TRIBOLOGICAL PERFORMANCE OF HYBRID COMPOSITES BASED ON PALM OIL FIBRES AND ALUMINA POWDER BLEND

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DECLARATION

I declare that this project report entitled “Tribological Performance of Hybrid Composites Based on Palm Oil Fibres and Alumina Powder Blend” is the result of my own work 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 : …………………………………...

Date : ..………………………………….

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.

Signature	:	…………………………………...
Supervisor's Name	:	…………………………………...
Date	:	..………………………………….

DEDICATION

To my beloved father, mother and brother.

ABSTRACT

Nowadays, the green technology is important and expected due to global warming threaten. The usage of agricultural waste product in industry manufacturing process is increased and more environmental friendly. The production of hybrid composites based on palm oil fibres from agriculture waste and alumina powder blend is considered as the substitution of materials which have large potential towards zero waste strategy as well as the composites can provide the better properties compared to one of material alone. The absent of hybrid composite which can provide high friction with low wear rate ability without using the lubricant is being focused due to low wear rate can extend the lifespan of tools. Thus, literature study on hybrid composites and applications has an enormous potential to explore the benefits of hybrid composites. The objectives of this project research were included the determination of the optimal composition ratio and investigation of tribological properties of hybrid composites based on palm oil fibres and alumina powder blend. The comparison of tribological properties in terms of coefficient of friction and specific wear rate is conducted in between hybrid composites and conventional composite, SK-2 carbon steel disc. The composition of specimen is focused in three categories such as 50 wt.%, 60 wt.% and 70 wt.% of composite reinforced with 50 wt.%, 40wt% and 30 wt.% of epoxy respectively. The physical-mechanical properties of specimen are determined using the physical testing and followed by carry out tribological testing using ball-on-disc tribometer where the testing parameters are set with 400rpm sliding speed, 49.05N applied load and 3000m sliding distance to investigate the tribological performance of hybrid composite. Then, the manual calculation is performed to determine the specific wear rate of specimens while the wear morphology of the specimens is studied through the optical micrographs of worn surface which is captured using 3D non-contact profilometer. The collected data were analysed through qualitative and quantitative approaches. From the study, the optimal composition ratio with 35 wt.% of palm oil fibres, 35 wt.% of alumina powder and 30 wt.% of epoxy is obtained for the hybrid composite with high friction and low wear rate in tribological properties.

ABSTRAK

Teknologi hijau ialah teknologi yang penting pada masa kini dan ini disebabkan oleh ancaman pemanasan global yang nyata. Penggunaan produk sisa pertanian dalam proses pembuatan industri semakin meningkat dan penggunaan ini adalah mesra alam sekitar. Pembuatan komposit hibrid berasaskan campuran serat minyak kelapa sawit daripada sisa pertanian dan serbuk alumina boleh dianggapkan sebagai penggantian bahan yang mempunyai potensi yang tinggi untuk menghapuskan sisa pertanian. Komposit hibrid dapat memberikan sifat-sifat yang lebih baik berbanding dengan komposit yang terdiri daripada satu jenis bahan sahaja. Kekurangan komposit hibrid yang mempunyai pretasi tribologi dengan geseran yang tinggi dan kadar haus yang rendah tanpa menggunkan pelincir adalah topic yang diberikan tumpuan kerana kadar haus yang rendah dapat memperpanjangkan tempoh umur alat. Oleh demikian, kajian kesusasteraan mengenai komposit hibrid dan aplikasinya teleh dijalankan, ia mempunyai potensi yang tinggi untuk memberi peluang dalam penerokaan manfaat yang diberikan oleh komposit hibrid. Objektif penyelidikan projek ini termasuklah menjalankan kajian mengenai nisbah komposisi yang optimum dan sifat-sifat tribologi dalam komposit hibrid berasaskan campuran serat minyak kelapa sawit dan serbuk alumina. Perbandingan sifat-sifat tribologi antara komposit hibrid dan komposit konvensional, cakera keluli karbon SK-2 pun telah dijalankan. Komposisi yang digunakan dalam pembuatan spesimen telah difokuskan dalam tiga kategori, iaitu 50 peratus berat komposit dengan 50 peratus berat epoksi, 60 peratus berat komposit dengan 40 peratus berat epoksi dan 70 peratus berat dengan 30 peratus berat epoksi. Ujian fizikal dijalankan untuk mengkaji sifat-sifat fizikal dan mekanikal dalam komposit hibrid manakala ujian tribologi yang menggunakan "ball-on-disc" dijalankan dengan parameter yang ditetapkan dengan kelajuan 400rpm, beban ujian sebanyak 49.05N dan jarak jauh 3000m untuk mengkaji prestasi tribologi bagi komposit hibrid. Pengiraan manual dijalankan untuk menggira kadar haus spesifik bagi komposit hibrid manakala kajian morfologi bagi permukaan spesimen dijalankan dengan menggunakan "3D non-contact profilometer". Data yang dikumpulkan dalam kajian telah dianalisiskan dengan kaedah kualitatif dan kuantitatif. Nisbah komposisi yang optimum bagi komposit hibrid ialah 35 peratus berat serat minyak kelapa sawit, 35 peratus berat serbuk alumina dan 30 peratus berat epoksi, ia mempunyai geseran ynag tinggi dan kadar haus yang rendah dalam prestasi tribologi.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF EQUATIONS

