SURFACE TEXTURED PALM KERNEL ACTIVATED CARBON REINFORCED POLYMERIC COMPOSITE AS A POTENTIAL SELF-LUBRICATING BEARING

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A report submitted

in fulfillment of the requirements for the degree of

Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this thesis entitled “Surface Textured Palm Kernel Activated Carbon Reinforced Polymeric Composite as A Potential Self-lubricating Bearing” is the result of my own research except as cited in the references.

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient iin terms of scope and quality for thhe award of the degree of the Bachelor of Mechanical Engineering.

Signature	:	....
Name	:	....
Date	:	....

DEDICATION

To my loving father and mother

ABSTRACT

A bearing is a device that controls all the relative motion to the desired motion while reduces operating friction. Self-lubricating bearings are plain bearings working without the need of any external lubrication. self-lubricating bearings are classified into two types. The first type is dry bearings which have solid lubricant such as graphite or polytetrafluoroethylene. The other type is bearing which has its own liquid lubricant reservoir such as porous metal structure which acts as a well for oil and dimples on surface which holds greases. Effect of speed and load on the tribological performance of surface textured palm kernel activated carbon reinforced polymeric composite (PKAC-E) need to be investigated. The performance of surface textured palm kernel activated carbon reinforced polymeric composite are compared to conventional bearing material. PKAC powder weighted at 60% are mixed with epoxy weighted at 40%. is then fabricated into disk specimen by hot press moulding. The PKAC epoxy composite disc specimen is patterned using a CO_2 laser surface pattering machine with pore diameter of 1000 µm with depth of 500 µm, contact ratio value of 0.21 and area density of 19%. The sliding experiments was performed with a ball-on-disc equipment in dry condition in room temperature. A microscope was then used to observe and analyse the morphology of wear tracks for both the ball bearing and discs. The wear track widths of the discs are also measured with the microscope at five different points and the average is calculated. Coefficient of friction of PKAC-E disk for textured and nontextured rises with sliding speed and applied load. Non-textured surface demonstrated a lower coefficient of friction at low speed and low load and at high speed and high load. Textured disc has a wider wear track on disc than nontextured disc which increases the wear of the material. Textured disc produced lower coefficient of friction at high speed and low load. PKAC has demonstrated to be the superior bearing material compared to SKD-II disc which is a conventional bearing material by producing lower coefficient of friction when tested at similar parameters.

ABSTRAK

Galas ialah peranti yang mengawal semua gerakan relatif kepada gerakan yang dikehendaki sambil mengurangkan geseran operasi. Galas pelincir diri adalah galas biasa yang berfungsi tanpa memerlukan pelinciran luar. Galas pelincir diri dikelaskan kepada dua jenis. Jenis pertama adalah galas kering yang mempunyai pelincir pepejal. Jenis lain adalah bearing yang mempunyai takungan pelincir cecairnya sendiri seperti struktur logam berliang. Kesan kelajuan dan beban ke atas prestasi tribologi komposit polimer bertetulang kernel sawit diaktifkan karbon (PKAC-E) perlu disiasat. Prestaskomposit polimer bertetulang kernel sawit diaktifkan karbon berbanding bahan galas konvensional. Serbuk PKAC yang berwajaran 60% dicampur dengan epoxy wajaran pada 40%. kemudian dituang ke dalam acuan dan menjalani pengacuan penekanan panas. Spesimen cakera epoxy komposit PKAC dibentuk menggunakan mesin penembusan permukaan laser CO2 dengan diameter pori 1000 µm dengan kedalaman 500 µm, nilai nisbah sentuhan sebanyak 0.21 dan kepadatan kawasan sebanyak 19%. Eksperimen gelongsor dilakukan dengan peralatan bola-pada-cakera dalam keadaan kering dalam suhu bilik. Mikroskop kemudian diguna untuk memerhatikan dan menganalisis morfologi trek haus untuk bebola galas dan cakera. Lebar trek haus cakera juga diukur dengan mikroskop pada lima tempat yang berbeza dan purata dikira. Pekali geseran cakera PKAC-E untuk permukaan berstruktur dan rata meningkat dengan kelajuan gelongsor dan beban. Permukaan rata menunjukkan pekali geseran yang lebih rendah pada kelajuan rendah dan beban rendah serta pada kelajuan tinggi dan beban tinggi. Cakera permukaan berstruktur mempunyai kelebaran trek haus yang lebih luas pada cakera daripada cakera permukaan rata. Ini meningkatkan kadar haus cakera. Cakera permukaan berstruktur menghasilkan pekali geseran yang lebih rendah pada kelajuan tinggi dan beban rendah. PKAC adalah bahan galas yang lebih baik berbanding dengan cakera besi SKD-II yang merupakan bahan galas konvensional dengan menghasilkan pekali geseran yang lebih rendah apabila diuji pada parameter yang sama.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Prof. Madya Dr Mohd. Fadzli Bin Abdollah from the Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for her essential supervision, support and encouragement towards the completion of this thesis.

