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Frictional properties of laser surface textured palm kernel activated carbon reinforced polymeric composite

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ABSTRACT – The purpose of this research is to investigate the relationship of speed and load on the friction coefficient of laser surface textured palm kernel activated carbon (PKAC) reinforced polymeric composites. The disc of the composite has been fabricated by using a hot compression technique and then was textured by using a laser machine with 1000μm dimple diameter. The tribological test was preceded by using a ball on disc tribometer. The sliding speed used was in the range of 50 to 200rpm and the applied load was in the range of 5 to 20N. A constant sliding distance which is 150m was applied during the sliding under lubricated condition. This study revealed that without considering the surface topography, the increase of applied load will increase the friction coefficient, but the increase of sliding speed has reduced the friction. The applying of surface texture also has reduced the friction compared to non-texture surface.

1. INTRODUCTION

Energy efficiency and component longevity are both demanding in mechanical applications, especially in the automotive industry. To fulfil this demand, low friction coefficient and high wear resistance tribological material comes from agriculture waste with low price has drawn attention among the researchers. One of them is PKAC reinforced polymeric composite which has produced low friction but still cannot achieve the coefficient of friction as demanded like diamond-like carbon (DLC) which is less than 0.01 [1-2].

Laser surface texture is one of the surface modification technique to control friction. Although various techniques in reducing friction have been studied nowadays, this surface modification technique has shown its ability in improving the tribological performance for many materials for years. The benefits of laser surface texture have proven in increase mechanical seal life, produce low friction for piston ring and the load carrying capacity of thrust bearing also has been improved [3-5].

Under lubricated condition, the dimples produced by the laser surface texture can act as a reservoir which the dimple can store and supply the lubricant in the reservoir during the sliding in relative motion. Besides, the surface contact area for textured surface is smaller than the surface without texture thus can reduce the friction [6-9].

From previous studies, polymers, metals and composite are mostly related to the parameters like surface roughness, lubrication, relative humidity, sliding rate and normal load to supervise the performance of friction and wear. Furthermore, sliding speed and applied loads are very crucial parameters compared to others in influence the mechanical component life for various materials [10-11].

The motivation that leads to this study is because of the potential of this new low-cost waste material which is PKAC reinforced polymeric composites and the capability of the surface texture technique in reducing the friction in previous studies. So, this study has been conducted in term of sliding speed and applied load effect on laser surface textures PKAC reinforced polymeric composite.

2. EXPERIMENTAL PROCEDURE

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 2.5MPa 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, was left to cure at room temperature for approximately one week.

The dimple surfaces of the composite disc were textured by using a CO_2 laser surface texturing machine with depth of 500μm and diameter of 1000μm. The contact ratio and area density used were 0.2 and 19%, respectively.

The sliding tests were conducted by using a ball-on-disc tribometer (Figure 1), where disc sample was slide against a ASTM 52100 (EN31) chrome steel ball, under lubricated condition at room temperature. All tests were conducted under room temperature with applied load in the range of 5 to 20N, sliding speed in the range of 50 to 200rpm and sliding distance of 1500m. Each test was repeated twice to reduce experimental errors.

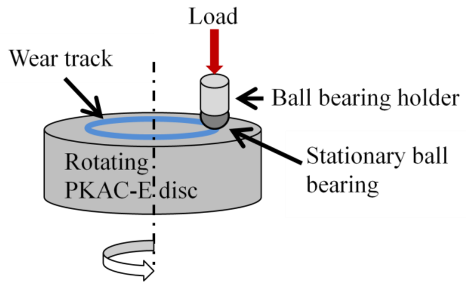
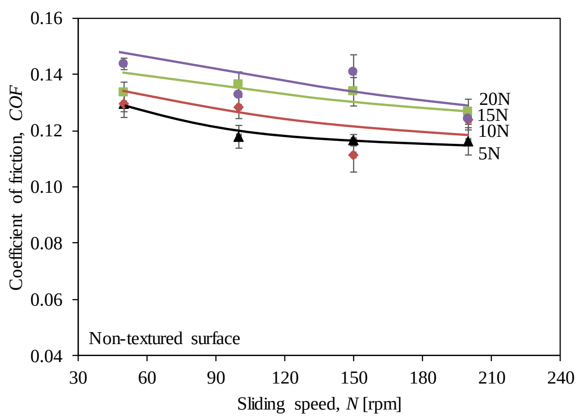


