A STUDY ON THE EFFECT OF MOLYBDENUM DISULFIDE ADDITIVE ON TRIBOLOGICAL PERFORMANCE OF MNR GREASE

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A report submitted
in fulfillment of the requirements for the degree of
Bachelor of MechanicalEngineering with honours

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I hereby, declared this report entitled a study on effect of wear performance of grease-Molybdenum disulfide additives under extreme pressure condition is the results of my own research except as cited in references.

Signature: ....

Author : Mohd Farriszakwan Bin Putit

Date: 25 August 2021

APPROVAL

This report is submitted to the Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Honours.

Signature: ....

Supervisor: Dr. Mohd Rody Bin Mohamad Zin

Date: 27 JULAI 2021...

DEDICATION

To my beloved parents

(Putit Bin Hip and Saloma Binti Amit)

My lovely family,

(Khairunisa Binti Putit, Mohd Noor Farhan Bin Putit, Amir Hamizan Bin Putit and Amir Lurman Bin Putit)

My Supervisor,

(Dr. Mohd Rody Bin Mohamad Zin)

My lectures,

And all my beloved friends

(Mohamad Ikhwan Bin Mohamed Razak, Azrin Ahmadin, Mad Haniff bin Mad Rasi, Rais Adham, Azamuddin Nasir, Fakhruddin Mutussin, Mohd Sazli Bin Amer, Mohd Haydir Bin Adzlee, Mohd Hasif Hamzi Bin Mustaffi, Mohammad Syahfiee Bin Hassanuddin, Jeremiah Camillus, Muhammad Nasrul Hadi Bin Mohd Halil, Mohd Izzat Izzuddin Bin Mohd Nasir, Muhammad Afirullah Bin Razali, Muhammad Anwar Bin Abdul Aziz, Ahmad Haikal Najmi Bin Ahmad Sazmy, Aiman Radzwan Bin Azra, Harith Bin Adnan, Muhammad Aiman Bin Wahid, Muhammad Dinie Haziq Bin Mohmad Fauzi, Muhammad Zaidan Bin Alias, Muhammad Syahmeen Asyraaf Bin Zamri, Muhammad Arash Iqhmal Bin Haris, Mohd Fakhrul Hafizuddin Ilman Bin Mahid, Sukri Bin Sinring, Mohd Muez Bin Mohd Hanapiah, Nur Adam Ariff Bin Aldrin, Jayadi Bin Mustari, Syarihan Bin Sadari and Kamal Syarafi Bin Roslan)

ABSTRACT

In this study, the tribological performance of grease with molybdenum disulfide additive (MoS_2) is investigated by using 4-ball tester. Greases were supplied by MNR Company. The experiment was conducted by using an ASTM D2266 standard. The result of friction and wear were compared between grease with MoS_2 additive and grease without additive. Results showed MoS_2 additive could reduce the friction, wear and surface roughness of the contacted steel balls. MNR with Molybdenum disulphide has gave lowest coefficient of friction and the average wear scar diameter (mm) with value of 0.038 and 0.34 while compared to MNR without Molybdenum disulfide has value of 0.082 and 0.57. From the graph, it showed percentage difference for the coefficient of frictions with 53.66%. For the average wear scar diameter (mm) has 40.35% percentage difference slightly small compared to coefficient of friction percentage difference. For the surface roughness of MNR grease it gives 54.02%. The result obtained is caused by the extreme pressure additive's molybdenum properties that exhibit wear.It also caused by Molybdenum disulphide that contains particle sharp edges that act as an abrasive agent. From the chemistry study, the formation of tribofilms on the worn surface is supported by inadequate pressures to withstand the Van der Waals forces.

ABSTRAK

Dalam kajian ini, prestasi tribologi minyak dengan aditif molibdenum disulfida (MoS2) disiasat dengan menggunakan penguji 4-bola. Gris dibekalkan oleh Syarikat MNR. Eksperimen ini dijalankan dengan menggunakan standard ASTM D2266. Hasil geseran dan keausan dibandingkan antara gris dengan aditif MoS2 dan gris tanpa aditif. Hasil kajian menunjukkan bahan tambahan MoS2 dapat mengurangkan geseran, keausan dan kekasaran permukaan bola keluli yang dihubungi. MNR dengan Molibdenum disulfida telah memberikan koefisien geseran terendah dan rata-rata diameter parut haus (mm) dengan nilai 0,038 dan 0,34 sementara dibandingkan dengan MNR tanpa Molibdenum disulfida mempunyai nilai 0,082 dan 0,57. Dari grafik, menunjukkan perbezaan peratusan bagi pekali geseran dengan 53.66%. Untuk rata-rata haus parut diameter (mm) mempunyai perbezaan peratusan 40.35% sedikit kecil berbanding pekali perbezaan peratusan geseran. . Untuk kekasaran permukaan gris MNR ia memberikan 54.02%. Hasil yang diperolehi disebabkan oleh sifat molibdenum aditif tekanan ekstrem yang menunjukkan keausan. Ia juga disebabkan oleh molibdenum disulfida yang mengandungi tepi tajam partikel yang bertindak sebagai agen pelelas. Dari kajian kimia, pembentukan tribofilms pada permukaan yang dipakai disokong oleh tekanan yang tidak mencukupi untuk menahan kekuatan Van der Waals.

ACKNOWLEDGEMENT

To my kind lecturer and supervisor, who has always guided me with direction, advice, and ideas as I developed this experiment. I've learned a lot of new things thanks to the unconditional sharing of knowledge. Many thanks to my supervisor, Dr. Mohd Rody Bin Mohamad Zin, for his help and patience. Finally, I'd like to express my gratitude to everyone who has helped me over this Final Year.

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LIST OF ABBEREVATIONS

EP	-	Extreme Pressure
R & D	-	Research and Development
WSD	-	Wear-Scar Diameter
MoS_2	-	Molybdenum disulfide
SEM	-	Scanning Electron Microscopy
EHL	-	Elasto-Hydrodynamic Lubrication
PTFE	-	Polytetrafluoroethylene
MoS2	-	Molybdenum disulfide
ZDDP	-	Zinc dialkyldithiophosphate

LIST OF SYMBOLS

λ	-	Film thickness ratio
h	-	The film thickness
σ	-	Root mean square (rms)
Ra	-	Average surface roughness
μm	-	Micrometer
T	-	Frictional torque, kg-mm
μ	-	Coefficient of friction
W	-	Applied load, N
V	-	Wear volume in, mm^3
H	-	Height of wear scar in, mm
R	-	Radius of the steel ball in, mm
A	-	Radius of the wear scar in, mm
K	-	Specific wear rate, mm^3/s t
t	-	Sliding time, s
r	-	Distance from the centre of the contact surface on lower balls to the axis of rotation, mm

CHAPTER 1

INTRODUCTION

1.1 Introduction

This section will explain more about the content of this experiment, a study on the effect of Molybdenum disulfide additive on tribological performance of MNR grease consisting of natural grease history in Malaysia and the use of grease in engineering applications that focus on automotive industry. This section will illustrate the mechanical characteristics, material utilization and implementation two types common of lubricants, grease and Molybdenum disulfide.

1.2 Background study

When humans used tools and machines, they discovered by applying lubricating oils or grease from time to time. They found it is a form of sustainable material that is widely used in Malaysia and around the world in a variety of industries, including automotive, manufacturing, civil, railways, offshore, aerospace, and defence. To know the properties of this lubricating oil or lubricant more clearly and in detail. Researchers take the approach of studying this matter through tribology. Tribology is about the study and engineering of interacting surfaces in relative motion, in term of the principles of friction, lubrication, and wear.

The lubricating oils are defined and chosen based on the several utilizing situations based on temperature rise, regular working temperature, working load, and excessive pressure. Special-objective oils and greases had been used to lubricate machinery throughout the industrial insurrection a long time ago. Lubricants created in a different of forms, including oil-based as liquid form, solid, and semi-solid.