I would also like to express my greatest gratitude to Mohmad Martini for her advice and suggestions throughout this entire project. Special thanks to my course mates for their advices and support.

Special thanks to all my peers, my mother, beloved father and siblings for their moral support in completing this degree. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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COF	Coefficient of Friction
ECM	Electrochemical Machining
IR	Infared
LST	Laser Surface Texturing
PKAC	Palm Kernel Activated Carbon
PKAC-E	Palm Kernel Activated Carbon Epoxy
RPM	Revolution Per Minute
UV	Ultraviolet

LIST OF SYMBOLS

Ds	=	Sliding distance
F	=	Frictional force
L	=	Applied load
N	=	Rotation speed
R_C	=	Contact ratio
t	=	Rotating duration
r	=	Radius of the pore
rw	=	Wear track radius
$A\rho$	=	Area density
ℓ	=	Distance between dimples
μ	=	Coefficient of friction

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

A bearing is a device that controls all the relative motion to the desired motion while reduces operating friction. Self-lubricating bearings are plain bearings working without the need of any external lubrication. Plain bearings can only be classified as self-lubricating bearing due to its operating motion which is sliding. Other bearings such as rolling element bearing such as ball bearing and roller bearing and elastomeric bearing are not considered as self-lubricating bearing because they do not require lubrication to operate.

According to Evans (1981), self-lubricating bearings are classified into two types. The first type is dry bearings which have solid lubricant such as graphite or polytetrafluoroethylene. The other type is bearing which has its own liquid lubricant reservoir such as porous metal structure which acts as a well for oil and dimples on surface which holds greases.

Usage of self-lubricating bearings are most predominant when the conditions are:

a) production of hydrodynamic oil layer is unable to take place due to the type of operation motion
b) the external environment such as vacuum and low temperature inhibits the utilization of regular lubricants
c) major simplification of devices or machines by removing lubrication supply

Solid lubrication is required in a rising amount of equipment especially in the aerospace field. This is because conventional fluid lubrication is insufficient in the elevated temperature and causes contamination in environment such as vacuum environment and sliding electrical contacts. Solid lubrication has the upper hand compared to fluid lubrication because fluid lubrication film has unpredictable life span and requires maintenance which can become costly and challenging. The most enticing substitute is to manufacture parts from material with self-lubricating property. Self-lubricating material can be described as a material that displays a little friction or abrasion in sliding motion even without the presence of an external lubrication. (Lancaster, 1967).

Since the last couple of years dry bearing material has pique the interest of engineers and researcher of linear motion bearings due to their special tribological characteristic and likelihood of removing grease-based lubrication. Due to pro-environmental purpose, engineers and equipment proprietor are obliged to replace conventional grease lubricated bearing components with self-lubricated bearings (Gawarkiewicz and Wasilczuk, 2006).

1.2 PROBLEM STATEMENT

As the world is ushering in an unprecedented level of environmental literacy, the current form of lubricant used needs to change because it is hazardous to the environment. Grease or oil-based lubricants are destructive to the environment especially when it is not disposed properly.