Equation 4.1	-	$D = 2\pi(r)(N)(t)$
Equation 4.2	-	$COF = \frac{Friction\ force\ (N)}{Normal\ force\ (N)}$
Equation 4.3	-	$V = \pi r^2 T$
Equation 4.4	-	$\rho = \frac{M_a}{V}$
Equation 4.5	-	$M_{loss} = M_b - M_a$
Equation 4.6	-	$V_{loss} = \frac{M_{loss}}{\rho}$
Equation 4.7	-	$k = \frac{V_{loss}}{W \times D}$

LIST OF ABBREVIATIONS AND SYMBOLS

COF	-	Coefficient of Friction
°C	-	Degree Celsius
ρ	-	Density of specimen
W	-	Load applied
µm	-	Micro-meter
nm	-	Nano-meter
N	-	Newton
POF	-	Palm Oil Fibre
Pa	-	Pascal
r	-	Radius of specimen
RPM	-	Rotation per Minutes
D	-	Sliding distance
k	-	Specific wear rate
Ra	-	Surface Roughness
T	-	Thickness of specimen
t	-	Time
wt.%	-	Weight Percent

CHAPTER 1

INTRODUCTION

1.1 Background

Hybrid composite is a mixture of two different material at various composition ratio. Hybrid composites have generated the significant interest for a researcher since the 1970s. The percentage difference or composition ratio in hybrid composite is directly affected the performance of composite (Harris, 2003). The important criteria for the effective use of hybrid composite are related to life durability. Thus, the method of combine two or more types of varied materials to develop the new types of hybrid composites and the hybrid composites are found the widest application use to the present time. The hybrid composites have the high probability to create the new tribological properties after combination (Shalin, 1995).

In this project, the hybrid composite based on palm oil fibres and alumina powder blend is used to test in term of tribological performance. The palm oil fibres are classified as the natural fibre and the natural fibre polymer composites have numerous application in almost all field of engineering (Chand, 2008). The advantages of using natural fibres compared to synthetic fibres include low cost with their low density, good relative mechanical properties and less damage of tool wear in machining operations. Thus, the palm oil fibre is useful and shown an enormous potential as a reinforcing material because our country, Malaysia is the plantation base for palm oil and the material can be obtained easily compared to other fibre (Mohanty, 2005). The alumina powder blend or it can be called as aluminium oxide is commonly used in engineering processes. Due to the desired properties of alumina powder composites, such as low weight and high specific strength, they have received a great interest in the recent years in engineering industry. Among the ceramic reinforced materials, alumina powder is the second most used in metal matrix composites due to the better corrosion and elevated temperature resistance in performance when compared to silicon carbide material (Rahimian, 2011).

