UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BRAKE DISC MATERIAL ANALYSIS USING PIN AND DISC SIMULATION

SUHAIL AZMIN BIN ROSMAN

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DECLARATION

I declare that this Choose an item. entitled " BRAKE DISC ANALYSIS USING PIN AND DISC SIMULATION " is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : SUHAIL AZMIN BIN ROSMAN

Date : 18 JANUARY 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Degree Engineering Technology (Automotive) with Honours.

Signature : 

Supervisor Name : *PN. SUSHELLA EDAYU BINTI MAT KAMAL*

Date : 18 JANUARY 2022

DEDICATION

This thesis is dedicated to our respective parents and family, to my supervisor Pn. Sushella Edayu Binti Mat Kamal who have been a constant source of inspiration. They have give me the drive and discipline also determination in completing the task. Without their support, the work may not have been done.

ABSTRACT

A brake is used in a vehicle to stop or slow down the vehicle. The brake works by creating a friction from the rubbing of the surface. The kinetic energy will transform into thermal energy and then the heat need to be dispersed. This act will slow down the vehicle until it stop. There are 2 types of brake system in vehicle which is drum brake and disc brake. This day, disc brake rise in popularity since disc brake is more efficient in stopping the vehicle. Many research has been made to find the best material for the brake disc. The material should be able to handle harsh environment, able to handle heat, and sturdy. The material should be long lasting to wear and long lasting. The material that often used in the brake material is gray cast iron and stainless steel. The gray cast iron are said to have good friction and wear performance while stainless steel is tolerant to almost all of the brake pad types. In this work, the performance of both Cast Iron and Stainless Steel was simulated using ANSYS Software. The design was based on the automobile disc brake and pad. The design was drawn on CATIA V5R20 and the file was saved to a types that is compatible to ANSYS Software. The test that was conducted is Steady State Thermal Analysis and Static Structural Analysis. From the result, it was found that, Stainless Steel is superior than Cast Iron. Cast Iron is slower in rising the temperature, but Stainless Steel has better heat flow and cooldown much faster. Stainless Steel also is more sturdy compared to Cast Iron. Stainless Steel deformed a lot slower and has better elasticity compared to Cast Iron. As a conclusion, the objectives for this project is achieved, which is to build a model to simulate brake disc and pad using CATIA V5R20. Next, to analyze the material of the brake disc its Structural and Thermal Analysis using ANSYS Software. Lastly, to determine the best material for brake disc and pad based on the analysis done.

ABSTRAK

Brek digunakan dalam kenderaan untuk menghentikan atau memperlahankan kenderaan. Brek berfungsi dengan membuat geseran dari gosokan permukaan. Tenaga kinetik akan berubah menjadi tenaga terma dan kemudian haba perlu dilepaskan. Tindakan ini akan memperlahankan kenderaan sehingga berhenti. Terdapat 2 jenis sistem brek kenderaan iaitu drum brake dan disc brake. Hari ini, brek cakera semakin popular kerana brek cakera lebih cekap dalam menghentikan kenderaan. Banyak penyelidikan telah dibuat untuk mencari bahan terbaik untuk cakera brek. Bahan harus dapat menangani persekitaran yang lasak, mampu menangani suhu tinggi, dan kukuh sifatnya. Bahan tersebut mesti tahan lama untuk dipakai. Bahan yang sering digunakan dalam brek disc adalah cast iron dan keluli tahan karat. Besi tuang kelabu dikatakan mempunyai prestasi geseran dan keausan yang baik sementara keluli tahan karat tahan terhadap hampir semua jenis pad brek. Oleh itu, dalam tesis ini, kita akan mensimulasikan prestasi besi tuang dan keluli tahan karat. Enjin simulasi yang kami gunakan adalah ANSYS. Perisian ini mempunyai banyak fungsi untuk menganalisis sifat material dan potensi hadnya. Reka bentuknya adalah berdasarkan brek cakera dan pad kereta. Reka bentuk telah dilukis pada CATIA V5R20 dan fail telah disimpan pada jenis yang serasi dengan Perisian ANSYS. Ujian yang telah dijalankan ialah Analisis Terma Keadaan Steady dan Analisis Struktur Statik. Daripada hasilnya, didapati bahawa, Keluli Tahan Karat adalah lebih unggul daripada Besi Tuang. Besi Tuang lebih perlahan dalam meningkatkan suhu, tetapi Keluli Tahan Karat mempunyai aliran haba yang lebih baik dan penyejukan lebih cepat. Keluli Tahan Karat juga lebih kukuh berbanding Besi Tuang. Keluli Tahan Karat berubah bentuk jauh lebih perlahan dan mempunyai keanjalan yang lebih baik berbanding Besi Tuang. Kesimpulannya, objektif projek ini tercapai iaitu membina model simulasi cakera brek dan pad menggunakan CATIA V5R20. Seterusnya, untuk menganalisis bahan cakera brek Analisis Struktur dan Terma menggunakan Perisian ANSYS. Akhir sekali, untuk menentukan bahan terbaik untuk cakera brek dan pad berdasarkan analisis yang dilakukan.

