UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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OPTIMIZATION OF TREATED SN 0W20 GRADE ENGINE OIL ENHANCE WITH hBN NANOPARTICLES

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

by

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This report is submitted to the Faculty of Engineering Technology of 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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DEDICATION

To my beloved parents, lecturers and friends.

ABSTRACT

Nowadays, the demand of new lubricant is highly undoubtedly due to the diverse application that keeps on increasing in industry. It is vital to be studied and produced the new lubricant to meet future demand. The problem is most of the lubricants is derived from the crude oil which is not adaptable to the environment because of its toxicity and non-biodegradability when it is discarded. Due to that problem, the used oil can be threatening to the world if it is not handled correctly. The recycling and regeneration the used oil can be an alternative way to prevent pollution by arranging the composition of the used oil by mixing it with additive oil. The purpose of this study is to determine the optimal design parameters and to indicate which of the design parameters that suitable for obtaining a low coefficient of friction (COF) with hexagonal boron nitride (hBN) nanoparticles, dispersed in fully synthetic engine oil (SN 0W20). Design of experiment (DOE) was constructed using the Taguchi method, which consists of L9 orthogonal arrays. Four-ball tester is used for conducting tribological testing by according to ASTM standard D4172 procedures. According to an analysis of S/N ratio, COF and wear scar was reduced significantly with the addition of hBN nanoparticles into the treated engine oil SN 0W20. The contribution of 0.1 vol% hBN nanoparticles and 0.3 vol% oleic acid into based oil be can an optimal composition additive to be added in the treated engine oil. Besides, the ideal parameter of the homogenization process is important to be considered as the optimal result obtained when the nano-oil was heated at 40℃ for 30 minutes by ha omogenizer. In addition, the expected reduction in COF and wear was achieved when the hBN functioning well as anti-wear additive.

ABSTRAK

Pada masa kini, permintaan pelincir baru adalah tidak diragui kerana pelbagai aplikasi yang terus meningkat di dalam industri. Adalah penting untuk dikaji dan menghasilkan pelincir baru untuk memenuhi permintaan masa depan dalam industri. Masalahnya adalah kebanyakan pelincir dihasilkan darpada minyak mentah yang tidak dapat disesuaikan dengan alam sekitar kerana keracunannya dan tidak terbiodegradasi apabila dibuang. Oleh kerana masalah itu, minyak yang digunakan boleh mengancam dunia jika tidak ditangani dengan betul. Kitar semula dan regenerasi minyak yang digunakan boleh menjadi alternatif untuk mencegah pencemaran dengan mengatur komposisi minyak yang telah digunakan dengan mencampurkannya dengan minyak tamabahan. Tujuan kajian ini adalah untuk menentukan parameter reka bentuk yang optimum dan menunjukkan parameter reka bentuk yang sesuai untuk mendapatkan tahap geseran yang rendah (COF) dengan mencampurkan nanopartikel heksagonal boron nitrida (hBN) ke dalam enjin minyak sintetik (SN 0W20). Reka bentuk eksperimen (DOE) akan menggunakan kaedah Taguchi, yang terdiri daripada tatasusun L_9 ortogonal. Penguji empat bola digunakan untuk menjalankan ujian tribologi mengikut prosedur ASTM standard D4172. Kejadian geseran dan haus dalam galas bola akan diperiksa dengan menggunakan mikroskop elektron imbasan (SEM) untuk mengenal pasti sifat-sifat tribologi komposisi minyak baru. Keputusan yang dijangkakan bagi kajian ini adalah untuk mencari parameter ideal bagi komposisi baru untuk minyak yang dirawat dan pengurangan pekali geseran dan kadar kehausan dengan menggunakan nanopartikel heksagonal boron nitrida (hBN) sebagai minyak tambahan.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, lubricants produced based on the different oil-based foundation for different usage. One of these lubricants is synthetic oil. Synthetic oil is a human-made lubricant that consists of chemical compounds which can be produced by using chemically modified petroleum instead of taking a large volume consumption of crude oil and it also can be synthesized from other resources. Synthetic oil is utilized as a substitute for refined petroleum while working at an outrageous temperature. It is widely used in industry such as modern engines, air compressors, coupling grease lubricate, pumpjack Gearbox and others (Jackson 1987).

