UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

THE EFFECTS OF ZINC DIALKYLDITHIOPHOSPHATES (ZINC DDP) AS AN ANTI WEAR NANOPARTICLES IN ENGINE OIL

Mu'Ammar Danii Bin Saifuddin

Bachelor Degree of Mechanical Engineering

2017/2018

THE EFFECTS OFZINC DIALKYLDITHIOPHOSPHATES (ZINC DDP)AS AN ANTI WEAR NANOPARTICLES IN ENGINE OIL

MU'AMMAR DANII BIN SAIFUDDIN

A report submitted

In fulfilment of the requirement for the degree of Bachelor Degree of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017/2018

DECLARATION

I Mu'Ammar Danii Bin Saifuddin declares that this project report entitled "The Effects Of Zinc Dialkyldithiophosphates (Zinc DDP) As An Anti-Wear Nanoparticles In Engine Oil", under the guidance of Dr. Mohd Rody Bin Mohamad Zin, and is my original work except references material.

Signature : ____

Name : Mu'Ammar Danii Bin Saifuddin

Date : ____

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of Bachelor of Mechanical Engineering.

Signature : ______________________________________

Supervisors Name : Dr. Mohd Rody Bin Mohamad Zin

Date : ______________________________________

DEDICATION

I dedicated my study to my beloved mother and father who always give motivation and encouragement to finish my study until the ends. I also want to thanks to my brother and sister the person never left my side cheer and raise my spirit to work harder to complete the study. Not forgotten to my friends who always supported me throughout the process. Last but not least, I will always appreciated all they have done especially to Dr. Rody the person always guide me to finish the work, Ms. Ayuma who assisted me in the laboratory and sharing knowledge. I want to give special thanks again to all person who helps in this works and supported me to the ends.

ABSTRACT

This study aims to investigate the effect of Zinc Dithiophosphate (ZDDP) nanoparticles when used as an additive in lubricating oil. The lubricant + ZDDP oil was prepared by dispersing an optimal composition of 2 per cent of Zinc Dialkyldithiophosphate in Max Pro SAE 15W – 40 engine oil using an ultrasonic homogenizer. The tribological testing was performed using a pin on disk tester following the ASTM standard. Based on the experiment, it was found that the Nano – oil has a potential to decelerate the wear on the contact surfaces. More wear was observed on the worn surfaces of ball bearing lubricated with SAE 15W – 40 engine oil as compared with the Nano – oil lubrication.

ABSTRAK

Kajian ini bertujuan untuk mengkaji kesan nanopartikel zink dithiophosphate (ZDDP) apabila digunakan sebagai bahan tambahan dalam minyak pelincir. Minyak pelincir yang dicampurkan dengan ZDDP disediakan dengan mencampurkan komposisi optimum 2 peratus daripada Zinc Dialkyldithiophosphate dalam Max Pro SAE 15W - 40 menggunakan homogenizer ultrasonik. Ujian tribologi dilakukan menggunakan pin pada penguji cakera mengikut piawai ASTM. Berdasarkan kajian, didapati bahawa minyak nano mempunyai potensi untuk mengurangkan haus pada permukaan yang bergesel. Lebih banyak *wear* diperhatikan pada permukaan yang dipakai bola yang dilincirkan dengan minyak enjin SAE 15W - 40 berbanding dengan minyak pelincir nano.

TABLE OF CONTENTS

TABLE OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The development of the new technologies solutions, such as introducing lightweight materials, less harmful fuels, controlled fuel combustion and more efficient gas after treatment are possible means to decrease environmental problems brought by vehicles and machines. Lubricant, fuel and engine materials are closely related to each other. The conventional mineral oil based lubricant is widely used in most of the engine system nowadays. However, the supply for this source is slowly decreasing as the source for this type of fuel comes from the based on fossil fuel (such as gasoline and diesel fuels). In order to recover the usage of the mineral oil, some additives are added to improve the quality of the mineral oil to maintain it sustainability. However, adding some additive will result in a good or a bad ways to the oil as it degrades lube oil quality and increases the wear rate of the engine components. There are various functions of lubricant oil which are to reduce wear and increase cooling that result from the contact surfaces in motion and reduce the coefficient of friction between two contacting surfaces. Other than that, the purposes of the lubricant is to prevent rust and reduce oxidation, to act as an insulator in transformer application and finally to act as a seal againstdirt and dust and water. A lubricant is a liquid that can reduces friction and wear by providing a protective layer between two surfaces in contact. Good lubricants have a high viscosity index (VI), stable in thermal, very high boiling point, low freezing point, have an ability that can prevent corrosion and resist to oxidation.

