EFFECT OF SLIDING SPEED ON TRIBOLOGICAL PROPERTIES OF PALM KERNEL AVTIVATED CARBON-EPOXY (PKAC-E) COMPOSITE

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"I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive)"

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This report is submitted in partial
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DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

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DEDICATION

Al-Fatihah and special dedication to my late father, Arwahyarham Hj. Yusuf Bin Hj. Awang, my beloved mother Hjh Roziyah Binti Hj.Hashim, my late brother, Arwahyarham Mohd Munir Bin Hj.Yusuf and my family members that always love, especially to my supervisor , Dr Mohd Fadzli Bin Abdollah, my beloved friends, my fellow colleague and all the faculty members.

For all your love, care, support and believe in me.

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ABSTRACT

Palm Kernel Activated Carbon-Epoxy (PKAC-E) composites acts as a potential solid lubricant are used to increase the service life of machining and equipment where oil and grease cannot be used. Raw material of Palm Kernel Activated Carbon-Epoxy (PKAC-E) composites were extract from kernel shell of palm oils tree. The kernel shell undergoing a long process of oxidation before activated carbon achived The interest based on porous carbon also known as activated carbon exhibited its potential for acts as a self-lubricating material for the reduction of friction and wear behaviors. In this project, the effects of sliding speed on friction and wear behaviors of Palm Kernel Activated Carbon-Epoxy (PKAC-E) composite under unlubricated condition will be investigated. The sample of Palm Kernel Activated Carbon-Epoxy (PKAC-E) composites was prepared by using hot compaction technique, then tribological test was carried out by using a pin-on-disc tribometer with a constant load, temperature, unlubricated condition, with varying sliding speed. After that, surface morphology observed under the inverted microscope. Coefficient of friction and specific wear rate will be observed after carry parametric testing, in order to know optimum sliding speed of Palm Kernel Activated Carbon-Epoxy (PKAC-E) composites with unlubricated conditions. From the research, Palm Kernel Activated Carbon-Epoxy have huge potential in composites industry that tends to give new composites that have a low coefficient of friction and low wear rate properties. It suitable as solid lubricant in mechanical application that need a low coefficient of friction and low wear rate properties at sliding speed at range 500RPM – 2000RPM operating at room temperature.

ABSTRAK

Palm Kernel Activated Carbon-Epoxy (PKAC-E) composit sebagai bahan berpotensi menjadi pelincir pepejal untuk meningkatkan jangka hayat mesin dan struktur mekanikal yang tidak boleh dikenakan pelincir cecair seperti minyak. Palm Kernel Activated Carbon-Epoxy (PKAC-E) composit dihasilkan daripada tempurung buah sawit dari pokok kelapa sawit. Tempurung sawit ini menjalani proses oksidasi yang panjang sebelum karbon teraktif diperolehi.Ini disebabkan karbon poros ataupun dikenali sebagai karbon teraktif yang dapat bertindak sebagai pelincir kendiri untuk mengurang geseran dan kehausan. Dalam projek ini, kesan kelajaun gelongsoran terhadap geseran dan kehausan Palm Kernel Activated Carbon-Epoxy (PKAC-E) composit dikaji. Sample Palm Kernel Activated Carbon-Epoxy (PKAC-E) composit dihasilkan mengunakan teknik pemapatan berhaba. Kemudian, experimen tribology dijalankan mengunakan peralatan pin-on-disc tribometer dengan beban, suhu dan panjang gelonsoran yang dimalarkan.,manakala kelajuan gelongsoran dimanipulasikan .Semua experimen dijalankan tanpa pelincir. Selepas itu,permukaan sample dilihat mengunakan mikroskope berbalik Kadar geseran dan kadar kehausan akan dikira selepas eksperimen dijalankan.,dalam usaha untuk mengetahui kelajuan gelongsoran yang paling baik pada Palm Kernel Activated Carbon-Epoxy (PKAC-E) composit tanpa ketidakhadiran pelincir. Hasil kajian menunjukkan Palm Kernel Activated Carbon-Epoxy (PKAC-E). mempunyai potensi besar dalam industri komposit yang mempunyai geseran yang rendah dan kadar haus yang rendah. Ia sesuai sebagai pelincir pepejal dalam industri mekanikal yang perlu geseran dan kadar haus rendah pada kelajuan gelongsor pada linkungan 500RPM - 2000RPM yang beroperasi pada suhu bilik.

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μ	=	coefficient of friction
N	=	newton
F	=	frictional force
mm	=	millimeters
m	=	meters
rpm	=	revolution per minute
W	=	applied load
ρ	=	density
g	=	gram
mm^3	=	volume loss
C	=	carbon
°C	=	temperature
%	=	percentage
wt. %	=	weight percentage
Mpa	=	megapascal

LIST OF ABBREVIATION

PKAC	=	Palm Kernel Activated Carbon
PKAC-E	=	Palm Kernel Activated Carbon-Epoxy
CFRC	=	Carbon fibre reinforced carbon
PbO	=	Lead oxide
Sb_2O_3	=	Antimony trioxide
PVD	=	Physical Vapor Deposition
COF	=	Coefficient of Friction
PTFE	=	Polytetrafluroethylene
Mos2	=	Molybdenum Disulfide
PEEK	=	Polyetheretherketone
DFL	=	Dry Film Lubricant
CVD	=	Chemical Vapor Deposition
ASTM	=	American Society for Testing and Materials

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In this millennium era, tribology technology rapidly growing compete with another engineering technology in order to occupy each other needed. One of the most rapidly growing is composite materials. Composites material includes polymer, metal, glass and ceramic. The wide variety of material with varying properties allows to expand the application of composite in engineering areas. In the context of tribology, each composite application in engineering required their specific properties of the material. As an example, brake pads and clutches need high coefficient of friction, coupled with low wear. Meanwhile, low friction and low wear composite material required to design gears and bearings.

Carbon-carbon composite or also known as carbon fiber reinforced carbon-matrix composite become a new interest of developing in tribology engineering. These materials are relatively new and expensive and, therefore, are not currently being widely discovered. Its high tensile moduli and high tensile strength at specific temperature to provide resistance to creep and fracture toughness. Coupled with low thermal expansion, high thermal conductivities and high strength provide relatively high resistance thermal shock. Their major weakness is easily oxides at high temperature (Chang, Li and Klaus Friedrich, 2012).

Therefore, this work aim to investigate carbon composites which are Palm Kernel Activated Carbon - Epoxy (PKAC-E) on tribological behaviors at different sliding speed.

1.2 PROBLEM STATEMENT

Lubricating composites are used to increase the service life of machinery and equipment where oil and grease cannot be used (Moisés Luiz Parucker et al., 2013). Overall, there is an extraordinary worry about enhancing the material properties and creating new materials so they can have better performance in engineering world.
Therefore, developing waste material that extract from palm kernel shell become valuable composites demanded such as activated carbon. Activated carbon that extract from kernel shell of palm oils tree mixed with epoxy to become carbon composite, Palm Kernel Activated Carbon-epoxy (PKAC-E).The interest in porous surface of carbon that able to reduce friction and wear is demanded.

Subsequently, this study to explore the effects of sliding speed on friction and wear behaviors of PKAC-E composite under unlubricated conditions

1.3 OBJECTIVE

To investigate the effects of sliding speed on friction and wear behaviors of Palm Kernel Activated Carbon-Epoxy composite under unlubricated conditions.

1.4 SCOPE OF STUDY

The research will develop and investigate new composite. The research begins with preparing the sample by using compaction technique. Then, sample undergo tribological testing. The tribological test was carried out by using a pin-on disc tribometer. After that, sample and disc were observed the surface morphology under the inverted microscope. Collected data analyzed to see friction coefficient and wear rate against sliding speed were studied.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND OF STUDY

The special characteristics of solid lubricant that not available in fluid lubricant is that provide a low friction coefficient. This is due to their low shear strength, and low hardness properties. Actually, many materials found that suitable for developing solid lubricant, but for reason of environmental, health, and safety issues, the number possible solid lubricant in use is reduced. Examples materials that no more considered suitable materials are such as Lead oxide PbO, antimony trioxide Sb_2O_3, and selenides. In the meantime, the utilization of solid lubricant and the methods are applied to surfaces such as physical vapor deposition (PVD) are expanding. Expanding operating and increasing part temperatures are restricting the utilization of oil and grease to lubricate surfaces, prompting expanded usage of solid lubricant as a best option for lubrications. Solid lubricant that want to developed need have good characteristic tribological behaviors depends on part engineering used.

2.2 TRIBOLOGY

Tribology also known as rubbing in the science of substances. It includes organic, inorganic, machinery, and even the human body. Tribology deals with contacting surfaces under relative motion. Tribosystem composed of 3 bodies in contact (1, 2, 3). Body (3) becomes third body approach as lubricant in between body (1 and 2) and works in a specific condition (4) as shown as **Figure 2.1**.

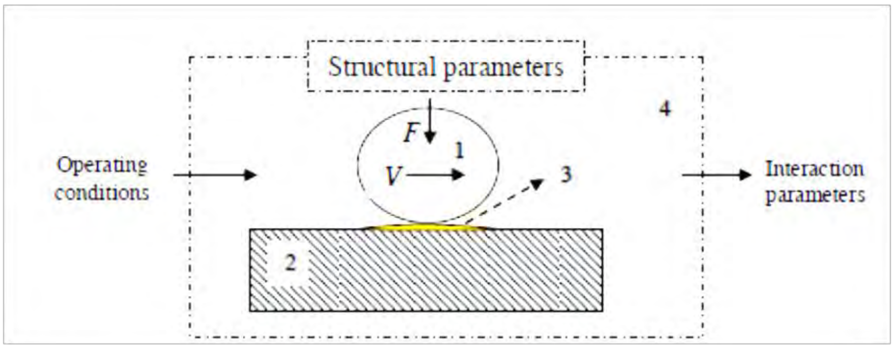


Figure 2.1:: Schematic illustrating a tribological system as a function of different parameters.(Source: Mahdiar Valefi, (2012))

In a tribosystem, operating parameters play an important role and include: normal force, sliding velocity, type of motion, contact time or sliding distance and temperature. The conditions strongly interact with the structural parameters of the tribosystem. These structural parameters are properties related to the mechanical and thermal behaviour of the material in the tribosystem and include: composition, roughness, elastic modulus, hardness and reactivity of the surfaces. Due to the operating conditions and structural parameters, the tribosystem leads to interaction parameters like: contact stresses, friction, heat generation, wear (D. Dowson, 1978).However, in this thesis only sliding speed are considered.

2.2.1 Friction

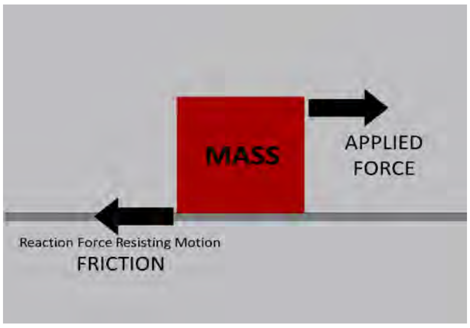


Figure 2.2 : Diagram shows relationship between applied load and friction (Source: www.gordonengland.co.uk)

The resistance to relative motion between a solid body and another solid body known as friction as shown in **Figure 2.2**. The friction force can be defined as the tangential force that takes place at the surface between two contacting bodies and is directed opposite to the relative velocity between those interacting bodies. The coefficient of friction (COF) is expressed as in Eq. (1) .

$$\mu = \frac{F}{W} \tag{1}$$

Where F is the frictional force and W is the applied load, both unit are in N.

2.2.2 Wear

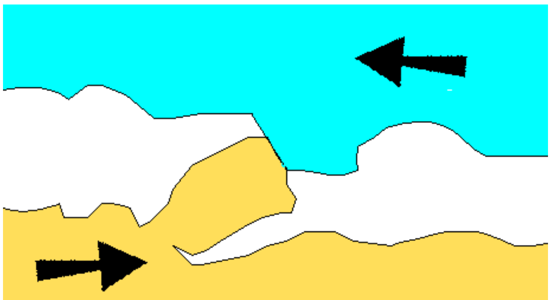


Figure 2.3: Mechanism of wear (Source:www.gordonengland.co.uk)

Wear is damage to a solid surface, usually cause by mass loss of material, due to relative motion between two surfaces as shown in **Figure 2.3** .The most common type of wear is adhesive wear which usually occur between contacting metallic, ceramic and composite materials. Studies of adhesive wear have been mainly based on empirical methods that rely on weight loss measurements and qualitative evaluation of surface damage by inverted microscopic. The wear volume and specific wear rate was determined based on Eq. (2, 3).

$$V_{loss} = \frac{mloss}{\rho} \quad (2)$$

$$k = \frac{Vloss}{WL} \quad (3)$$

Where

Vloss is the volume loss (mm^3)

mloss is the mass loss (g)

ρ is the bulk density (g/mm^3)

k is the specific wear rate (mm^3/Nmm)

W is the applied load (N)

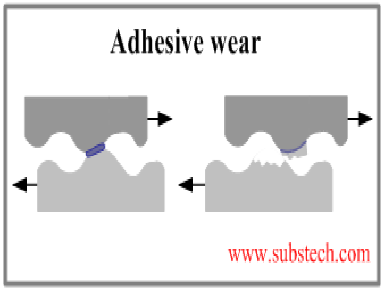
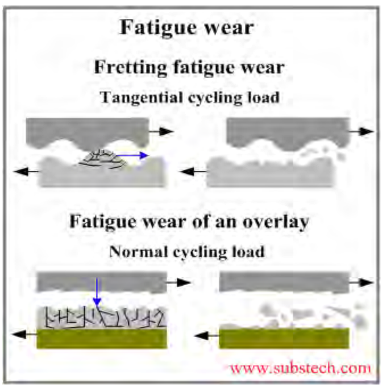
L is the sliding distance (mm)

2.2.3 Wear Mechanisms

Understanding of wear mechanisms is very important in order to design materials which are suitable for wear reduction. The following three basic wear mechanisms are: adhesive wear, abrasive wear, and fatigue wear as shown in **Table 2.1.** The main wear mechanism in ceramic tribopairs is microfracture when the load is beyond a threshold. While severe wear is associated with contact fracture, mild wear is associated with localized plastic flow and tribochemical wear. (Chang, Li and Klaus Friedrich, 2012)

Table 2.1: Mechanism of Adhesive, Abrasive and Fatigue Wear

(Source:www.substech.com)

	Adhesive wear is caused by the surface interaction and welding of the asperities junctions at the sliding contact. This wear mechanism is affected by the bonding type (ionic, covalent, metallic and van der Waals) in the contact junction.
	Abrasive wear is the removal of material when hard asperities or particles slide over/between two surfaces in relative motion. If a hard asperity or particle moves against a softer surface, the surface deforms plastically and grooves are produced in the surface. Accordingly, wear debris can be generated by microcutting.
	wear debris is generated by cyclic loading of the contact. Fatigue wear can be characterized by crack formation and flaking of surface material.