Synthetic oils are known for its better performance than conventional oils in a lot of ways in diverse applications. Synthetic oil made with highly refined base oil than mineral oils as it offers your engine a superior protection and performance. Synthetic engine oils offer a variety of benefits that keep the optimal performance of your engine for long terms. According to Gryglewicz et.al (2003), synthetic oils offer greater engine protection from wear. As the car moving at high speed, car's engine will highly expose to an extreme environment which can cause the engine to break down and causing wear. As conventional oils break down, their ability to prevent is diminished. On the other hand, the synthetic oils retain their wear protection properties for a much longer time.

Recently, numerous studies have been conducted on how to improve engine oil by enhancing with nanoparticles. Nanoparticles are particles that have a size normally around 100 nanometers or less. According to Khairul et al. (2016), nanofluid generally is known as a two segments blend which are base fluid and nanoparticles that blend with no synthetic response between these two segments. The surface layer commonly comprises ions, nonbiological and biological molecules. Biological molecules covering nonbiological nanoparticles are known as stabilizers, capping and surface ligands, or passivating agents. Nanofluids have good properties in such a way of thermal conductivity, viscosity, thermal diffusivity and convective heat transfer coefficients. The high surface area of nanoparticles improves the thermal conductivity of two nanofluids from the heat transfer takes place on the particle surface. The number of atoms existing on the nanoparticles surface is bigger compared with the interior. In addition, the nanoparticle may reduce erosion and clog due to the smaller size which contributed.

1.2 Problem statement

Technically, there are various types of lubricant used all over the world such as mineral oil, synthetic oils and bio-lubricant oils. But the most used lubricants are mineral oil which is derived from crude oil that happens not to be adaptable to the environment because of its toxicity and non-biodegradability. (Adhvaryu, Liu, and Erhan 2005). Through the disadvantage of the mineral oils, it becomes threatens to the world because they are not friendly-environment especially the used lubricant. In order to solve the problem, the used lubricant can be one of the alternative sources to produce a new lubricant by enhancing the lubricant with additive such as nanoparticles. According to Wang et al., (2017) the

dependency on petroleum fuel can be reduced by recycling the used lubricants and save the limited resources of crude oil. This can be achieved by optimizing a new develop used engine oil with a strategies such as design of experiment (DOE).

The requirement for productive and environmentally new lubricants are vital to be produced for relevant reasons, for instance, for use of extreme condition of machine materials. The requirement keeps on increasing due to the availability and application limit of existed lubricant; limitedness and arising cost of mineral oils as oil-based lubricants; health issues which can causing pain to human body due to polluted environment; to embody the awareness of recycling and regeneration of used chemical fluids (Astakhov and Godlevskiy, 2012; Mang and Dresel, 2007). Thus, the study of oil behavior must be studied on which it may changes due to certain factors such as temperature, time and additive.

Lubricants have been used to for many usages in many applications which applied in various light and extreme condition. The properties of lubricants have the possibility to affect its performance as the properties change over time due to many factors. As the solution, the properties of the lubricant can be maintained its performance by controlling the degradation rate that exhibited in the lubricant which influence from the changes in viscosity. This can be analyzed by studying the wear mechanism that inherent on the metal surface. Through this process, it can effectively extend the lubricant life-span, reduce the usage of lubricant and discharge an environmentally friendly waste lubricant. The reasons of degradation of oils are caused from oxidation occurrence, degradation atomic chains and pollution by insoluble deposits and metal contaminations because of thermal experienced and mechanical abrasions. Thus, the changes of viscosity are also affecting the deterioration of lubricant.

1.3 Objectives

The objectives of this proposal project:

1. To optimize the tribological performance of new develop SN 0W20 grade engine oil.
2. To investigate the effect of different parameters of sample preparation.
3. To determine the wear mechanism occurs on the worn surface of the ball bearing.