1.2 PROBLEM STATEMENT

A huge amount of loss has become a whole wide problem that were caused by the friction and wear. Maximum efficiency and at the same time being environmental friendly can be obtain if the friction and wear in the automotive is reduced. By reducing waste consistently creates an increasing demand for research in Tribology, especially in lubrication. Accordingly, presenting more efficient lubrication or self – lubricating materials may be the solution in overcoming these problems.

Nowadays, studies on carbon reinforced with various types of matrix as reinforcement has become popular as an alternative to current lubricating materials has become an attraction in Tribology field. Studies on the use of natural products such as fiber into composites have already been done by a number of researchers such as Nirmal et. al (2015) and Bakry et. al (2013). However, there is a research gap on the use of waste as self – lubricating materials. The conventional mineral oil based lubricantwas developed based on fossil fuel (such as gasoline and dieselfuels) which is not suitable for the biodiesel – fueled engine as itdegrades lube oil quality and increases the wear rate of the enginecomponents.

The supply mineral in this world is slowly decreasing and it is expected to go extinct in the few years to go. The addition of some anti – wear nanoparticles in into the mineral oil as the additive is like the solution for this problem as it will reduce the usage of the mineral oil. However, in order to get the optimum ratio of the anti – wear nanoparticles so that the additive will work perfectly in the mineral oil and not degrading the oil in a bad ways, a research have to be done.

1.3 OBJECTIVE

The study objectives were largely influenced by findings from other previous studies as well as anchored on the potential in reducing friction and wear. The scope and limitations of the study further limits the study to the following objectives:

1. To study the tribology of zinc dialkyldithiophosphate anti – wear nanoparticle lubricant under normal condition.
2. To study the effect of anti – wear nanoparticles lubricant on tribological properties of steel vs aluminumcontact.
3. To compare the lubricant oil without zinc DDP as the anti – wear nanoparticles with the lubricant oil with zinc DDP additives.

1.4 SCOPE OF STUDY

The actions that need to be carried out to achieve the objective in this project are listed below.

1. Literature review

Journals, articles or any materials regarding the project will be reviewed

2. Experiment

The experiment of the Pin on Disk test will be made based on the data input

3. Analysis and proposed solution

Analysis will be presented on how the zinc dialkyldithiophosphate anti – wear nanoparticles can effects the lubricants efficiency. Solutions will be proposed based on the analysis.

4. Report writing

A report writing on this study will be written at the end of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Nano Technology

Today, almost all of the mobile parts need at least some amount of lubrication system to avoid wear during use. (Herdan, 2000). Commercial lubricants have been used mostly in a lot of vehicle such as cars, motorcycle and even in heavy vehicle like lorry and buses. However, the aim of the usage of the lubricants are always stay the same, which is to reduce wear to the lowest level as it can reach and to increase the coefficient of friction (COF) between two surfaces in contact (Obiols, 2014).

Nowadays, a lot of things has become a nano – invention as the world moves towards nano – technology. At this moment, lubricant technology has also moved to the nano – lubricants (Wu et al., 2007), giving an increase to the idea of discovering an optional nano – additive. (Zhou et al., 2001) explored that the purposes of LaF_3 – DDP nanoparticles as an oil additive can significantly increase the load – carrying capacity and anti – wear property of the base oil and has a good friction reducing properties.

2.2 Better Automotive Technology Demand

During 2014, Malaysian Government released a guideline statement following its new looks for the automotive industry. Under the National Automotive Policy, the Malaysian government informed that Malaysia will now undergoing and at the same time will also encouraging energy efficient vehicles or EEV mostly in the production of local car. Other than that, the Malaysian government also aim for the target of by the year 2020 for the EEV to at least reach the standard terms of carbon emission level and fuel consumption (Dasar Automotif Nasional, 2014).

Referring to the journal by Holmberg et. al (2012), at maximum, around 21.5% of the energy produced in the engine were fully used to move the car. He also stated that the energy loss were classified into loss to the exhaust, loss due to cooling process, and also mechanical power. The mechanical energy were then separated into friction loss and air drag resistance. 11.5% were loss at the engine, 5% were loss at the transmission, 11.55 were loss at the rolling resistance and the remaining of that are lost to the brakes which is 5%, all of that are come from the friction loss percentage. The friction at the rolling resistance, the brakes, and also the air drag were actually very impossible to be eliminated as it is important to move the car. In this case, there are a lot of energy loss in a single car at this moment. The division of the energy consumption were shown in Figure 2.1. Thus, it can be conclude that even if a minimum upgrade is made, the efficiency of the engine would be increased with respect to the increase of efficiency.

