Analysis On Surface Texturing Design for Wear Protection of Automotive Engine Part

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ANALYSIS ON SURFACE TEXTURING DESIGN FOR WEAR PROTECTION OF AUTOMOTIVE ENGINE PART

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‘I hereby declare that had read this work and for my/our opinion this work is adequate in terms of scope and quality for receiving the Bachelor of Mechanical Engineering (Automotive)’

Signature :.....

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Date :.....

I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : .....

Author : Nor Shazwan Azrul Bin Norazni

Date : .....

This report was done specially for Puan Sushella Edayu Mat Kamal, Norazni Bin Abdul Hamid, Aini Binti Mat Hassan and Beloved Family.

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ABSTRACT

Surface texturing is used as the quality indicator for the machined surfaces after undergoes manufacturing process. These characteristic is the important factor that effect on several properties such as wear resistance, fatigue strength, coefficient of friction, lubrication, wear rate and corrosion resistance of the machined parts. The texture on the material surface alters the properties itself during sliding conditions which to reduce friction and wear of material. However, it still depends on the pattern or shape of the texture on the surface of material under certain sliding condition. For the design of surface texturing, the surface texture with thousands of micro-dimples used to improve the tribological performance in order to reduce the friction and wear between two sliding material. This research contribute on conduct the simulation and analysis using ANSYS FLUENT and CFD in order to study effect of surface texturing using dimpled texture. In this research, the dimples with a circle and elliptical shape were investigated according to the sets of diameter size with fix depth and dimple density.

ABSTRAK

Penteksturan permukaan digunakan sebagai penunjuk kualiti untuk permukaan yang dimesin selepas menjalani proses pembuatan. Ciri-ciri ini merupakan faktor penting yang mempengaruhi beberapa sifat seperti rintangan kepada haus, pekali geseran, pelinciran, kadar kepada haus dan rintangan terhadap karat pada bahagian yang dimesin. Tekstur pada permukaan bahan mengubah sifat-sifat itu sendiri dalam keadaan gelongsor untuk mengurangkan geseran dan kehausan bahan. Walau bagaimanapun, ia masih bergantung kepada corak atau bentuk tekstur pada permukaan bahan. Bagi reka bentuk penteksturan permukaan, tekstur permukaan dengan ribuan mikro lubang-lubang kecil digunakan untuk meningkatkan prestasi tribological bagi mengurangkan geseran dan haus di antara dua bahan yang bergesel. Kajian ini berkait dalam menjalankan simulasi dan analisis menggunakan ANSYS FLUENT dan CFD untuk mengkaji kesan penteksturan permukaan menggunakan tekstur lekuk. Dalam kajian ini, lubang-lubang kecil dengan bulatan dan bentuk elips disiasat mengikut set saiz diameter dengan kedalaman dan ketumpatan yang tetap.

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A	=	Reference Piston Body Area
b	=	Cylinder Characteristic Length or Bore
C_p	=	Specific Heat at Constant Pressure
g_i	=	Body Force Term
h	=	Heat Transfer Coefficient
k	=	Gas Thermal Conductivity
L	=	Length of the Body That the Flow Travels Across
p	=	Pressure
q	=	Overall Heat Transfer
S_h	=	Radiation Sources
T	=	Temperature
Γ_h	=	Exchange Coefficient
U	=	Characteristic Gas Velocity
V	=	Velocity of the Flow
v	=	Kinematic Viscosity of the Fluid

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

In this chapter, there are discusses about the introduction in this project. In order to make the reader understand about this project, a research background of the surface texturing design is explains more detail. In this chapter also, there are include of the objectives of the project, scopes and the problem statement while doing this project.

1.1 RESEARCH BACKGROUND

In many applications, materials are subjected to vibrating, impact or oscillating forces. The behavior of materials under such load conditions differs from the behavior under a static load. Because the material is subjected to contacted surface in actual use, designers are faced with predicting wear resistance, which is defined as the frictional energy losses under specified loading conditions.

