DRY FRICTIONAL CHARACTERISTIC OF SURFACE TEXTURED ACRYLIC USING PIN-ON-DISC

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Project report submitted in fulfilment of the requirement for the Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I hereby declare that the effort put into this thesis entitled “Dry frictional characteristic of surface textured acrylic using pin-on-disc” is the result of my own research except for references which have been cited.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality as a partial fulfillment of Bachelor of Mechanical Engineering.

Signature : ……

Supervisor's Name : ……

Date : ……

DEDICATION

To my beloved mother and father, family members and friends who been with me throughout the journey of this 24 years of amazing life.

ABSTRACT

This project focus on study the different in surface texturing pattern towards tribological performance. Tribological performance means friction, wear and lubrication. The dry frictional characteristic of a surface textured acrylic disc is investigated. By using laser engraving method, several types of texture pattern are produced on testing specimen. These textured specimens are then run on Pin-on-disc machine to find out its friction and wear performance. Only textured pattern is concern in this project, type of material is not in the scope. Calculations of friction coefficient and wear rate is determined through certain formulas. 3D non-contact profilometer is used to obtain the magnified image of wear track and debris entrapment inside the dimple for further analysis. Coefficient of friction and wear rate is the data that is going to be used to compare tribological performance of different surface texturing.

ABSTRAK

Projek ini bertujuan untuk mengetahui prestasi tribologi untuk permukaan yang ditekstur. Prestasi tribologi termasuklah geseran, kadar kehausan, dan pelinciran. Acrylic akan digunnakan sebagai bahan kajian dan menggunakan laser untuk menghasilkan bentuk tekstur yang berlainan. Bahan kajian akan diuji pada keadaan yang tidak dilincirkan. Mesin Pin-on-disc akan digunakan untuk mengaji geseran and kadar kehausan. Pengiraan untuk pekali geseran dan kadar kehausan adalah menggunakan rumus. Mesin 3D non-contact profilometer digunakan untuk mengambil gambar diperbesar untuk analisa yang lebih teliti. Pekali geseran dan kadar kehausan adalah data yang akan digunapakai untuk membandingkan prestasi tribologi untuk setiap spesimen.

ACKNOWLEDGEMENTS

First, I would like to take this opportunity to express my gratitude to my supervisor, Mr Mohd Rody bin Mohamad Zin from Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for his patience supervision, advice and support towards the completion of this thesis.

I would also like to express my sincere acknowledgment to the panels Mr Faizul Akmar Bin Abdul Kadir and Dr Fauzi Bin Ahmad during the viva session which they provided useful comments towards my work and suggestion to improve my project.

Thanks also to Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka in funding me the cost for this project. Specials thanks to all the laboratory staff and technician who help me during my effort in completing this experiment.

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LIST OF ABBREVATIONS AND SYMBOLS

N	-	Newton
g	-	Gramm
m	-	meter
μm	-	Micro meter
R_a	-	Roughness average
RPM	-	Revolution per minute
m/s	-	Meter per second
L	-	distance travelled
R	-	wear track radius
t	-	time
k	-	specific wear rate
V_L	-	volume loss
F	-	load
F_L	-	applied load
F_f	-	friction force
COF	-	Coefficient of friction
LST	-	Laser surface texturing
PKAC-E	-	Palm kernel activated carbon-epoxy
Fs	-	Femtosecond

ns	-	Nanosecond
SEM	-	Scanning electron microscope
SIMPS	-	Snake inspired microstructured surface
UHMWPE	-	Ultra-high-molecular-weight polyethylene
PMM	-	Poly(methyl methacrylate)

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CHAPTER 1

INTRODUCTION

1.1 Background

Tribology is defined as the study of friction, wear and lubrication of two interaction surface that is undergoing relative motion. Whenever two surfaces are sliding against each other, there will be some forces that resist the motion. That force is known is friction force. Coefficient of friction is the parameter that used to measure the degree of friction. Nearly every applications, motion, or movement happens in our daily life deals with friction. For example, we can hold onto something using our hand is because of the textured palm surface. The texture on our hand creates an interlocking phenomenon between our palm and the object. This will prevent the object from slipping away from our hand. If we are born with smooth palm, we will unable to hold any object using our hand. Some of application requires even greater friction such as racing cars. The racing cars tires requires a lot of traction to allow sufficient power transmission to move the car on road. So, the design of tires must have high friction with the road but not too high that it will negatively affect the car performance on road. However, there are also some cases where low friction is desired. In car engine, piston moves reciprocatively. The high moving speed of piston requires low friction contact with the cylinder wall for highest possible efficiency.