Almost all lubrication consumed by the automotive and production industry are oil or grease based. This form of lubrication is hazardous to the environment and non-biodegradable. A lot of pollutants can be introduced to the waste line when the lubrication is disposed. In the long haul, the waste lubricants will amass and be destructive to the environment. This causes environmental government agency to continue implement strict regulations on the usage, storage and removal of oil and grease-based lubricants. This also rises the cost of disposal of conventional lubricants (Menezes etal., 2012).

1.3 OBJECTIVES

The objectives of the project are as follows:

a) To investigate the effect of load-speed on tribological performance of surface textured palm kernel activated carbon reinforced polymeric composite

b) To compare the performance of surface textured palm kernel activated carbon reinforced polymeric composite with conventional bearing material

1.4 SCOPES OF PROJECT

The scopes of project are as follows:

a) The test samples are fabricated in only disc shape.

b) The test samples are only experimented with ball-on-disc test in dry condition at room temperature.

c) The max load used to test the test samples is 15N.

d) The maximum speed used to test the test samples is 200rpm.

e) The maximum sliding distance used to test the test samples is 1000m.

CHAPTER 2

LITERATURE REVIEW

2.1 Surface Texture

Wear and friction of a surface can be decrease with the correct choice of surface engineering techniques. It can be achieved through modifying the components dimension, increasing hardness, applying surface coating, anti-friction additives, refine surface quality, creating definite surface configuration which is known as surface texturing (Sedlacˇek and Podgornik, 2017). The primary benefit of surface texturing on the enhancement of tribological attributes is with microcavities functioning as lubricant reservoirs which then thicken the film layer between the joining parts. A resulting lift effect that deceases bearing surface contact is produced from the hydrostatic pressure generated from the increment in film thickness (Ibatan et al., 2015).

2.2 Fabrication of Surface Texture

2.2.1 Laser surface texturing

The most promising way employed currently to texture surfaces in engineering application is laser texturing (LT). It can be utilized on a wide variety of materials. It supports the formation of arrangements with minuscule attributes. For instance, attributes with depth of 200nm and radius of 10mm can be achieved in steel specimen by utilizing a femtosecond pulse laser. The utilization of more advanced optics can result in laser beam sizes lower than 5mm. Other way, depend on laser-induced periodic surface texturing, utilized a femtosecond laser to form an array on concavities was not deterministic. Nevertheless, the utilization of LT display constraints. For starters, the cutting mechanism constantly prompt the generation of heightened features surrounding the pockets which comes from the expelled molten materials. These lateral rims are usually solid from the microstructural alterations as a result from the process could lead to harsh abrasive wear of the opposing surface. Therefore, these rims need to be eliminated via mechanical or laser polishing. This occurrence is essentially removed by utilizing very short pulse laser such as femtosecond laser. The secondary concern for LT is the texturing speed. The process comprises of ablation which alter the material state instantly from solid to gaseous with minimal metallurgical surface harm. The ablation fluence ranges for materials varying to soft metals to glasses and hard composites is within 0.2 to 20Jcm^{-2}.[29]. If the laser system is supplied with significantly high maximum pulse energy, a tiny concavity can be form by laser ablation using a fixed laser spot with size on par with the dimple and remove the necessity to conduct laser spot scanning as long as the laser influence is at least greater than the ablation fluence range for the specific material and then the depth of the concavity will be based on the number of pulses. The utilization of high pulse energies, miniscule spot diameters and very short pulse periods has enable material removal to be accomplished for a large variety of materials at higher texturing speeds. Nevertheless, since the patterns are usually formed in a serial sequence, the processing time for bigger parts can still be higher, especially lower cost LT equipment that utilized long pulse periods and big spot sized. Many parts the can have their performance enhance by surface texturing are affordable so they might need lower cost texturing ways to enhance of tribological performance accomplished by texturing to be economical (Costa and Hutchings, 2014).