1.4 Scope

From the objectives, the study is narrowed down to become more specific as to give clearer view of this experiment on the critical points. The scopes including in this study is:

1. Optimizing the tribological performance of new develop SN 0W20 grade engine oil by using Taguchi method.
2. Investigating the effect of differences parameters of sample preparation by using four-ball tester in accordance of ASTM D 4172.
3. Determining the wear mechanism occurs on the worn surface of the ball bearing by using scanning electron machine (SEM).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will focusing on the studies have been conducted by other researchers about the type of lubricant used nowadays which prefer as an important thing to understand the type of lubricant. Every aspect of this study's approach will affect the result of an experiment which can bring changes to the lubricant industry through different perception.

For the last decades, the industries have been characterized by complex optimization through the evolution of technology; for example; a modern lubricant, oil additive, and optimization of new composition oil. These characteristics can be strengthened by implementing a mathematical method into chemical process and physical motion. One of the methods is the design of experiment (DOE) which is invented to reduce the number of trials; simultaneous varying the parameters that need to conduct by the experimenter; and enables the reliable solution to be obtained after each sequence of the experiment. As for that, to choose the optimal experiment design to conduct an experiment that need to be analyzed should be considerable . By designing an experiment, it standardized the process of an experiment to be more efficient and generates the accurate results with a less of experiment's trials and lowest possible material cost.

2.2 Design of Experiment (DOE)

Design of experiment (DOE) is a method of conducting an experiment with an organized order that stands with its own terminology, methodology and subject of research like any other scientific discipline method. The assign in such manner numerical technique itself apparently shows full arrangements upon an exploratory method which exceedingly perform in research, improvement and enhancement of system. This technique is regularly utilized as a part of labs, pilot plants, full-scale plants, agricultural, facilities, and others. An investigation might be physical, physiologically or model base that might be performed straightforwardly on the model or its subject. normally, the model is not quite the same as the subject in its region and in some cases in its inclination. In addition, the exploratory may likewise be directed on mathematical technique. At the point when a model depicts the subject unequivocally enough, the experiment on the subject is generally replaced by an experiment on the model. lately, because of a fast improvement of computer technology, the physical models are replaced with the mathematical method.

According to Balestrassi et al. (2009), the design of experiment (DOE) showing the promising result compared than other existent methods. DOE is a method that allows experimental practices that are capable of producing proper information for an efficient measurable investigation. The DOE is a successful arranged approach for deciding circumstances and end results connections to get perfect conditions through few investigations essential (Semioshkina and Voigt 2006). Through a smaller number of essential equipment which is the parameters, the experiment will be easy to handle and

control as we set the parameters that need to be studied in the first place. Besides, the DOE is more efficient than statistical method because the DOE can reduce the number of trials experiments if the parameters is chosen properly and there are no losses in any information due to the reduction of number trials experiments.

2.2.1 Response Surface Methodology (RSM)

Response surface technology (RSM) is a collection of mathematical method and statistical method for observed model building. The main purpose to designated RSM is to improve the efficiency of the output variables that influenced by the input variables. The input variables will be changed from one factor to another factors as a series of test to identify what causes for changes in output variables. (Gunst, 1996).

RSM was developed to model experimental responses and then shifted into the modelling the numerical experiments. In RSM, errors are assumed to be random due to differences error that generated by the response. Meanwhile in physical experiments, inaccuracy can happen in a matter of time. For example, the existence of error in measurement during the computer experiments causes a numerous noise; which resulting from incomplete convergence of iterative process, round-off errors or continuous discrete physical representation of physical phenomena (Giunta et al., 1996; van Campen et al., 1990, Toropov et al., 1996).

2.2.2 Factorial design

Full factorial is likely the most widely recognized and natural technique of experimental design. In this method, there are 2 factors which are "k" and "L" and it consist

of 2 levels per factor. The samples will be tested out by every possible combination of the factor values in which the sample size is N= 2k.

