UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

FRICTION IMPROVEMENT OF PALM KERNEL ACTIVATED CARBON-EPOXY BY OIL AND WATER IMPREGNATION

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Master of Mechanical Engineering (Energy Engineering)

2019

FRICTION IMPROVEMENT OF PALM KERNEL ACTIVATED CARBON-EPOXY BY OIL AND WATER IMPREGNATION

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A thesis submitted
In fulfilment of the requirements for the degree of
Master of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Mechanical Engineering (Energy Engineering).

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Date :....21/2/2019.......................

DECLARATION

I declare that this thesis entitled "Friction Improvement Of Palm Kernel Activated Carbon-Epoxy By Oil And Water Impregnation" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : MAZIAH BINTI IBRAHIM

Date : 20/2/2019

DEDICATION

This study is wholeheartedly dedicated to my beloved parents, who have been my source of inspiration and gave me strength when I thought of giving up, who continually provide their moral, spiritual, emotional, and financial support. To our brothers, sisters, relatives, mentor, friends, and classmates who shared their words of advice and encouragement to finish this study. And lastly, I dedicated this thesis to the Almighty God, thank you for the guidance,strength, power of mind, protection and skills and for giving me a healthy life. All of these, we offer to you.

ABSTRACT

It has become a whole wide problem that friction and wear causing a huge amount of energy loss. Friction improvement is needed to obtain maximum efficiency and at the same time being environment-friendly by reducing waste. Some study show that 50% of premature bearing failure were due to lubricants. The purpose of this project is to study the improvement of friction by using PKAC composite and to investigate the effect of impregnated time on friction and wear properties of the PKAC. The composite will be impregnated by palm oil, paraffin oil and water for 1 day and 8 days as solid lubricant since lubricant can reduce friction between surfaces. The result of coefficient of friction and wear rate of PKAC will be taking by using ball-on-disc tribometer. Basically, the composite were formed into disc shaped using hot compaction technique. When the composite were ready, basic mechanical test were done. Then the composite were tested through ball-on-disc tribometer. The results show that the COF of composite impregnated by water and oil are better than COF of un-soaked composite. From the study, it is interesting to find that COF of composite impregnated by palm oil is better than paraffin oil. While wear rate of paraffin oil is better than palm oil. This behaviour shows that the effect of COF and wear is also depend on the temperature, viscosity of lubricants and any others. In addition, the effect of impregnation time are not really significant in friction. The lubricant quickly fully absorb when the composite impregnated for a long time. In conclusion, the result of COF of PKAC impregnated by water and oil were better than the un-soaked composite which is between 0.04 to 0.06 COF. Thus, it can be said that palm oil and paraffin oil can be good impregnated medium for PKAC to improve friction.

ABSTRAK

Pengurangan geseran diperlukan untuk mendapatkan kecekapan maksimum dan pada masa yang sama menjadi mesra alam dengan mengurangkan sisa. Sesetengah kajian menunjukkan bahawa 50% kegagalan bearing pramatang adalah kerana pelincir. Tujuan projek ini adalah untuk mengkaji peningkatan geseran dengan menggunakan komposit PKAC dan untuk mengkaji kesan masa rendaman pada geseran dan haus sifat PKAC. Komposit ini akan diregregasikan oleh minyak kelapa sawit, minyak parafin dan air selama 1 hari dan 8 hari sebagai pelincir pepejal kerana pelincir dapat mengurangkan geseran antara permukaan. Hasil koefisien geseran dan kadar haus PKAC akan diambil dengan menggunakan alat pengukur "ball-on-disc". Pada asasnya, komposit itu terbentuk menjadi cakera berbentuk menggunakan teknik pemadatan panas. Apabila komposit telah siap, ujian mekanikal asas telah dilakukan. Kemudian komposit itu diuji melalui tribometer. Keputusan menunjukkan bahawa COF komposit yang diresapi oleh air dan minyak lebih baik daripada COF komposit yang tidak direndam. Dari kajian ini, adalah menarik untuk mengetahui bahawa COF komposit yang diresapi oleh minyak kelapa sawit adalah lebih baik daripada minyak paraffin. Manakala kadar haus minyak parafin adalah lebih baik daripada minyak sawit. Tingkah laku ini menunjukkan bahawa kesan COF dan pakai juga bergantung kepada suhu, kelikatan pelincir dan mana-mana yang lain. Di samping itu, kesan masa impregnasi tidak begitu penting dalam geseran. Pelincir dengan cepat menyerap sepenuhnya apabila komposit diresapi untuk masa yang lama. Kesimpulannya, hasil COF PKAC yang dibersihkan oleh air dan minyak lebih baik daripada komposit yang tidak direndam antara 0.04 hingga 0.06 COF. Oleh itu, boleh dikatakan bahawa minyak sawit dan minyak parafin boleh menjadi medium yang baik untuk PKAC untuk mengurangkan geseran.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Associate Professor Dr. Mohd Fadzli bin Abdollah from the Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for her essential supervision, support and encouragement towards the completion of this thesis.

