UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF TRIBOLOGICAL PERFORMANCE FOR PURIFY ENGINE OIL

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Bachelor's Degree of Mechanical Engineering Technology (Maintenance Technology)) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of (Bachelor's Degree of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

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(DR. ILMAN HAKIMI CHUA BIN ABDULLAH)

ABSTRAK

Keperluan dalam pembanggunan kitar semula minyak pelincir daripada sisa minyak enjin mendapat perhatian penyelidik hari ini. Menurut fakta, rizab minyak mentah di dunia sedang mengalami pengurangan kerana sumber minyak mentah yang sedia ada tidak boleh diperbaharui dan terdedah kepada isu pencemaran alam sekitar. Tujuan kajian ini adalah untuk mengoptimumkan sifat tribologi minyak enjin selepas dibersihkan. Ini adalah disebabkan oleh kesan pembuangan sisa minyak enjin memberikan kesan terhadap alam sekitar dan usaha mengitar semula sisa minyak enjin menjadi salah satu isu penting. Berdasarkan masalah yang dihadapi, objektif kajian ini adalah untuk menghasilkan set sampel minyak yang telah dibersihkan dengan menggunakan unit penapis minyak dan pensampelan mengikut kaedah L9 Taguchi. Objectif kedua untuk kajian ini adalah untuk menguji minyak yang baru dibersihkan kepada sifat-sifat tribology mengikut ASTM D 4172. Ujian Tribological minyak enjin yang telah dibersihkan dilakukan dengan menggunakan empat bola penguji mengikut ASTM D-4172. Kerosakan permukaan dan kehausan diameter parut bola galas telah dijalankan menggunakan Mikroskop Imbasan Elektron (SEM). Hasil kajian menunjukkan bahawa pekali geseran (COF) dan kehausan parut bola dikurangkan dengan ketara selepas proses penapisan dilakukan tiga kali (nilai purata COF = 0.082). Di samping itu, kehausan diameter parut bola lebih kecil apabila nilai purata COF rendah di mana ia menunjukkan bahawa geseran boleh menyebabkan haus dan kerosakan permukaan. Oleh itu, geseran mempunyai hubungkait dengan kehausan.

ABSTRACT

The need for the development of recycling lubricant from waste engine oil is in the limelight of researcher today. As the matter of fact, the reserve crude oil in the world is undergoing depletion due existing mineral based oil is non-renewable sources and vulnerable to environmental issues. The aims of the study are to optimize the tribological properties of purify engine oil. This is due to the environment effect imposes by waste engine oil making the effort of recycling oil to be essential. Based on the problem encounter, the objectives of this study is to produce set of purify engine oil samples by using oil filtration unit and sampling according L_9 Taguchi Method (DOE). A set of purify engine oil samples will be prepared by using filtration unit. The sample will be sampling according to L9 Taguchi Method (DOE). Another objective of this study is to test new develop purify engine oil on the tribological properties according to ASTM D-4172. Tribological testing of purify engine oil was performed using four ball tester according to ASTM D-4172. Surface damage and wear scar diameter of ball bearing were carried out using Scanning Electron Microscope (SEM). The results show that the coefficient of friction (COF) and wear scar of the ball reduced significantly after filtration process done three times (average value of COF = 0.082). In addition, wear scar diameter of ball smaller when average value of COF low where it shows that friction can cause wear and surface damage. Thus, friction has strong correlation with wear.

