UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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IMPROVING WASTE COOKING OIL LUBRICITY PROPERTIES WITH ENHANCEMENT OF NANOPARTICLE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

by

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Signature: .....

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Date: 11 JAN 2019

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Pada era globalisasi masa kini, minyak sayuran menjadi keutamaan dalam industri minyak pelincir. Minyak sayuran ini membolehkan ianya diguna kerana biodegradasinya mempunyai ciri-ciri seperti mesra alam sekitar, boleh diperbaharui dan kadar toksik adalah sedikit. Kajian ini dijalankan kerana untuk menambahbaikkan minyak pelincir yang berasaskan minyak petroleum. Proses kajian ini dijalankan dengan menggunakan sisa minyak masak yang dicampurkan dengan aditif iaitu hBN sebagai nanopartikel dan asid oleic sebagai ejen surfaktan. Sisa minyak masak ini perlu ditapis dengan mengikuti ASTM D 7317. Selepas proses penapisan dijalankan, sampel yang diperolehi perlu dicampurkan dengan nanopartikel dan ejen surfaktan dengan menggunakan ultrasonik homogenizer. Kajian ini dijalankan untuk mengetahui, membandingkan dan mengesan komposisi nanopartikel yang berbeza terhadap sifat-sifat geseran. Menurut ASTM D 4172 dengan menggunakan empat bola galas, nilai geseran dan saiz pada permukaan di bola galas diperolehi. Mekanism haus pada permukaan bola galas dianalisis dengan menggunakan kaedah SEM dengan mengimbas imej permukaan yang haus tersebut. Seteleh ke semua data dicapai, data itu akan mula di analisakan. Nilai purata optimum bagi pekali geseran yang diperolehi adalah 0.0705 daripada hasil keputusan data yang telah dianalisakan. Selain itu, apabila purata geseran semakin rendah, diameter kesan haus pada permukaan bola galas juga semakin kecil. Hal ini kerana, geseran mempengaruhi kerosakan dan haus pada permukaan tersebut. Kesimpulannya, sisa minyak masak dan nanopartikel mempunyai potensi untuk menjadikan minyak pelincir lebih baik.

ABSTRACT

In the era of globalization today, vegetable oil has the top spot in industrial oil lubricants. This vegetable oil allows it to be used because its biodegradability has such characteristics as environmentally friendly, renewable and toxic levels are minimal. This study is conducted in order to improve the lubricant oil based on petroleum. The process of this study was conducted using waste cooking oil mixed with additive, hBN as nanoparticle and oleic acid as surfactant agent. The waste cooking oil had been filtered by following the ASTM D 7317. After the filtration process is carried out, the sample obtained should be mixed with nanoparticles and surfactant agents using ultrasonic homogenizer. This study was carried out to determine, compare and track different nanoparticle compositions to frictional properties. According to ASTM D 4172 using four ball bearings, the friction value and the size on the surface of the bearing ball is obtained. The wear mechanism on the bearing ball surface is analysed using SEM's balance by scanning the image of the wear-resistant surface. After all the data is obtained, all the data began to analyse. The optimum average value of the frictional coefficient obtained from the results which have been analysed was 0.0705. Additionally, when the average friction is lower, the diameter of the bearing effect on the bearing surface of the ball is also smaller. This is because, friction affects damage and wear on the surface. In conclusion, waste cooking oil and nanoparticle have the potential to make lubricating oil better.

DEDICATION

To my beloved parents

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Al_3O_2	Aluminium Oxide
ASTM	American Society For Testing And Material
$CaCO_3$	Calcium Carbonate
COF	Coefficient of Friction
CuO	Copper Oxide
DOE	Design of Experiment
hBN	Hexagonal Boron Nitride
RSM	Respond Surface Method
SEM	Scanning Electron Microscopy
S/N RATIO	Signal/Noise Ratio
WCO	Waste Cooking Oil
WSD	Wear Scar Diameter
ZDDP	Zinc-Dialkyl-Dithio-Phosphate
ZrO_3/SiO_2	Zirconial/Silica Composite

CHAPTER 1

INTRODUCTION

1.1 Background

Utilization of the plants and animals oils and plants had been practice in industrial application for many years especially in lubricants. Economic concerns and environmental issues first paved way for this technology to come into existence. Plants oils based lubricants shown an excellent in lubricity and may cause the majorly used in industry. This is because plants oil have superior viscosity index and great anticorrosion properties which high affinity towards metallic surface. Thus, it high lubricant provide a property of non-flammability and also due to non-polluting, non-toxic, renewable nature.

