UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION ON THE NANOPARTICLE SUSPENSION FOR BETTER DISPERSION IN LIQUID PHASE

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

by

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………………………......

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ABSTRAK

Kajian ini memberi tumpuan dengan mengaplikasikan kaedah Design of Experiment (DOE) dalam mengkaji kesan perbezaan ejen surfaktan ke atas penyebaran nanopartikel yang lebih baik di dalam fasa cecair. Nanopartikel mempunyai masalah pengumpalan apabila ia ditambah ke dalam minyak pelincir sebagai bahan tambahan. Pengumpalan yang berlaku pada nanopartikel menghasilkan pemendapan nanopartikel di dalam minyak . Keadaan ini boleh menjejaskan kestabilan minyak nano. Prosedur eksperimen telah di jalankan untuk mengenal pasti kesan perbezaan ejen penyebaran menyeragamkan minyak enjin SAE 15W40 gred konvensional ditambah dengan nanopartikel sebagai sampel minyak-nano. Ejen surfaktan yang berbeza iaitu cholate natrium, asid oleik dan Sulfonate Benzene Dodesil Natrium (SDBS) dalam proses penyeragaman ini. Nilai keserapan minyak nano telah diukur menggunakan UV-spektrometer sebagai keputusan kuantitatif. Sampel juga telah diperhatikan secara berkala dengan menangkap imej minyak-nano sebagai kualitatif analisis. Nanopartikel yang digunakan dalam eksperimen ini adalah nitrida boron heksagonal (hBN), alumina (Al_2O_3), dan grafit. Hasil kajian ini telah menunjukkan bahawa penggantungan dalam minyak enjin konvensional SAE 15W40 dengan tambahan nanopartikel hBN oleh ejen SDBS campuran adalah stabil sepanjang tempoh 58 hari. Keadaan ini diperkukuhkan dengan membandingkan nilai keserapan dan kecerunan pada nano minyak dengan campuran hBN nanopartikel dan ejen SDBS adalah lebih besar berbanding dengan sampel yang lain di mana menunjukkan sampel dengan tambahan SDBS ejen memberikan lebih kestabilan penyebaran melalui nanopartikel hBN dalam minyak.

ABSTRACT

This study focused on applying the Design of Experiment (DOE) method to investigate the effect of difference surfactant agent for better dispersion of solid nanoparticles inside the liquid phase. The nanoparticles have agglomeration problem when its added in the lubricant as an additive. Occurrence of agglomeration towards nanoparticles can produce the sedimentation of nanoparticle inside the oil. This condition can affect the stability of the nano-oil. An experimental procedure was conducted to identify the effect of difference dispersion agent homogenize the conventional engine oil SAE 15W40 grade added with nanoparticles as Nano-oil sample. Difference surfactant agent were used which are sodium cholate, oleic acid and Sodium Benzene Dodecyl Sulphonate (SDBS) for the homogenize process. The absorbance value of the nano-oil was measured using UV-spectrometer as quantitative results. The samples also was be observed periodically by capturing the image of the Nano-oil as a qualitative result. The nanoparticles that were used are hexagonal boron nitride (hBN), alumina (Al_2O_3), and graphite. The outcome of this study was demonstrated that suspension in the conventional engine oil SAE 15W40 with the addition of hBN nanoparticles by mixed SDBS agent was stable over the period of 58 days. This condition was strengthened by comparing the absorbance values and the gradient on the nano-oil with the mixtures of hBN nanoparticle and SDBS agent is greater compared to others sample whereby indicates sample with the addition of SDBS agent gives more stability dispersion through the hBN nanoparticles inside the oil.

DEDICATION

To my beloved parents

ACKNOWLEDGEMENT

First and foremost, I express my profound gratitude to my creator, God almighty for his unfading love upon my life. Another from that, I would like to thank to my supervisor, Dr Muhammad Ilman Hakimi Chua Bin Abdullah, for his guidance and support through this case study. I cannot thank my family enough for all the prayers they been offering on my behalf, especially my father, my mother, my brother and my sisters. I say a big thank you. Lastly, my sincere thanks to all my friends that always give support and advice during completing the work of this thesis.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCULTURE

Al_2O_3	-	Alumina Oxide
ASTM	-	American Society for Testing and Materials
BN	-	Boron nitride
CeO_2	-	Cerium oxide
CMC	-	Critical micelle concentration
cP	-	Measurement of kinematic viscosity
cSt	-	Measurement of absolute viscosity
DOE	-	Design of Experiment
DOF	-	Degree of freedom
EP	-	Extreme pressure
hBN	-	Hexagonal boron nitride
IF	-	Inorganic fullerene
IUPAC	-	International Union of Pure and Applied Chemistry
LCFA	-	Long chain fatty acid
mM	-	macromolecule
MoS_2	-	Molybdenum disulphide
mV	-	milli Voltage
η	-	Fluid kinematic viscosity
NLGI	-	National Lubricating Grease Institute
nm	-	nanometer
P	-	Load
PAO	-	Polyalphaolefin
pH	-	A measure of acidity or alkalinity of water solube substance
PTFE	-	Polytetrafluorethylene
SAE	-	Society of Automotive Engineer
SDBS	-	Sodium Benzene Dodecyl Sulphonate

SEM	-	Scanning electron microscopy
talc	-	Soapstone
TEM	-	Transmission electron microscopy
V	-	Velocity
λ	-	Wavelength

CHAPTER 1

INTRODUCTION

1.1 Introduction of Nanoparticles

Lubricant is a substance that being used as a material to improve the smoothness movement of one surface contact over another. Lubricants are categories with three types which are solid, semi-solid and liquid. Lubricating oils also are known as liquid lubricants and further classified into three types, animal or vegetables oils, mineral or petroleum oils and Polyalphaolefin (PAO) or blended oils. The advantages of lubricating oils which are high boiling point, low freezing point, adequate viscosity for proper functioning in service, high resistance to oxidation and heat, non-corrosive properties and stability to decomposition at the operating temperatures.

The present of nano-lubricant today is to improve the performance of the current lubricant. A lot of research works have been made to improve the lubricant characteristic. The effected of friction and wear causes a great portion of the maintenance, replacement and spares part costs of the mechanical parts. The life of the machine not only will be reduces by wear and tear, but also shortens the lifespan its general maintenance period (increases the service costs) and causes the oil change needs to emerge more frequently. Other than that, from the friction issues it will be causes overheating and indicates more energy consumption. Engine additives produced in the world for the last 50 years, are chemical additives aimed at reducing friction and wear, which are the biggest problem of tribology. This thesis more likely do a research and experiment to control the stability of the oil with adding a convenient additive.

The stability of nanoscale particles is an important concern. Un-stability indicates unwanted changes in the properties of the particles. These changes could be as simple as an aggregation of the nanoparticles to form a larger mass, which no longer preserve the properties or dimensions of the original particles. The ability of these nanoparticles to resist change relies on how they interact with their surroundings. The solubility and specific functionality of the particles are often determined by the single molecule thick coatings on the nanoparticles‟ surfaces (e.g., biologically active molecules) (Giljohann et al. 2010). The surface properties of the particles can be easily controlled by tuning the composition of these molecular coatings (Sanjalal et al. 2010). However, the ability of the nanoparticles to preserve these specific properties depends on the resistance of the molecular coating to degradation, such as oxidative damage or other types of displacement of these molecules from the surfaces of the particles (Pekcevik et al. 2012).

Nanoparticles are widely pursued for their unique properties relative to their bulk counter parts (Eustis et al. 2006). According to Burda et al. (2005), the relatively high surface area to volume ratio of these particles is desirable for their increased catalytic activity. This increased activity can be partially attributed to the increased density of the edge and corner sites on the faceted surfaces of the crystalline nanoparticles (Bratlie et al. 2007). The chemically dynamic destinations are potential powerless focuses in any sub-atomic coatings and must be topped with surfactants to balance out the particles against undesirable collaborations with their encompassing surroundings. This less desirable cooperation‟s incorporate aggregation of the particles when dispersed in an arrangement.

In order to get the better stability in nanoparticles size, those must have the mixture with the proper additive. This research is focused on the adding of stabilizing agent with the surfactant agent or suspension agent in different sample of. The information will demonstrate a different result from an alternate centralization of oil after it combines. If the mix of both oils is accomplishment, the sedimentation in the multi-grade oil will be decreases.

1.2 Problem Statement

Any substance introduced between two contacting surfaces with aims to reduce the friction (or frictional resistance) between them, is known as a lubricants. The main purpose of a lubricant is to keep the contacting surfaces apart, so that friction and consequent destruction of material is minimized. The process of reducing friction between contacting surfaces, by the introduction of lubricants in between them, is called lubrication. Even though lubricant can help reduce the friction and wear, lubricant still have their disadvantageous which is it will degrade and deteriorate very rapidly in some operating conditions.