DEDICATION

To my beloved parents

ACKNOWLEDGEMENT

ASSALAMUALAIKUM Wrt. Wbt. and wish the best for the viewers of my thesis or this report. First of all, I am grateful to Allah S.W.T for giving this opportunity to me to able complete this Final Year Project Report. I would like to express my deepest appreciation to all those who provided me the possibility to complete this report. A special gratitude I give to my final year supervisor, Dr. Muhammad Ilman Hakimi Chua bin Abdullah, whose contribution in stimulating suggestions and encouragement, helped me to coordinate my project especially in writing this report. All the guide, teaching, passion by Dr. to my will be remembered for me to carry on to pursue a better knowledge. Best regards to my entire family member that continuously support me and helping until this research and my studied to be completed. With their support and praying for are helping me a lot to finish studies at UTeM. Furthermore, I would also like to acknowledge with much appreciation the crucial role of the staff of UTeM especially technicians in FTK laboratory, who gave the permission to use all required equipment and the necessary materials to complete this final project. Special thanks go to my entire classmate 3BETM, that always provide assistance in any circumstances for me and all the students who participate in Final Year Project. With all their effort and guide, this report can able to finished within the time given. Last but not least, I am also grateful to all the lecturers, technicians and also anyone supporter which continuously guide me until this research to be completed.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ρ	-	Density
API	-	American Petroleum Institute
ASTM	-	American Society of the International Association for Testing and Materials
C_nH_{2n}	-	Alkene
COF	-	Coefficient of Friction
DOE	-	Design of Experiment
F	-	Friction
H	-	Hardness
KOH	-	Potassium Oxide
N	-	Normal Force
PAO	-	Polyalphaolefins
PP	-	Pour point
RPM	-	Revolution per Minute
Ra	-	Surface Roughness
S/N RATIO	-	Signal Noise Ratio
SAE	-	Society of Automotive Engineers
TBN	-	Total Base Number
VI	-	Viscosity Index

CHAPTER 1

INTRODUCTION

1.1 Background

Lubricant technologies are one of the most vital in an industrial world where it's used widely in automotive industries, transportation and all heavy machinery (Farhanah and Bahak 2015). This technology currently was growing progressively to cater the high demand for lubricating oil for all industries. In the local or international market, there is various types and brand of lubricant that can be found. Besides, the existing of additives in lubricant technologies causes the performance of the oil increase compare to oil without additives. According to Abdullah et al, 2013, the lubricant that added with impressive additive especially the engine oil lubricant which gives a better lubricating performance. The depletion of crude oil causes high awareness in the usage of lubricant because base oil became one of the main sources in the production of lubricating oil. According to statistic, 24 million tons of waste lubricant engine oil (WO) was produced each year throughout the world, posing a critical treatment and disposal problem for modern society (Lam et al, 2011).

According to Hamawand et al., (2013), waste engine oil is a high toxic material that required proper disposal. Proper disposal of waste engine oil is important because it has contaminants such as lead cadmium, chromium, arsenic, dioxins, benzene and polycyclic aromatics. If these contaminants released into the environment, they can be harmful to human, animal and plant. On the other note studied by, Lam et al., (2011), the mixture of low and high molecular weight of aliphatic and aromatic hydrocarbon is in waste engine oil has potential sources of high value and chemical feedstock. Most countries around the world prefer incineration and combustion for energy recovery although hydrotreatment and vacuum refining have been researched to recycle this waste. In any case, these disposal courses are turning out to be progressively impracticable as worries over natural contamination, and extra cost, sludge, and wastewater disposal are perceived because of the undesirable contaminants present in the waste engine oil (Brinkman and Dickson, 1995)

To countermeasure of this issue, the recovery and recycling the waste engine oil is required to save the limited crude oil as well as avoid the environmental pollution (Wang et. al., 2013). As part of the growing interest in waste oil recycling, alternative treatment has been conducted with the aim to recuperating both of energetic and chemical value of waste engine oil. The objective of this research is to study the optimization of tribological performance for purifying engine oil. In this research, waste engine oil is used as a sample for purifying engine oil by using filtration process. Filtration technique has recently shown great promise as an economic and environmentally disposal for waste engine oil. The recycled oil obtained by this method has been shown to have great potential for reuse as an engine lubricant.

1.2 Problem Statement

Nowadays, due to the harmful characteristics of fossil fuel, the usage of petroleum oil based lubricants is making concern regarding environmental issues. The reserve crude oil in the world is undergoing depletion and the consumption of the lubricant to the transportation and all machinery increasing dramatically thus, the important issue is to find the alternative lubricant to meet the future demand (Shahabuddin et al., 2013). This statement supported by Scwaderlapp and Schommers, the depletion of fuel usage in modern combustion engines is the main driving force for new innovation of lubricant in engine development. Most of the current lubricants are based on mineral oil extracted from petroleum oil but it is not adaptable to the surrounding because containing high toxic and non-biodegradable nature (Shahabuddin et al., 2013).