Greases are one of type lubricant material that have more advantages that frequently applied in chemical mixtures and in the process of digitisation in high temperatures, heavier loads, and long-term use. The main base material of lubricants that are divided into three categories which are performance additives, inhibitors & stabilizers, and detergents. The performance additives are spread in thickeners, which gives the grease semi-solid and act as traps for pockets of oil that are kept released as surfaces interact. Thickeners made of a variety of forms which are simple soaps, complex soaps, and non-soap thickeners.

Molybdenum disulfide is one of the best types of solid additives that become gives more benefits and it became necessary used in aerospace and military applications. Because it commonly used in a range of industry applications. It is significantly used in grease and specialty grease-like products form paste. It's also utilised in a variety of fluid lubricants, including automotive and industrial gear oils. Molybdenum is found in two crystalline forms hexagonal and rhombohedral. The hexagonal shape is by far the most common, and it is also the only sort of disc. (Winer, W. O.,1967)

The wear scar diameter and friction coefficient has been used in the experiment as the standardised method to find out the contact friction and wear temperature that causes lubrication failure. Lubricants are firstly used to control friction and wear temperature. As a result, extreme pressure (EP) and anti-wear (AW) additives are applied to enhance performance friction and wear characteristics.

The standard schedule has become the outlines for the test and equipment conditions as well as the procedure .As comparison , utilising American data (ASTM D 2266) that use four-ball tester machine .Grease without additives and grease containing Molybdenum disulfide as an additive is commonly used as a lubricant addition to exhibit anti-wear protection and avoid oxidation. The chemical test of an addition and its concentration in the formulation determine its effect. The experiment's goal is to determine the impact by using the four-ball tester as illustrated in figure 1.1, test the wear and weld of greases with various additions. Fig 1.1. The material of the test balls is 100Cr6 steel with a hardness of 24-62 HRC.

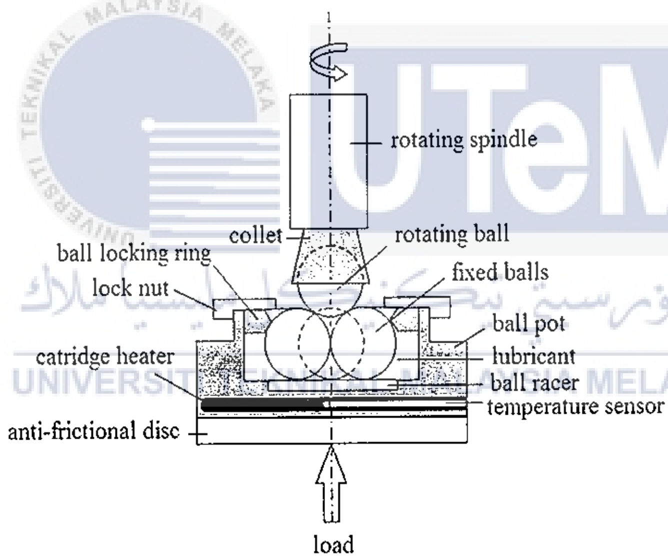

Figure 1.1 Schematic diagram of the 4-ball tester machine

1.3 Problem Statement

The Load Carrying Capacity of Extreme Pressure is important scale for the Extreme pressure test (EP). To get the benefits of grease wear scar diameter, viscosity provides anti-wear it must be reduced. The percentage of additives indicate effects on the rise and low in viscosity. The anti-wear additive was ventured under test conditions to produce the anti-wear good properties. Lubricants contain certain qualities. During the experiment, the four-ball tester machines were applied with the same parameters but different types of formulation additives.

From the research, additives able to enhance grease performance. It also can lower lubricant consumption ability. Furthermore, power loss can be lowered through oil-soluble lubricants to decrease friction. Based on the study during the manufacturing process, molybdenum, which is mixed up to the grease as an additive, produce a low-friction surface coating. The main purpose of this paper is to do the comparison and find the best additives for improve grease formulation performance under high load operation.

