EFFECT OF SLIDING SPEED ON TRIBOLOGICAL PROPERTIES OF ELEVATED TEMPERATURE PALM KERNEL ACTIVATED-EPOXY COMPOSITE (PKAC-E)

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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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ABSTRACT

Palm kernel activated carbon (PKAC) give a new light as a new raw material use as lubricant. Palm kernel activated carbon epoxy composite as a new solid lubricant used in industry. There is less research how the PKAC-E can with stand the effect as a lubricant. Tribology test were carried out to achieve a new data of PKAC-E composite. Friction and wear test will determine how good PKAC-E composite to be use in industry. This research focus on effect of sliding speed on tribological properties of elevated temperature PKAC-E composite by using Pin-on-Disk laboratory. At high temperature how the PKAC-E composite will react to the different of speed as solid lubricant. The specimen of PKAC-E formed as cylinder pin using mold provided using compacting technique. The Tribology test carried out using Pin-On-Disk laboratory experiment with constant load, constant distance travel and constant high temperature (140^{o}C) with varying sliding speed. The surface morphology observed in order to know the effect on both specimen and disk under inverted microscope. From the research, Palm Kernel Activated Carbon-Epoxy (PKAC-E) gives new composite properties that has low coefficient of friction and wear rate. As the experiment done, PKACE-E composite give the new light in the industry as the composite that can be used as new solid lubricant.

ABSTRAK

Karbon teraktif kelapa sawit (PKAC) memberikan cahaya baru sebagai bahan mentah yang bole digunakan sebagai pelincir. Karbon teraktif kelapa sawit sebagai salah satu pelincir pepejal yang baru dan boleh digunakan dalam industri. Penyelidikan terhadap komposit daripada karbon teraktif kelapa sawit sebagai pelincir yang baru masih kurang. Ujian Tribologi telah dijalankan untuk mencapai data baru PKAC-E. Ujian geseran dan hausan akan menentukan samada karbon teraktif kelapa sawit sesuai untuk digunakan dalam industri. Fokus penyelidikan ini adalah untuk mengesan sifat tribology terhadap karbon teraktif kelapa sawit pada suhu tinggi mengunakan kelajuan yang berbeza menggunakan "Pin-on-Disk". Sebagai pelincir pepejal bagaimana karbon teraktif kelapa sawit bertindak balas terhadap kelajuan akan di bincangkan. Komposit karbon teraktif kelapa sawit dibentuk menggunakan bekas yang disediakan menggunakan teknik pemandatan. Ujian Tribology dijalankan mengunakan peralatan makmal iaitu Pin-On-Disk dengan beban, jarak gelonsoran dan suhu tinggi (140^{o}C) yang dimalarkan, manakala kelajuan gelosonran yang berbeza. Morfologi permukaan dilihat bagi mengetahui kesan yang terjadi pada sampel dan disk menggunakan mikroskope berbalik. Hasil kajian, Palm Kernel Activated Carbon-Epoxy (PKAC-E) memberi sifat komposit baru yang mempunyai pekali geseran dan kadar haus yang rendah. Melalui kajian ini, PKAC-E komposit memberi cahaya baru dalam industri sebagai pelincir pepejal baru yang boleh digunakan.

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LIST OF SYMBOL

μm	=	Micrometer
nm	=	Nanometer
μ	=	Coefficient of Friction
F	=	Tangential Force Exerted by Friction
W	=	Normal force exerted between the surface normally weight
w	=	Wear rate
K	=	Wear coefficient
d	=	Sliding distance
p	=	Applied load
H	=	Bulk hardness
V_{loss}	=	Volume loss
m_{loss}	=	Mass loss
ρ	=	Bulk density of material
k	=	Specific wear rate
L	=	Sliding distance
mm^3	=	Millimeter cubic
g	=	Gram
ºC	=	Degree Celsius
v	=	Velocity
r	=	Radius
f	=	Frequency
ω	=	Angular Momentum

LIST OF ABBREVIATION

EDP	-	Electronic Data Processing
PKAC-E	-	Palm Kernel Activated Carbon-Epoxy
RSPO	-	Roundtable on Sustainable Palm Oil
POME	-	Palm oil mill effluent
AC	-	Activated carbon
PKAC	-	Palm Kernel Activated Carbon
PTFE	-	Polytetraflouroethylene
MoS_2	-	Molybdenum disulfide
ASTM	-	American Society for Testing and Material
POD		Pin-On-Disk

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

In this chapter, a brief explanation about tribology and composite material will be explained. This chapter also discussed about problem statement, objectives and scope of the study for the research project.

1.1 TRIBOLOGY

Tribology is the science and technology of interacting surface in relative motion. It includes the study and application of the principle of friction, wear and lubrication. Tribology is a branch of mechanical engineering and material science. Tribology effect take place when there are two surfaces touching each other, thus produce a friction. In this condition applied, when the friction occurs, the process may result in loss of material while touching each other, this known as wear. Rudolf Hillebrand (2005) state,

depth knowledge in the field of tribology will provide benefits in energy and material consumption, production and maintenance. Energy and raw material resources can be saved, environmental damage is avoided and worker protection is improved. The application of tribology to technology comprises all fields of the development, construction, fabrication and maintenance of mechanical motion systems in different branches of industry and sectors of the economy such as mechanical engineering, production engineering, motive power engineering and materials-handling technology, automotive and motor industry, rail vehicle technology, aeronautics and space operations, basic industry, structural engineering, precision mechanics, power supply, EDP technology and medical technology .

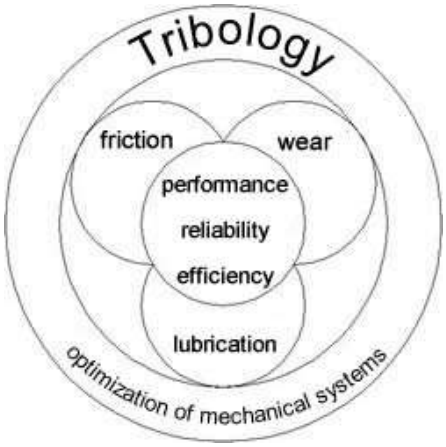

Figure 1.1: Tribological Aspect

The purpose of the research in tribology is to minimize and remove losses that occur due to friction and wear at all levels, where rubbing, grinding, polishing and cleaning of surface take place. Tribological parameters include surface roughness, mechanisms of adhesion, friction and wear, and physical and chemical interactions of lubricants. Interacting surfaces must be understood for optimal function and long-term reliability of components and devices and economic capability. Under basic understanding of the nature and consequences of materials interaction, the atomic and molecular with sizes are in the range of μm or nm. Tribological techniques that are equipment and methods were designed for testing on those small scales represent a growing area. Using this method a certain material can be tested, thus make show the ability of the material itself.

1.2 COMPOSITE MATERIAL

Nowadays, industrial activities make a very high improvement, thus resulted in developing new multinational material that poses unique combination properties. However, convectional engineering are unable to meet this requirement of such special combination of properties such as high coupled with low density. This paved way for the emergence of the new class engineering material known as composites.

A composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other (Royal Society of Chemistry, 2014). There are some properties that can be improves by forming a composite material such as strength, stiffness, corrosion resistance, wear resistance, weight, fatigue life, thermal insulation, thermal conductivity, insulation and attractiveness.

According to Robert M. Jones (1998) there are four commonly accepted type of composite material that are fibrous composite, laminate composite, particulate composite and combination of some or all the first three.

1.3 PROBLEM STATEMENT

Palm kernel shell, is an abundant tropical waste from palm oil processing mills in tropical countries like Malaysia and Thailand. They either treat the waste by disposing it or use it as fuel. To economically utilize these agricultural by-products, it proposed to use them as prospective starting materials for the preparation of activated carbon. For the past few years a number of studies have been conducted on the preparation of activated carbon from palm kernel shells.

However, so far there is no research has been done on application of palm kernel shell base activated carbon as a material to withstand the effect of Tribological of the

material. The present work was devoted to study kernel shell based activated carbon as the material in based on wear and friction of the material.

1.4 OBJECTIVE

To investigate the effect of sliding speed on friction and wear behavior of Palm Kernel Activated Carbon-Epoxy (PKAC-E) composite under elevated temperature condition.

1.5 SCOPE OF STUDY

i. Friction and wear behavior of PKAC-E composite is to be investigating under different sliding speed at constant elevated temperature condition.
ii. PKAC-E specimen will be form to cylindrical shape by compacting technique under constant pressure.
iii. Tribological behavior test will be carried out by using Pin-On-Disc tribometer in dry sliding condition by applying constant high temperature at different sliding speed.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter will give an explanation through the fundamental that used to successfully and meet the objective of this research. The main topic that include and elaborated in this chapter focusing more on Palm Kernel activated carbon, tribology properties, friction, wear, solid lubricant and other knowledge that corresponding to the experimental method.

2.1 THE PALM OIL

According (Where is palm oil grown? ,2014) to Roundtable on Sustainable Palm Oil (RSPO) ,Malaysia holds the second place as top production of palm oil from Januarys to December 2013. As stated 19.2 million tons of palm oil was produced in Malaysia. As a larger manufacturer, there will be a certain impact on environment. P.B. Elham.(2001)in his previous research state this industry will create a number by-product and residue. The main excess from the milling of the fruit bunches are the mesocarp fiber, shell kernel cake, boiler ash, empty fruit bunches, palm oil mill effluent (POME) and bunch ash.