Wear is defined as an interaction between surfaces which material will removal and deform on a surface as a result of mechanical action of the opposite surface (Qiu et al, 2013). The definition of wear may include loss of dimension from plastic deformation if it is originated at the interface between two sliding surfaces. Wear can also be defined as a process where interaction between two surfaces or bounding faces of solids within the working environment results in dimensional loss

of one solid, with or without any actual decoupling and loss of material. In practice a real component from a machine or structure will generally have various surface finishes and different mechanical properties.

One of the main methods to enhance the performance of mechanical seals studied and discussed in the literature of tribology is surface texturing. Many theoretical and experimental studies showed the benefit of surface texturing on the mechanical and automotive part performance. The types of dimple texture have been particularly studied by (Erdemir, 2005). Density and depth ratio are the main parameters studied and optimized to enhance lubrication. However, in recent years, studies have shown that geometric shape and distribution of dimples have an obvious influence on the performance of textured surfaces (Qiu et al, 2013).

The automobile industry is experiencing in competition due to rapid technological improvements and advances. Thus, it is necessary to have a better understanding of the effect of friction and wear in automotive part in order to meet competitive durability goals in the automobile industry. For this reason, surface modification be a good and effective way to improve the tribological characteristics of mechanical components. Hence, surface texturing is important on improving the on reducing friction and wear was depended considerably on the shape, size, density, and pattern of dimples.

1.2 PROBLEM STATEMENT

Wear is a complex phenomenon that is affected by a number of factors, such as the surface finish of the component, environmental effects, heat treatments, presence of stress concentration factors, etc. Therefore, it is important to carefully analyses components that subjected to fluctuating loads so the desired reliability can be built into these components and over-designed or under-designed components can be avoided. It is well known that wear resistance generally initiate from the surface and the performance of the component or part dependent on the surface finish produced by machining or other manufacturing processes.

Surface texturing is used as the critical quality indicator for the machined surfaces and has influence on several properties such as wear resistance, fatigue strength, coefficient of friction, lubrication, wear rate and corrosion resistance of the machined parts (Etsion, 2009). Nowadays, developing more fuel efficient and compact automobile engine with reduced environmental impact is one of the biggest challenges that tribologists are facing in this era. The friction loss in an internal combustion engine is a major factor in determining the engine efficiency, performance and fuel economy of the vehicle (Etsion, 2009). Hence, surface texturing is used to increase hydrodynamic pressure and reduce friction and wear between two surfaces by creating patterned microstructure on the mechanical contact surface. The shape, geometry and distribution pattern play a key role to the tribological behavior of that surfaces in contact. Thus, investigating of surface texturing important for enhancing tribological properties of mechanical components in order to improve wear protection and enhance fatigue or toughness indirectly to increase the lifetime of components.

1.3 OBJECTIVE

This research aims to design parameter of surface texturing for dimples and to investigate the influence of surface texturing on the lubricant flow. It is intended that the research finding will contribute to conduct the simulation and analysis using ANSYS FLUENT and CFD.

These above aims raise the following core research objective:

1. To investigate the effects of the shape of surface texturing for dimples by using simulation.

2. To evaluate the distributions of the geometry of surface texturing for dimples.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

In this chapter there are consists of all previous studies related to this project and explains more detail and deeper history of the surface texturing design and performance aspect of surface texture. However, to investigate the effect of the shape and the distribution of geometry of dimples, the background of the study should be exposed. The early section of this part will be explaining some of the literature review about surface texture of dimples. The other part involves on elaborating in design consideration of texture and the surface influences on lubricant flow.

2.1 SURFACE FINISH

Surface finish, or texture, can be viewed from two very different perspectives which is result from the manufacturing process. Texture can be changed by altering the process while by changing the surface finish specification; the functionality can be enhanced and be improved. Today, various forms and geometric features of surface texturing for tribological applications are carried out widely. There are have a various texturing techniques in these studies including machining, photoetching, etching techniques, ion beam texturing, and laser texturing.

