UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Design Analysis of High Performance Motorcycle Disc Brake

SESI PENGAJIAN: 2012/13 Semester 2

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN ANALYSIS OF HIGH PERFORMANCE MOTORCYCLE DISC BRAKE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) (Hons.)

by

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2013

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) (Hons.). The member of the supervisory is as follow:

……

DECLARATION

I hereby, declared this report entitled “Design Analysis of High Performance Motorcycle Disc Brake” is the results of my own research except as cited in references.

Signature	:	…….
Author’s Name	:	YONG SZE YEAU
Date	:	28 JUNE 2013

ABSTRAK

Cakera brek adalah brek yang digunakan untuk memperlahankan kelajuan kenderaan dengan hasilan geseran. Geseran tersebut dihasilkan oleh brek pad yang dilampirkan dengan satu set kaliber tekan terhadap cakera yang berputar. Cakera membantu dalam membebaskan haba yang dihasilkan oleh geseran terutamanya dalam keadaan brek kecemasan. Projek ini telah dijalankan untuk menyiasat parameter reka bentuk brek cakera depan HONDA GL1500 VALKYRIE motosikal. Selain itu, analisis terma fana dan analisis statik strutur dijalankan ke atas cakera brek motorsikal dengan 3 jenis bahan yang berlainan. Satu bahan yang sesuai untuk HONDA GL1500 VALKYRIE motosikal telah dikemukakan selepas simulasi tersebut. CAD model cakera brek telah dilukis dengan menggunakan perisian Solidworks 2010. Analisis terma fana dan analisis static strutur pada brek cakera dilakukan dengan menggunakan perisian ANSYS. Hasil analisis statik stuktur telah ditafsirkan dalam tiga aspek: tegasan, pengubahan bentuk dan faktor keselamatan. Jangkaan hayat brek cakera untuk bahan yang dipilih juga ditentukan dalam analisis dan simulasi. Martensit, Tempa AISI 410 didapti dapat menahan haba dan tekanan dalam analisis simulasi. Hal ini demikian, projek bercadang bahawa martensit. AISI 410 menjadikan cakera brek disc kepada HONDA GL1500 VALKYRIE motorsikal.

ABTRACT

A disc brake is a brake that slows down the vehicle's speed by the friction caused by the brake pads press against the rotating disc with a set of calipers. Disc rotor helps to dissipate the heat which caused by the friction especially under hard braking conditions. This project was performed to investigate the design parameters of the front disc brake of the HONDA GL1500 VALKYRIE motorcycle. Besides that, transient thermal analysis and static structural analysis were performed on the high performance motorcycle disc brake with 3 candidate materials. A suitable material for HONDA GL1500 VALKYRIE motorcycle was proposed after the simulation and analysis. The CAD model of the high performance motorcycle disc brake was created by using the Solidworks 2010 software. Transient thermal analysis and static structural analysis were performed on the disc brake by using ANSYS software. The result of static structural analysis was interpreted in three aspects: stress, deformation and Factor of Safety (FoS). Cyclic loading of disc brake for the suitable material was also defined by simulation analysis. It was found that Martensitic Stainless steel, Wrought AISI 410 was able to withstand the heat and stress in the simulation analysis. Thus, it was proposed that Martensitic Stainless steel, Wrought AISI 410 used as the material for HONDA GL1500 VALKYRIE motorcycle.

DEDICATION

To my beloved parents, siblings and friends for their love and support

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I would like to express my sincere gratitude to my dedicate co-supervisor, Dr Taufik, for his guidance in conducting and writing this report. I am grateful for his professionalism and his tolerance of my naive mistakes.

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TABLE OF CONTENT

CHAPTER 1
INTRODUCTION

This chapter introduces the main idea of thermal stress analysis of high performance motorcycle disc brake. This chapter provides general background of disc brake, problem statement, objectives and scope of the project.

1.1 Background

In the last decade, there had been a large growth in motorcycling in many (Haworth, in press). In the majority of Southeast Asian countries, the main road users were motorcycles (Hussain *et al*., 2005) and (Lin and Kraus, 2009).

There were about 20 times of the risk of death of motorcycle crash higher compared to other vehicles for every kilometer traveled by according to Chang and Yeh (2006) and Department for Transport (2008). In Malaysia, MIROS (2011) stated that the majority of traffic fatalities were motorcyclists which were about 60%. Therefore, the safety of these vulnerable road users should pay close attention.

Performance of vehicle relies on several elements; motive power that propels vehicle and its load, steering system, suspension system, braking system and other issues. Davoodi (2012) states that the braking system is not only provides the means to slowing down and stop a vehicle, it also ensures the stationary position of the vehicle

can be maintained especially when standing on a steep road. Thus, the brake system is as crucial as it concerns to safety of passengers. Kang and Cho (2012) highlight that brake systems face more severe operating conditions as high and fast outputs of motorcycle engines. Due to these environments, the study is ongoing (Ryu *et al*., 2008). Hence, it is important to recognize the importance of the motorcycle brake system due to the continuous increase motorcycle accident cases in Malaysia.

