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DESIGN AND FABRICATE CHASSIS FOR PERSONAL ELECTRIC VEHICLE FOR UTEM

MOHD. FAISAL BIN ABDUL MANAS

The PSM (Projek Sarjana Muda) report is considered as one of the essential for student to compete 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 : …….....
Date : …….....

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ABSTRACT

Due to the need for green technologies, Universiti Teknikal Malaysia Melaka (UTeM) requires an electric vehicle that is not dependent on the fossil fuel sources and at the same time can reduce the impact of the environmental pollution. In addition, to large university requires students and staffs move from one place to another with the aid of the motoring vehicle. This will require more time and energy for those who had to walk around campus. In the case, an eco-design mobility that can help the movement from one place to another place in faster and save energy should be created. The main objectives of this project are to design and fabricate UTeM's first personal electric vehicle chassis and to select material for the chassis and vehicle's body parts. The purpose of this full report is to provide a clear presentation of the chassis design and material selection of the personal electric vehicle. The project scopes are including research conducting and studies on chassis design and materials selection, to do sketching, 3D drawing and other design process of the PEV, to conduct Finite Element Analysis (FEA) using CATIA V5R16 and finally to fabricate the chassis and whole parts of personal electric vehicle. The methodology for this PSM project includes research for chassis design and material selection, sketching and designing process, small scale modeling and finally fabricating process. The result of the project describes about the outcome of finite element analysis, the chassis design and material that selected to manufacture the chassis. The discussion of the project explains about the design modification of PEV along designing process and discussion about the analysis result.

ABSTRAK

Atas dasar keperluan untuk teknologi hijau, Universiti teknikal Malaysia Melaka (UTeM) memerlukan sebuah kenderaan elektrik yang tidak bergantung pada sumber bahan api fosil dan pada masa yang sama boleh mengurangkan kesan pencemaran alam sekitar. Selain daripada itu, bagi sebuah universiti besar memerlukan pelajar dan kakitangan bergerak dari satu tempat ke tempat lain dengan bantuan kenderaan bermotor. Hal ini akan memerlukan lebih banyak masa dan tenaga bagi mereka yang harus berjalan di sekitar kampus. Dalam kes ini, sebuah mobiliti eko-desain yang dapat membantu pergerakan dari satu tempat ke tempat lain dengan lebih cepat dan menjimatkan tenaga harus dicipta. Objektif utama projek ini adalah untuk merekabentuk dan membuat casis untuk kenderaan elektrik peribadi (PEV) pertama UTeM dan untuk memilih material untuk casis dan bahagian tubuh kenderaan. Laporan lengkap ini adalah bertujuan memberikan persembahan yang jelas tentang rekabentuk casis dan pemilihan material bagi kenderaan elektrik peribadi. skop projek ini meliputi penyelidikan dan kajian yang dijalankan pada rekabentuk casis dan pemilihan bahan, melakukan lakaran, lukisan 3D dan lain-lain proses rekabentuk kenderaan elektrik peribadi (PEV), melakukan Analisis Elemen Terhad (Finite Element Analysis) dengan menggunakan CATIA V5R16 dan akhirnya untuk membuat casis dan seluruh bahagian kenderaan elektrik peribadi. Metodologi untuk projek PSM ini meliputi kajian untuk rekabentuk casis dan pemilihan bahan, membuat lakaran dan proses rekabentuk, membuat model berskala kecil dan akhir sekali proses fabrikasi. Keputusan dari projek ini meliputi penjelasan tentang perolehan daripada analisis elemen terhad, rekabentuk casis dan bahan yang dipilih untuk menghasilkan casis. Perbincangan dari projek mengulas tentang modifikasi terhadap rekabentuk PEV sepanjang proses rekabentuk dan diskusi tentang keputusan analisis.

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LIST OF SYMBOLS

σ	Maximum bending stress
w	Uniform weight/length
L	Length
r_0	Radius
I	second moment of area
δ	Maximum deflection
E	Young's modulus
T	Torque
J	Polar second moment of area
θ	Angle of twist
G	rigidity modulus

LIST OF ABREVIATIONS

2D	two-dimensional
3D	three-dimensional
AISI	American Iron and Steel Institute
BEV	battery electric vehicle
EV	electric vehicle
FEA	Finite Element Method
FEA	Finite Element Analysis
iMiEV	Mitsubishi Innovative Electric Vehicle
PEV	personal electric vehicle
Fe	Iron
C	Carbon

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CHAPTER 1

INTRODUCTION

1.1 Overview

Electric vehicles (EV) enabled by high-efficiency electric motors and controllers and powered by alternative energy sources provide the means for a clean, efficient, and environmentally friendly urban transportation system. Electric vehicles have no emission, having the potential to curb the pollution problem in an efficient way (Husain, 2003). EVs were designed to do whatever was wanted in the past and can be designed and refined to do whatever is needed in the future (Leitman and Brant,2009).

