INVESTIGATION OF CONTAMINATION IN BALL BEARING OPERATED UNDER HEXAGONAL BORON NITRIDE (hBN) NANOPARTICLE ADDITIVES MIXED WITH ENGINE OIL

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A report submitted

in fulfillment of the requirement for the degree of

Bachelor of Mechanical Engineering (Plant and Maintenance)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

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 (Plant and Maintenance).

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Date : …….

DECLARATION

I declare that this project report entitled "Investigation of Contamination in Ball Bearing Operated under Hexagonal Boron Nitride (hBN) Nanoparticle Additives Mixed with Engine Oil" is the result of my own work except as cited in the references

Signature : ……..

Name : …….....

Date : ……..

DEDICATION

To my beloved mother and father

ABSTRACT

Rolling element bearings are widely used as mechanical structures which support the shafts, axles, wheels or any rotating components on the machines. As the machines continuously operating under a long period of time, a high speed and a heavy load, consequentially cause early fatigue failure to the bearings. The presence of contaminants inside the lubricant is probably one of the main reasons for this phenomenon. Considering to this problem, the potential use of hexagonal boron nitride (hBN) as additive in SAE 15W40 diesel engine oil was studied. An experimental work was conducted on a test rig in order to identify the contaminant characteristics and the effect of different percentages concentration volume of hBN mixed with diesel engine oil in producing contaminations and wears on several conditions of rolling element bearings. Oil View Analyser indicates that the contamination index and wear rate are reduced significantly by increasing the percentage of hBN concentration volumes. The contamination and wear rate are lowest at 0.5 % concentration volume of hBN. Besides that, microscopic examination result shows the presence of contaminants and wears are typically in the form of fibers and ferrous metals respectively. Therefore, performance of hBN nanoparticles as contaminant, wear and friction reducing agent is clearly relevant.

ABSTRAK

Elemen galas berputar digunakan secara meluas sebagai struktur mekanikal yang menyokong aci, gandar, roda, atau mana-mana komponen berputar pada mesin. Mesin yang beroperasi dalam tempoh masa yang panjang, pada kelajuan yang tinggi dan beban yang berat secara tidak langsung meyumbang kepada kerosakkan peringkat awal galas. Kehadiran bahan cemar di dalam minyak pelincir merupakan salah satu faktor dominan yang menyumbang kepada fenomena tersebut. Oleh hal yang demikian, potensi penggunaan heksagon boron nitrida (hBN) sebagai bahan tambahan dalam SAE 15W40 minyak enjin diesel telah dikaji secara terperinci. Eksperimen telah dijalankan ke atas mesin ujikaji untuk mengenal pasti ciri-ciri bahan cemar dan kesan peratusan jumlah kepekatan hBN berbeza yang telah dicampurkan dalam minyak enjin diesel untuk mengurangkan bahan cemar dan bahan haus berdasarkan beberapa jenis kondisi galas berbola. Mesin analisa minyak menunjukkan bahawa kadar pencemaran dan kadar kehausan makin berkurang dengan penambahan peratusan jumlah kepekatan hBN yang dimasukkan. Berdasarkan analisa minyak yang dilakukan, penggunaan hBN 0.5 % menunjukkan kadar kehausan dan kadar pencemaran yang paling rendah Selain itu, hasil pemeriksaan mikroskopik menunjukkan kehadiran bahan cemar dan bahan haus adalah dalam bentuk gentian dan logam ferus. Justeru itu, penggunaan partikel nano hBN sebagai agen pengurang bahan cemar, kehausan dan geseran adalah relevan.

ACKNOWLEDGEMENT

Final Year Project (FYP) was an amazing experience and a great chance for learning and professional development. Therefore, I felt grateful and such a lucky individual as I was given an opportunity to be a part of it. I am also excited for having a chance to meet so many wonderful people and professionals who guided me while completing this project.

First and foremost, I would like to express my deepest gratitude to God for giving me strength to complete this final year project successfully at given period. I would also like to express my deepest gratitude and special thanks to the President of JK-PSM, Associate Professor Dr Azma Putra who in spite of being extraordinarily busy with his duties, took time out to hear, guide and keep students on the correct path and encouraged us to accomplish our final year project at given time duration.

Then, it is my radiant sentiment to place on record my best regards, deepest sense of gratitude to my supervisor, Dr Rainah binti Ismail for her careful and precious guidance which were extremely valuable for my study both theoretically and practically.

I would also like to convey my sincere gratitude to my project examiners Mrs Anita Akma binti Kamarolzaman and Professor Dr. MD. Radzai bin Said. Without their kind direction and proper guidance, this project would have been little success. Not to forget to my parent, seniors and friends for keep supporting and encouraged me in completing this final year project.