According to recent numerous studies, the nanotechnology can indeed improve the lubrication properties oils. By mixing lubricant with nanoparticles (additives) it can maximizing the performance of the lubricant. Somehow, by adding the additives into the lubricant, an issue regards of the nanoparticle (additive) agglomeration. The nanoparticles not dissolve with the lubricant. As reported by Yu and Xie (2012) that the agglomeration of nanoparticles results is not only the settlement and clogging of micro-channels but also the decreasing of thermal conductivity of nano-lubricant. So, investigation regarding on the stability is needed as it influences the properties of nano-lubricant for application, thus, the influencing factors to the dispersion stability of nano-lubricant can be studied and analyzed.

The uncontrolled factor for the stability of nanoparticle in the lubricant is the sedimentation. Sedimentation means settling of particle or floccules occur under gravitational force in liquid dosage form. To decrease the sedimentation, the dispersion or suspension agent must be added into the lubricant. Moreover, this both agents also can help to increase the stabilization of nano-lubricant and enhance the thermal conductivity.

1.3 Objective

i. To optimize the nanoparticle suspension inside the liquid phase condition.
ii. To investigate the effect of different surfactant agent and suspension agent for better dispersion of solid nanoparticle inside the liquid phase condition.

1.4 Scope

i. Optimizing the nanoparticle suspension by using Taguchi Method.
ii. Investigating the effect of different surfactant agent and suspension agent for better dispersion of solid nanoparticle inside the liquid phase condition by using UV-spectrometer.

CHAPTER 2

LITERATURE REVIEW

2.1 Classification of Lubricant

Today, a lubricant is the most important things for any machinery parts that appearing in this world. The main features of lubricant are to controls resistance and friction between surfaces through supplying a durable film. However, the level of protection that provided was dictated by the condition or “regime” it works or its application. Lubricants operate under three common lubricating regimes which are boundary lubrication, mixed film lubrication, and hydrodynamic lubrication. This regime lubrication is given by Figure 2.1, the Stribeck Curve (Kondo. et. al 2013), which plot and highlights the frictional characteristic as it relates to its viscosity, speed, and load. Stribeck Curve is basically a curve where it shows the relationship between coefficient friction and bearing number. The schematic of the Stribeck Curve shows that the horizontal axis indicates the parameter that is the combination of another variable: $\eta V/P$ while the vertical axis indicates the friction coefficient. This formula shows that P is the load on the interface per unit bearing width, η is the fluid kinematic viscosity, and V is the relative speed of the surfaces.

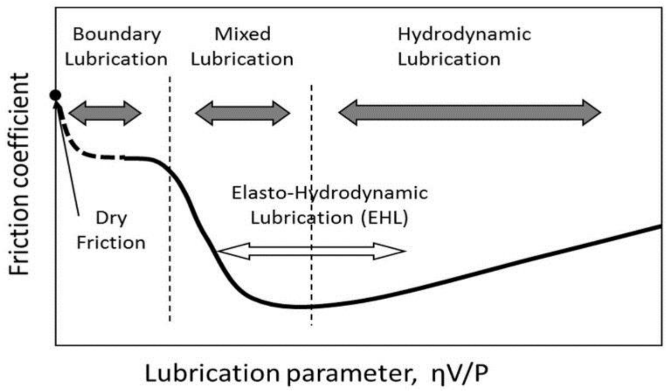

Figure 2.1 Schematic diagrams of Stribeck curve

(Source: Kondo. et. al 2013)

As the graph curve is moving in the right direction on the horizontal axis, the reading shows it has reduced of friction on the coefficient friction and shows the increased of impact speed (viscosity). The border of lubrication is when the situation of fluid film negligible and there is numerous of asperity (peak) exposure. On this regime, it will release the highest level of resistance and friction. The decreasing of load and increasing the viscosity it will begin to segregate the surface from contact each other by the formation thin film that supports the load begins. Mixed of film lubrication represent the situation where the asperities (peak) of two surfaces contact despite a lubricating film is present. The lubrication film is thicker than a boundary lubrication, it is a combination of hydrodynamic and boundary lubrication. The increasing speed or viscosity, the separate will continue to separate and extent of the formation of a full fluid fill and no contact between surfaces.

Hydrodynamic lubrication is a regime that indicates a low friction and wear. It occurs when there are full fluid films between the surfaces and there is no contact with each other. In the hydrodynamic region, friction will increase due to the fluid drag (friction produced by fluid). In the thicker fluid film may cause the high speed and also increasing the fluid drag on the moving surfaces. It also can be seen from the viscosity properties, when the viscosity is higher, increasing the thickness of the fluid film and also the drag of the fluid. In normal conditions, friction and wear happen when all machinery exhibit boundary lubrication at start up and shut down, before the transformation to hydrodynamics lubrication at normal operating