In engineering fields, surface texturing as a means for enhancing tribological properties of mechanical components is well known since many years. It is the most familiar and earliest commercial application of surface texturing in engineering. In most cases, surface finish control starts in the drafting room. The designer has the responsibility of specifying a surface that will give the maximum performance and surface life at the lowest cost.

There are two principal reasons for surface control which is to reduce and control friction and wear in order to extend the lifetime oh mechanical systems, to improve their efficiency and reliability, to conserve scarce material resources and energy, and to improve safety. The degree of friction is expressed as a coefficient of friction μ, which is expressed as the ratio of force required to initiate or sustain relative motion to the normal force that presses the two bodies together. Two modes of friction may occur either in sliding or rolling friction. In friction reduction, surface texture created a film of lubricant between two moving parts and the surface irregularities must be small enough so they will not penetrate the oil film under the most severe operating conditions.

2.2 DIMPLED SURFACE TEXTURE

Dimples texture is a surface texturing form by micro or nano scale cavities or pockets in an arrayed pattern on one of the sliding surfaces. Several fabrication techniques can be used to manufacture this type of texture, such as vibro-rolling, reactive ion etching, abrasive jet machining, LIGA, vibro mechanical texturing and laser surface texturing (Etsion, 2009). In recent years, surface texturing has been surfaces lift that contact increase successfully in many applications to improve the tribological properties of sliding surfaces, such as golf ball, engine cylinder, modern magnetic storage device, sliding bearing and mechanical seal, and slider and disc of hard disc driver (Wakuda et al, 2000).

In surface engineering, surface texturing of dimples be the most advanced methods for tribological application. Different patterns have also been used either being linear grooves, crossed grooves, or circular dimple-like depressions (Qiu et al,

2013). These patterns are useful for effective lubrication between contact by providing micro-hydrodynamic bearing, lubricant reservoirs and traps for wear debris in both lubricated and non-lubricated application, which protect the surface from scratching. In cases of mixed lubrication, micro-scale dimple can create an asymmetric pressure distribution that can change hydrodynamic and boundary lubrication, thus reducing both friction and wear. At this stage, pressure increase in the thin lubricant film to separating the sliding surfaces, so that the additional pressure will increases the separation between the sliding surfaces and correspondingly reduces the friction and wear.

2.2.1 Tribological Effect of Dimpled Surface

According to (Amanov, 2013), they found that a dimpled pattern reduced the coefficients of friction, whereas a grooved pattern increased. They observed that laser surface texturing could reduce the friction on components operating in a boundary-lubricated regime. This study included different sized dimples, but its more focused on the tribological behavior rather than the effects of the dimple dimensions. Figure 2.1 shows that texturing the surface reduced the coefficient of friction, and the transition from the hydrodynamic regime to the mixed or boundary lubrication regime increase in the wear lifetime.

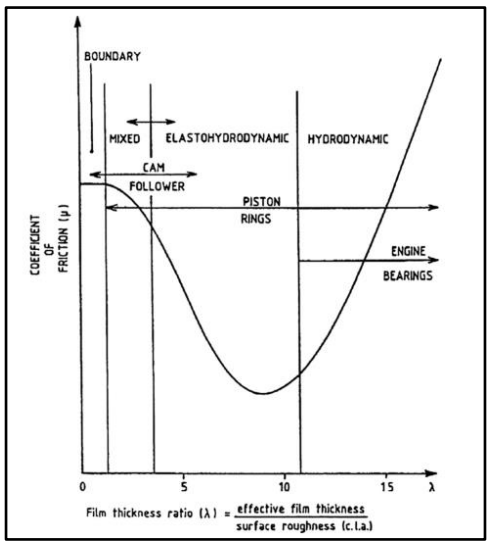

Figure 2.1: A Modified Stribeck Curve On Automotive Engine Part (Amanov et al, 2013)