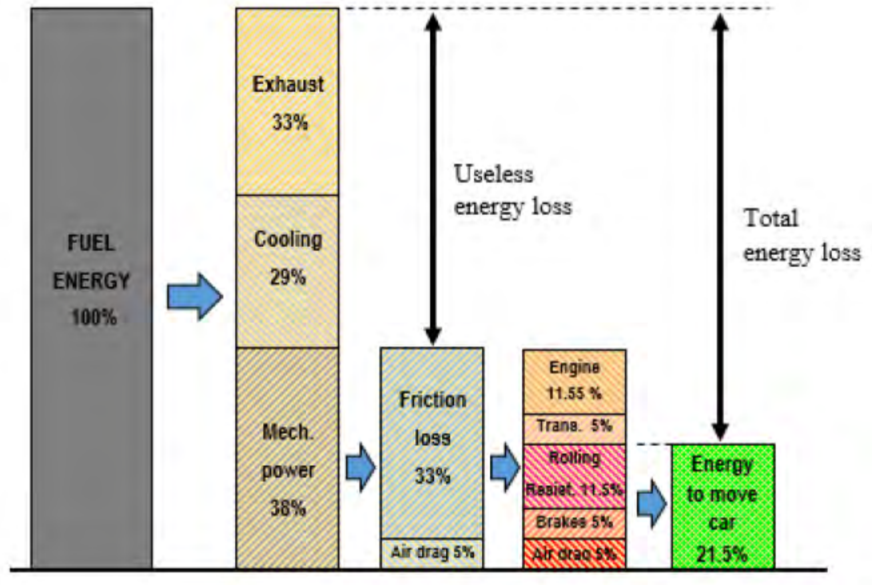

Figure 1: Breakdown of a passenger car energy consumption

[Source: Holmberg et. al (2012)]

From the figure above, Figure 2.1 it is obvious that the total energy loss were triple than the energy used to move the car. In order to increase the efficiency of the engine is by minimizing the energy dissipated to the surrounding due to mechanical interactions in the system. The mechanical contacts in the engine, which is the main objective of this study, are importantly the friction and wear between moving parts of the engine, including components such as bearings, clutches and pistons.

2.3 Lubrication Theory

The main reason to have a lubrication system in your vehicle is to reduce wear. Other than that, a lubrication is also widely used as a heat removal system between two contacting surfaces. The lubricants oil will acts as a layer that will avoid the two surfaces in contact from directly contacted. The separation lessens the impact of the friction and heat between the contacting surfaces will also be reduced as a result of the separation. As a result, the wear and tear of parts are reduced. Other than that, this will be a good alternative to avoid the damage in engine system become faster and will make the engine last longer. Lubrication is also used to reduce oxidation and prevent rust. According to Nosonovsky and Bushan (2012) sometimes, lubrication is used as insulation in components. Besides, the purposes of lubrication is also to clean the engine as it will help to remove the debris or particles and send them to an oil filter. The lubricants also help to produce a seal between two parts and thus avoid the compression gas escape into the crankcase area.

Lubrication can be divided into three groups, solid, liquid and gas type. Lubrication is introduced between two contacting surfaces to act as a boundary layer between those surfaces. This means that, the asperities between the surfaces are not touching each other technically. Figure 2.2 illustrates the presence of lubrication between two contacting surfaces.

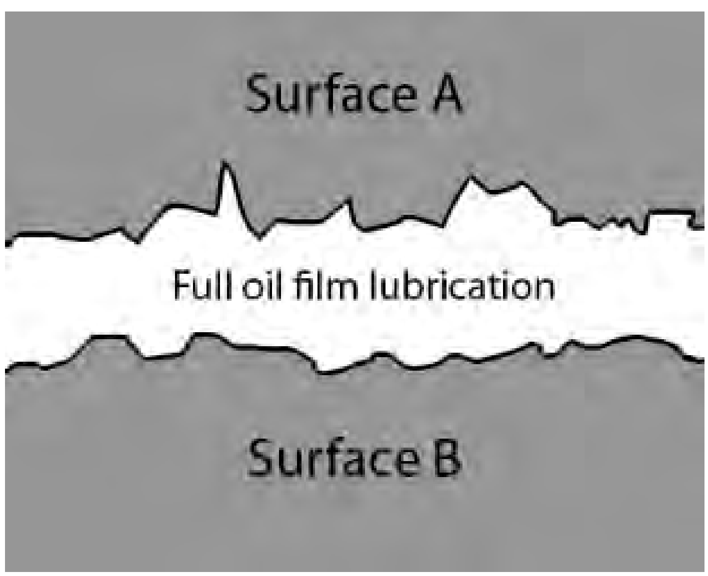

Figure 2: Lubrication between two contacting surfaces

2.4 Contaminants in Engine Oil

There are a lot of contaminants in the engine oil. The contaminants can be very harmful for the engine as it can make the combustion in the engine cannot happen effectively. Contaminants in engine oil can happen if the engine is not cleaned correctly and frequently. It also happen if some of the parts that are present in the engine are broken or loose.

