STUDY ON THE EFFECT OF WATER CONTAMINATION ON ZINC DIALKYLDITHIOPHOSPHATE (ZDDP) ADDITIVE IN LUBRICANT

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This report is submitted
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DECLARATION

I declare that this project report entitled “Study on the effect of water contamination on Zinc Dialkyldithiophosphate (ZDDP) additive in lubricant” is result of my own work except as cited in references

Signature : …………………………………

Name : Nurul Afiqah Binti Arbain.

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 the degree of Bachelor of Mechanical Engineering.

Signature : ….............................

Name of Supervisor : Dr Reduan Bin Mat Dan

Date : …………………………......

DEDICATION

To my beloved father, Mr Arbain Bin Hj Sabar and my lovely mother, Madam Zaleha Binti Mohd Saman.

ABSTRACT

Water has long been identified as the most destructive lubricant contaminant. It can have a significant impact on wear performance, particularly in bearing systems. The lubricant that exposed to water contaminant can gives an adverse effect on the base oil, additive contain and also cause the lubrication system failure. Zinc Dialkyldithiophosphate (ZDDP) is an anti-wear additive that are added into lubricant to improve the surface contact especially surface under sliding contact by the growth of tribofilm layer. The existence of water or moisture from humid environment into the lubrication system can interrupt the development of tribofilm layer. The effect of water on bulk properties of the lubricant in terms of viscosity, Total Acid Number and physical appearance were also investigated. The comparative study was conducted in determining the effect of water on the tribofilm thickness and wear depth under sliding contact condition. The aim of this study is to validate the findings on the sequence of wear generated due to the presence of water in the lubricant.

ABSTRAK

Air telah lama dikenal pasti sebagai bahan pencemar pelincir yang paling merosakkan. Ini boleh memberi kesan yang signifikan terhadap prestasi haus, terutama pada sistem galas. Pelincir yang terkena pencemaran air boleh memberikan kesan buruk pada minyak asas, bahan tambahan dan juga menyebabkan kegagalan sistem pelinciran. Zinc Dialkyldithiophosphate (ZDDP) adalah bahan tambahan anti-haus yang ditambahkan ke dalam pelincir untuk memperbaiki hubungan permukaan terutama permukaan di bawah sentuhan gelangsar oleh pertumbuhan lapisan tribofilm. Kewujudan air atau kelembapan dari persekitaran lembap ke dalam sistem pelinciran dapat mengganggu perkembangan lapisan tribofilm. Kesan air terhadap sifat pelumas pukal dari segi kelikatan, Jumlah Asid dan penampilan fizikal juga disiasat. Kajian perbandingan dilakukan dalam menentukan kesan air pada ketebalan tribofilm dan kedalaman haus dalam keadaan sentuhan gelongsor. Tujuan kajian ini adalah untuk mengesahkan penemuan mengenai urutan haus yang dihasilkan kerana adanya air di pelincir.

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I am blessed that I have given a chance to complete the thesis successfully. I would like to thank Allah S.W.T, the Almighty for giving me good health to finish this thesis.

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LIST OF ABBREVIATIONS

ZDDP	Zinc Dialkyldithiophosphate
API	The American Petroleum Institute
TAN	Total Acid Number
MTM	Mini Traction Machine
SLIM	Spacer Layer Interferometry Method
PAO	Polyalphaolefin
SHCs	Synthetic Hydrocarbons

CHAPTER 1

INTRODUCTION

1.1 Background

Lubrication is the application of a friction-reducing film between moving surfaces that are in contact to reduce friction and wear. Lube oil system provide lubrication to the system, such as shaft bearings, oil pump bearing and as well as for motor bearing.

Lubrication oil consists of two major components which is base fluid and additives packages. New technologies have been used to formulate the oil lubricant with various type of additive that helps in increasing the performances of the lubrication system. For example, turbine oil formulations are much simpler as it only contains 0.5 to 1.5 percent of additives comparing to another type of lubrication (Sander, J. 2012).

When moisture is suspended in lubricating oils, it is considered as water contamination. Depending on the conditions, its damaging effects especially in bearing applications can approximate or beyond particle contamination. Though, most of the lubrication oil is formulated to be able to separate from water, but there are many factors that causes the demulsibility of the oil impaired and unable to split the oil and water. The poor oil-water separation can be offset with the right combination and quality of additives including antioxidants, anti-wear, rust inhibitors, and demulsibility improvers (Kamal, Girish. 2013).

1.2 Problem Statement

Additive packages are added into the lubrication oil to enhance the existing performance and properties of the lubricating system. Zinc Dialkyldithiophosphate (ZDDP) is an additive that are added into lubricant that intended to perform as anti-wear and also antioxidant additives. However, the existence of water can give a negative effect to the additive and the base fluids. Water contaminations that occur in the lubrication system can promote oxidation, hydrolysis, water washing and also additive depletion. ZDDP additives may react and result an adverse effect when the water incorporated in the oil that can also change the properties of the oil. The reaction between water and ZDDP additives can cause them chemically and physically deplete and also produce others contaminant in the lubrication system.

According to Parsaeian. P et al (2017), the reduction of ZDDP additives in the lubricant occurred due to the presence of water and causes the tribofilm layer generated on the surface that helps to prevent direct contact between two surfaces becomes thinner. Nedelcu et al (2012) point out that water can interfere the formation of the tribofilm layer by altering the length of polyphosphate chain through hydrolysis process and slow down the performance of the ZDDP additives. The thinner tribofilm will cause the significant change in wear behaviour of the tribological system.

1.3 Objectives

The objectives of this project are as follows:

1. To understand the characteristics and properties of lubricant and to identify the change of lubricant bulk properties with existence of water
2. To study the formation of anti-wear tribofilm generated by the Zinc Dialkyldithiophosphate (ZDDP) additives.
3. To analyse the performance of ZDDP tribofilm thickness and wear depth generated when water contamination occurs in the lubricant.

1.4 Scope of Project

The scopes of this project are:

1. The study will focus on water as a source of contaminant with reference to comparable case study, methods of experiment and statistical data taken from secondary sources (journal and articles).
2. This research highlighting primarily on the effect on Zinc Dialkyldithiophosphate (ZDDP) additives contain in lubricant and focusing on lubrication under sliding contact condition.

1.5 Thesis Outline

This thesis consists of five main chapters, begin with the introduction, comprehensive literature review, methodology, result and discussion as well as a conclusion part to summarize the findings.

In Chapter 1, explain briefly on the lubrication and its additive content that could be deteriorate due to the existence of water. Other than that, the problem statement, objectives, and scopes of this project also mention in this chapter. Chapter 2, will be the comprehensive literature review done by referring to the journals and articles that are published by other researches. This chapter reviews, the lubrication properties, ZDDP additive tribofilm, and process that could happen when water contamination occurs.

Chapter 3 focuses on the project's methodology and explanation on experimental that carried out to validate the findings. The experiment is designated to achieve the research objectives begins with the bulk properties identification through Infrared Spectroscopy and continues with tribology test by using Mini Traction Machine (MTM) with Spacer Layer Interferometry Method (SLIM). The comparative study is conducted in this chapter.

Chapter 4 focuses on the results obtained from the experiments in previous chapter. Then, the analysis of ZDDP tribofilm thickness and wear depth will be taken on the results obtained by other researchers. Chapter 5 will be the final conclusion for the study, including the recommendation for upcoming research.

CHAPTER 2

LITERATURE REVIEW

2.1 Lubricant composition and functions.

The lubricant is composed of two main components which are base stock and additives. In line with the era of modern technology, there are wide range of both base fluids and chemical additives that has been used to formulate the modern lubricant to improve the performance (Kamal.G ,2013).

