EFFECT OF SURFACE ROUGHNESS ON TRIBOLOGICAL PROPERTIES OF 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) with Hons"

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Laporan ini dikemukakan sebagai
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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"

Signature: ………………………………….

Author: AHMAD FARID BIN ZAINI

Date: …………………………...…………….

DEDICATION

This thesis is special

for

Dearest Dad and Mom

Mr Zaini bin Osman and Pn Hassiah Binti Osman

For they were the one who encourage me to finish this project

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In the name of Allah the Most Gracious, Most Merciful

Alhamdulillah, a very huge thanks for Allah, for he has guide me in choosing this project entitle “ Effect of surface roughness on tribological properties of PKAC-E composite”. He has also given me the strength and health to do this project from the start to the end. By putting my trust on him that I have gotten the courage and ideas to finnish this thesis.

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ABSTRAK

PKAC-E merupakan sejenis bahan kompaun komposit yang masih baru dan perlu dikaji dengan lebih mendalam. Kerana kebolehan pengunaannya didalam bidang pelincir pepejal, kajian mendalam mengenai ciri- ciri tribologinya adalah penting untuk memastikan ianya sesuai untuk fungsi tersebut. Untuk di terima sebagai pelincir pepejal yang baik, bahan ini haruslah mempunyai nilai daya geseran dan pekali kepada geseran yang rendah, iaitu 0.0 ke 20.0 N dan 0.05 ke 0.5 masing- masing. Nilai kehausan juga haruslah rendah. Untuk itu, sebuah eksperimen telah diatur untuk mengkaji kepelbagaian parameter untuk mengetahui kesan langsung perubahannya terhadap kadar haus dan daya geseran bahan tersebut. Untuk eksperimen ini, kekasaran permukaan bahan uji-kaji telah di pilih sebagai pemboleh-ubah yang dimanipulasi, manakala suhu, jarak geseran, beban dan halaju geseran. Perkadaran kompaun PKAC-E ialah PKAC wt70%, Resin wt25% dan pengeras wt5%. Banchuhan kompaun kemudiaannya di kenakan daya tekanan sebanyak 2.5 Mpa pada suhu 80^0C mengunakan mesin ujian hidraulik bermotor. Permukaan pin kemudiannya di gosok untuk mendapatkan kekasaran yang diinginkan iaitu 1.0, 1.5, 2.0, 2.5, and 3.0 µm. spesimen kemudiannya di uji di atas “pin- on- disc tribometer”. Hasil ujikaji telah mendapatkan nilai daya geseran dan pekali kepada geseran. Dari keputusan itu nilai kehausan dan kadar kehausan dapat dicari.

ABSTRACT

PKAC-E is a relatively new composite material that still needed to be study. Due to its possible application in the dry lubrication, the study of its tribology properties is important to ensure that it is suitable for that function. To be considered ad a good dry lubricant, this material must have very low friction and coefficient of friction value of approximately 0.0 N to 20.0 N and 0.05 to 0.5 respectively. Wear rate for the material must also be relatively low. To study the required properties an experiment have been conducted with different variable perimeter to determine each direct effect toward the wear and friction of the material. For this particular experiment, surface roughness of the material had been decided to be the variable while keeping the temperature, Sliding distance, load, and sliding speed as a constant. The compound ratio consist of PKAC wt70%, Resin wt25% and Hardener wt5%. the compound was made by using Motorise hydraulic test machine at 2.5 Mpa for 80^0C temperature. To obtain different surface roughness, the surface was rubbed against polishing machine to get variation of 1.0, 1.5, 2.0, 2.5, and 3.0 µm. Before conducting the experiment, the speciment of PKAC-E needed to be prepared. The specimen was then tested on a Pin-on Disc tribometer. The result taken from the setup was friction and coefficient of friction. From that, the value of wear rate and wear volume was calculated by using suitable correlation

TABLE OF CONTENT

CHAPTER	TOPIC			PAGE

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL

V_i	= Wear Volume, m^3
$F = F_N = W$	= Normal Load, N
$S = L$	= Sliding Distance, m
$k_i = K$	= Specific Wear Rate Coefficient, m^2/N or m^3/Nm
F_f	= Frictional Force, N
μ	= Coefficient of friction
V_{loss}	= Volume loss, mm^3
M_{loss}	= Mass Loss, g
P	= Density, g/mm^3

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Composite material fabrications have been one of the most rapidly growing industries. Many type of composite material can be made to increase the physical properties of an original material, thus allowing each material to have its own special characteristic. In the field of tribology study, different situation call for different measure. For example, some material needed a high coefficient of friction properties to work (e.g , Break shoe) while other material needed material with low coefficient of friction (e g, piston cylinder).

Carbon fiber reinforced carbon- matrix composite is among the most study field in material engineering. Their properties of high- tensile strength is the most look characteristic, In the material manufacturing field. Moreover, this kind of composite is known to have high thermal conductivities and low coefficient of friction. Therefore, even if the material is relatively pricy, it is an opportunity for engineer to discover more about this composite material as it is a promising field.

