‘I admit that had read this thesis and in my opinion this thesis was satisfied from the aspect of scope and quality for the purpose to be awarded Bachelor of Mechanical Engineering (Automotive)’

Signature	: ………………….
Name of Supervisor I	: Dr. Muhammad Zahir Hassan
Date	: 22 April 2011

DESIGN AND FABRICATE A BRAKE SYSTEM FOR UTEM PERSONAL ELECTRIC VEHICLE (PEV)

MUHAMMAD AIZUDDIN BIN OSMAN

The PSM (Project Sarjana Muda) report is considered as one of the essential for student to complete their bachelor program in Mechanical (Automotive)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2011

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

Signature : ……………………..
Author : Muhammad Aizuddin bin Osman
Date : 22 April 2011

Dedicated to Osman bin Akar and Fatimah binti Abdul Malek

Siblings and friends

ACKNOWLEDGEMENT

Alhamdulillah with His Mercy and blessings, my greatest gratitude to Allah the Almighty for the chances given to me to complete this project. First and foremost, I would like to thank to my advisor of this project, Dr. Muhammad Zahir Hassan for the valuable guidance, information, advice and encouragement. His willingness to motivate me contributed tremendously to my project.

Besides, I would like to thank to my beloved parents, Osman bin Akar and Fatimah binti Abdul Malek for their support and advice to me finish this final year project. Without their support, I will never go this far.

Last but not least, an honorable mention goes to my friends especially PEV members for their understandings and supports on me in completing this project. Without helps of the particular that mentioned above, I would face many difficulties while doing this project.

ABSTRACT

The purpose of this project was to design and fabricate an optimized disc brake rotor for UTeM personal electric vehicle. There are several properties of the disc brake rotor must be consider to make sure that the product that will produce have a quality from all aspects which are low noise level, life cycle cost, pollution rates, energy consumption, material consumption, provide safety and reliability, and high serviceability. There are three differences of disc brake rotor was design that represent two type of ventilated disc brake rotor and one for solid disc brake and all this design was evaluated to chose the best and suitable for this personal electric vehicle. All the design was conducted by using CATIA software (V5R16). The selected disc brake rotor was analyzed in terms finite element analysis (FEA). For this FEA, the thermal analysis was conducted to analyze this brake system by applying the different material for disc brake system like Gray Cast Iron Grade 220, Titanium Ti-6Al-4V Grade 5, and Stainless Steel Grade 420. From the result, the best material is Gray Cast Iron Grade 220 that produces the low thermal analysis compare with others material and it will be selected for this project. This analysis was run by using ABAQUS software version 6.9.

ABSTRAK

Tujuan projek ini di jalankan adalah untuk merekabentuk dan memasang brek cakera yang dioptimakan untuk kenderaan elektrik persendirian di UTeM. Ada beberapa ciri-ciri brek cakera yang harus dipertimbangkan untuk memastikan bahawa produk yang akan dihasilkan mempunyai kualiti dari semua aspek dimana ia mempunyai tahap kebisingan yang rendah, kos kitaran hidup yang rendah, kurang tahap pencemaran, penggunaan tenaga yang rendah, penggunaan bahan yang berpatutan, memberikan keselamatan dan kebolehpercayaan dan kebolehkhidmatan yang tinggi. Terdapat tiga rekabentuk yang berlainan yang mewakili dua rekabentuk dari jenis yang mempunyai pengudaraan dan satu dari jenis brek cakera yang padu dan semua rekabentuk dinilai untuk memilih brek cakera yang terbaik dan sesuai untuk kenderaan elektrik persendirian ini. Semua rekabentuk dijalankan dengan menggunakan perisian CATIA (V5R16). Brek cakera yang dipilih dianalisis menerusi analisis unsur terhingga (FEA). Untuk sesi ini, analisis terma dijalankan untuk menganalisis sistem brek dengan menggunakan bahan yang berbeza untuk sistem brek cakera seperti Besi Tuang Kelabu Gred 220, Titanium Ti-6Al-4V Gred 5, dan Besi Tahan Karat Gred 420. Dari hasil kajian yang diperolehi, analisis terbaik ialah Besi Tuang Kelabu gred 220 yang menghasilkan analisis termal yang rendah jika dibandingkan dengan bahan yang lain dan ia dipilih untuk projek ini. Analisis ini dijalankan dengan menggunakan perisian ABAQUS versi 6.9.