Mineral oil based always used in industries thus it causes concern to the environment pollution (Manipal et al., 2013). According to Abdullah et al., (2014) with the rising number of vehicles, the problems with fuel consumption and environmental pollution are becoming more importance. According to the statistic, there are almost 5 million vehicles in Beijing and the number will rise rapidly to 7 million in the future (Wang et. al., 2013). We assume that the average amount of oil consumption will affect the environment. Waste substance from mineral based oil also causes concern to the level of environmental hygiene. Another statistic has been reported that annually 12 million tons of wastes are released to the environment (Tonten et al., 2003). However, it is very hard to dispose of the waste safely due it's toxic and non-biodegradable (Shahabuddin et al., 2013). This report proved that, our high dependency on the mineral base oil in daily life.

Used lubricating/ waste oil are one of the alternative resources for producing another alternative lubricant. According to Wang et al., 2013 to reduce our dependency on petroleum fuel, the recovery, and recycling of lubricating oil can save the limited crude oil resources. There are much-used oils that idle in our environment. Idle used oil can be harmful to our environment and ecosystem. The used engine oil can be recycling to a new lubricant for the low-grade machine. With this method, environmental pollution can be avoided. As a result, the phenomenon such as the sprinkle, combustion or leakage of waste lubricating oil will be decreased (Elbashir et al., 2002; Wang et al., 2010). However, there a few problems that occur from recycling used engine oil. First, used engine oil has been mix with water and it causes the oil oxidize. There are also exist contaminant and foreign object in the oil. Henceforth, this study will focus on optimization of tribological performance for purifying engine oil to develop new lubricant using used engine oil.

1.4 Objectives

Based on the problem statement above, the objectives of this research are listed below:

- To produce a set of purifying engine oil samples by using oil filtration unit and sampling according to L_9 Taguchi Method (DOE).
- To test new develop purify engine oil on the tribological properties according to ASTM D-4172.

1.5 Scope

In order to achieve the objective, the scopes are prepared as shown below:

- Producing a set of purifying engine oil samples by using oil filtration unit and sampling according to Taguchi Method.
- Testing tribological performance using Tr-20 Four-ball tester according to ASTM D-4172, Standard Test Method for Wear Preventive Characteristics of Lubricating Fluid (Four-ball tester).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Lubricant

Lubrication technology has been developing rapidly in recent years in line with the existence of transportation and all machinery, but the root of lubrication has existed a very long time ago. Lubrication started been used back dates in ancient Egypt. During this time, large stones and other heavy objects are been moved by using olive oil as a lubricant. According to Nehal and Amal, (2011), the farmer used animal fat (tallow) to lubricate wheels on chariot axels. Pirro, et al. (2011), mentioned that a mixture of fats and calcium can produce grease that can be used to lubricate chariot wheel. During 16th century, usage of lubricant normally based on vegetable oil, animal oil, or a combination of both two oil (Anderson, 1991). In response to growing demands, particularly from the increase rapidly in the auto industry, lubricant manufacturers begin to formulate their petroleum-based oils to improve lubricant in order to reduce friction and wear in engine. With lubricant, reduction in friction and wear also can be increased thereby engine free from rust and corrosion. Lastly, other important benefits of modern lubricant are it can be used as a cooling agent for engine and debris removal

2.1.1 Function of Lubricant

Lubrication oil is vital in a mechanical world where it's broadly utilized as a part of the car industry, transportation, and all machinery. According to Ludema, 1996, lubricant also knows as principles of sliding load on a friction reduction film. Minimizing the friction between two moving surface in contact with each other is the main function of lubricating oil (Duzcukoglu and Sahin, 2010).

The main part of the transportation is the engine. It generates power to the shaft and other rotating parts in the machine for it works efficiently. Lubricant in the engine is very important to prevent the wear and corrosion occurs. According to Watson et al. (1955) wear in the engine normally occurs in pistons rings, cylinders, bearings and cam lobes. This statement supported by Jiang and Wang (1998) where it described that failure of an engine commonly caused by wear at the cylinder bore and piston rings. Engine lubricant is one of the processes or technique to minimize wear occurred on the both surface in close proximity.