According to Panadre et al. (2015) the use of the waste cooking oil is one of the step to reduce the pollution occur and it act as new raw material which can be produce as new renewable source. Currently, vegetable oil is highly recommended of using it in industry because the potential of the oil in lubricant is high. The significant advantages of vegetable oil to an environment such as ecological and possessed acceptable performance in a variation of utilization help researcher to study the potential of vegetable oil as new lubricant (Gawrilow et al. 2013). Additionally, high viscosity index, great bio-degradability, high flash point, low toxicity and low evaporation loss were obtained in the vegetable oil. However, the vegetable oil have it weakness. To control the weakness, an additive were been used such as hexagonal boron nitride (hBN) while the surfactant agent is oleic acid.

According to a study done by Abdullah et al. (2014) nanoparticles can be categorized as a new low friction in technology and a step to reduce wear properties. There are lot of advantages over organic molecules and their nanometer size allows them to get in into contact areas freely. There are various types of nanoparticle have been used during the preparation of nano lubricants such as polymers, metals and organic and inorganic materials. In other research described that the copper (Cu) nanoparticles was used as an oil additive can improve anti-wear, load-carrying and friction-reduction performance. The friction reduction and anti-wear behaviours were depending on the characteristics of nanoparticles itself. There are several example such as size, shape and concentration. The size of the nanoparticle normally used in average of 2 up to 120 nm. Thus, the addition of a low concentration of nanoparticles (between 0.2 vol. % and 0.3 vol. %) into the lubricating oil is acceptable to improve tribological properties based on research conducted by Tsui et al. (2007). Qiu et al. (2001) found that the concentration of nickel (Ni) nanoparticles in between from 0.2 % and 0.5 % accommodate the best friction reduction and anti-wear behaviour.

1.2 Problem Statement

At this moment, the use of petroleum is very important in terms of human consumption to the needs. For that reason, the entire drainage in the drain or inside the river will be discarded. Wastes that contain high toxicity cause pollution to occur and effected in daily life (Shahabuddin et al. 2012). The lubricant waste were reported about 12 milion tons were damped to the sea (Tottea et al. 2003).

A study conducted by Quinchia et al. (2014) seem that vegetable have the potential substitute to petroleum based oil due to the characteristic of the oil which renewability, less toxic content, environmentally friendly and containing lubricant properties like high in viscosity index, high in lubricity and low volatility (Nizam et al. 2009). It is extremely troublesome deteriorate the mineral lubricant in petroleum oil because of its non-biodegradable nature. Same goes to waste cooking oil which had been damped to the drain and may cause the pollution. Since the vegetable oil have an oxidation, low thermal and hydrolytic stabilities characteristic, it can be enhance as a new lubricant with adding with nanoparticle as an additive.

1.3 Objective

The objective of the proposal project:

1. To develop design of experiment (DOE) for optimize waste cooking oil (WCO) sample by additive hbN nanoparticle.

2. To investigate the tribology performance of filtration of waste cooking oil (WCO) with addition of hBN.

3. To determine the wear mechanism on the worn surface of the ball bearing.

1.4 Scope of Work

In order to achieve the objectives, several scope had been determined:

1. Development of DOE by using L_9 orthogonal array Taguchi method for optimizing WCO sample additive with hBN nanoparticle.

2. Investigating the tribology performance of filtration of waste cooking oil (WCO) with additive hBN by using Tr-20 four ball tester according to the ASTM D 4172 standard test method.