There are few ways to reduce friction effect, lubrication, using low shear material or smoothen the contact surface. Each of this method has its own pros and cons. Lubrication is very effective in reducing friction however the lube might trap dirty particle and thus reducing its effectiveness. Lube might also need to often be replaced, the cost and sustainability is also a concern. Material choice mainly depends on the molecular structure and operating condition required. There are some previous research which validate the effect of surface texture on reducing friction effect (Mat Tahir, Abdollah, Hasan, & Amiruddin, 2016; Navale, Aher, Nagare, Bajaj, & Wakchaure, 2016; Wos, Koszela, & Pawlus, 2017).

1.2 Problem Statement

Various studies had been done regarding the effect of surface texture on friction effect. Study by (Mishra & Polycarpou, 2011) shown that surface textured improves tribology effect. Since the dimples on contacting surface act as a lubrication reservoir and the texture reduce the total contacting surface. However not every dimple size or texture pattern is ideal for reducing friction. Besides, the theory of surface texture act as lubricant reservoir and debris entrapment is validated. What if lubrication is not available in surface textured condition. Thus, testing must be performed to identify how different surface texture will affect the friction and wear rate. Application of textured surface to reduce friction can be widely used if the operating condition and working rate is identified.

1.3 Objectives

The objectives of the project are as follows:

i. To study the effect of surface textures on dry friction and wear of acrylic disc

ii. To propose the optimum characteristic of acrylic disc surface textured for dry friction and wear condition

1.4 Scope of project

The scopes of the project are:

i. The project only focusses on the effect of surface texture towards testing performance

ii. Testing will only seek for two results, coefficient of friction and wear rate

iii. No lubrication will be used to achieve dry frictional condition

1.5 General Methodology

i. Literature review

Journals and articles or any suitable material that are related will be reviewed. This is for finding the gaps between previous researches. Based on the gaps, the objectives of this study are identified.

ii. Sample preparation

In this study, the sample is prepared by using laser engraving machine. The sample is acrylic disc which is engraved according to proposed design.

iii. Testing and analysis

The testing is performed by using Pin-on-disc machine. The results will be coefficient of friction and wear rate of the disc. To investigate the characteristic of friction and wear of the disc, the optical images of wear track will be analyzed. The images are obtained by using 3D non-contact profilometer.

iv. Report writing

Testing results will be written into a complete report.

The methodology of this study is summarized in the flow chart as shown in below.