I would also like to express my greatest gratitude to Cik Noor Ayuma Mat Tahir, PHD student from Faculty of Mechanical Engineering, for her advice and guidance provided throughout the project.

Particularly, I would also like to express my deepest gratitude to Pn Nur Hidayah, the technicians from tribology laboratory Faculty of Mechanical Engineering, and Mr. Hairul Nezam Bin Wahid, technician from innovative and prototype lab Faculty of Mechanical Engineering for their assistance and efforts in all the lab and analysis works.

Special thanks to all my peers, my beloved parents and siblings for their moral support in completing this master. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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LIST OF ABBREVIATIONS

m	-	Meter
g	-	Gravity
N	-	Newton
μm	-	Micrometer
T	-	Temperature
Ra	-	Surface Roughness
F	-	Applied Load
k	-	Specific Wear Rate
COF	-	Coefficient of Friction
RPM	-	Rotation per Minutes
PKAC	-	Palm Kernel Activated Carbon
PKAC-E	-	Palm Kernel Activated Carbon reinforced Epoxy
SEM	-	Scanning Electron Microscope
EDX	-	Energy Dispersive Xray
DLC	-	Diamond Like Carbon
PTFE	-	Polytetrafluoroethylene
Mtoe/a	-	Million Tonnes of Oil Equivalent
Km/a	-	Kilometer per year
CO_2	-	Carbon Dioxide
°C		Degree Celcius
PFMP	-	Pavement Friction Management Program
CrN	-	
MTM	-	Minimum Traction Machine
XPS	-	X-Ray Photoelectron Spectoscopy
AFM	-	Atomic Force Microscopy

CHAPTER 1

INTRODUCTION

1.1 Background of Study

In passenger cars, one-third of the fuel energy is used to overcome friction in the engine, transmission, tires, and brakes. Based on figure 1.1, the direct frictional losses, with braking friction excluded, are 28% of the fuel energy. In total, 21.5% of the fuel energy is used to move the car.

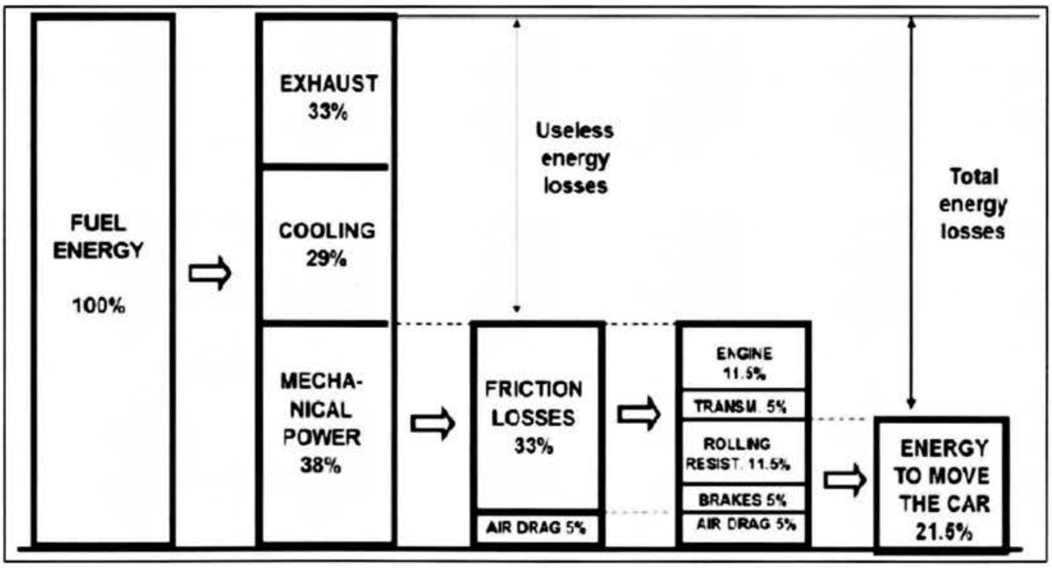

Figure 1.1: Breakdown of passenger car energy consumption.