There is increased awareness about the properties of natural fibre-based hybrid composite to meet the engineering requirements (Mittal, 2016). The natural fibre-based hybrid composite will be able to be classified as a suitable material in manufacturing of engineering product with maximum usage of natural fibres. In this project, the study is focused on the tribological performance of hybrid composite which is based on palm oil fibres and alumina powder blend in term of wear rate and coefficient of friction analysis by using ball-on-disk tribometer, hence to provide the optimal composition ratio for hybrid composite which is having the superior tribological performance with high friction and low wear rate.

1.2 Problem Statement

The demand of searching the suitable material or hybrid composites which can be operated in machine parts without using the liquid lubricant as a medium to increase the wear performance of the composites. The absent of hybrid composite which can meet the requirement of high friction and low wear rate in the automotive industry is being focused, due to the expected hybrid composites are environmental-friendly which can be targeted as reducing waste instead of replacing with new one after a short lifespan. In general, the research in creating the more efficient hybrid composite in term of wear performances can lead to determine the solution in overcoming these problems. The hybrid composite with efficient tribological performance is highly demanded in automotive industry, the high friction, high temperature resistance and low wear loss hybrid composite is suitable to be used as manufacturing material for bearing or brake pad in automotive parts to replace the conventional materials. Thus, the study in tribological performance of hybrid composite is important and it will be an interesting topic by using the ball-on-disk tribometer.

1.3 Objective

The objectives of this project are as follows:

a. To determine the optimal composition ratio of hybrid composite based on palm oil fibres and alumina powder blend with high friction and low wear rate.
b. To investigate the tribological properties of the hybrid composite based on palm oil fibres and alumina powder blend.
c. To compare the tribological performance of hybrid composites with conventional composite, SK-2 carbon steel disc.

1.4 Project Scope

The project research is limited to the study of tribological performance of hybrid composites based on palm oil fibres and alumina powder blend which is focused in wear friction and wear rate of the hybrid composite. Hence, the tribological testing in this project is carried out using the parameters as stated as below:

a. Materials: Palm Oil Fibres, Alumina Powder Blend and Epoxy
b. Materials composition:
    - 50 wt..% of composite and 50 wt.% of epoxy
    - 60 wt.% of composite and 40 wt.% of epoxy
    - 70 wt.% of composite and 30 wt.% of epoxy
c. Machine: Ball-on-disk Tribometer

d. Load applied: 49.05N

e. Sliding speed: 400rpm

f. Sliding distance: 3000m

g. Sliding temperature: Room temperature

h. Sliding condition: Dry sliding

i. Surface roughness: 0.2µm – 0.8µm

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is discussed the literature review for project title keywords based on previous research or reference from books. In this chapter, the selected keywords such as tribological performance, hybrid composites, palm oil fibres and alumina powder blend are used for further discussion. The purpose of literature review is to provide background information on the issues to be considered in this project and to emphasize the relevance of the present study. The wide range of explanation in details are important to provide the sufficient of information before the experiment is conducted to test the tribological performance of hybrid composites.

2.2 Tribological Performance

Tribological performance is an important term in tribology which is included the study of friction, lubrication and wear of the materials. The tribological performance is a significant parameter for hybrid composites and it can be tested by using pin/ball-on-disc tribometer. Thus, the terms of friction and wear will be studied in tribological testing because this criterion can differentiate the usage of hybrid composites in industry or real-life application. Stachowiak (2005) states that the tribological process is a contact process where two surfaces are in relative motion and it involves the friction, wear and deformation mechanisms at different scale levels and of different types. The study of tribological performance is significant in engineering fields where it allows the researcher to explore the tribological properties of material or composite, hence the research can provide the improvement to reduce the friction and wear in machine.