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LIST OF SYMBOLS AND ABBREVIATIONS

A	-	Area
C	-	Carbon
CI	-	Cast Iron
CE	-	Carbon Equivalent
EC	-	Elemental Carbon
P	-	Perimeter
SS	-	Stainless Steel

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CHAPTER 1

INTRODUCTION

1.1 Background

A brake is a component in a vehicle that used to slow or stop the vehicle by applying pressure to the wheels. The purpose of braking system is to transform mechanical strength of shifting vehicle into some other shape, which leads to lessening the rate of the vehicle. The kinetic energy of the moving vehicle is converted into the thermal energy from the friction results, which then cause the heat to dissipate into the environment. A brake disc plate is fitted to and spins with the wheel. Two brake pads are positioned inner a calliper set up on the knuckle, that is hooked up at the chassis. When the driving force hits the brakes, the brake cylinder strain will rise, and the piston pushes the pads into contact with the disc. The friction pressure among the brake pads and disc exerts braking torque on the disc, that is related to the wheel, and the following friction among the tire and the road makes the vehicle slow down.

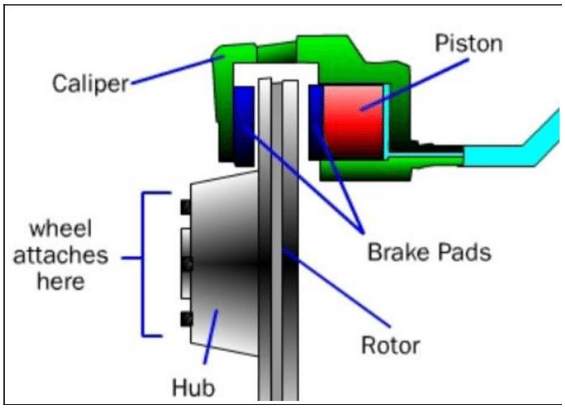

Figure 1-1 Brake Disc types component.

In the process of braking, the friction system generates a boundary film on the friction interface, which is different depends on the materials. Because of its composition and structure that are complex and diverse, it became one of the important factors of automobile braking. Example of material are Cast iron, cast iron is a common material for automobile brake discs. According to (Wanyang Li), the vermicular graphite of cast iron has significant amount of good friction and wear performances. The other material is a Stainless steel. It is very tolerant to almost all brake pads and particularly to. It is highly resistant to wear and does not shatter and it resists heat very well. (Katsuhisa, 2008) But the friction coefficients were not as good as cast iron, which lead to some researcher to state that cast iron is still the right material.

1.2 Problem Statement

To study the reaction on the brake disc material for its structural and thermal analysis, tribology research is used. Tribology is defined as a reaction of interacting surfaces in relative motion. To perform it, need an expensive equipment and professional skill to handle the equipment. So, to solve the problem, researchers can use an ANSYS Software. This software can simulate the component material and structure, then perform a full analysis on it. This way, we can save cost and run any numbers of simulation using the software. For material used, two types are pick, which is cast iron and stainless steel. By the end of the analysis, a comparison will be made among the two materials.

1.3 Research Objective

a) Building a model to simulate brake disc and pad using CATIA V5R20.

b) To analyse the structural and thermal analysis of brake disc and pad friction using ANSYS Software.

c) To determine the best material for brake disc based on the structural and thermal analysis.

1.4 Scope of Research

The simulation of structural analysis and thermal analysis of the brake disc material using two type of material. Two simulations was conducted with one using stainless steel as material and the other simulation used cast iron as the material. The simulations was conducted to study the reaction of the material under certain pressure. The result of both simulations was compared to, and the conclusion was made based on the result.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed the previous research and sources related to the investigation of wear mechanism in general and material used in disc brake on automobile. The sources include journals, report, book, and websites. The sources are used as a guideline to complete this study by using the related information, ideas and knowledges obtained from it. In this study, theories and analysis related to the investigation of natural fiber composite is discussed.

2.2 Wear mechanism

According to (Stachowiak, 2005) These surfaces are moving in relative motion, which is by sliding, rolling, or under load. Wear occurs because of the high stress on the material which is usually cause by environment factors. There are many types of wear to the material.

2.2.1 Abrasive wear

Abrasive wear is when a soft surface material rubbing against hard surface material. If the abrasive wear involved two rubbing part, it is called two body wear. (Rabinowicz, 1961) The harder material will cause asperities on the softer surface. If the wear is caused by a hard particle or grit trapped among the two-rubbing surface, it is called three body wear. We can see the three-body wear in a classic cutting model for abrasive wear. According to

(SIN, 1978), the volume wear rises with grit size up to some critical diameter and then slowly rises with grit size. The micro-level abrasive action can cause a wear mode, which is ploughing, cutting, and cracking.