TABLE OF CONTENTS

CHAPTER	CONTENT	PAGE

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS

ICE	Internal Combustion Engine
BEV	Battery-Electric Vehicle
HEV	Hybrid-Electric Vehicle
GHG	Obal Greenhouse Gas
UTeM	Universiti Teknikal Malaysia Melaka
PEV	Personal Electric Vehicle
DC	Direct Current
FEA	Finite Element Analysis
Fe	Iron

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

This project was conducted to design and fabricate a brake system for UTeM personal electric vehicle. Electric vehicles have been around since the inception of the automobile. But in the early race for dominance, the internal combustion engine (ICE) quickly won out as the best power system for cars.

Electric vehicles are divided into two general categories which are battery-electric vehicles and hybrid-electric vehicles, which represent the design orientation of the vehicles' power system. Battery-electric vehicles or BEVs are vehicles that use secondary batteries (rechargeable batteries, normally called storage batteries) as their only source of energy (Riley, 2007).

A hybrid-electric vehicle or HEV combines an electrical energy storage system with an onboard means of generating electricity or augmenting the energy stores of the battery, normally through the consumption of some type of fuel (Riley, 2007).

In this project, battery-electric vehicle is choose because of it costs to built it cheaper compare with hybrid-electric vehicle. The aim of this project is to design a suitable brake system for UTeM personal electric vehicle.

1.2 PROBLEM STATEMENT

Nowadays, there are several problems occurs that related with vehicles which can harm the communities such as air pollution, noise, increasing vehicle on the road and so on. Therefore, personal electric vehicle that does not compromise safety issues such as braking is the best way to solve this problem to prevent this problem from getting worse. From here, the problem statement can be released and there are:

- Mobility
- Green technology
- Eco-design
- Affordability
- Reduced trip times

1.3 OBJECTIVES

The objectives of this project are:

1. To design a disc brake rotor for UTeM personal electric vehicle.
2. To fabricate a brake system forthe use of UTeM personal electric vehicle.

1.4 SCOPE AND LIMITATION OF PROJECT

The scopes and limitation of this project are:

1. To design the associatesdisc brake system for the UTeM personal electric vehicle.
2. To conducta thermal analysis of the disc brake system.
3. To install the brake system onto the personal electric vehicle.

1.5 THE STRUCTURE

This thesis contains 6 sections as shown below:

Chapter 1: This chapter provides an introduction to the project

Chapter 2: The research about previous studies that related with this project such as the review of personal electric vehicle, disc brake system and analysis for disc brake system.

Chapter 3: All the method use in this project including theoretical and experimental

Chapter 4:In this chapter, the result for disc brake analysis will be present

Chapter 5: The discussion about the result obtained from the previous chapter

Chapter 6: This section contains a summary of the whole project involve methodology, results, findings and recommendation for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

The transportation sector accounts for a large and growing share of global greenhouse gas (GHG) emissions (Anglin, 2008). In 1950, there were only 70 million cars, trucks, and buses on the world's roads. By 1994, there was about nine times that number or 630 million vehicles (SAIC, 2002). Since the early 1970s, the global fleet has been growing at a rate of 16 million vehicles per year. This expansion has been accompanied by a similar growth in fuel consumption (American Automobile Manufacturers Association, 1996). Because of these phenomena, electric vehicle was construct and commercialized.

This chapter begins with an introduction of electric vehicle, to give an origin of the electric vehicle as well as their advantages. Then, it continues with the automotive disc brake system, to give an overview of disc brake components and their function. A review of disc brake analysis literature is then presented that explains the method to do an analysis. There are two types of analysis which are experimental analysis and finite element analysis. For the experimental analysis, the brake dynamometer was represented and contact pressure analysis and thermal analysis are the method under finite element analysis.

2.2 ELECTRIC VEHICLE

2.2.1 History of Electric Vehicle

The first electric vehicle construction is credited to the French inventor and electrical engineer M. GustaveTrouvé, who demonstrated a motorized tricycle powered by lead-acid batteries in 1881. In the US, Andrew L. Riker is credited for building the first electric vehicle (also a tricycle) in 1890, and by 1891 William Morrison had built the first electric four-wheeler (Wakefield, 1998).