One of the contaminants in engine oil is the road dust and dirt. The road dust and dirt can come from the external environment. It can be very harmful to the engine. It is the job of the oil system to remove these contaminants.

Other than that is the carbon and fuel soot. This happen because many particles of carbon and soot are not burned completely. Pressure produced by the combustion force some of this unburned fuel and carbon pat the rings into the crankcase area (blow – by).

The most common contaminants in engine oil the water contamination. It is due to the leaks in the cooling system or from water vapor from the combustion by – product. Blow – by process forces the water vapor into the crankcase area. As the water vapor enters the crankcase, it cools and condenses into a liquid. The water can produce problems with the sludge and acids. Sludge are produced when the oil becomes thickened with water or other contaminants.

Fuel contamination is also the most common contaminants that can obtained in the engine. It is due to the fuel dilution. The presence of fuel in excess of 5% gasoline or 7% diesel fuel may lead to rapid engine wear.

Oil oxidation. It is defined as the combining of hydrocarbons and other combustion products with oxygen. The oil oxidation can increases in oil temperature and in water in the crankcase enhance oil oxidation.

Other than that is the acids in engine. This contaminants can cause a lot of problems to the engine. One of the effects is it can cause the corrosion and failure to the engine.

2.5 Zinc Dialkyldithiophosphate

Mineral base engine oil has been used as lubricant in the engine for a long time. According to Gawrillaw (2003), base oil was used as lubricant to lubricate machineries since 1650BC. However, there is a limitation of using the mineral base oil as lubricant because the characteristics of base oil is low oxidation. This statement was supported by Cheenkachoma (2013), where he stated that an inherent property of base oils is low oxidative stability.

Therefore, adding the additive in the mineral base oil is one of the solutions. The additive that is suitable to overcome the oxidation is Zinc Dialkyldithiophosphate (ZDDP). A research by Johnson et al. 1986 found that the interactions between ZDDP and oxidations products were thought to have led to the observed decrease in activity. This statement also been supported by Barnes et al. 2001, it stated that ZDDP’s were used mainly for their antioxidant properties and their ability to prevent wear.

CHAPTER 3

METHODOLOGY

3.1 Introduction of methodology

This chapter is describing all the methodology used in this project to obtain the best result of the tribological studies of zinc dialkyldithiophosphate (ZDDP) anti – wear nanoparticles lubricant under normal condition. This project starts by experimenting the most suitable way to obtain the best sample preparation. Thus, it will result in a good way to the experiment and the experiment will give a good result.

3.2 General Process

This project focused on finding the tribological effects of anti – wear nanoparticles lubricant under extreme temperature using the Pin on Disk Tester experiment. To achieve the discussed objectives that have been mentioned earlier in Chapter 1, the process was divided into six phases. The graphical diagram of the process is shown in Figure 3.1.

Phase 1 started with the Literature review. Basically, this involved with the research of the past journal that discussing the related topics. A few journals are taken as the reference for this experiment to ensure that the experiment is relevant and rational.

For Phase 2, started with the preparation of the materials. Particularly, this involved with the deciding the best percentage for zinc dialkyldithiophosphate (ZDDP) nanoparticles lubricant that will be used in this experiment. The percentages of the nanoparticles are decided based on the past journal.

For Phase 3, this involved with the preparation of the zinc dialkyldithiophosphate nanoparticles anti – wear. The nanoparticles anti – wear can be provided by the lab assistant or can be obtained from the supervisor. The process of mixing the nanoparticles anti – wear is also done in this phase.

Phase 4 is the pin on disk testing experiment. Once the nanoparticles and the oil are ready, the pin on disk test is done to the lubricant oil.

For Phase 5, it involves with the quantitative analysis calculation of COF, wear rate, and both wear and friction equation determination. All the reading from the experiment are recorded and a few calculations are made. The first analysis conducted was quantitative analysis through calculation of coefficient of friction and wear rate. Then, from the results, friction wear equation was proposed.

For Phase 6, it involves with the qualitative analysis and the worn surface analysis. Based on the calculation from the Phase 5, the analysis from the result are made to get the exact and useful information. The weight loss and the volume loss of the pin is measured by weighing the pin before and after the experiment. Discussion will be made and a conclusion can be done.