There are many types of electric vehicles that used today, but this project is focused on the battery electric vehicle type. Deeply, this thesis points to design and fabricate the chassis and body of the electric vehicle. To design an electric vehicle, we should know what the major parts are in an electric vehicle. The battery electric vehicle has the propulsion system that contains electric battery, electric motor and controller; which combined with the body and chassis (Leitman and Brant, 2009).

Before anyone sits down to design anything, including an electric vehicle they should write a design specification outlining precisely what they want to achieve (Larminie and Lowry, 2003). For example, is the vehicle required high speed motorway driving, or is it simply for delivering people about town at low speeds? This fact alone will lead to great differences in the shape of the vehicle. The designing process is requires work flows, such as starting with ideas brainstorming,

researching, sketching, 3D software drawing, software prototyping and so on before the design is able to fabricated.

1.2 Problem Statement

Environmental as well as economical issues provide a compelling impetus to develop clean, efficient, and sustainable vehicles for urban transportation. Environmental technology or green technology is the application of the environmental science to conserve the natural environment and resources, and to curb the negative impacts of human involvement. One of focus area in green technology is energy and that includes the development of the alternative fuel or recycles energy. When people continue to exploit the earth for natural resources, they are increasingly aware of the damage caused by their actions. In the last century, people increasingly realize how serious environmental damage due to their actions and this makes them increasingly trying to rectify this situation. Since 70% of the sources of air pollution caused by fossil fuel use, it is logical for people to limit consumption of fossil fuels, particularly oil.

One of the main reasons the oil is excavated from the earth is to use as fuel of transportation vehicles. Apart from pollution sources, fuel oil is available in limited amounts. That would be up at a moment when the earth will run out of oil and this will cause problems to the transport system. Scientists and researchers are realizing that transportation vehicles such as trucks and cars do not need oil alone, but there are other fuel options. Due to this, various fuel options have been developed to replace oil. Among the fuels that have the opportunity to be developed as bio-fuel, electricity and hydrogen.

Due to the need for green technologies, Universiti Teknikal Malaysia Melaka (UTeM) requires an electric vehicle that is not dependent on the fossil fuel sources and at the same time can reduce the impact of the environmental pollution. In addition, a wide area university requires students and staffs move from one place to

another with the aid of the motoring vehicle. This will require more time and energy to those who had walked. In the case, an eco-design mobility that can help the movement from one place to another place in faster and save energy should be created.

The best solution for these problems is to design and fabricate the first personal electric vehicle (PEV) for UTeM. As a summary, the problem statements for this project are:

i. The need of green technology
ii. Efficiency
iii. Eco-design
iv. Mobility device

1.3 Aim, Objectives and Scope

The overall aim of this project is to develop the first UTeM's personal electric vehicle (PEV). In brief, this project is focus on design and fabricates the chassis of the personal electric vehicle. It focus on the study of chassis design, materials selection for chassis, chassis fabrication and finally to conduct Finite Element Analysis (FEA).

The main objectives for this project are as follow:

i. To design and fabricate UTeM's first personal electric vehicle chassis.
ii. To choose material to manufacture chassis.

The project scope are including research conducting and studies on chassis design and materials selection, to do sketching, 3D drawing and other design process of the PEV, to conduct Finite Element Analysis (FEA) using CATIA V5R16 and finally to fabricate the chassis and whole parts of personal electric vehicle.

The project of personal electric vehicle for Universiti Teknikal Malaysia Melaka is doing in group of 4 members. The other members of the group are focusing on brake system, propulsion system and vehicle simulation.

1.4 Organization of Thesis

The remainder of this thesis is compromised of 3 further chapters as summarized below.

Chapter 2: A review of literature relevant to the present study comprising the general study of electric vehicle, chassis design, materials for the chassis and Finite Element Analysis.

Chapter 3: The methodology, comprising the process of conducting the project from the beginning till the end of the project.

Chapter 4: Result and analysis of this project.

Chapter 5: Discussion about the result and whole project.

Chapter 6: Conclusions are drawn from the overall findings of the research along with recommendations for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The subject of electric vehicle chassis design has generated a considerable volume of literature which includes a number of theories that have been formulated. Studies on electric vehicle chassis design involve two major areas of study; which are chassis components and materials selection. The chapter begins with the introduction of electric vehicle, to give overview about the electric vehicle before go further to the chassis design studies which has more explanation of information and theories. This chapter also including the literature of the materials and finally and a summary of the existing approaches is provided together as the guideline in design process of the personal electric vehicle.

2.2 Historical Background of Electric Vehicle

2.2.1 The Early Years

Electricity is one of the oldest automobile propulsion methods still in use today. The history of electric vehicle is interesting. The first demonstration electric vehicles were made in the 1830s, and commercial electric vehicles were available by the end of the 19^{th} century. The electric vehicle has now entered its third century as a commercially available product and as such it has been very successful, outlasting many other technical ideas that have come and gone (Larminie and Lowry, 2003). According to Husain (2003), prior to the 1830s, the means of transportation was only

through steam power, because the laws of electromagnetic induction, and consequently, electric motors and generators, were yet to be discovered. Faraday demonstrated the principle of the electric motor as early as in 1820 through a wire rod carrying electric current and a magnet, but in 1831 he discovered the laws of electromagnetic induction that enabled the development and demonstration of the electric motors and generators essential for electric transportation.