2.1.1 The base fluid of lubricant

The primary quantities of lubricating fluids are base oils and it is already known that viscous fluids have been established empirically to provide lubrication efficiency (I. Minami, 2017). Each type of base oil is classified based on the viscosity index, saturated hydrocarbon content and also sulphur content. According to Girish Kamal (2013) to eliminate impurities, base oils have been solvent-refined and this fluid class is known as Group I. Throughout the modern lubricant market, Group II oils have been the dominant base stock and also known as hydro-processed oils and are comparable to Group I as turbine lubricants due to the reduced sulphur and aromatic content. Although, Group II is a most selected base fluids because it is more oxidation-resistant but the degradation of this base stock produces less soluble by-product that will result in precipitate.

The differences between Group II and III is only the Viscosity Index (VI) described from the American Petroleum Institute (API) (Girish ,2013). Group IV base oils are synthetic base oils composed of Polyalphaolefin (PAO) as it is also known as synthetic hydrocarbons (SHCs) and the base oils of Group V contain all the base oils not represented by the other groups. The variation of formulated base fluids of the turbine lubricant accordingly from the Group I, Group II, Group III, Group IV and Group V as shown in Table 2.1

Table 2.1: The American Petroleum Institute (API) base stock categories from the source (Noria Corporation)

API BASE OIL CATEGORIES

	Base Oil Category	Sulfur (%)		Saturates (%)	Viscosity Index
Mineral	**Group I (solvent refined)**	>0.03	and/or	<90	80 to 120
Mineral	**Group II (hydrotreated)**	<0.03	and	>90	80 to 120
Mineral	**Group III (hydrocracked)**	<0.03	and	>90	>120
Synthetic	**Group IV**	PAO Synthetic Lubricants			
Synthetic	**Group V**	All other base oils not included in Groups I, II, III or IV			

2.1.2 Additives content in lubricant

Additives are supplemented to the base oil of a lubricant that does not have all the properties that the formulation needs and they are used to boost the base oils' beneficial properties and they also compensate for the weaknesses serves in base oil systems (Debbie,2017). Figure 2.1 shows the composition of the lubricant which consists of 70 to 99 percent of base fluid and 1 to 30 percent of additives package depending on type of lubricant.