The biomass oil palm can be reuse by adding the additive that will produce good value added product. As example, palm kernel shell can be used to produce activated carbon.

2.1.1 Activated Carbon

Activated carbon (AC) is a member of a family of carbon ranging from carbon black to nuclear graphite, form carbon fibers and composites to electrode graphite and many more (Marsh, H et al, 2006). Activated carbon forms large and important classes of porous solids, which have create a wide range of industrial applications. As a consequence, the porous structures of these materials and their adsorption of gases, vapors, and liquids have been broadly studied (N.A.B. Jabit., 2007). It is outside the scope of this contribution to consider in detail the very many industrial applications and processes that employ activated carbon.

Activated carbons have been described in different way of meaning from several authors and this will provide a basis understanding of activated carbons as solid carbon materials. The fine structure of activated carbons gives the surface forces in pores that provide the powerful adsorptive properties of activated carbons. Z.N.B.M.Salleh.(2010) state that activated carbon can be prepared from a large number of raw materials, especially agro-industrial by-products like palm kernel shells by one of the following process; physical reactivation and chemical activation. Palm kernel activated carbon (PKAC) is one of the products from agro industrial.

2.3 TRIBOLOGY

According to You-Bai (2011), "Tribology" was defined as one of the four major discipline of Mechanical System by a committee of the NSF of US in 1983 (The Panel Steering Committee for the Mechanical Engineering and Applied Mechanic Division of the NSF, 1984) and then the "Journal of Lubrication Technology" was rename as "Journal of Tribology" of Transaction of SME. There are three problem occur in development of tribology itself. Firstly many know tribology as the friction, wear and lubrication only, but the different of the friction, wear and lubrication is not investigated yet. Secondly tribology is important in engineering and industry, thus the technique developing in tribology is increasing but it only can be used to a certain application only. Thirdly is the data from the tribology itself, where people can't relate the data from other tribology test thus make the development in calculating and differentiate the data from different resource of tribology hard to be performed.

Without system there would be no tribology (You Bai, 2011). When there is a system there will be a motion, this motion including the moving of the part. When the part is moving there are conditions where the two part touch each other by mean two

surfaces touching each other in motion. The interaction of the surface called relative motion of surface.

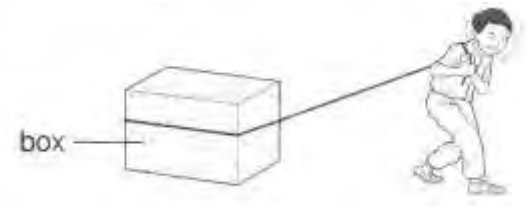

Figure 2.1: Pulling a box (Simple Mechanism)

For example, as shows in Figure 2.1 there is a kinematic motion occurs. Assume the boy as the power source in this system. When the boy is start pulling the box, there surface contact between the outer surface of the box and floor. This kind motion will create the friction and wear. The interacting between two surfaces in relative motion will be resulted for behavior and technology related to tribology system constructed. Nowadays, most relative motion system to reduce friction and wear related to liquid, gas or fat lubricant that interacting between to surface.

Tribology science and technology is very important in getting the best way (theory and application) to complete the motion function of tribo-systems. Tribology exists universally. Where there is relative motion there is tribology. Tribo-systems play sometimes very critical roles in machine systems and work sometimes under extreme condition. It hint that the motion guarantee function must be put into use with high reliability, low energy use, low cost, low pollution, and human and environment friendship (You Bai, 2011).