Palm kernel is a one of biomass waste after the extraction of oil palm. All over the world, Malaysia is among the leading country in the palm oil industries. Recently, there is new study conducted by local university to find a good use for the waste. The study is about activated carbon obtained from the burning of palm kernel. This carbon known as palm kernel activated carbon has been studied to discover its physical properties as lubricant.

1.2 PROBLEM STATEMENT

Palm tree is planted at large scale in Malaysia and having production life spend of up to 20 to 30 years before it need to be cut down. However, after the processes the stalk is being left to rotten. For quite some time, researchers have testing different kind of solid lubricant material to reinforce and coating material for tribological application. (Erdemir et al., 2000; Heimberg et al., 2001; Tokoroyama et al., 2006; Liu et al., 2009; Baradeswaran, 2011; Abdollah et al., 2012; Masripan et al., 2013). By burning the palm kernel, activated carbon material can be produce, a type of carbon that has self lubricating properties. This experiment is done to understand the effect of surface roughness of the material to the wear rate and coefficient of friction of the PKAC-E material under un-lubricated condition.

1.3 OBJECTIVE

The study is done to fulfill the objective which is:

1) To study the Palm Kernel Activated Carbon material as a possible dry lubricant.

2) To investigate the effect of surface roughness on friction and ware behaviors of Palm Kernel activated carbon - mix with epoxy (PKAC-E) composite under un-lubricated condition.

1.4 SCOPE OF STUDY

1) Using Palm Kernel activated carbon - mix with epoxy (PKAC-E) as material of the specimen.
2) Two parameter that need to be observe is wear rate and friction of coefficient.
3) Both parameters is to be investigate under different surface roughness of material PKAC-E.
4) The PKAC-E specimen form to cylindrical shape using compacting method.
5) Experiment on tribology behavior of the material is conduct using Pin-on-disc tribometer under dry-sliding condition.

CHAPTER 2

LITERATURE REVIEW

2.1 SOLID LUBRICATION

Solid lubrication or dry lubrication is a lubrication obtained from material that is in a solid form. Despite it being in the solid form it has the ability to reduce the coefficient of friction and ware between two moving surfaces of material. Commonly used in the form of powder or a thin layer of film. This lubrication was able to slides in-between two colliding surface without the need of liquid as a medium. Dry lubricant often used on the application at a higher temperature at which liquid lubricant unable to operate perfectly (Lancaster,1973).

There were four most common solid lubricants in use which were graphite, molybdenum disulfide (MoS_2), Hexagonal boron nitride, and tungsten disulfide. Each lubricant operates on different functions. The most commonly used is graphite and Molybdenum Disulfide (MoS_2).

Graphite is a polycyclic carbon atom plane composed to each other and in hexagonal orientation.

Due to the longer distance between planes, the bonding between planes is weaker. Thus making it easier for the bond to break, when minimal force is apply. This ability gives it the low friction properties.

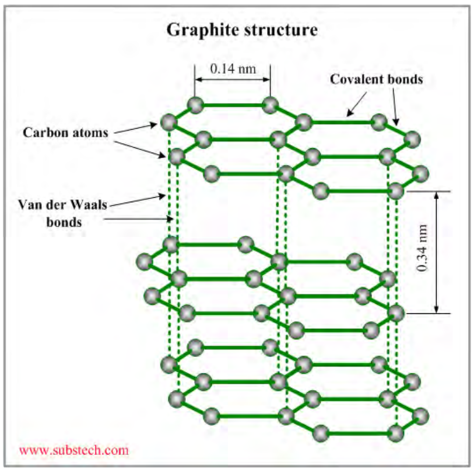

Figure 2.1 : Graphite structure (source http://www.subtech.com)

2.1.1 Aplication of Dry Lubricant on Material

There were several method that can be use in order to apply the lubricant to a material. Different lubricant uses different method of application. There are lubricant mixed with solvent to produce paste like substance which can be smeared on a surface, other lubricant have to be mixed with certain polymer to produce a self- lubricating composite, lubricant such as Teflon (PTFE), Graphite and Molybdenum disulphate (MoS_2). There's also anti friction coating, where a material which have good mechanical properties but poor tribological properties, uses dry lubricant coating to enhance it tribological properties,(baradeswaran, et al, 2014). Such material were aluminum which posses high strength to weight ratio, and stiffness but have poor resistance to wear.

2.2 OIL PALM KERNEL

Oil palm is a worldwide industry which being produce in 42 countries. Covering around 27 million acres. For each acre it is estimated that average of 10,000 lbs/ acre. The industry is expanding vastly over the past few decades.

Table 2.1: Palm Oil production in the world

Top 10 Countries in the production of palm oil		
	Country	Palm production, Metric Ton
1)	**Indonesia**	31,000,000
2)	**Malaysia**	19,200,00
3)	**Thailand**	2,100,000
4)	**Colombia**	1,000,000
5)	**Nigeria**	930,000
6)	**Papua New Guinea**	630,000
7)	**Ecuador**	565,000
8)	**Honduras**	430,000
9)	**Cote D'Ivoire**	400,000
10)	**Brazil**	340,000

From the table, Malaysia is among the world top palm oil producer even though it is only a small country. This shows that the abundance of oil palm which will produce large quantity of biomass after the extraction of palm oil. One example of the biomass is the oil palm kernel (endocarp). The oil palm kernel can be reuse in an activated carbon production.