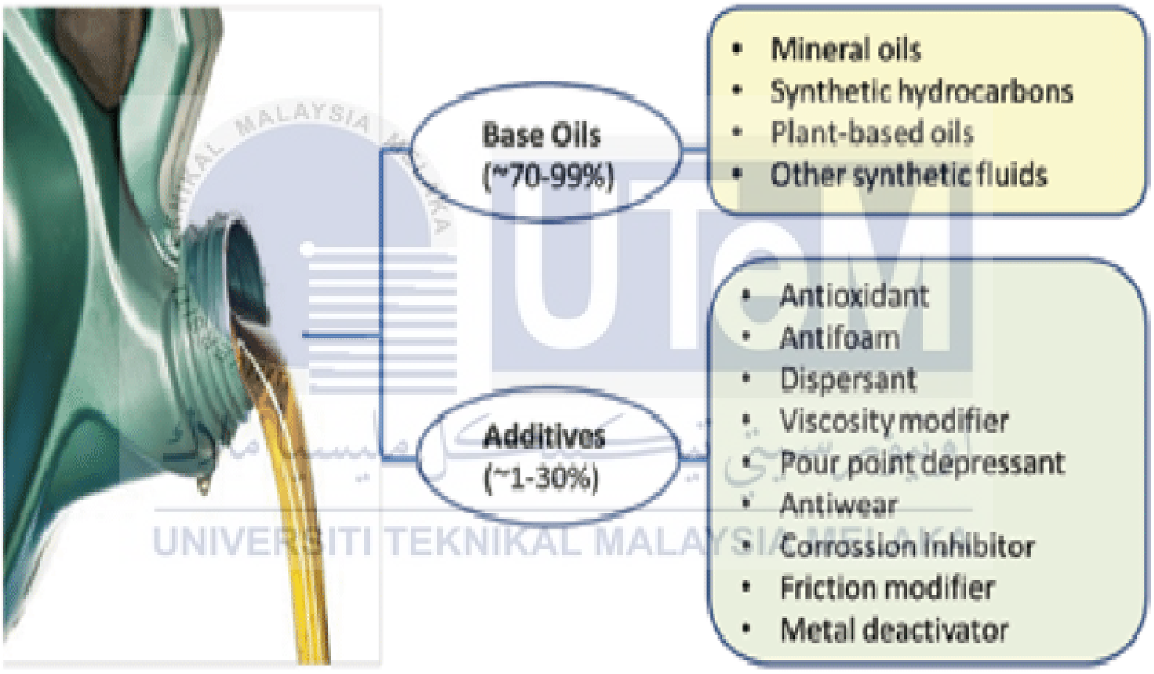
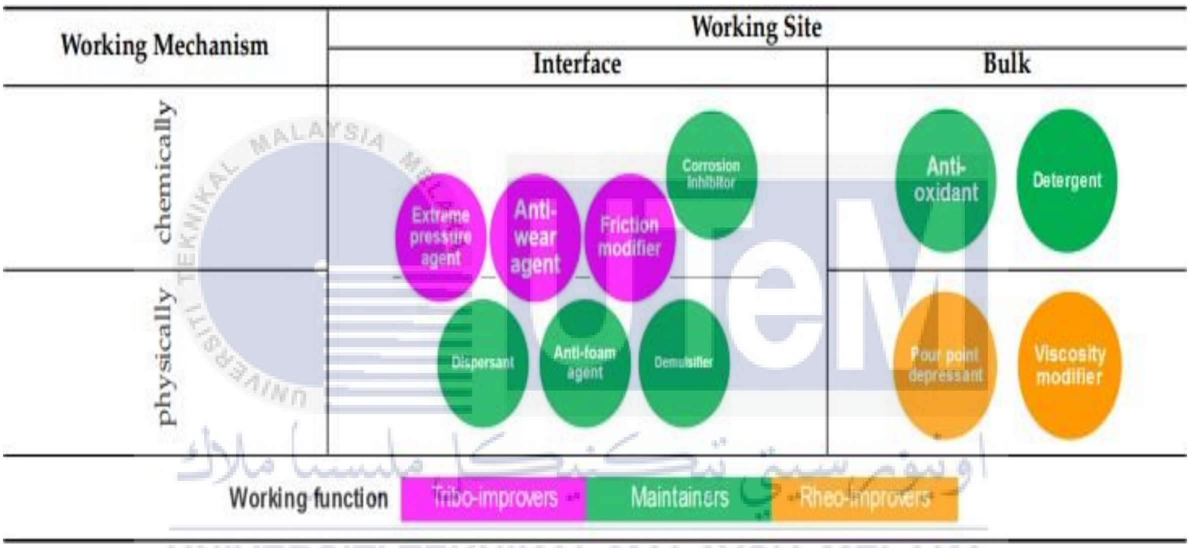


Figure 2.1 : The general composition of lubricant from the source (Tang, S. W. et al, 2017)

Certain additives introduce new and beneficial properties to the lubricant, others improve the properties already existing and also some of them minimize the unwanted changes take place in the substance throughout its service life (S,.N,.& M., A. et al, 2011). Additives may consist of antioxidant, rust inhibitors, foam inhibitors, demulsifier, anti-wear or extreme pressure compound. The additives are classified under different working mechanism as shown in Table 2.2.

Table 2.2: Difference classification of additives from the source (I. Minami, 2017)



2.1.3. Conventional lubricant additives

Additives are divided into several classifications which consist of the function as surface protective additives, performance additives and lubricant mainteners. Table 2.3 shows the list of additives that are intended to play a roll as surface protective.