Lubricant also can increase machine or engine more efficient where it protects them against wear and corrosion hence maximize their life (Imran et al, 2013; Quinchia et al, 2014). According to Farhanah and Bahak (2015), lubricant usage is very important for internal combustion of the engine. A lubricant can perform another critical function besides reducing wear such as cooling, cleaning, and suspending (Nehal and Amal, 2011). The quality of the lubricant oil used in the engine plays an important role to protect and prolong the engine life where it also can improve the performance of an engine.

2.1.2 Types of Lubricant

There are many types of lubricant that exist in the market based on the function and characteristic. Lubricant can be divided to three types which are solid lubricant, semi- solid lubricant and liquid lubricant.

Types of Lubricant

Synthetic oils

- Polyalphaolefins (PAO)
- Synthetic ester
- Polyalkylene glycols (PAG)
- Phosphate ester
- Alkylated naphthalenea (AN)
- Ionic fluids

Aqueous lubrication

Hydrated brush polymer PEO)
Act as solid lubricant at liquid solid interface
Maintaining high fluidity between brush interface leading to low COF

Solid lubricant

Basically dry lubricant
Such as PTEE, inorganic solid (graphite, hBN, MoS2, WS2 and metal alloy (Cd, Au, Pb, Sn, Zn, bronze)
Used as grease additives or the Sole constituents of sliding Surfaces and bearing

Bio lubricant

Basically based on vegetable oils.
Applied to lubricant which are rapidly biodegradable and and nontoxic for human and environment

Base oil

	API designated	Saturated	VI SAE	Processing process	Remark
Mineral oil (Derived from Crude oil)	Group I	<90% and or Sulfur >0.03%	80~120	-Solvent extraction -Solvent or catalytic dewaxing -Hydro-finishing process	-common group -150 SN (solvent natural -500 SN and 150 BS (brightstock)
	Group II	<90% and or Sulfur >0.03%	80~120	-Hydro-cracking -Solvent or catalytic dewaxing	-superior anti-oxidation -water white color
	Group III	<90% and or Sulfur >0.03%	>120	-isohydromerization	-can be manufacture from base oil or slax wax from dewaxing process
	Group IV	-	-	-	-polyalphaolefins (PAO)
	Group V	-	-	-	-all other not included group (I-IV) such as napthenics, PAO, esters

Table 2.1 Types of lubricant (Sources: Abdullah et al, 2015)

2.2 Liquid as lubricant

Liquid lubricants have been existing a long time ago and it has developed from conventional mineral oil to the finished synthetics oil (Lois et. al. 2001). The liquid lubricant can be classified into three categories which are mineral oil, synthetic oil, animal fat, vegetable oil and mixture of two or more of these oils (Bhushan, 2013). It used widely in machinery lubricating system to prolong the machine life. According to Ludema, (1996) lubrication in the machine is one types of maintenance that is crucial to keep the machine operation without failing. The breakdown and failure of the machine are frequently determined by the material of lubricating oil. Mobarak, et al (2014), he stated that high viscosity index, high boiling point, thermal stability, low freezing point, corrosion prevention capability, and high resistance to oxidation process is several characteristic of good lubricating oil.

2.2.1 Mineral based

Mineral based also known as base oils, mineral oils or lubricant base oil are chemical substances extracted from crude petroleum oil. According to Mobarak et al. (2014) nowadays, mineral oil is the most widely used in all machinery as lubricating oil because it has excellent boundary lubricants compare to natural oil. Besides, it also has good properties compare to natural oil which is good thermal stability, good water resistance, better heat transfer and good adhesive. According to (Bart, et al., 2013) refining is a process of changing over petroleum raw petroleum into completed mineral base oil. Another name for refining process is solvent extraction, solvent dewaxing, distillation, acid refining, etc.

The refining process starts with vacuum distillation. Next, it will isolate the oil into a few products and classified with a comparable boiling point and viscosity. After the vacuum refining finished, the oil must be filtered to expel or change undesirable compound. (Bart, et al. 2013) stated that base oil acquired by preparing of petroleum crude oil in the refining process. It also has been classified and named as a refined and