2.2.2 Adhesive wear

Adhesive wear commonly occurs at the sliding contact among materials with comparable hardness in the presence of a strong adhesive force. According to, (Ramin Aghababaei, 2016), during sliding, welding actions occur among a limited number of surface asperities which undergo large plastic deformation. The load applied to the contacting asperities is so high that they deform and adhere to each other forming micro-joints. The motion of the rubbing counter bodies results in rupture of the micro-joints. When considerable areas of the rubbing surfaces are joined during the friction a seizure resistance of one of the bodies by the counter body may occur. (Ramin Aghababaei, 2016)

2.2.3 Fatigue wear

According to, (Wang, 2013) fatigue wears is a crack on the surface of the material than deteriorate to the subsurface. It happened when the load applied is heavier than the fatigue strength of the material. Example of fatigue wear is fretting wear caused by sliding of two surfaces across each other with a small effect. Fatigue of overlay at an engine bearing can spread the crack to the middle layer of the bearing and might break eventually.

2.2.4 Corrosive wear

Corrosive wear is an oxidation of the material resulting in increasing the wear rate of the material. Usually because the rise temperature in the surrounding area of the material and the removal of the protecting oxide film from the surfaces that caused the oxidation process. (LACHOWICZ, 2019)

2.2.5 Erosive wear

Erosive wear is caused by damage from particles like solid, liquid, or gaseous form, which cause the fragment to chip from the momentum of the particles. The particles move relatively fast against the material surface. The particle that rubbing the surface cuts a small particle of the surface. (Hirani, 2019)

2.3 Material for disc brake

A disc brake types used on automobile are functioning by using the calipers to squeeze pairs of pads against a disc or a rotor to create friction. This action will slow down the rotation of a shaft, such as a vehicle axle, to reduce its rotational speed or to hold it stationary. The motion energy is converted into waste heat and need to be released outside. To withhold such energy to stop a vehicle, material for disc brake need to have a great thermal capacity, a good elasticity, low deformation, light, long lasting, low and reasonable cost. To abide by those criteria, research and engineer mixture a lot types of material with different properties. (Weintraub, 1996) says these days, there are over than 1500 types of different material that are exercised in brake system.

According, (Halderman, 2000) says that the shape, the measurement, and the chemical structure of brakes affect the heat flux direction, the sturdiness, the sound generation, and the operation of the two types of brake systems which is the drum brake and the disc brakes. Disc brake is better to wear resistance compared to drum brake and simpler to maintenance.

2.3.1 Chemical composition

The main function of brake disc are the fusion of significant involuntary force and decreasing of the heat from disc when braking. The temperature of work is depending on how frequent the driver braking, it can reach among room temperature, and sometimes it will reach until 700°C. This will rise the temperature slopes in the disc, which lead to thermal exhaustion problems. (Baron Saiz, 2015)

(Maluf, 2004) says that cast iron is often used since it has better metallurgic stability behavior, lower cost and can be produce easier. There are also other type of material that was used but for greater capability braking situations, which is the part is succumbed to a very high temperatures. Example, composite resources of carbon matrix has a high heat capacity but the cost is to great and the production is to hard for automobile production There is also a brake disc made of cast iron with titanium, element that rises the component strength, but reduces the friction coefficient, which can be a major problem when there is little braking distance. Figure 2-1 shows the reduction of the friction coefficient with the rise of titanium percentage in the disc.

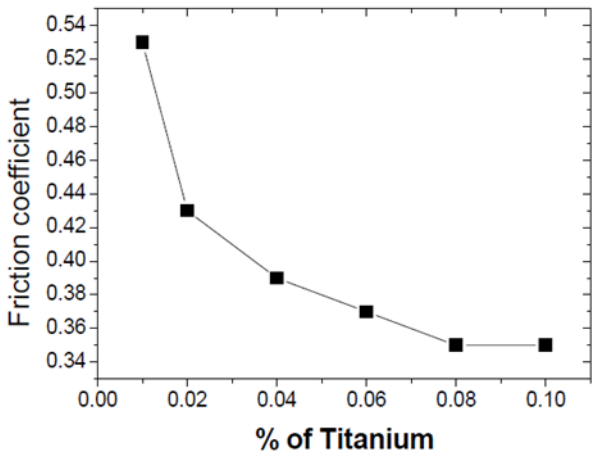

Figure 2-1 Friction coefficient against the percentage of titanium for a brake disc cast iron.

Source: (Maluf, 2004)

According to (Maluf, 2004), aluminum alloys including silicon carbide is used because they have low density. But it is low in weight and do not dissipate the heat as well as the gray cast iron. Thus, cast irons are the most suitable materials to create brake disc components. It is classified as portrayed, which is gray in color, with nodular, vermicular, and malleable. Moreover, gray cast iron is a lot cheaper compared to other material and are used in a lot of automotive brand. To produce a different types of cast iron, the metallic load to be molten is included with alloy elements, scrap iron and pig iron.

2.3.2 Physical and mechanical properties

Cast irons are not choose only because of its low cost, it also has an excellent thermal conductivity which helps dissipates the heat created from friction of the pads and the disc during braking process, and the capacity of damping vibrations which are main characteristics of the component.