In tribological performance, the friction term of material is important in tribology can be defined as the resistant force to the relative motion of two solid surfaces or fluid layers. Neglecting the wear processes in tribology, friction rises from the transfer of collective translational kinetic energy into nearly random heat motion. The concept of friction is illustrated in Figure 2.1. The sliding or slipping may or may not occur in between two solid body surfaces because it depends on the conditions where the applied force can overcome the friction force which is opposing it (Peter, 2008). In this project, the sliding friction in dry condition is focused in the study of tribological performance of hybrid composites. Persson (2013) stated that the sliding friction is mainly depends on the physical properties which included the surface roughness of materials. During sliding processes, two bodies which are generally in contact over very small discrete areas where the sliding friction is ouccured in between the contact surface. The sliding friciton occurs in between the contact surface will transform the kinetic energy in desired motion into the heat energy or mechanical energy where it is caused the wear of contacting bodies (William, 2010). The sliding friction of a material can be related to determination of coefficient of friction where the applied force is included in calculation. Based on the law of frcition, the depence of of the frcition force upon normal load applied is proven and it is significant in generation of coefficeint of friction (Bartenev, 1981). However, the coefficient of friction of a material or composite is independent of the apparent area of contact. Moreover, the coefficeint of friction is often nearly velocity independent unless the sliding velocity is very low, where the thermal activation becomes very important and could affect the result in testing. Therefore, the friction force of composite is important in tribological performance where it can classify the properties of composite. Besides, Niklas (2001) research found that the friction is required to be measured in the stable, steady-state conditions so that the results are useful in characterizing the long-term properties of the system.

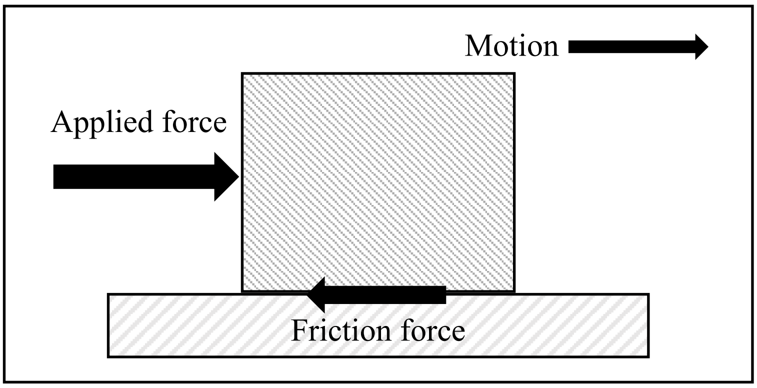

Figure 2.1: Concept of friction force

In tribological performance, the wear of a material or composite is a significant outcome in tribological testing. Bayer (2004) studied that the wear can be recognized as the process which included loss of material from a surface, transfer of materials from one surface to another or movement of material within a single surface. Hence, a simple statement or explanation regarding the wear term in tribology is that wear is a damage to a solid surface and generally involving the progressive loss of material. However, the wear of a material also can lead to the change in geometry or dimension of a part as results of plastics deformation. Wear is not a material property not it is a unique physical mechanism. The materials can be wear by variety of mechanisms and wear behaviour can be influenced by material properties and operational parameters (Bharat, Principles and Applications of Tribology, 1999). Study of wear is a common and useful practice in engineering because it is related the performance of a designed materials. Furthermore, the study in wear performance can lead to discover the wear behaviour and wear mode of a composite. The wear is one of the important characteristics in engineering design such as automotive design. The selection of materials is based on the wear performance or wear behaviour criterion, so that the linear relationship in between of design and wear (Bayer, 2004). The wear can be classified into various form which included lubricated wear, unlubricated wear, severe wear, mild wear, sliding wear, rolling contact wear and impact wear. However, the wear processes involve the wear mechanisms in term of abrasion, adhesion, fatigue and oxidation (George, 2004). The wear mechanism of adhesive wear and abrasive wear which is commonly happen in tribological testing are presented in Figure 2.2. According to Bharat (2002), adhesive wear is occurred when two nominally flat solid bodies are in sliding contact with or without lubracation where the asperitiy is contacted at the interface and these contacts are sheared by sliding such as tribological testing using ball-on-disc tribometer. The sheared contacts are caused the detachment of a fragment from one surface and attachment to the other surface as well where the process in known as material transfer. Furthermore, Karl (1987) presented that the abrasive wear is a type of material removal mechanism which is similar to the grinding in manufacturing process. During the sliding process, the hard asperities or particles of a rough, hard surface are penetrated into the softer surface under normal applied force and damage the interface by plastic deformation. For the abrsive wear, the scratching effect which is usually appears on softer surface can be observed as a series of grooves parallel to the direction of sliding.