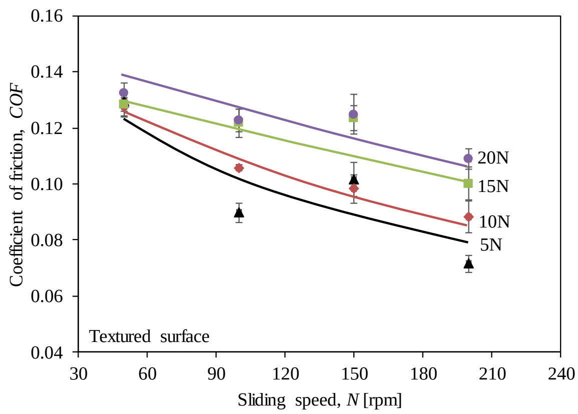
Figure 1 Schematic diagram of ball-on-disc tribometer

3. RESULTS AND DISCUSSION

The graph of Figure 2 shows that the friction increases as the applied load increase meanwhile the friction reduced as the sliding speed increase for both textured and non-textured surface. When the load increase, the contact area also increases as the oil squeeze out of the sliding contact and increase the friction value [12-13]. As the speed increase, the hardness reduces because more heat generated between the contact during the sliding. This cause the carbon on the surface material penetrate the ball and contribute to carbon-carbon contact instead of steel-carbon contact thus decrease the friction [14].



(a)



(b)

Figure 2 Effect of the sliding speed of (a) non-textured and (b) textured surface of activated carbon composite derived from palm kernel at different applied loads. Error bar is for standard deviation

Furthermore, the textured has produced lower friction compared to non-textured by increasing the speed. This happens because textured can act as reservoir that can supply lubricant to the tribocontact by relative motion [5]. In addition, at higher speed, more carbon attached to the ball bearing of the textured surface than non-textured, as shown in Figure 3, that lead to decrease of friction.

4. CONCLUSION

In conclusion, regardless of surface texture, the friction of palm kernel activated carbon (PKAC) reinforced polymeric composites increase with the increase of applied load and decrease when sliding speed increased. The textured surface also produces lower friction than non-textured surface.

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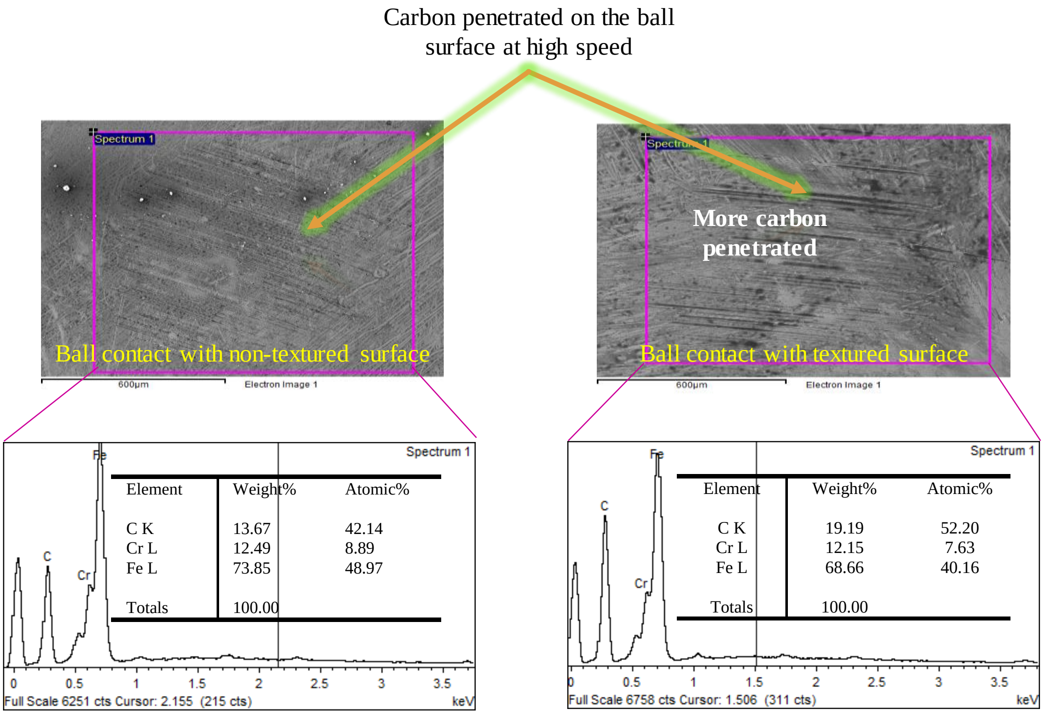

(a) (b)

Figure 3 Scanning Electron Microscopy (SEM) micrograph and Energy Dispersive X-Ray (EDX) spectrum for (a) non-textured and (b) textured surface of activated carbon composite derived from palm kernel testing at an applied load of 20N and sliding speed of 200rpm