For the last couple of years, laser surface texturing has been accounted as a productive and manageable way to fabricate texture of micro dimples by a rising amount of papers. By applying laser surface texturing, surface micro-textures can be fabricated on pretty much any materials. Laser is very quick and can manage the form and size of the micro dimple well. Processes of sublimation, melting and vaporization is generated by every laser pulse send to the surface, producing in a pore. The strong intensity of the laser beam pulse causes the area near to the dimple to also be subjected to melting and rapid re-solidification. This damage can be reduced by lowering the laser pulse duration (Vilhena et al., 2009).

Laser surface texturing (LST) is one of the most cutting-edge surface texturing approach in generating tiny concavities arrangements for sliding contacts. The laser utilized is remarkably quick which enables low processing duration and allows exceptional management of the form and dimension of the micro dimples that enables attainment of ideal design as shown in Figure 2.1. It can also be applied on a wide range of materials such as ceramics, hardened steel and polymers. The texturing process comprises of a concentrated pulsed laser to generate tiny concavities arrangements neighboring by a hardened melt rim. Melting and vaporization of material occur with laser surface texturing because of the intense energy usage. This causes heat affected area to be in a solidified melt rim state which transform the microstructure and mechanical characteristics. In order to reduce this effect, pulse energy and frequency need to be adjusted. CO_2 and Nd:YAG are the types of laser frequently used in laser surface texturing. Nd:YAG is more suitable to be used on metals due to Nd:YAG being inert gas which will improve the surface absorptivity hence resulting in a higher surface texture quality than CO_2 thickness (Ibatan, et al., 2015).

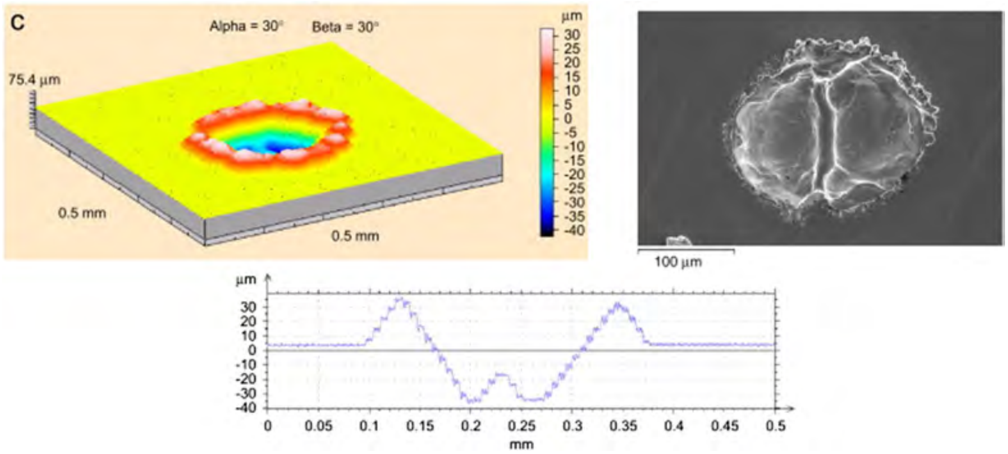

Figure 2.1: Surface topography of a LST processed micro-dimple (Ibatan, et al., 2015)

Development in laser surface texturing utilizing ultraviolet (UV) light lately has enable new prospects for tribological surface geographical alteration. It is currently feasible to generate micron-sized concavities on the surface of rigid ceramic coatings via pin-point modulation over location, size, depth and surface density. Solid condition pulsed UV laser surface texturing is affordable, quick and contributes a significant diminution in neighboring surface overheating compared to infared (IR) lasers. Laser surface texturing process was studied for hydrodynamic lubrication modulation and may be employed to generate solid lubricant well that are optimal in depth, geometry and surface density. Besides that, laser processing can be sectionally administer to the surface of hard ceramic layers to produce an ideal abrasion resistance and load support with least influence on the surface fatigue life in aerospace systems (Voevodin and Zabinski, 2006).

2.2.2 Micro-ball end milling

Micro mechanical machining is considered as an alternative to fabricate texture surface. Press load is manipulated to obtain the desired size of dimple. Production of micro dimples by pellet pressing was effortless and inexpensive. Majority of the mechanical