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Tribological Characteristics of Surface Textured PKAC-E Created by Laser Surface Texturing under Boundary Lubrication

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ABSTRACT – The purpose of this study is to investigate the effect of dimple size on the tribological characteristics of surface textured palm kernel activated carbon-epoxy (PKAC-E) composite. The PKAC-E disc with 74 mm diameter was fabricated using hot compression moulding technique. Three different types of surface contacts were prepared by using a CO_2 laser surface texture machine: non-dimpled surface, 500μm and 1000μm in diameter dimples. The sliding test was carried out by using a ball-on-disc tribometer under boundary lubricated conditions with constant sliding speed, sliding distance and applied load. The results found that the surface texture with 1000μm in diameter dimple shows the lowest COF as compared to dimpled surface with 500μm in diameter and non-textured surfaces.

1. INTRODUCTION

Recently, a low cost carbon material from agriculture wastes in the form of activated carbon composite is proposed to be a new self-lubricating material, where low friction coefficient and high wear resistance are desirable for energy efficiency and component longevity [1]. However, the performance of palm kernel activated carbon (PKAC) material is still low and under the desirable friction coefficient compared to diamond-like carbon (DLC), which has less than 0.01 [2].

Under such circumstances, a technology to control friction force by surface texturing technique is favourably required. Surface texture has been tested on several materials and has proven that it can improve friction performance on the sliding but still depends on the materials, lubricants and contact conditions. The texture helps to reduce the surface contact area and function in trapping the wear debris. Besides, it can act as reservoir for lubricant under lubricated condition [3-5].

The texture is also capable in increasing the load carrying capacity as the higher hydrodynamic pressure produced. Well defined micro dimple has also contributed in longer life of sliding bearing and the engine performance become more efficient [4]. The benefits and excellent contributions of textured surface in terms of tribogical study led to further investigation on tribological characteristics of textured PKAC material through surface texturing technique.

2. METHODOLOGY

The materials used in this study are PKAC and high-density epoxy [West system 105 epoxy resin (105-B) and West system 206 slow hardener (206-B)]. The PKAC was obtained from manufacturer and the preparation of the PKAC is confidential. The 250μm particle size of PKAC was weighed to 60 wt.% and mixed with epoxy 40 wt.% (at a resin to hardener ratio of 4:1). The mixed PKAC and epoxy were then placed into a mould, hot-pressed at 80ºC with 2.5 MPa pressure for approximately 5 minutes and left to cool at room temperature for approximately 15 minutes before being pressed out from the mould. The disc specimen, with diameter of 74 mm, were left to cure at room temperature for approximately one week.

The micro dimple surfaces of the PKAC-E disc were textured by using a CO_2 laser surface texturing machine with two different diameters of 500μm and 1000μm.

The sliding tests were conducted by using a ball-on-disc tribometer against a polished SKD11 ball bearing under boundary lubricated condition at room temperature. The mechanical properties of the disc specimen and ball bearing are shown in Table 1. All tests were conducted under room temperature with constant applied load of 20N, sliding speed of 20RPM and sliding distance of 1500m. Each test was repeated twice in order to reduce experimental errors.

3. RESULTS AND DISCUSSION

Figure 1 shows the average steady state value of COF from each textured and non textured PKAC-E. The COF for 1000μm in diameter dimple was lower than dimpled surface of 500μm in diameter and non-textured surfaces. The results revealed that COF was reduced with increasing dimple diameter and depth. The oil stored in the dimples can be considered as a secondary source of lubricant, which is supplied to the tribocontact by the relative motion to reduce friction and wear. The existence of dimples on rotating disc surface is supposed to improve adhesion resistance significantly due to low contact area.

The tribological analysis of worn surfaces caused by friction, may determine the wear mechanisms involved. Considering friction for dimpled surface with 500µm in diameter, worn surface is more damaging (adhesive wear) than 1000µm in diameter dimple and non-textured surfaces, as shown in Figure 2. This could be the reason of the greater COF for dimpled surface with 500µm in diameter.

It is verified that the friction and wear properties influence upon the size of dimples under boundary lubricated sliding contacts. It was also further indicated that dimples has a great potential for reducing friction and wear, if the dimples were set at appropriate dimensions.

Table 1 Mechanical properties of the disc and ball materials before testing.

Properties	[a]PKAC-E disc	[b]SK11 ball
Hardness (GPa)	8.36	7.32
Density (g/cm^3)	1.4	7.72
Arithmetic surface roughness (µm)	0.4	0.02

[a] Properties from laboratory measurements.
[b] Properties from manufacturer.

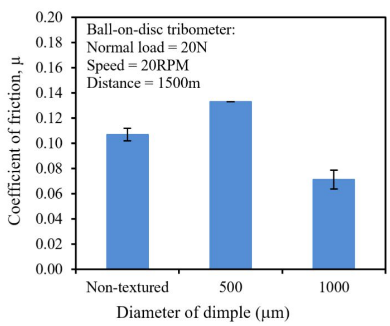

Figure 1 Effect of dimple size on COF of PKAC-E.

4. CONCLUSION

In this study, it can be concluded that type of surface finishing and size of dimples have an effect on the COF and wear of interacting surfaces in relative motion. In future, dimple should be produced in appropriate size in order to obtain the minimum COF and wear.

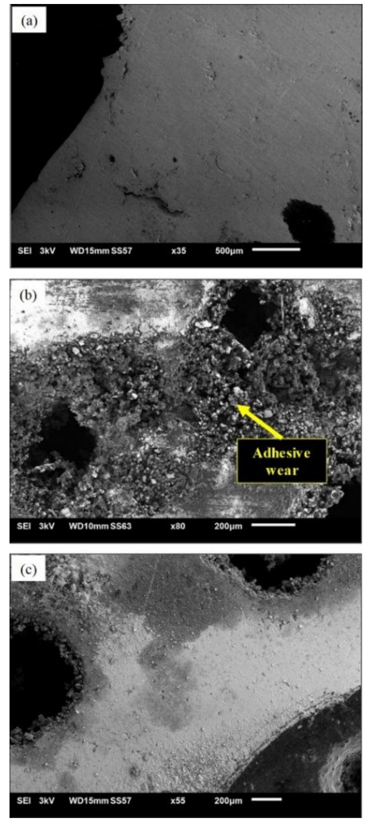

Figure 2 SEM micrograph of worn surfaces of (a) non-textured surface, (b) 500µm and (c) 1000µm in diameter dimples.

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