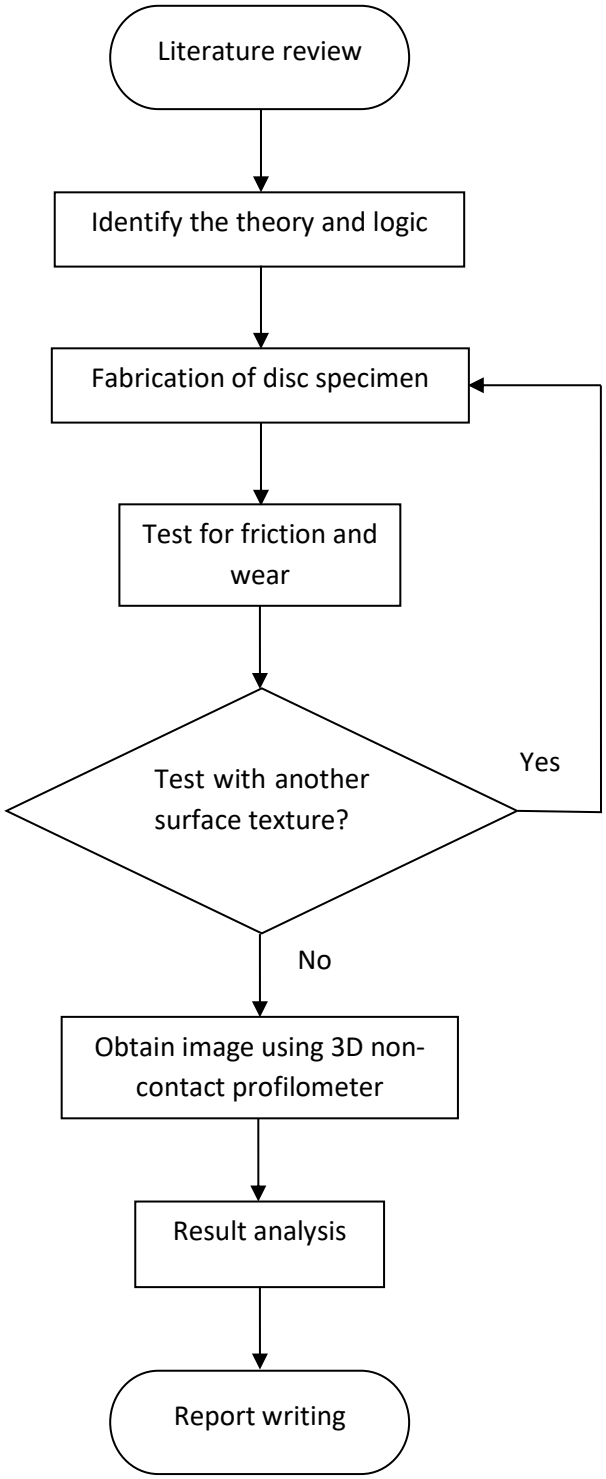

Figure 1.1: Flow chart of the methodology

Chapter 2

Literature Review

2.1 Tribology

The term tribology refers to the study of friction, wear and lubrication of two contacting surface that are moving relative to each other. The main parameters in tribology study is coefficient of friction COF, wear rate and lubrication (boundary lubrication, mixed lubrication and full film lubrication). According to (Gachot, Rosenkranz, Hsu, & Costa, 2017) during the Tong Dynasty in China, the people carve patterns on their shoe to allow them walking on slippery surface. As human technology evolves, vehicles wheels are also textured for better traction performance on road. Both of this cases are related to tribological properties of contacting surface. (Hirano, 1995) said that the stimulus to research in tribology started from the needs to reduce material and saving of energy. A lot of machines or mechanism requires low friction to operate ideally such as engine piston and gear mechanism. High friction and high wear rate will not only reduce the efficiency but also reduce lifespan of the parts. Author also mentioned that tribological studies is now a main consideration and aspect in engineering design. Most often the effect of tribology defect is shown after the design process is completed. Only if we acquire sufficient knowledge about tribology studies then we can implement the design before product completion. It means that when we design

a certain product we take consideration of the tribological properties into it during the design process.

2.2 Surface texturing

Surface texturing is a way to change the topography of a surface. It can be used to create pattern or microstructure on a surface. There are a lot of method to perform surface texturing. Commonly known methods include laser surface texturing LST, maskless electrochemical texturing, abrasive jet machining and reactive ion-etching. Each of the method have its own pros and cons, it comes to the user to decide which type of texturing method they want to use. Surface texturing also can be categorize into few types, material adding, material removal, material moving, self forming(Costa & Hutchings, 2015). The technology for surface texturing improves rapidly. People are looking at how to increase the texturing speed, the accuracy, the feature size, operating cost. The demand for good quality, low cost and rapid surface texturing technology lead to the fast development in equipment today.

Currently surface texturing is one of the option to improve tribology properties. This includes wear resistance, loading capacity, friction coefficient and lubrication. The basic concept of texturing to improve tribology properties is by creating micro structure on a certain surface. This micro structure will act as entrapment for debris, reservoir for lubricant and reducing the total contact surface.

According to (Costa & Hutchings, 2015), maskless electrochemical texturing is the cheapest but the minimum feature size is very large. It can only used on material with good electrical conductivity. In contrast, ink jet printing followed by etching is better in producing

smaller features with good resolution. The setback is the lengthy processing time. Laser texturing is considered to best available method currently. This method is capable of handling wide range of material and feature size is a lot encouraging compared to others. Notable issue with laser texturing is the rims produce around the pockets. The rims can be removed with certain method, either is by manual polishing, chemical polishing or laser polishing depends on requirement.

2.3 Surface texture and tribology

As today, numerous studies about how surface texture can improve tribological properties is performed such as to reduce coefficient of friction and wear rate. Research from (Mishra & Polycarpou, 2011) indicates that the surface texture on two contacting surface greatly improves the wear and friction. The objective of their study is to figure out tribological performance of surface textured pattern under operating condition imitating the actual condition of air conditioning and refrigerator compressor. The disc and pin is made from gray cast iron. Each of the pin is surface textured with laser. It is then tested using pin-on-disk tribometer. They are using a custom designed tribometer with a pressurized chamber to simulate the working condition of a compressor. A load of 178N is used since the actual working condition of a compressor is under extreme and aggressive motion. A drop of lubricant (22mg of Polyalkylene Glycol) is used on every specimen testing. Lubricant was added to create the operating condition of starved lubrication.

Below is the specification of each specimen. Pattern A1 and A2 having the same diameter and depth, the only different is the area density. Subsequent patterns for B1 and B2, C1 and C2 follow the same trend.