Electric cars then were running on lead-acid batteries at 1909, had exceeded 100 miles per hour, and achieved ranges of 180 miles and more per charge. Battery swapping had been implemented on an industrial scale. Hub motors were used in production vehicles. Charging stations for industrial vehicles had been developed in major centre's (McMahon, 2009).

By the 1920s, the piston-type internal combustion engine had prevailed as the dominant automotive power plant. Most production and development work on electric vehicles ended during the 1930s (Wakefield, 1998). Interest revived in electric vehicles as a result of concern with diminishing petroleum reserves, rising cost of crude oil production, and air pollution from the automotive engine that burned gasoline which was refined from crude oil.

Over the years, a few electric vehicles had been constructed, usually by converting small light cars and trucks into electric vehicles by removing the engine and fuel tank and installing an electric motor, controls, and batteries (Wakefield, 1998). However, during that time no major automotive manufacturer brought out an electric vehicle.

The electrics of the 1990 until now were different. They embraced leading edge electronics technology, advanced batteries and were designed to be fully functional, highway-capable cars. They intended to displace the internal combustion engine vehicle, not complement it in the urban mission only role (McMahon, 2009).

2.2.2 Personal Electric Vehicle (PEV)

The personal electric vehicle (PEV) emerged as a new category of transportation device in the late 1990s. PEVs transport a single passenger over trip distances of 1–10 km and employ electricity as the motive energy source. The category is principally comprised of electric-powered scooters and cycles (American Automobile Manufacturers Association, 1993).

Personal electric vehicles offer several potential benefits to consumers and to society. The PEV therefore offers many intriguing possibilities for extending the human range of mobility from about 1 km (via walking) to 10 km or more. However, the full potential of the category has not been realized, to a large extent because the vehicles are not light enough, do not go far enough, and cost too much (American Automobile Manufacturers Association, 1993). The benefits or the advantages of the personal electric vehicles are:

- Lower total operating costs than automobiles
- Use as auxiliary transportation with public transportation
- Use as auxiliary transportation with an automobile
- Lower door-to-door trip times for short distances and/or in dense urban environments
- Reduction of automobile use in congested urban environments
- Quiet and clean transportation
- Mobility for those with limited ability to walk

Normally personal electric vehicle consists of several main components. These components will affect the PEV performances. The components are:

i) Battery Charger

- The charger replaces the energy in the batteries after a long ride. A large charger will recharge batteries more quickly than a small charger. Some are built-in, while others are separate and must be carried along if you want to charge away from home. Chargers are rated in terms of amps of output the higher the amp output.

ii) Batteries

- The ‘fuel tank’ of an EV is the battery pack. Battery packs are rated in volts (typically multiples of 12V; i.e. 24V or 36V) and amp-hours of energy. More amp-hours provide more range.

iii) Electric DC Motors

- Drives the rear wheel either directly or through one or more belts or chains. Generally larger motors can produce more torque and more power. Motors are rated in terms of voltage and output power in watts.

iv) Motor Speed Controller

- Provides electric power to the motor based on inputs from the throttle and also motor speed. Controllers are rated in volts (e.g. 24 volts or 36 volts) and maximum current in amps. A controller with a higher amp rating can deliver more power to the motor. A high quality controller will allow for smooth and precise control of speed and acceleration.

v) Brake

- This part were generally not used in personal electric vehicle because the combination between motor speed controller and electric DC motor will produce it own brake but it is not strong enough. That is why brake is important as a safety part in PEV in case when it riding down the hill.

2.3 BRAKE SYSTEM REVIEW

2.3.1 Historical Background

A brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine (SAE International, 2003). A brake disc (or rotor in US English), usually made of cast iron or ceramic, is connected to the wheel or the axle. To stop the wheel, friction material in the form of brake pads (mounted in a device called a brake caliper) is forced mechanically, hydraulically or pneumatically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.

Experiments with disc-style brakes began in England in the 1890s; the first ever automobile disc brakes were patented by Frederick William Lanchester in his Birmingham factory in 1902, though it took another half century for his innovation to be widely adopted .Reliable modern disc brakes were developed in the UK by Dunlop and first appeared in 1953 on the Jaguar C-Type racing car (Harper, 1998). The sport-type design of brake disc is similar to the present type of disc brake which can be found on most road vehicles (Oppenheimer, 1977).

Disc brakes were most popular on sports cars when they were first introduced, since these vehicles are more demanding about brake performance. Discs have now become the more common form in most passenger vehicles, although many use drum