The first electric vehicles of the 1830s used non-rechargeable batteries. Half a century was to elapse before batteries had developed sufficiently to be used in commercial electric vehicles. By the end of the 19th century, with mass production of rechargeable batteries, electric vehicles became fairly widely used. Private cars, though rare, were quite likely to be electric, as were other vehicles such as taxis. An electric New York taxi from about is shown in **Figure 2.1** (Larminie and Lowry, 2003).

Figure 2.1 *New York taxi cab in about 1901, a battery electric vehicle* (Larminie and Lowry, 2003)

2.2.2 The Middle Years

At the start of the 20th century electric vehicles must have looked a strong contender for future road transport. The electric vehicle was relatively reliable and started instantly, whereas internal combustion engines were at the time unreliable, smelly and needed lighting and the thermal efficiency of the engines was relatively low (Larminie and Lowry, 2003). With oil and gasoline prices again approaching their 1970s levels, everyone lost interest in electric vehicles, and the capital coffers of the smaller electric vehicle manufacturers were simply not large enough to weather the storm. Even research programs were affected. From mid-1983 until the early 1990s, it was as if everything having to do with electric vehicles suddenly fell into a black hole; there were no manufacturers, no books, not even many magazine articles (Leitman and Brant, 2009).

According Larminie and Lowry (2003), the reasons for the greater success to date of internal combustion engine vehicles are easily understood when one compares the specific energy of petroleum fuel to that of batteries. The specific energy of fuels for internal combustion engines varies, but in around 9000 $Whkg^{-1}$, whereas the specific energy of a lead acid battery is around 30 $Whkg^{-1}$. Besides that, some major problem that arises with batteries is the time it takes to recharge them. Even when adequate electrical power is available there is a minimum time, normally several hours, required to recharge a lead acid battery, whereas 45 litres of petrol can be put into a vehicle in approximately one minute. Yet another limiting parameter with electric vehicles is that batteries are expensive.

Despite the above problems there have always been uses for electric vehicles since the early part of the 20th century. They have certain advantages over combustion engines, mainly that they produce no exhaust emissions in their immediate environment, and secondly that they are inherently quiet. This make electric vehicle ideal for environments such as warehouses, inside buildings and on golf courses, where pollution and noise will not be tolerated (Larminie and Lowry, 2003).

2.2.3 Developments Towards The End of The 20th Century

During the latter part of the 20th century there have been changes which may make the electric vehicle a more attractive proposition. Firstly there are increasing concerns about the environment, both in term of overall emissions of carbon dioxide and also the local emissions of exhaust fumes which help make crowded towns and cities unpleasant to live in. secondly there have been technicals developments in vehicle design and improvements to rechargeable batteries, motors and controllers. In addition, batteries which can be refueled and fuel cells, first invented by William Grove in 1840, have been developed to the point where they are being used in electric vehicles. Environmental issues may well be the deciding factor in the adoption of electric vehicles for town and city use. Leaded petrol has already been banned, and they have been attempts in some cities to force the introduction of zero emission vehicles (Larminie and Lowry, 2003).

2.3 Types of Electric Vehicle in Use Today

Referring to Larminie and Lowry (2003), there are effectively six basic types of electric vehicle. Developments of ideas from the 19th and 20th centuries are now utilized to produce a new range of electric vehicles that are starting to make an impact. The six types may be classed as follow. Firstly there is traditional battery electric vehicle, which may is the type that usually springs to mind when people think of electric vehicle. However, the second type, the hybrid electric vehicle, which combines a battery and an internal combustion engine, is very likely to become the most common type in the years ahead. Thirdly there are vehicles which use replaceable fuel as the source of energy using either fuel cells or metal air batteries. Fourthly there are vehicles supplied by power lines, fifthly there are electric vehicles which use energy directly from solar radiation. Sixthly there are vehicles that store energy by alternative means such as flywheels or super capacitors, which are nearly always hybrids using some other source of power as well.

2.3.1 Battery electric Vehicles

The concept of the battery electric vehicle is essentially simple, which consists of an electric battery for energy storage, an electric motor, and controller. The battery is normally recharged from mains electricity via plug and a battery charging unit that can either be carried onboard or fitted at the charging point. The controller will normally control the power supplied to the motor, and hence the vehicle speed, in forward and reverse.

There is a range of electric vehicles of this type currently available on the market. At the simplest there are small electric bicycles and tricycles and small commuter vehicles. In the leisure market there are electric golf buggies. There is a range of full sized electric vehicles, which include electric cars, delivery trucks and buses. **Figure 2.2** and **Figure 2.3** show these types of electric vehicle that ever designed nowadays.

Figure 2.2 *The Honda 3R-C three wheeled battery electric vehicle.* (dieselstation.com, 2010)