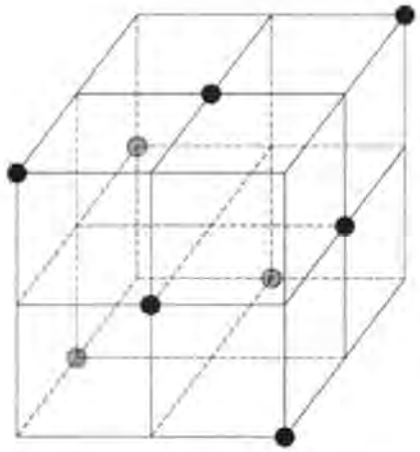

Figure 2.1: A 33 full factorial design (27 points)

The two levels that present in factors known as "h" (high) and "l" (low) or "+1" and "-1". The full factorial system stated when the sample in which the factors are changed, it is still in the sample space. This principle of each factor won't be influenced by different factors because of reaction factors. In writing, it happens to experience full factorial outlines in which additionally the essential issue of the plan space is added to the examples. The essential issue is the example in which every parameter has an average value which is the normal between their low and abnormal level and in 2k full factorial tables can be individuated with "m" (mean value) or "0". full factorial outline with three variables and two levels for each factor (Table 2.1). The full factorial is an orthogonal trial outline strategy. The term orthogonal gets from the way that the scalar result of the segments of any two-factors is zero.

2.2.3 Taguchi method

Taguchi's methods developed based on fractional factorial arrays that focusing in selected parameters for study purpose, known as orthogonal arrays (Rushing et al. 2013). Dr. Taguchi has developed a design of experiment that reduce the number of trials to conduct experiment because the interaction between two design variables are not necessary to consider in response surface methodology 25. Eventhough this method has the ability to handle different variables, the truth is that Taguchi ignore the interactions in the parameter (Gunst, 1996).

According to Sharma et al. (2005) and Semioshkina et al. (2006), the primary step to produces a high quality of Taguchi method is by identifying the process of parameters. Identifying the parameters can improve the efficiency of characteristics and minimal the number of experiments and cost. Unlike the other methods, the ideal process parameters acquired from Taguchi method is not restricted to the variation in environmental conditions and other noise. Taguchi's approach depends on arranging the factors in a process either controllable factors or uncontrollable factors and finding the settings for the controllable factors that limit the changeability transmitted to the reaction from the uncontrollable factors (Rushing et al. 2013).

Hence, the Taguchi was intended to emphasis the quality engineering on minimize variation the primary purposes behind enhancing quality. The idea is to design products and performance of experiment that is not impacted by the external factors and set up parameters that should be studied only. The parameters empower main variable and associations to be examined in a less number of trials. Besides, the Taguchi method uses the idea of

fundamental functionality in which means that this method will help the people to identify the common goal of conducting experiment due to its characteristics that are meant to investigate only the set up parameters (Semioshkina et al. 2006) .

2.2.3.1 L_9 Orthogonal arrays

The orthogonal arrays can be developed in many ways which are meant to be attached to different types of variable and level. The exhibits are autonomous upon on what number of trials need to be led. For instance, on the off chance that one needs to lead an examination to comprehend the impact of four different selected variables with every variable having three set qualities (level qualities), at that point a L_9 orthogonal array may be the correct decision. The L_9 orthogonal array is implied for understanding the impact of four autonomous variables each having three-factor level qualities. This array expects that there is no connection between any two variables. While much of the time, no collaboration show supposition is legitimate, there are a few situations where there is an unmistakable confirmation of cooperation. A run of the mill instance of collaboration would be the association between the material properties and temperature.

$L_9(3^4)$ Orthogonal array					
	Independent Variables				Performance Parameter Value
Experiment #	Variable 1	Variable 2	Variable 3	Variable 4	
1	1	1	1	1	p1
2	1	2	2	2	p2
3	1	3	3	3	p3
4	2	1	2	3	p4
5	2	2	3	1	p5
6	2	3	1	2	p6
7	3	1	3	2	p7
8	3	2	1	3	p8
9	3	3	2	1	p9

Figure 2.2: Layout of L_9 orthogonal array

(http://www.ecs.umass.edu/mie/labs/mda/fea/sankar/chap2.html