3. Optimizing the wear mechanism on the worn surface of the ball bearing by using SEM.

CHAPTER 2

LITERATURE REVIEW

2.1 Design of Experiment (DOE)

According to Roy et al. (2001) design of investigations (DOE) is a skilled truthful the technique exhibited by Fisher in England in the 1920's to ponder the effect of various factors in the meantime. In beginning applications, Fisher expected to find how much rain, water, fertilizer, and daylight are relied upon to make the best yield. Since that time, much change of the strategy has happened in the academic condition, yet helped make various applications in the generation level. Dr. Genechi Taguchi implemented significantly research with design of experiments (DOE) methods in the late 1940's. Dr. Genechi Taguchi spent impressive push to make this exploratory system more easy to use (simple to apply) and connected it to enhance the nature of produced items. Dr. Taguchi's institutionalized variant of DOE, prominently known as the Taguchi technique or Taguchi approach, was presented in the USA in the early 1980's. Today it is a standout amongst the best quality building apparatuses utilized by engineers in a wide range of assembling exercises. The DOE utilizing Taguchi approach can financially fulfill the requirements of critical thinking and item/process plan improvement ventures. By learning and applying this procedure, engineers, researchers, and analysts can essentially decrease the time required for trial examinations.

Design of experiments can be highly efficient when it can be optimize the product and the design process, the study effectiveness of various factors on the performance and solve production problems by objectively laying out the investigative experiments.

Taguchi design is one of the most capable DOE methods to analyse experiments (Yuvaraj et al. 2012). It is widely recognized in many areas, especially in the development of new products and processes in quality control. The main features of this method which a straightforward, proficient and precise technique to upgrade item/procedure to enhance the execution or decrease the cost, help touch base at the best parameters for the ideal conditions with minimal number of scientific examinations, it is a logically taught system for assessing and actualizing upgrades in items, forms, materials, equipment and facilities. Hence, the Taguchi method has great potential in the area of low cost experimentation. Thus it becomes an attractive and widely accepted tool to engineers and scientists.

The researcher Yang et al. (1998) agreed that as DOE utilizing Taguchi approach endeavors to enhance quality which is characterized as the consistency of execution. Consistency is accomplished when variety is diminished. This should be possible by moving the mean execution to the objective and also by decreasing varieties around the objective. The prime motivation behind the Taguchi experiment design technique is to achieve reduced variation (also known as ROBUST DESIGN). This system, thusly is engaged to achieve the coveted quality destinations in all means. The established DOE does not particularly address quality. The essential issue tended to in traditional factual test configuration is to demonstrate the reaction of an item or process as an element of numerous elements called display factors. Variables, called irritation factors, which are excluded in the model, can likewise impact the reaction. The essential issue tended to in Robust Design is the way to diminish the difference of an item's capacity in the client's condition (Phadke et al. 1989).

2.1.1 Respond Surface Method (RSM)

In respond surface method (RSM) by Aziz et al. (2013) statistics it is widely used in determining the numerical connection between at least one factors and reactions or different reactions. In the industry, today RSM world is utilized as a part of numerous applications in view of its viability and cost time adequacy in dissecting scientific studies as it reduces in cost and time in correlation with other scientific analysis strategies for example, research facility tests. RSM utilized as a part of numerous logical fields, for example, chemical science, sociologies, engineering science and formal science. The RSM technique was first presented in Malaysia 1951 by G.E.P. Box and K. B. Wilson. The thought is to make a financial plan for. The response utilizes a low level of polynomial either the primary level of the polynomial if there is a moment straight or polynomial relationship if the relationship is curvature. Despite the fact that the primary spending won't be precise, it will give an overview of the relationship amongst respond and variable and how the reaction will be extraordinary or carry on with the variable.

In statistics, there is an essential part of RSM where it is utilized as a measurement strategy and as a mathematical way to deal with observational model building, (Box et al. 2007). Using a cautious design model, it is difficult to get a productive apparatus division where the principle objective is to build the reaction given (output variable) for example, enhancing motor effectiveness and drag reduction friction force (Larson et al. 2006). Output variable are frequently impacted by various free factors regularly planned through an arrangement trial information and input variable are then controlled to recognize how to influence output respond (Cornell et al. 2011).