In mechanical systems, tribology found failures detected for around 30% of all failures for each test. The error should be minimised by using the suitable grease structure for wear and friction contemplation. In general, additives are used to lower and control contamination. It also can avoid defection to the metal machine surface by contact the surface. Thus, the best-compose greases will lower friction, heat, and wear properties. In addition, the high quality of grease formulation makes longer the life of the machinery. At the end, it saves the manufacturing sector cost, time, and energy by enabling for better efficient and effective production. So, the machine can works become more stable and safer.

1.4 Objective

The objective of this project is:

-To study the effect of Molybdenum disulphide (MoS_2) additive on friction, wear and surface roughness of MNR grease

1.5 Scope of project

There are several important activities that must be contemplated in order to achieve the study's objective. To accomplish this study, crucial scopes must be identified. MNR oil is applied in the formulation of multifunction grease in this test. The MNR oil formulation grease, which has a heavy-duty grease made from recycled base oil, has been used in this test. Furthermore, this grease is created to produce exceptional performance at a minimal cost. It also gives safe and friendly to the environment. Besides that, the additive will be utilized for study to produce the greases an extra benefit feature. Each addition has a unique property, such as prevent wear, anti-corrosion, antioxidant, and extreme pressure resistance, as well as solid lubricant.

1.6 General Methodology

There are five chapters in this report. The introduction, problem statement, objective, and project scope are all included in the first chapter. Chapter 2 discusses the literature review, while Chapter 3 discusses project methods. In Chapter 4, the outcome and data collecting will be discussed. The project will be summarised in Chapter 5 along with some recommendations. Here the main topic

The background of the whole operation, as well as the problem statement from the previous to this, will be explained in Chapter 1. The main of this project's objective is to state the problem statement. Furthermore, the scope of work is a project limitation that prevents future problems. This project's main chapters are listed below.

The research, identify and read relevant topics from sources such as reference books, the internet, and journals will be covered in Chapter 2 to gain details knowledge and information for the project. Research on a same system that is already on the market to learn about the system's characteristics can help with this project.

In Chapter 3, we'll go over the project's work flow from start to finish. The flow chart is used to visualise the project's work flow. The goal is to have a roadmap to follow while working on this project.

Chapter 4 will focus on the study's results and findings, which we've achieved after following the approach in Chapter 3. In this chapter, it will briefly explain the project's findings.

The results of this experiment will be summarised in the closing chapter, Chapter 5. It will also address a number of proposals for future development and improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The information for this chapter started from previous research as well as sources such as journals, papers, reports, websites, and books. The objective of this chapter is to give the opportunity as a guideline for running the project based on previous information and concepts. The objective is attained by the tribological research that focus on the lubricant of parts of machine.

This chapter is arranged in the following order: Section 2.2 will cover more about tribology studies, Section 2.3 will cover lubricant knowledge, Section 2.4 will cover grease parameters knowledge, and Section 2.5,2.6, and 2.7 will cover all experiment conditions.

2.2 Tribological Study

The idea of tribology is established and discovered by the UK Department of Education and Science in 1966, and it confine the integrative science and technology of surfaces that response in relative motion with subjects and practises. Tribology is the study about the friction of surface contact between moving joined surfaces.

Tribology can affect on decreasing the frictional resistance of a surface when it moves relative to another object under a specific load. In addition, the definition embraces the work of lubricants that are hydrodynamic, hydrostatic, and Elasto Hydrodynamic Lubrication (EHL). (Sperka, P., Krupka, I., & Hartl, M. 2016)

2.2.1 Nano additives as improver lubricants

Oil additives are chemical substances that help the performance of lubricants, particularly base oils. In industrial, the producer can use a different of oils, enabling them to use the similar base stock for each composition while selecting different additives for each application. There are some oils have additives that contribute to 5% of the total weight. Nowadays, motor oils contain additives, whether synthetic or petroleum-based, are commonly used in the automobile industry. Oil additives are crucial in today's internal combustion engines to perform optimum lubrication and long-lasting performance. It may become hazardous, contaminated, easily break down, leak out, or be unable to maintain engine parts in any condition without the oil additives. There are several advantages can use additives in gearboxes, automated transmissions, and bearings. Another main discovery is that it is applied for viscosity and lubricity, contaminant control, chemical breakdown control, and seal conditioning. Some grease with additives allows engines to perform better under harsh conditions, such as high-risk contamination and intense pressures and temperatures. (Stolarski, T. 1997)