[Source: (Holmberg et al. 2015)]

Worldwide, 208,000 million liters of fuel (gasoline and diesel) was used in 2009 to overcome friction in passenger cars. This equals 360 million tonne oil equivalent per year (Mtoe/a) or 7.3 million TJ/a. Reductions in frictional losses will lead to a threefold improvement in fuel economy as it will reduce both the exhaust and cooling losses also at the same ratio.

Globally, one passenger car uses on average of 340 liters of fuel per year to overcome friction, which would cost 510 euros according to the average European gas price in 2011 and corresponds to an average driving distance of 13,000 km/a.

According to Holmberg et. al. (2015), by taking advantage of new technology for friction reduction in passenger cars, friction losses could be reduced by 18% in the short term (5–10 years) and by 61% in the long term (15–25 years). This would equal worldwide economic savings of 174,000 million euros and 576,000 million euros, respectively; fuel savings of 117,000 million and 385,000 million liters, respectively; and CO_2 emission reduction of 290 million and 960 million tonnes, respectively.

The friction-related energy losses in an electric car are estimated to be only about half of those of an internal combustion passenger car.

Potential actions to reduce friction in passenger cars include the use of advanced coatings and surface texturing technology on engine and transmission components, new low-viscosity and low-shear lubricants and additives, and tire designs that reduce rolling friction.

According to Mat Tahir, N.A. (2016), Palm kernel activated carbon is actually the waste from palm oil extraction process. As shown in Figure 1.2, the palm oil is actually made up of exocarp, mesocarp, endocarp, and endosperm. After the extraction process, what is actually left to become activated carbon is the endocarp part, which is called the kernel. Through the extraction process, the potential of this kernel or endocarp is found through the ash content, the moisture content, and the physical condition—that is, high density, hardness, and volatile content.

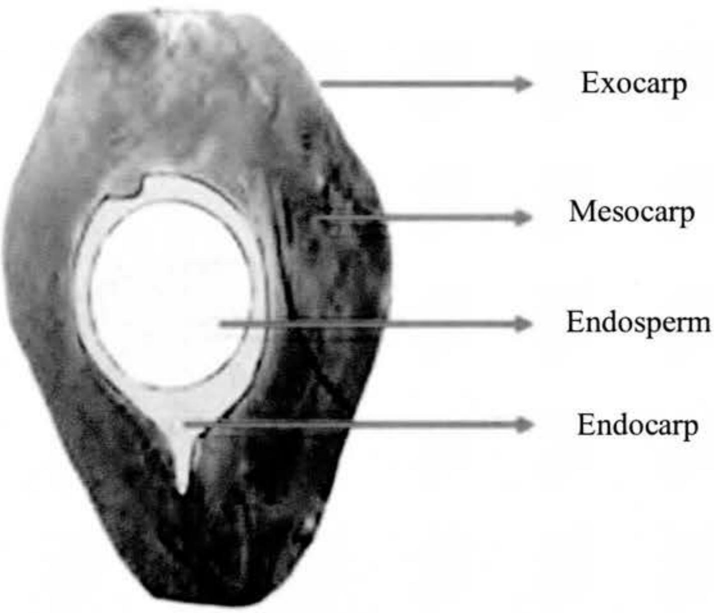

Figure 1.2 Components of palm oil fruit

[Source: http://www.bgrimmgreenpower.com/biodisel-sourcing.php]

Ash content can lead to increase hydrophilic ability and can have catalytic effects as well, causing restructuring process during regeneration of used activated carbon. The inorganic material contained in activated carbon is measured as ash content, generally in the range of 2 to 10%. Moreover, some activated carbons can absorb considerable moisture from over 25 to 30% for over a month under humid conditions, but maintain to appear dry. Although this obviously dilutes the carbon, sometimes, the moisture content does not affect the absorptive power of active carbons at all.

Recently, a significant shift to oil palm is an acknowledged emerging trend in the cooking oil industry. From Figure 1.3, it can be seen that Malaysia and Indonesia are leading other countries in the world's palm oil production. As global players in the palm oil market, it can be expected that there will be a huge abundance of palm oil waste or biomass in both countries. However, this waste may be reused in consideration that biomass can be recycled and transformed into potentially marketable value-added products with the help of additives and other materials.