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LIST OF ABBREVIATIONS

hBN	Hexagonal Boron Nitride
COF	Coefficient Of Friction
RCW	Rolling Contact Wear
MACs	Multialkylated Cyclopentanes
MWNTs	Multi-Walled Carbon Nanotubes
NCB	Nano-Calcium Borate
LDLS	Laser Dynamic Light Scattering
CAD	Computer Aided-Drawing
WDA	Wear Debris Analysis

LIST OF SYMBOLS

ρ	Density
m	Mass
v	Volume

CHAPTER I

INTRODUCTION

1.1 Background

Figure 1.1: Various type of bearings

(Source from www.weiku.com)

Nowadays, there are many types of bearings as shown in Figure 1.1 that have been used and required in various industrial sectors or everyday objects in order to operate such as washing machines, food processors and tumble driers. Besides, rolling element bearings are also widely used as mechanical structures which support the shafts, axle, wheel or any rotating component on the machines. As the machine continuously operating at a long period of time, under a high speed and a heavy load, indirectly will cause a critical damage or early fatigue failure to the bearing. This phenomenon might be occurred due to the huge friction and presence of contaminants on the bearing itself. The unbalance and misalignment of

existing components on the machines might be also one of the several reasons that lead to a high vibration on the machine component and cause machinery breakdown. As a result, the performance of the machine to operate decrease and could be dangerous to the users while running the machine. Moreover, the maintenance cost would be high if there is a critical damage or broken part on the machine component.

Figure 1.2: Lubricant Oil

(Source from autoworld.com.my)

Figure 1.3: Grease

(Source from www.techtransfer.com)

As a solution to this problem, lubricant is required to lubricate the machine component in order to reduce the friction, corrosion and seizure on the bearings. The existence of lubricant on the bearing, increase the performance of the machine while operating. Today, lubricant oil and grease are basic types of lubricants that commonly used in rotating machinery. Lubricant oil as shown in Figure 1.2 is a liquid lubricant which is combination of base oil and additives. It has low viscosity that provides great versatility and low friction which is really suitable for lubricating parts that rotate at high speed. Meanwhile, grease as in Figure 1.3 is semisolid lubricant which is made up of dispersed thickener and liquid lubricant. It is less expose to aging and usually recommended for long-life products. These type of lubricants are still accepted, used and practiced until now.

Figure 1.4: Hexagonal Boron Nitride Powder

(Source from www.supervacoils.com)

Recently, several researches on nanoparticles lubricant have been studied due to its efficiency to low friction and wear. The performance of this nanoparticles lubricant have been reviewed in tribology field. Therefore in this case, Hexagonal Boron Nitride (hBN) powder as shown in Figure 1.4 is used as lubricant additive. It can be dispersed in oil

lubricant, grease, solvent and water. Due to its characteristics of strong thermal resistance, good thermal conductor and good insulator, therefore it is really suitable being an additive for a high temperature lubrication and on a high friction of contact surfaces (Gao Y et. al., 2011). In addition to that, detail experimentation and testing must be carried out from time to time in order to optimize the performance of hBN as lubricant additive.

1.2 Problem Statement

Friction or early fatigue failure on the bearing of rotating machinery is a critical problem that could lead to total damage to the machine components and dangerous to users while running the machines. Besides, as the rotating machine continuously operating for a long time under a high speed and heavy load, it will cause the bearing to wear out and reduce the performance of the machines. The solid contaminants in lubricants of the bearings are also one of factors that lead to bearing failure. As a result, the lifespan of the bearings will be shorten and the maintenance cost would be expensive if there is serious damage on the machine components.

There are few studies that have been conducted by several researchers regarding the performance of hBN nanoparticles as lubricant additives in reducing the wear rate and coefficient of friction (COF) of machine components. They found that the performance of hBN nanoparticle was influenced by the percentage of volume concentration of hBN powder that mixed with base oil. Muhammad Ilman Hakimi Chua Abdullah et al. (2013) stated that the contribution of 0.5 vol. % of hBN can be used as an ideal additive composition in conventional diesel engine oil to achieve a lower COF. Therefore, a detail experimentation and testing are carried out to propose an effective percentage of hBN volume concentration as wear reducing agent and in order to achieve the objectives of this study.

1.3 Objectives

1. To investigate the effects of certain contaminant characteristics on bearing and hBN performance.
2. To study the effects of concentration of hBN mixed with diesel oil in producing contamination on rolling bearings.

1.4 Scope of Project

The scope of this project are:

1. Do an experimental work in order to identify the performance of hBN nanoparticles mixed lubricants on new and defected rolling bearings at different concentrations value operating for long time under high speed and heavy load.
2. Obtain the contaminants inside the tested lubricant sample by using debris machine.
3. Conduct vibration test to obtain the trends in the amounts of vibration affected by different contamination in the hBN mixed lubricant.
4. Perform gravimetry and ferrography test to obtain the roughness measurements and microscopic observation.

1.5 Gantt Chart

Table 1.6 Gantt chart for PSM 1

Weeks / Activities	PSM 1													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Problem Statement & Objectives	■													
Literature review		■	■	■	■	■	■	■	■	■	■			
Design of project		■	■	■										
Fabrication of project					■	■	■	■	■					
Sample preparation of experiment							■	■	■	■				
Experimental work								■	■	■	■			
Preliminary data collection									■	■	■			
Preliminary data analysis										■	■	■	■	
Draft of report writing	■	■	■	■	■	■	■	■	■	■	■	■	■	
Report writing submission														■
Seminar 1 presentation														■

Table 1.7 Gantt chart for PSM 2

Weeks / Activities	PSM 2													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Introduction to PSM 2	■													
Literature review		■	■	■	■	■	■	■	■	■	■	■		
Materials finding				■	■	■								
Test rig modification and fabrication							■	■	■	■				
Experimental work								■	■	■	■			
Progress report submission								■	■	■	■			
Final data collection									■	■	■			
Final data evaluation										■	■	■	■	
Writing draft of final report	■	■	■	■	■	■	■	■	■	■	■	■	■	
Submission of final draft report														■
Seminar 2 presentation														■