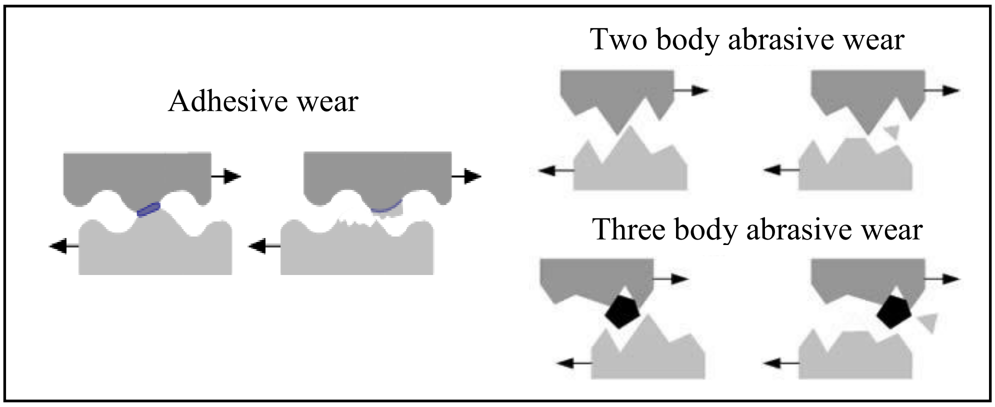

Figure 2.2: Concept of adhesive wear and abrasive wear

2.3 Hybrid Composites

Hybrid composites can be defined as the combinations of two or more materials assembled in nanometer or molecular level as to have characteristics which are not offered by any one materials alone, besides the compounds is a mixture of organic and inorganic in nature (Ashby, 2005). Another study by Yamada (1989) defined the hybrid composites as a mixtures of two or more materials by new electron orbitals formed between each material and the hybrid composites are created with new properties as well. Hybrid composites must have superior functions or better properties while comparing to traditional composites so there is more option in selection of materials in manufacturing. The categorization of hybrid materials and their related materials in detail is shown in Table 2.1.

Table 2.1: Categorization of hybrid materials

Composites	Mixture of materials consisting of matrix and micron-level dispersion
Nanocomposites	Sub-micron level mixture of similar kinds of materials
Hybrids	Sub-micron level mixture of various kinds of materials
Nanohybrids	Atomic or molecular level mixture of varied materials with chemical-bonds between the varied materials

Moreover, Nanko (2009) presented that there is no strict definition of hybrid materials however the definition of hybrid materials is required an atomic or nanometer-level mixture of materials. Thus, the classification of materials by different scale levels are proposed to define a clearer boundary for hybrid materials or hybrid composites as in Figure 2.3.

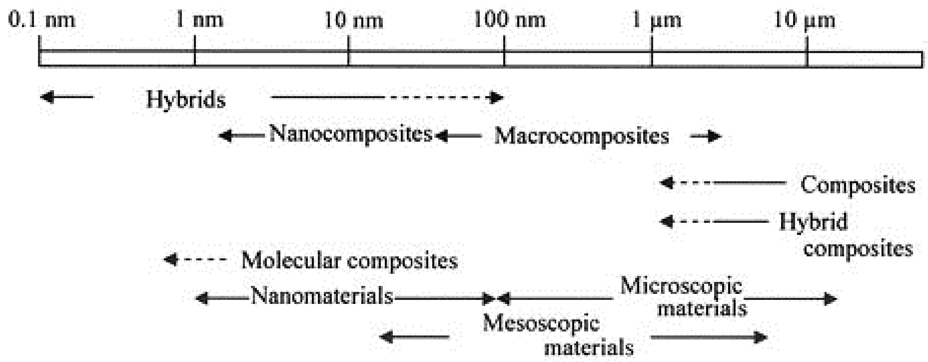

Figure 2.3: Classification of materials at different scale levels