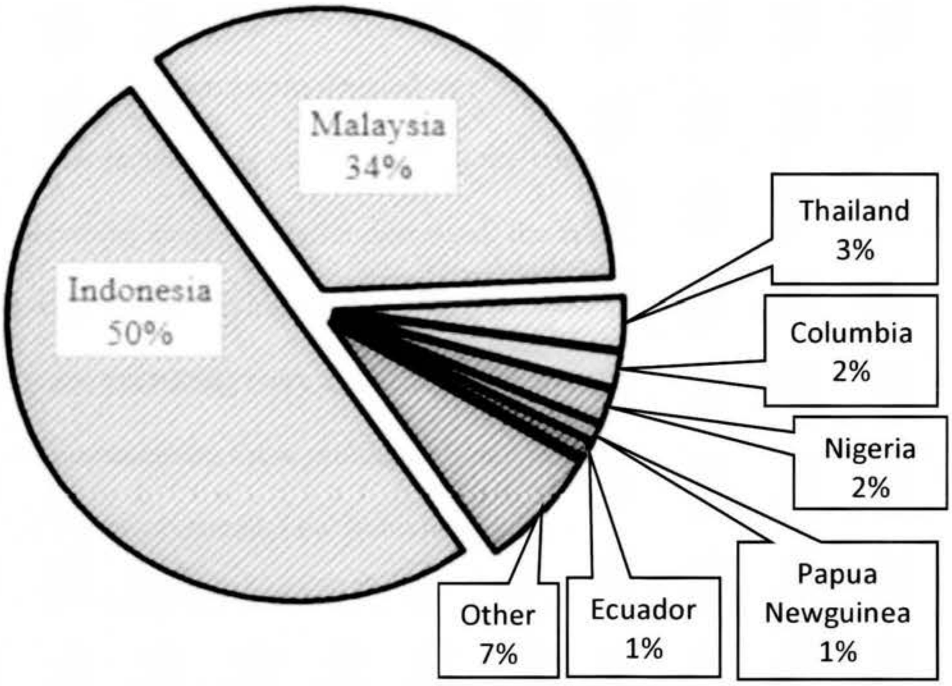

Figure 1.3 Distribution of palm oil worldwide in 2013

[Source: GreenPalm at slideshare.net]

Some of the application that related to material that can sustain in intermitten lubrication system are pump motor, piston engine, gas meter pipi and ball bearing. For example, ball bearing can be replaced by PKAC to find how long the PKAC can sustain in intermitten lubrication system to reduce friction.

1.2 Problem Statement

It has become a whole wide problem that friction and wear causing a huge amount of loss. Internal combustion engines are notoriously inefficient. According to Allmaier et. al. (2013), only about 20 percent of the energy from the fuel is used to actually move the car. Friction is one of the factors that further reduce that already low efficiency. As with any mechanical device, energy is lost due to friction.

The need to reduce friction and wear in the automotive industry to obtain maximum efficiency—while at the same time being environment-friendly by reducing waste—consistently creates an increasing demand for research in Tribology, especially in lubrication. Friction reduction is needed to save the energy as well as reducing the fuel consumption. Since the usage of fuel is decreased, the emission of carbon from fuel will decrease and it will save the environment.

Accordingly, presenting more efficient lubrication or self-lubricating materials may be the solution in overcoming these problems. Some research had been done to overcome the friction by using new material, new technology and new lubricants. Unfortunately, they had an issue in developing a new material for friction improvement.

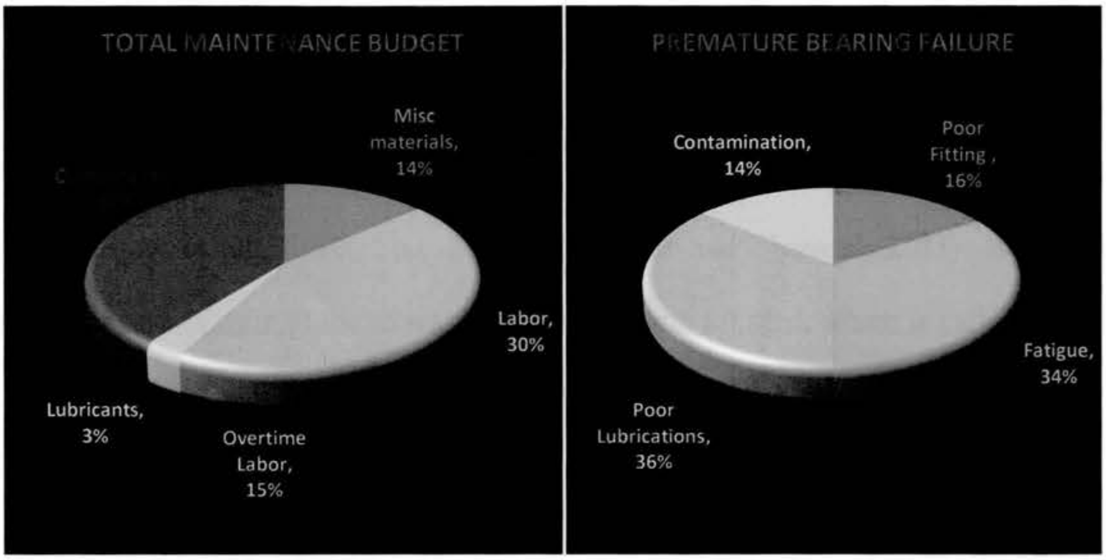

Figure 1.4: Percentage of total maintenance budget and premature bearing failure.

[Source: (Richard et al. 2013)]

As shown in Figure 1.4, the cost of lubricants typically represents 1-3% of a maintenance budget. Richard et. al. said that approximately 50% of premature bearing failures are due to issues such as too much or too little lubricant; lubricant contamination or cross-contamination with incompatible lubricants; lubricant-chemical degradation; and use of the wrong type or grade of lubricant.

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. Some studies shows that palm kernel activated carbon can be used to study the friction improvement as it is potential as future tribological material due to low coefficient of friction and wear (Bakri et. al., 2013). Studies on the use of natural products such as fibre 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.

It is noted that carbon may come in many forms such as fibres, flakes, tubes, and more (Brostow et. al., 2010, Luo, 2013, and Zamri and Shamsul, 2011). In addition, amorphous carbon were found as waste product of palm oil seed, which is called activated carbon (Zamri et. al 2011). According to Zamri et. al., 2011, activated carbon has the potential to act as a self-lubricating agent when reinforced with aluminium. It would be highly beneficial if these unique properties of carbon can be used as self-lubricating agents for reducing friction and wear besides reducing the waste product from the oil extraction process. Meanwhile, oil extraction process from palm oil produces lots of waste that may become a problem on later days. This waste has potentials to become self-lubricating materials due to its residual oils, but with transformation as activated carbon.

The purpose of PKAC-E was impregnated by oil and water is to investigate how long the material can sustain in lubrication condition. The engine piston in automotive or machinery is one of the example of application that related with impregnation. To summarize, the need to maintain optimal function of automotive machines is a pressing issue that calls for efficient solutions. The direction is to recycle waste product, particularly of palm oil into self-lubricating materials. It is also a sustainable and environment-friendly alternative.

1.3 Research Objectives

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

1. To compare the **friction properties of PKAC impregnated into palm oil, paraffin oil and water**.
2. To investigate the **effect of impregnated time on friction and wear properties of the PKAC.**

1.4 Research Scopes

The scope of this project consist of the material used, standard of tribology test, test load, test speed, lubrication, temperature, balls material and impregnation time. This research is limited to the study of palm kernel activated carbon (PKAC) reinforced epoxy (E). Specifically, the parameters studied were sliding temperature ranging from 27 °C (room temperature) up to 150 °C. Meanwhile the sliding distance and sliding speed is constant at 1000 m and 200 rpm respectively. The composition of PKAC is 60%, surface roughness (Ra) ranging from 2.1 μm to 3.0 μm, and applied load is constant which is 4.905 N. Accordingly, the work done in this study was divided into several stages. First, the samples were prepared using the compaction method, after which the specimens were subjected to hardness test. After arriving at a suitable composition, the composites were first tested on the ball-on-disc tribometer testing or tribological test at temperatures and sliding distances as stated before. Then, the composite will be impregnated into water, palm oil and paraffin oil for 1 day and 8 days. It should be noted that these tests were done in order to analyse the behaviour of the composites after being impregnated, and additionally, to analyse the effect of water and oil as lubriation system. Likewise, the surface morphology of the worn surface was taken under 3D Non-Contact Profilometer to determine wear track form on the composites. Finally, data results from the tests were utilised to propose both wear and friction equation.