Figure 2.2: Palm Kernel Shell (source from http://envirocarbon.com.my)

Figure 2.3: Palm Shell Charcoal (source from http://envirocarbon.com.my)

2.3 WEAR IN SOLID MATERIALS

In tribology field of study, wear properties is among the most important thing to be considered to choose a lubrication. Wear in material is commonly caused by the displacement between two surface materials caused by the action of one surface to the other. The mechanism of sliding will result in few type of wear: (i) abrasive wear – occur between two material of different hardness. (ii) Adhesive wear- when two body collided, there were micro-welding form on the opposing asperities of the two counter body, when motion is applied the micro-welding will rupture. (iii) Fatigue wear- fatigue between surface occur when the fatigue strength exceeding the applied load. (iv) Corrosive wear- Occur due to the oxidation on the surface of contact, the oxidation result in corrosion when two surfaces collided. (v) Erosive wear- caused by impingement of outside particles which upon application of momentum, removing fragments of the material.

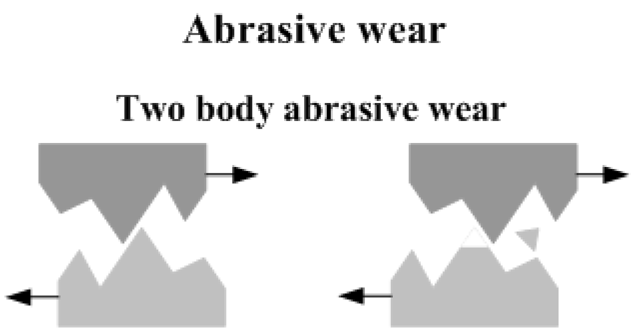

Figure 2.4: Mechanism of abrasive wear between two body (source http://www.subtech.com)

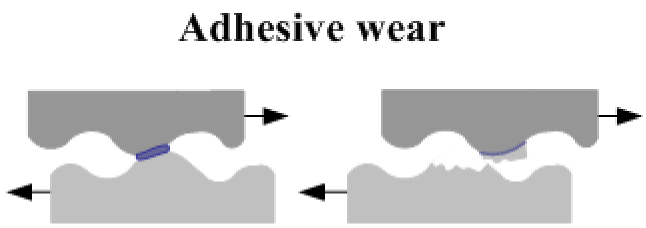

Figure 2.5: Mechanism of Adhesive Wear (source http://www.subtech.com)

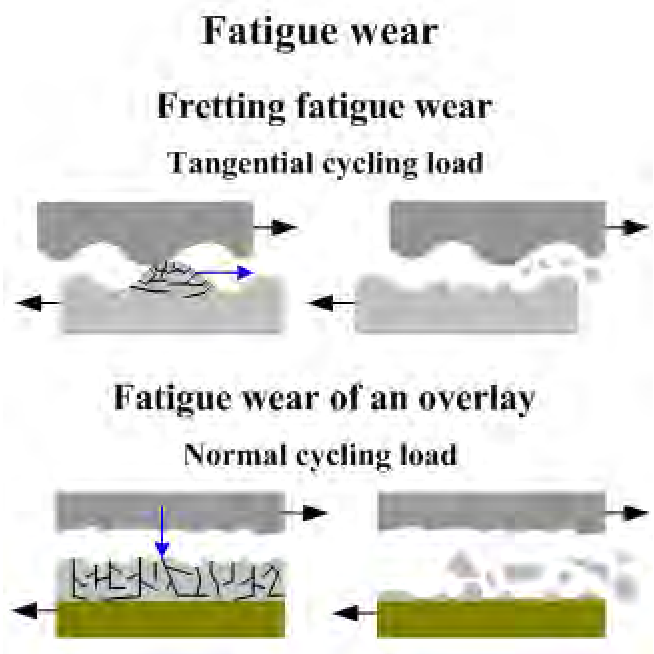

Figure 2.6: Mechanism of Fatigue wear (source http://www.subtech.com)

All the type of wear will cause one of two results: (i) the constant friction between two surfaces will produce a thin layer on the surface area in contact which will break off, producing debris; (ii) the thin layer could also fracture thus producing flake like debris.

In the first result, when two surfaces is in contact due to application of motion, the asperity junction (the real surface area on contact) has a concentrated loading on each of its peak, this will result in increasing stress thus inducing plastic deformation on the area, upon several repeated sliding the bond between asperity would break of into small debris.

2.4 WEAR RATE

Even though wear mechanism is inevitable between two colliding material, there were ways to reduce it effect by controlling the wear rate. Wear rate can be defined as the rate of wear of a material on an applied load for a certain distance (Archard's wear equation).

$$V_i = k_i F s$$

Where:

V_i = Wear volume, m^3

F = normal load, N

s = sliding distance, m

k_i = Specific wear rate coefficient, m^2/N or m^3/Nm