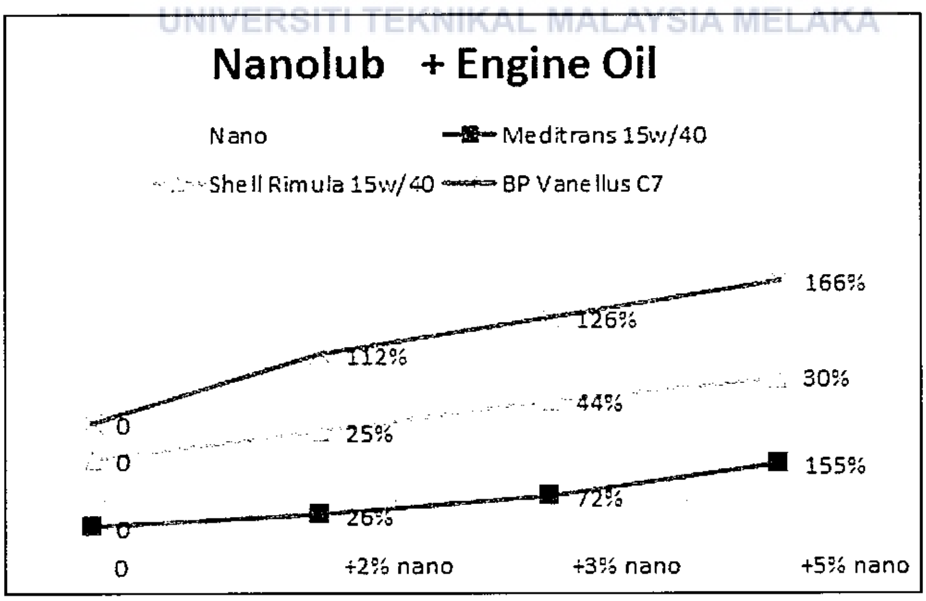

Figure 2.1: Test confirms benefit of Nano additives

2.2.2 Ideal concentration of nano-additive

The concentration of the additive is one important factor to ensure optimum tribological performance during dispersing nano-additive. Suitable concentration will be affecting the lubricant properties of Nano-lubricant. When the concentration is too low, it would be insufficient and make mechanism would be inconsequential when it reducing the friction. In high concentration, it would be uncontrolled and it will lead to dispersant performance for other additive such detergent. Addition of nanoparticles, either too little or too much, may causes harmful effects in some cases either by increasing friction or wear. (Jason, Y. J. J., 2020) To enhance and the friction and wear it supposedly use a suitable concentration of nanoparticles behaviour. Summary of literature showing range of concentrations and optimum concentrations along with role of nano-additive for different lubricants and nanoparticles combinations. It is interesting to observe that same MoS_2 nanoparticles show different optimum concentration for two different lubricants i.e. 0.58 wt% for mineral oil and 0.53 wt% for coconut oil using pin on disk contact (Forero, 2020). Contradictory to it, a fixed optimum concentration of 0.5 wt% nanoCuO and nanoZnO has been used for mineral, synthetic and vegetable oils for ball on disk contact. (Marcucci Pico, 2020) It indicate that the optimum concentration is vigorously system specific which means it will change for each test condition.

2.3 Grease and MoS_2 tribological performance

Grease is a solid or semisolid lubricant produced from distribution of thickening agents that found in a liquid lubricant. Basically, it comprises of a soap emulsified mix with mineral or vegetable oil. One of attribute that beneficial in the industrial which is it possess a high initial velocity that mostly use in the application of shear that provide the