UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATE THE VISCOSITY OF USED ENGINE OIL BEFORE AND AFTER FILTRATION AND ENHANCE BY NANOPARTICLES

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

by

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APPROVAL

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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(Dr. Muhammad Ilman Hakimi Chua Bin Abdullah)

ABSTRAK

Pada masa kini, pelincir yang digunakan khususnya pada suhu yang tinggi kebiasaannya menunjukkan perubahan peningkatan kelikatan minyak pelincir yang telah digunapakai. Antara faktor yang menyebabkan kelikatan minyak pelincir terjejas kebiasaannya disebabkan oleh pengoksidaan, digradikasi, kehadiran air dan lain-lain lagi. Justeru itu, minyak enjin yang digunakan kebiasaannya akan menjadi bahan buangan sahaja. Peningkatan sisa minyak enjin yang telah digunakan semakin meluas terutamanya dalam aplikasi industry pada masa kini. Walau bagaimanapun, sisa minyak ini boleh digunakan semula dengan peranan nanopartikel. Ini kerana, nanopartikel boleh meningkatkan sifat-sifat kimia minyak pelincir dengan lebih baik jika dibanding dengan bahan tambahan yang digunakan pada masa kini, terutama dari segi kelikatan minyak tersebut. Kajian dijalankan bagi mengkaji kelikatan nanopartikal yang ditambah di dalam minyak terpakai sebelum dan selepas ditapis. Dengan merujuk kepada ASTMD2270, indeks kelikatan sampel kemudiannya dikira dan di nilai berdasarkan keputusan yang diperoleh. Akhir sekali, sebagai pengesahkan kepada keputusan ujikaji yang dijalankan, „flash point‟ bagi tiap sampel dikenalpasti dengan merujuk kepada ASTM D3828. Keputusan dari ujikaji yang di jalankan menunjukkan sampel yang di campur dengan nanopartikal dapat mengurangkan kelikatan kinetik sebanyak 3-7% pada suhu 40°C dan 2-8% pada suhu 100°C. Bagi indeks kelikatan pula, sampel-sampel yang melalui proses penapisan sebanyak tiga kali menunjukkan peningkatan sebanyak 5.5% dengan graphite mencatat indeks kelikatan paling tinggi melebihi minyak terpakai dengan 0.61%.Manakala, keputusan „flash point‟ yang diperoleh menunjukkan nilai lebih rendah dari nilai rujukan dengan nilai „flash point‟ paling rendah, 145.5°C, dan 156°C mencatat suhu tertinggi untuk sampel flash.

ABSTRACT

Currently, most of the lubricants used were reflected in high temperature applications which usually increase the possibilities of the lubricant viscosity been distorted. The symptom for viscosity distorted usually caused by oxidation, degradation, the presence of water and such that lead to this problem. Therefore, the used engine oil will become a waste. This waste increase day by day as the engine oil are wide been used especially in industrial application. However, this waste oil can be re-used by enhancement of nanoparticles. Nanoparticles could improve for the better lubricant chemical properties compared to the currently used additives, especially for the viscosity characteristic. Thus, testing was conducted in order to investigate the viscosity of used engine oil before and after filtration with enhancement of nanoparticles. The viscosity index of prepared samples was calculated and evaluated according to ASTM D2270. The flash point of the samples was determined in order to verify the result obtained according to ASTM D3828. Result shows reduction of the kinematic viscosity value around 3-7% at 40°C and 2-8% at 100°C compared to the pure used engine oil. The viscosity index for the prepared samples with three-time filtration process indicated the highest value compared to the other by 5.5% increment. And, graphite mark as the highest viscosity index value that exceeds the viscosity index of used engine oil by 0.61%. The lowest value of prepared sample flash point obtained is 145.5°C, with 156°C mark as the highest flash point of the sample.

DEDICATION

This thesis I dedicate to my beloved parents.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al_2O_3	-	Alumina
API	-	American Petroleum Institute
ASTM	-	American Society of the International Association for Testing and Materials
BN	-	Boron nitride
C	-	Viscometer constant, mm^3/s)
C	-	Carbon
CH	-	Carbon-hydrogen
CI	-	Compression-ignition
Co	-	Cobalt
cP	-	Centipoise
cSt	-	Centistokes
Cu	-	Copper
CuO	-	Copper oxide
EHL	-	Elastohydrodynamic
Fe	-	Ferrum
H	-	The kinematic viscosity at 40 ºC of an oil of 100 viscosity index that have the same value as the kinematic viscosity at 100 ºC of the oil that the viscosity index to be calculated, mm^2/s
hBn	-	Hexagonal boron nitride
HL	-	Hydrodynamic lubrication
Hz	-	Hertz
L	-	The kinematic viscosity at 40 ºC of the oil that the viscosity index to be calculated, mm^2/s
m	-	Meter
m	-	Mass

mL	-	mililiter
η	-	Dynamic / Absolute viscosity, pa-s
ºC	-	Celsius
ºF	-	Fahrenheit
P	-	Pressure, Pa
P	-	Poise
p	-	Density, g/cm^3
PAOs	-	Polyalphaolefins
s	-	Second
Sn	-	Tin / stannum
t	-	Time, s
TiO_2	-	Titanium oxide
U	-	The kinematic viscosity at 40 ºC of oil with the value of viscosity index is 0 and having the same kinematic viscosity at 100 ºC as the oil whose viscosity index is to be calculated, mm^2/s
USA	-	United State of America
v	-	Volume
VI	-	Viscosity Index
vol.%	-	Volume friction
ω	-	Rotational speed, rps
ν	-	Kinematic viscosity, cSt

CHAPTER 1

INTRODUCTION

1.0 Introduction

Lubricant has been used for many years as a substance to reduce wear and friction between the surface areas. Different kind of lubricant properties is formulated in order to optimize the key performance features. Lubricant can be classified into three categories; the solid lubricant, semi-solid lubricant, and liquid lubricant. The three different type of liquid lubricant in used is synthetic, mineral oil and bio-based oil, which are choose based on the application critical parameter. In order to optimize the lubricant to it desired characteristic, additive are used to scatter the molecule of the lubricant. Therefore, wear, friction, corrosion and others can be reduced, (Zhang et al., 2009). Synthetic oil is synthetically designed for a specific sub-atomic piece with a customized and uniform structure where the molecules are saturated with carbon-hydrogen (CH) bonds.

Due to the saturated CH bonds in synthetic oil, the lubricant has more advantage compared to mineral oil in withstanding higher temperature, good viscosity, have better oxidative stability and high load-carrying capacity. However, in any lubricant oil mixture, suitable added substances should be incorporated to upgrade certain properties, such as oxidation strength, friction reduction, wear, hostile to erosion, and strength against organic attack. Therefore, the lubricant ought to have the capacity to keep the added substance fix the certain properties as desired in operating order, (Mortier et al., 2010). Most of the applied lubricant nowadays lubricate for high temperature applications which cause most of this lubricant face distortion in oil viscosity. Nanoparticles are viewed as solutions to re-used distorted lubricant by enhancing the lubricant with nanoparticles.

Recently, some studies in developing nanoparticles and nanotubes as another sort of added substance material for oils been conducted due to their structure, size and other special properties. Currently, nanofluid are new engineering lubricants, which are produced using nanostructures technology, (Lee et al., 2009). Among the nanofluid properties, the viscosity is an essential property since it demonstrates the liquid's resistance. With the expanding of viscosity, the required vitality for pumping and blending increase. Also, pumping power and weight drop are two key components that rely on upon consistency, (Mahbubul et al., 2012). In this research, the viscosity of used engine oil before, after filtration and enhance by nanoparticle will be investigated. The viscosity index will be measured by using ASTM D2270 in order to identify the viscosity index of samples prepared where the aim is for the used engine oil with the enhance of nanoparticles give the same viscosity index as pure engine oil.

1.1 Problem Statement

The growth of industrial technologies made the used engine oil as the most plentiful material of waste available. Because of the application used for engine oil is at high temperature, the viscosity, specific gravity and flash point properties will reduce. Moreover, the disposes of the contaminant that comes from dirt or wear of metal part disposed into the oil also lead to the degradation of oil properties, (Cooke, 1982). Thus usually, the used engine oil has low grade quality and can no longer suitable to use. Moreover, the used engine oil is toxic and harmful to the environment. Which the used engine oil can pollute around two hundred thousand gallons of drinking water and cause damage to soil productivity for around forty thousand square feet, (Suriani, 2014). Therefore, the responsible management is needed in order to solve the problem regarding the disposal of waste.

Engine oil is usually used in high temperature equipment where the viscosity of the lubricant is expanded because of vanishing of the light mixes, oil oxidation, nitration and defilement by soot. Due to the build-up of engine oil temperature, the viscosity of used engine oil will be distorted where the lower viscosity index of the lubricant could increase the change of lubricant with the change of temperature.

However, with added of additive the viscosity index can be improved, the viscosity of a fluid is utilized to depict the resistance of relative development between stream layers. At the point when strong additives are included into lubricant, fluid drag that follows up on a strong surface affects the liquid consistency and the hydrodynamic weight. It has been reported that the state of an added substance influences the sum of fluid drag, (Leal, 1980).

1.2 Objective

The objectives of this project are:

1. To investigate the viscosity of used engine oil before and after filtration with enhancement of nanoparticles.
2. To evaluate the viscosity index of prepared sample by using ASTM D 2270.

1.3 Scope of Work

1. Investigating the viscosity of used engine oil before and after filtration and enhance with different nanoparticles after been homogenize by the ultrasonic homogenizer (Sartorius LABSONIC P).

2. Evaluating the viscosity index of the prepared sample using ASTM D 2270 Standard Practice.

CHAPTER 2

LITERATURE REVIEW

2.0 Literature Review

This chapter will cover all of the aspects needed that use as a review of the study made for the final year project. In order to gain full knowledge on the study, this chapter explains further information from lubricant background, type of lubricant, polyalphaolefins (PAOs), nanoparticle, lubricant viscosity until viscosity improver. All of this information is gathered from the journal, books, and article.

2.1 Background of Lubricant

Lubrication is first introduced centuries ago based on discoveries by archaeological. During ancient Egypt time, in order to move the large and heavy object, the olive oil is used as a lubricant. After few centuries, animal fat is introduced as a lubricant in order to keep up demand from industrial that expanding. The animal fat that being used are whales; especially sperm whale because it can provide a large quantity of oily wax that can also be called as case oil. It is widely used for almost everything from industrial purpose until household, such as lamp oil, (Anderson, 1991).

According to Bradley‟s (1996) starting from the 1850s in Titusville, Pennsylvania the world is introduced to petroleum when it is successfully drilled and became the first petroleum well. In the 1920s, after a lot of different process and development been made in order to boost up the quality of lubricant performance the solvent refining are used as one of the effective solutions, (Wilson et al., 1994). After a decade, the additive is then discovered before it is widely used in the 1940s to enhance the lubricant properties and the start of regular lubricant analysis are made in late 1940s in order to restrain from engine failure, (Bui, 1999).

This is when the development of synthetic lubricant is made in the 1950s and the quality of base oil is upgraded dramatically in 1970s. The Group II base oil, one of the groups in mineral oil, that widely used in the 1970s is classified officially into groups by American Petroleum Institute (API) at 1990s and followed by Group III until Group V accordingly. From the 2000s until today, thousands of studies still continue to meet the requirement of better lubrication to optimize the performance while reducing waste, cost and also environmentally friendly, (Kramer et al., 2001).

2.1.1 Introduction of Lubricant

Currently, the development of machinery technology is extended due to the industrial demand which also lead to the evolution of lubricant. Lubricant is known for decades as an important medium in machinery system. Lubricant is used to reduce energy lost and machinery failure in the system. This application is viewed as an approximately efficient in order to protect the equipment from wear and reducing friction of the surface contact. Lubricating could also control other contamination such as improve the coefficient of friction and heat withstand in the system.

Until today, many studies are made in order to fulfil the needs of current machinery technology. It because lubricant is a must in order to extend the machinery lifetime for modern machinery technologies. Therefore, the lubricant is consists of additive and based fluid, where based fluid not only lubricates but also acts as the additive carrier, (Rizvi, 2009). Some of the properties of lubricant are viscosity, corrosion/oxidation stability, thermal solidity, viscosity index, flash point, cloud point, pour point and etc. But because of lubricant has the limitation of their properties which influence and reflects on its performance. The substances of additive are added up in the lubricant to improve the properties of the lubricant based on the application situation, (Choi et al., 2009).

Lubrication film is viewed as an important mechanism in the lubricant in order to control the contamination in machinery systems and also protect the metal surface from corrosion.

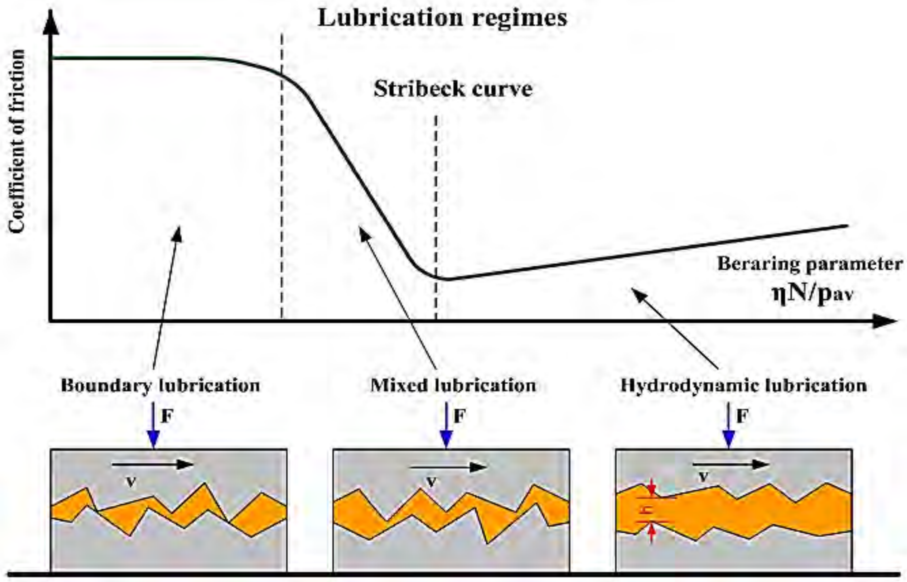

Figure 2.1: Lubricant regimes

(Source: www.substech.com, n.d)

Lubricant can be classified into three regimes, which are hydrodynamic lubrication (fluid-film or thick-film lubrication), boundary lubricant (thin film lubrication) and mixed lubrication (extreme pressure lubrication). Hydrodynamic lubrication (HL) occurs when two surfaces are in sliding motion that is relatively to each other but completely isolated by the liquid film. Thus, the surfaces are not in contact with each other due to the liquid film. Therefore, the contact surfaces are fully protected from friction and wear.

Figure 2.2: Hydrodynamic layer

(Source: www.cuiet.info/notes/chemistry/Lubricants, n.d)

Elastic deformations that occur when the surfaces are in rolling motion form elastohydrodynamic lubrication (EHL). Even though EHL can withstand greater pressure, it has a thinner liquid film form compared to HL. EHL is divided into hard EHL and soft EHL. The characteristic of both EHL forms are summaries in the table below, (Bernard et al., 2004).

Table 2.1: Elastohydrodynamic characteristic

Characteristic	Hard EHL	Soft EHL
Material type	High elastic modulus material	Low elastic modulus material
Maximum pressure (P_{max})	~1 Gpa	~1Mpa
Minimum film thickness (h_{min})	>0.1μm	~1μm

(Source: Bernard et al., 2004)

Boundary lubrication occurs in the same case of hydrodynamic lubrication except that the surface roughness of the composite is more than the standard thickness of it liquid film formation. This lead to high friction, wears and other contamination because of the asperities from both surfaces collides relatively to each other, (Hsu & Gates, 2005).

Meanwhile, mixed lubrication presents in the middle between hydrodynamic and boundary lubrication where even though the liquid film are separating the surface but it still collides due to the surface asperities. According to Bernard et al. (2004) Stribeck curve is a practical way in order to easily comprehend the different between lubrication regimes of those three types of liquid film. It is widely known when Stribeck finally found the explanation of friction that occurs in journal bearing.

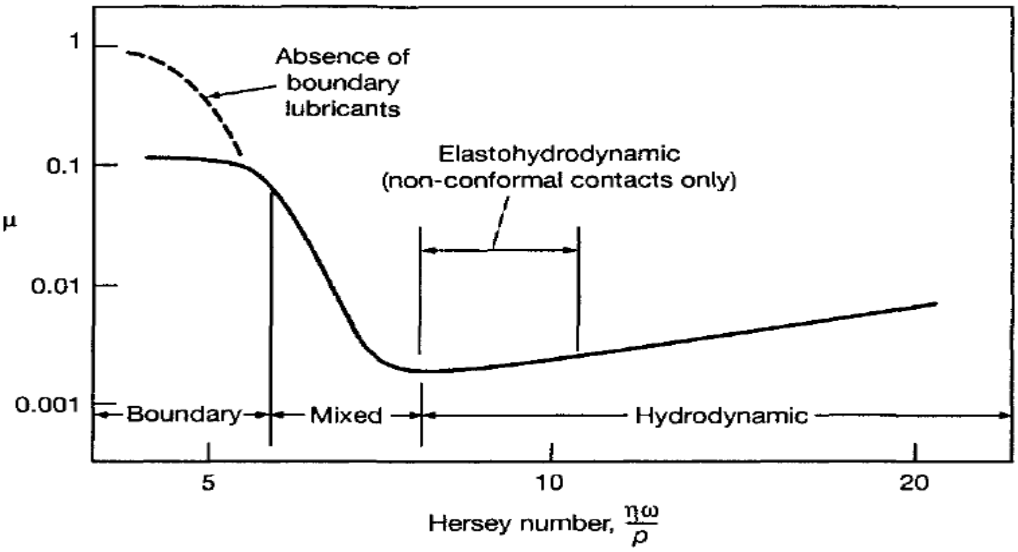

Figure 2.3: Stribeck curve
(Source: Bernard et al., 2004)

The graph above is a result of steady state condition of lubrication film that shows the coefficient of friction and the thickness of the lubricant film using the Hersey number. The lubrication film thickness can be determined by using Hersey number. The higher number of Hersey number mean the thicker lubricant film will be and it can be calculated from the formula as below:

$$Hs = \frac{\eta\omega}{\text{Ꝑ}} \tag{2.1}$$

Where, Ꝑ is for pressure in Pa, Ƞ is for absolute viscosity, pa-s, and ω is rotational speed, rps.

2.1.2 Type of Lubricant

Being divided into the biological and non-biological origin, the lubricant can also be used for some other different purpose aside from friction and constrain the development of wear. The evolution of technology leads to the development of better formulation lubricant. The enhancements of lubricant properties are used in order to expand the application of lubricant. Lubricant can be classified into three categories which are solid lubricant, semi-solid lubricant, and liquid lubricant.