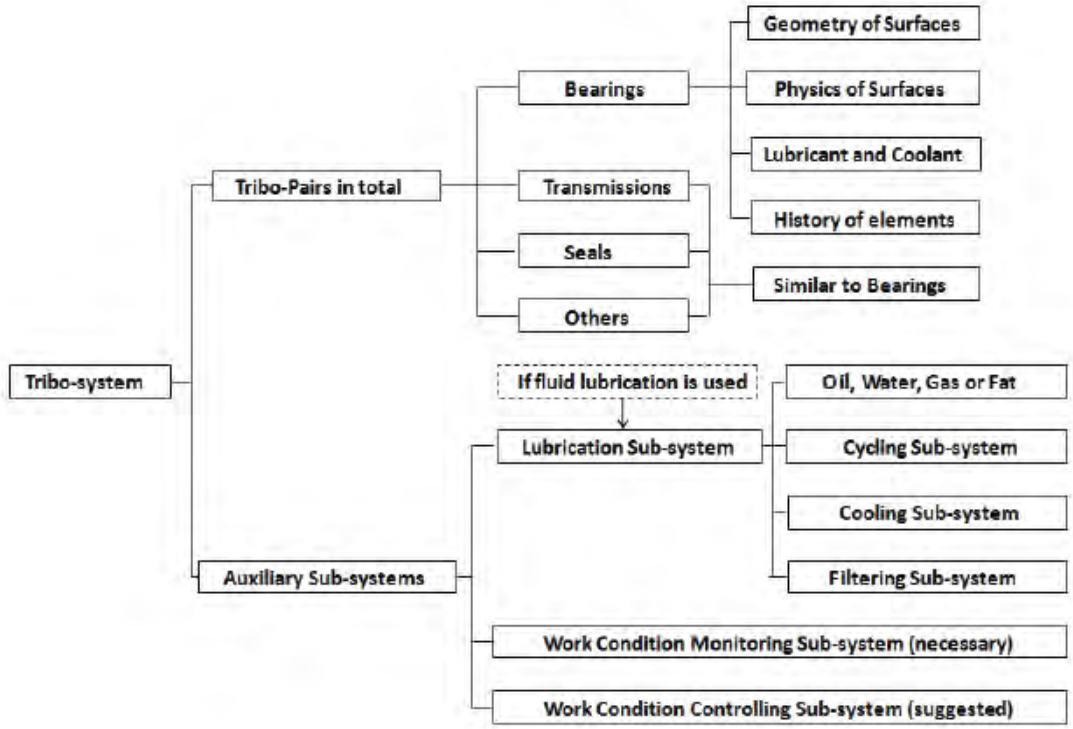

Figure 2.2: The block diagram of typical Tribology System (You Bai, 2011)

2.4 FRICTION

According to J. Claret.Tournier.(2007) the force known as Friction may defined as the resistance encounter by one body in moving over another. Friction force always exerted in opposite site to the movement between two surfaces of contact. There are two types of friction that is static friction and kinetics friction. Similar to meaning of the word static friction mean the two bodies are not moving relatively to each other. It responds to the beginning force to get an object moving (J. Claret.Tournier.2007). Rolling friction classified under static friction.

Kinetic friction occurs when two object or surface moving to each other and touch each other. Sliding and fluid friction is classified as kinetic friction because the force corresponds to keep the motion at constant speed. As comparison, less force required to overcome rolling friction than sliding friction. Solid friction coefficient is high when no lubrication applied to the surface. Example for kinetic and static friction shows in the figure.

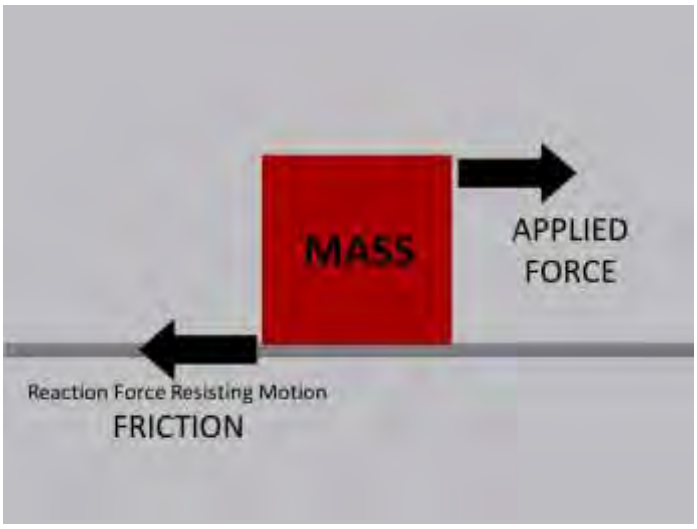

Figure 2.3: Sliding Friction (9.2: Friction and Traction., 2012)

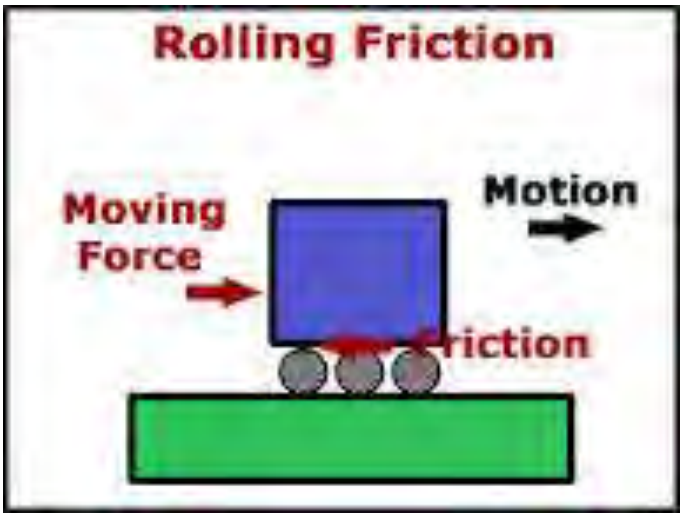

Figure 2.4: (Dynamic friction, 2013)