According to Abdo (2009), brake is a device that applies friction to move the device to slow it down and bring it to a stop. Motorcycle braking is accomplished by the friction produced when brake linings are forced against a rotating disc and drum. Friction between the linings and disc or drum will eventually stop wheel rotating. Therefore, disc brakes or drum brakes play an important role in the brake system. Ma (2008) explains that the brake requires friction materials with certain material properties. For instance, the disc brake material had to have high and stable friction coefficient, low cost, no noise, low wear rate, and also friendly to the environment.

1.2 Problem Statement

The brake discs are in contact with two pad discs on their sides. These works highlighted the importance of contact analysis of brake disc (Tehrani and Talebi, 2012). It is very important that brake systems quickly dissipate the heat that is generated by the friction of the braking action to ensure that the stopping force is consistent (Abdo, 2009).

According to Newcomb (1998), temperature and thermal gradients are very high in the braking phase. The excessive rise of temperature causes fades phenomenon, which induces performance-degrading, by curing the friction part of the brake (Kim *et al.,* 2008). Therefore, a study is necessary for temperature rise in friction parts of

the disc and the resulting thermal deformation in the design of the disc brake (Joo et al., 2009) and (Yeo, 2002).

Thermal deformation is caused by the non equilibrium thermal expansion of the rotor. It contributes to a number of geometrical distortions in the rotor. The consequences of the thermal deformation may lead to a warped friction ring (thermal buckling), or result in disc coning (Sterne, 1989). Majcherczak *et al*., (2001) and Colin *et al.,* (1988) states that, the appearance of cracks was the consequence of the form of stresses and deformation.

Crack, warp and scar are the most common failure found in the disc brake. It is due to the temperature rises during the emergency hard braking. As the disc brake fails to function, a serious accident case will be occurring. Therefore, a study of thermal stress analysis through finite-element analysis is needed to find out the stress and heat distribution in transient time.

1.3 Objectives

a. To investigate the design parameters of high performance motorcycle disc brake.

b. To perform the transient thermal analysis and static structural analysis on the high performance disc brake.

c. To propose the suitable material for HONDA GL1500 VALKYRIE disc brake.

1.4 Scopes and Limitations

The disc brake rotor used for simulating transient thermal analysis is specified disc brake used in high performance motorcycle – HONDA GL1500 VALKYRIE. Besides, it is specified that the disc brake used is from the front wheel. It is because an inertia force acting at the center of gravity of the vehicle causes the weight of the vehicle to shift to the front of the vehicle when a vehicle decelerates (Hilliers and Coombes, 2004).

1.5 Report Organization

This report is divided into several chapters, which corresponding to the following consideration. Chapter 1 introduces the general ideas on the braking system and the importance of disc brake. This chapter also discusses the problem statement, report objectives and scopes.

Chapter 2 reviews of the previous study published by other researchers. Besides, current braking systems and the detailed review of disc brake rotor have been described. This chapter also explains the theory of heat transfer and thermal stress analysis.

Chapter 3 methodology which explained the method used to achieve the objectives. A step-by-step flow chart is presented to show the overall process flow in this project implementation. Besides that, manual calculations are performed in order to find the simulation input data.

Chapter 4 is discussed on the result of transient thermal analysis and static structural analysis which simulate by using the FEA method. This chapter is first discussed on the thermal distribution of disc brake in transient time. Then, the design parameters such as stress, deformation and factor of safety are discussed. A suitable material is proposed as the material for HONDA GL1500 VALKYRIE disc brake.

The last chapter is about summarizing of the full report. In this chapter, the conclusion is done based on the finding results and limitations.

1.6 FYP Time Schedule

Gantt chart for PSM 1 and PSM 2 are shown as Table 1.1 and Table 1.2.

Gantt chart for Final Year Project 1 (FYP 1)

Table 1.1: Gantt chart for Final Year Project 1 (FYP 1)

Task	Academic Week of Semester 1															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selection of PSM Title																
PSM Title Selected & Filled the Form																
Identify the Scope and Objective of the Project																
Review of Problem Statement																
Explore the Information, Journals and Reference Book																
Implement Introduction and Literature Review																
Preparing Flow Chart of Methodology																
Implement Methodology																
Complete PSM 1 Report																
Review on PSM 1 Report																
Presentation																
Modify and Repair the Report																
Submit PSM 1 Report																

Gantt chart for Final Year Project II (FYP II)

Table 1.2: Gantt chart for Final Year Project II (FYP II)

Task	Academic Week of Semester 1															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Finalize the Design and Preparing Drawing																
Review Literature Finding and Methodology																
Performing Analysis and Simulation																
Review and Intepreting Result																
Result ans Discussion																
Develop Conclusion																
Review and Identify weakness																
Develop Recommendation																
Complete PSM II Report																
Review PSM II Report																
Presentation																
Modify and Repair the Report																
Submit PSM II Report																

CHAPTER 2
LITERATURE REVIEW

This chapter discusses about the previous studies by researchers in order to provide sufficient background information and establish the need to perform and analyze high performance motorcycle disc rotor. The braking system and types of brake are discussed. The epistemology of disc rotor and its relevant analysis are chosen to be deeply investigated. Some relevant information such as the selected motorcycle specification and useful software are also considered in this chapter.

