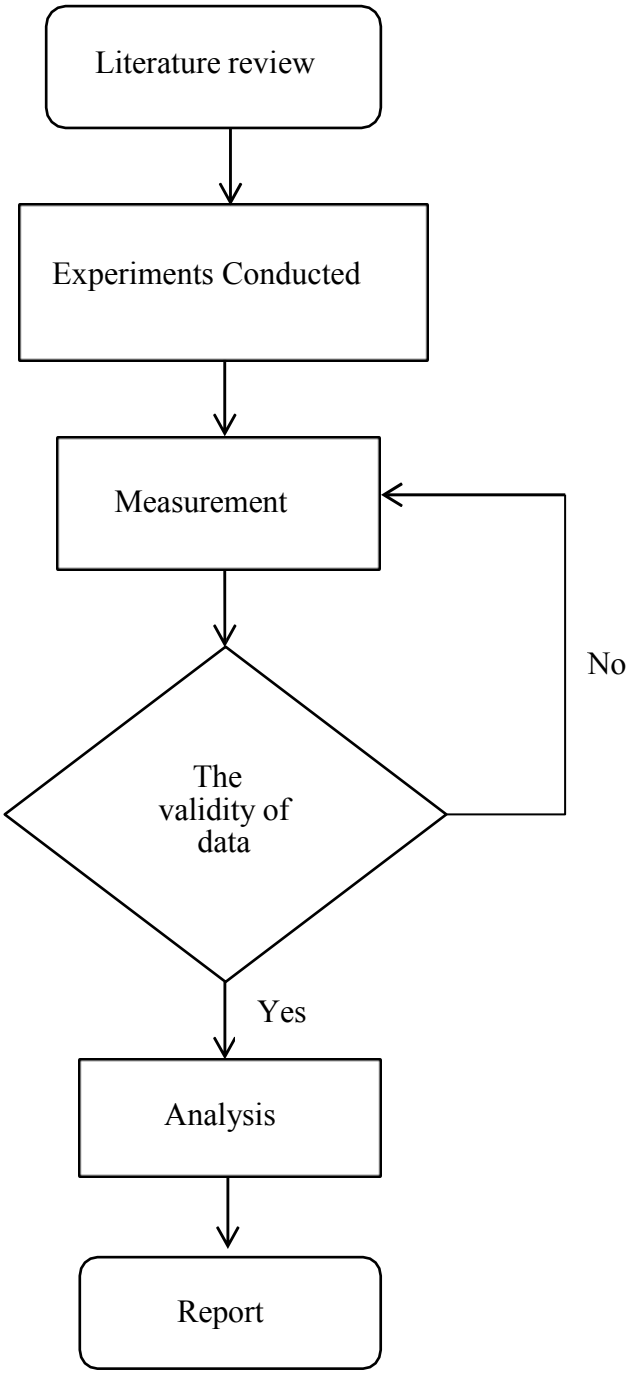

Figure 1. 1: Flow chart of the methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Literature review is focused on previous study in the field to obtain knowledge and information for the present study. This chapter will cover on the research finding about the performance of the tribological properties. There are many techniques or methods that can be used to conduct the experiment in order to study the performance of tribological properties. In this report, the method that has been chosen is four ball-testers. This method will be investigated the physical properties of ball bearing that been used in the experiment. Furthermore, theory about the natural oil-based performance also will be discussed in this chapter.

2.2 Background of Project

Various studies on lubricants properties have been carried out by many researchers in the past. This chapter reviews the previous published literatures, which lays foundation and basis for further work in this project. This helps give a better understanding about the topic and also acts as a guideline for the whole report structure. Main focus of the study is on lubricants properties and use of carbon nanotube (CNT).(Yong et al. 2016).

2.3 Fundamental of Tribology

Science and engineering of interacting surfaces in relative motion are the combination called Tribology. Study and application of principles of friction, lubrication and wear, these are the things that it discuss in tribology. Materials science and mechanical engineering, are the brunch that have in tribology that we can discuss.

Result in loss of materials from the surface will be obtained if the tribological interactions of solid surfaces exposed face with interfacing materials and environment. "Wear" is called the process leading to loss of materials. There are many types of major wear such as abrasive wear, friction (adhesive and cohesion), erosion, and corrosion. Modifying the surface properties of solids by one or more of "surface engineering" process (also called surface finishing) or by use of lubricant.(Mannekote & Kailas 2012)

2.4 Fundamental Theories of Lubricant

Friction, wear, and lubrication are tribological phenomena that run the behaviour of interacting surfaces in a wide range of machine components. Understanding the physical and chemical nature of these phenomena is critical to achieving long component lifetime and economical operation. Research in the field of tribology is highly interdisciplinary, and encompasses the fields of physics, chemistry, engineering, and mathematical modeling. Lubricants calls contributions on new advances in all areas of tribology for publication as peer-reviewed research articles, reviews of current research, letters, and communications.

A lubricant is a substance introduced to reduce friction between surfaces in mutual contact, which eventually reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces. The property of reducing friction is known as lubricity.

2.4.1 Function of Lubricant

The main of lubricant is to minimize the friction between the interacting surfaces by prevent the direct contact between two metal surfaces. Besides that, lubricant also used to control wear, temperature, oxidation and corrosion of metal surfaces, form a seal and remove contaminants. All types of lubricant should be inert to the metal surface and should not under any chemical reaction toward the metal surface.(Cornelio et al. 2016)

2.5 Natural Oil-based Lubricant

Lubricant must be more environmentally influenced, level of performance must be higher, and total life cycle cost must be lower than already lubricant present. For that lubricant to be formulated, we have to know very well the properties of those based fluid. The formulated lubricant that has been influenced by based fluid properties, have three different divided groups.

The three group as mentioned before are physical, chemical, and film formation properties. An investigation of the properties from all the group must be done to make sure

that information about their influenced on based fluid overall performance.(Fox & Stachowiak 2007)

2.6 The influence of fatty acids on tribological and thermal properties of natural oils as sustainable biolubricants By (Reeves et al. 2015)

This is a study several natural oils were selected to represent a broad range of saturated and unsaturated fatty acid compositions within bio-based oils. These oils were investigated to understand the properties of fatty acid composition on friction and wear performance under ambient conditions using a pin-on-disk apparatus. The experiment was carried out based on American Society for Testing of Materials (ASTM) standard.

A thermogravimetric analysis was used to determine the correlations between the fatty acid composition, tribological performance, and the thermal response of the natural oils.

2.6.1 Methodology

2.6.1.1 Natural oils

Eight oils were selected to investigate the tribological performance of natural oils. These oils were chosen because they represent a variety of saturated, monounsaturated, and polyunsaturated fatty acid compositions within natural oils.