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FRICTIONAL PROPERTIES OF PALM KERNEL ACTIVATED CARBON-EPOXY COMPOSITE UNDER VARIOUS NORMAL LOADS

Khai Wei Chua[a], Mohd Fadzli Bin Abdollah[a,b*], Noor Ayuma Mat Tahir[a], Hilmi Amiruddin[a,b]

[a]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[b]Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

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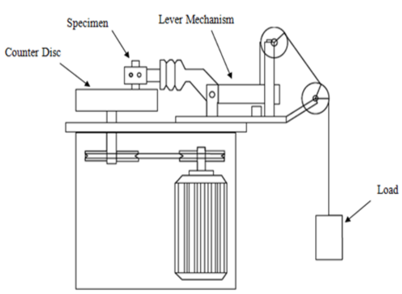
*Corresponding author
mohdfadzli@utem.edu.my

Graphical abstract



Abstract

This study investigates the effect of normal load on the frictional properties of palm kernel activated carbon-epoxy (PKAC-E) composite. The PKAC-E composite specimen was fabricated by hot compression molding method. The dry sliding test was performed by using a pin-on-disc tribometer at various normal loads, range from 5 – 100N. The sliding speed and distance were constant. All tests were performed at room temperature. It was found that the coefficient of friction decreases with normal load, though at 60N, friction coefficient increases slightly and remains almost invariant at about 0.04 with normal load. The main conclusion of this study is that PKAC-E composite has a potential for tribological material application but only limited at low normal load under unlubricated conditions.

Keywords: Friction coefficient, composites, palm kernel activated carbon, epoxy

1.0 INTRODUCTION

Friction and wear are response acts of describing the contact of bodies in tribological aspects. Although friction and wear are related to each other in each state of contact with a system; it is not a simple relationship. Previous tribology studies have introduced several successful methods of controlling wear, such as film coating, multi-phase alloying, and composite structuring; as an addition to lubrication [1-7]. Wear can be further reduced by understanding the wear mechanisms to confirm the tribological characteristics of materials in terms of surface roughness, hardness, ductility, reaction conditions, and adhesive/abrasive transfer.

Recently, a substantial amount of research has shifted focus from monolithic materials to composite materials to meet the global demand for lightweight, high performance, eco-friendly, and wear and corrosion resistant materials. The advantages of composite materials include their permeability, cost effectiveness, and different strengthening mechanisms.

Several researchers have found that composites activated by either graphite or carbon have the potential to act as self-lubricating materials when reinforced with other metal materials, such as aluminium [8-11].

For most tribological applications, graphitic carbon has been used because its addition reduces the coefficient of friction and increases wear resistance as compared with the matrix. This commercial self-lubricating material is relatively expensive. Thus, consisting of a carbon material from agriculture wastes as new reinforcement substitutes in the fabrication of polymer matrix composites, are supposed to have large potential for a zero waste strategy in improving tribological properties at an affordable cost [8-9].

A few researcher found out that porous carbon also known as activated carbon, such as palm shell activated carbon (PSAC), exhibited its potential to act as a self-lubricating material when reinforced in aluminium alloy, which significantly improved wear resistance by increasing PSAC content up to 10 wt.% [8-9].

In general, as observed from previous studies, there are a limited number of studies to investigate the potential of activated carbon materials as solid lubricants in polymer matrix composites. Hence, the aim of this study is to investigate the effect of normal load on the frictional properties of palm kernel activated carbon-epoxy (PKAC-E) composite.

2.0 EXPERIMENTAL PROCEDURE

In this study, the materials used are palm kernel activated carbon (PKAC), West System 105 Epoxy Resin (105-B) and West System 206 Slow Hardener (206-B). All specimens were fabricated by hot compression molding method. The PKAC particulate was ground into smaller particle and mixed with epoxy resin (E) and hardener at a composition ratio of 70 wt.% PKAC and 30 wt.% E. The compression process was conducted using hot press machine at 80oC and 2.5MPa of compression pressure. The green specimen was then cured under room temperature for 2 - 3 days. The length and diameter of the specimen were 30 mm and 10 mm, respectively, as shown in Figure 1.

Figure 1 Specimen of PKAC-E composite

The dry sliding testing was performed to determine the friction coefficient between the contact surfaces using a pin-on-disc tribometer. The testing procedure followed the ASTM standard G99-95a (Standard test method for wear testing with a pin-on-disk apparatus). All tests were performed at room temperature with a constant sliding speed and distance at 200rpm and 3770m, respectively. Prior to the sliding test, pin was ground by sliding against 600grit silicon carbide (SiC) paper at one end. Then, both pin and disc were cleaned using acetone in an ultrasonic bath. As illustrated in Figure 2, The pin was then mounted vertically on the tester arm at one end and the other pin surface was held against the rotating EN-31 carbon alloy steel disc (hardened to HRC 62; ground to Ra = 0.8μm) with a diameter and thickness of 16.5mm and 8mm, respectively.

The coefficient of friction, μ is then being determined as follows:

$$\mu = F/W \qquad \text{(Eq. 1)}$$

Where F is the frictional force in N and W is the normal load in N.

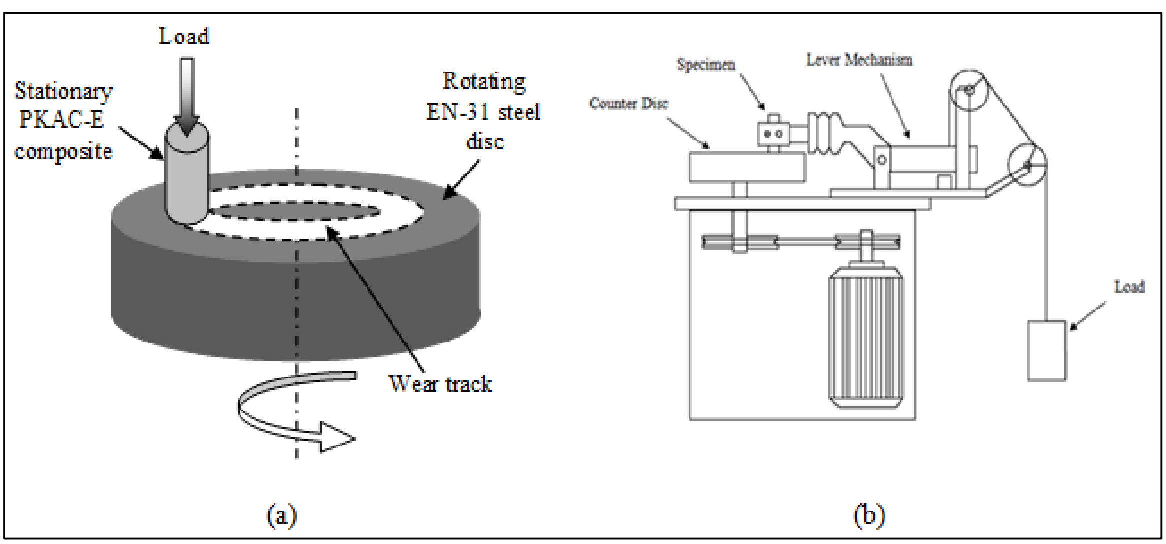


Figure 2 (a) Illustration and (b) schematic diagram of the sliding test using a pin-on-disc tribometer

3.0 RESULTS AND DISCUSSION

Figure 3 indicates the friction coefficient decreases with the increase of a normal load within the observed range, though at 60 N, it increases slightly and remains almost invariant about 0.04 with a normal load. The frictional heating, which will induce tribofilm formation, is believed to be responsible for the decrease of friction with the increase of applied load. There was a strong dependence of tribofilm formation on temperature [13]. The tribofilm generated from the preferential wear of the soft carbon material results in a carbon based tribofilm adhering on the worn surface which breaks the adhesive joints between the asperities and thereafter leads to low friction [14]. However, as stated by Bakry et al. [11], at higher load, the tribofilm was broken and carbon shows a drastic reduction in lubricity; consequently increases friction coefficient.

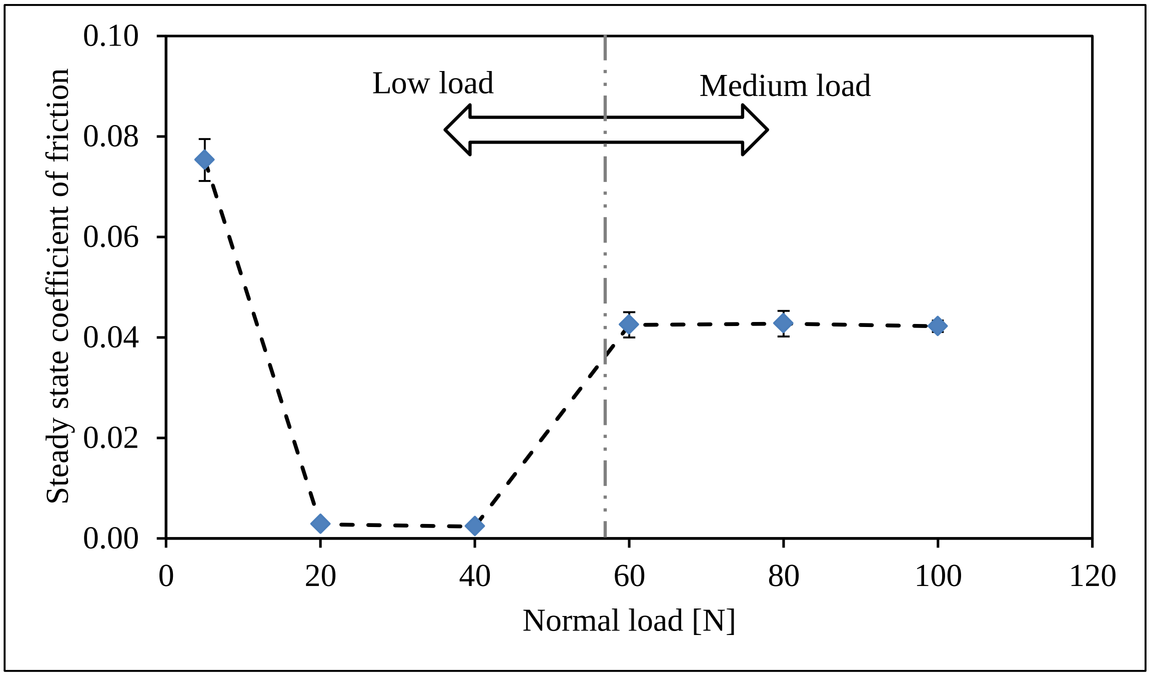


Figure 3 Steady state friction coefficient at different normal loads with a standard deviation error bar

4.0 CONCLUSIONS

As a conclusion, it was found that the friction coefficient of PKAC-E composite decreases with a normal load. However, starting at 60N, friction coefficient increases slightly and remains almost invariant with a normal load. From the overall findings, PKAC-E composite is proposed as a new tribological material but only limited at low normal load under unlubricated conditions.

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