2.1 Brakes System

A braking system is a vital safety control of a vehicle to stop within the possible shortest distance during the emergency braking, normal operation and parking conditions (Dukkipati, 2008) and (Akop, 2009). According to John *et al*., (1999), motorcycle braking is accomplished by the friction produced when brake lining is forced against a rotating disc or drum. Motorcycle brakes commonly actuated by either hydraulic (fluid pressure) or mechanical (cable or linkage) mechanisms (John *et al*., 1999).

2.1.1 Mechanical Brake System

When the brake is applied, a cam pushes two semicircular shoes to expand. It is then pressed against the rotating drum and thus limiting its free rotation (Abdo, 2009). Figure 2.1 shows the mechanical brake system.

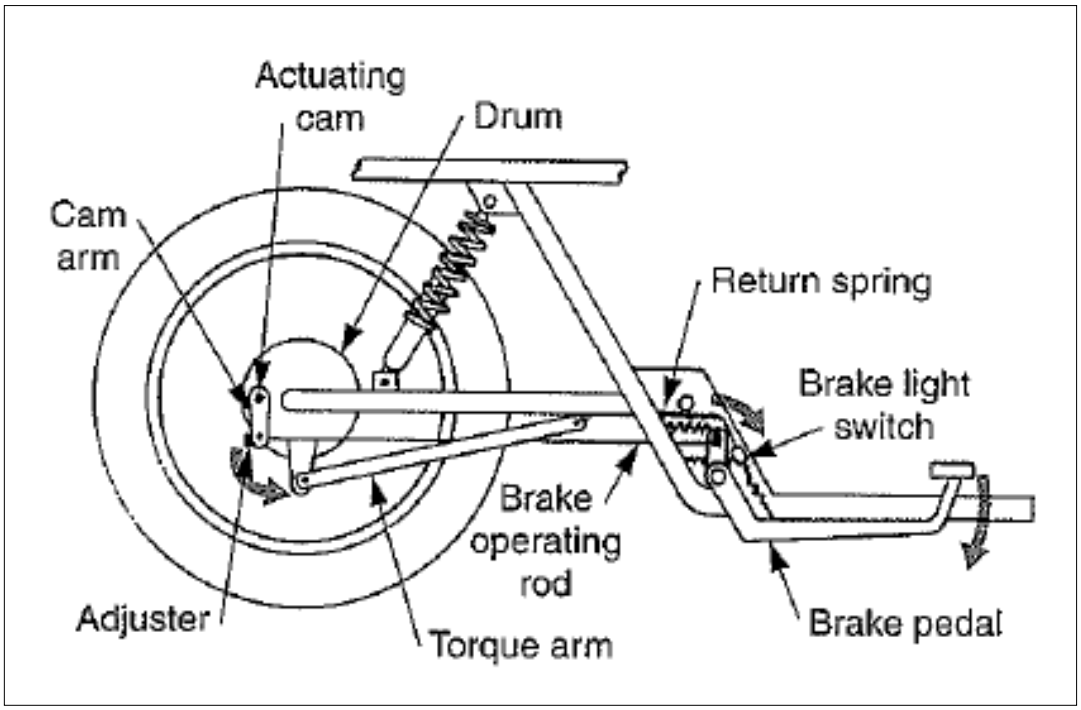

Figure 2.1: Mechanical brake system (Source: John *et al.*, 1999)

According to John *et al.*, (1999), the stopping ability of the mechanical brake system is determined by:

a. The system's mechanical leverage
b. The brake lining surface area
c. The composition of the brake lining
d. The brake drum's ability to dissipate heat

2.1.2 Hydraulic Brake System

Hydraulic, often called fluid pressure, is a method of transmitting motion or force (Birch. 1999). Seeley (2004) states that the hydraulic disc brakes are more commonly used on motorcycles today compared with hydraulic operates drum brakes. Figure 2.2 shows the hydraulic brake system:

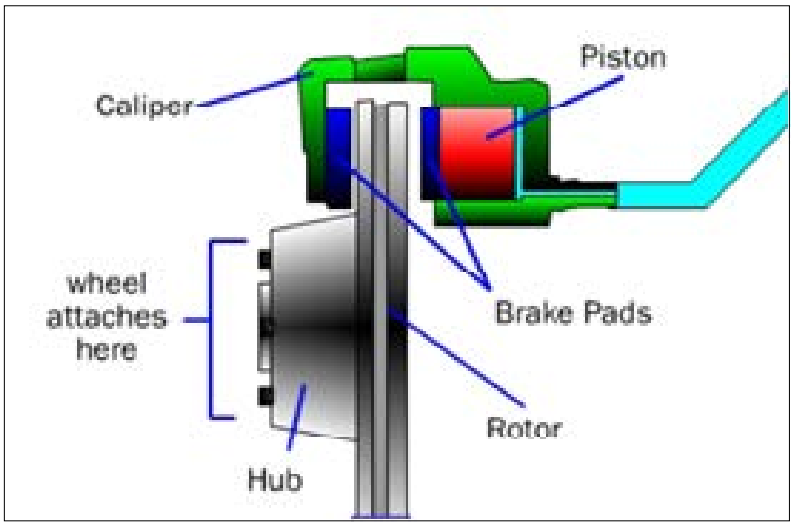

Figure 2.2: Hydraulic brake system (Source: goodkarmaproductions, 2012)

As the brake lever is pulled, a pushrod makes the piston moves forward. This movement causes the brake fluid pressurizes in the line and caliper. The pressure is then exerted against the caliper piston, which force the brake pads against the disc.

2.1.3 Types of brake

According to Hiller and Coombes (2004), two main types of brakes are used which is drum and disc. Disc brakes are usually found in the front, with drum brakes in the rear (Gilles, 2005). The trend in brake design is moving forward disc brake on all bikes (John *et al*., 1999).

2.1.3.1 Drum brake

Halderman (2010) defines that drum brakes were the first types of brakes used on motor vehicles. John *et al*., (2009) states that the drum brake is a brake that the friction is caused by a set of shoes which press against the inner surface of a rotating drum.

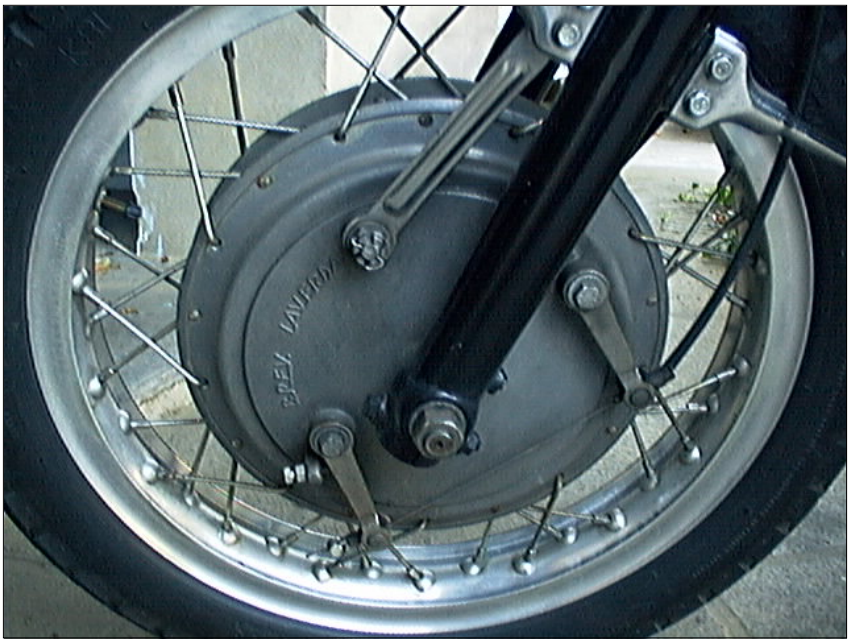

Figure 2.3: Drum brake (Source: seismo, 2012)

Most researchers include Erjavec (2004), Hillier and Coombes (2004), Gilles (2005) and Halderman (2010), had investigated the advantages and disadvantages of drum brake. Table 2.1 reveals the result from those researchers.

Table 2.1: Advantages and disadvantages of drum brake

Advantages	Disadvantages
• Provide good initial stopping ability • Provide a means for a good, inexpensive, mechanical parking brake • Offer self-energizing action that helps force the brake lining tightly against the drum • Offer servo-action that enables a brake shoe to exert greater stopping power	• Brake fade – inefficient in dissipating heat • General evolution of the design

2.1.3.2 Disc brake

Based on John *et al*., (1999) and Seeley (2006), disc brakes are commonly used on both front and rear wheels. It is because the operation of disc brake is simpler than that of drum brakes as claimed by Birch (1999). Abdo (2009) writes that a disc brake relies on friction being applied to both sides of a spinning disc of brake pads. Figure 2.4 shows the disc brake: