STRUCTURAL ANALYSIS OF NEW MODULAR AND LIGHTWEIGHT AUTOMOBILE BODY STRUCTURE

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DEDICATION

The world of knowledge is fast developing day to day, and only persons can be efficient who are dominant on today's knowledge.

This thesis is dedicated to all people who endeavor to develop knowledge, and to my beloved and kind parents who always supported me and filled my heart with nothing but their love and finally to all peaceful people of Iran.

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Mechanical)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JUNE 2013

ACKNOWLEDGMENT

In the Name of God

I would like to express my deepest gratitude to PROF. MOHD NASIR BIN TAMIN, who always advised and encouraged me with his perfect knowledge throughout the project. His constant support and invaluable suggestions made this work successful. This research project would not have been possible without the help of many people.

Special thanks to my family for the support they provided me through my entire life.

ABSTRAK

Penambahbaikan keselamatan, pengurangan penggunaan tenaga dan pengurangan pelepasan gas menjadi salah satu isu yang amat diketengahkan dalam industri automotif beberapa tahun kebelakangan ini. Salah satu penyelesaian terbaik ialah pelaksanaan badan kereta yang ringan seperti yang diterangkan dalam projek ini. Reka bentuk, pelaksanaan, dan pencirian parameter badan kereta yang ringan juga diambil kira. Selain daripada itu, struktur modular meningkatkan kadar pembelian dan pengeluaran. Dengan mengambil kira spesifikasi reka bentuk, konsep casis modular baru dan ringan telah diiktiraf. Di peringkat awal, simulasi model rasuk telah digunakan. Tiga simulasi utama iaitu kekukuhan lenturan, kekukuhan kilasan dan analisis modal telah dilaksanakan. Oleh itu, keputusan yang telah disahkan digunakan sebagai asas untuk membuat model yang lebih kompleks. Model ini menggunakan elemen kerangka, di mana ia boleh digunakan untuk melaksanakan simulasi kedua yang lebih tepat dan serasi dengan simulasi keupayaan struktur melindungi penumpang semasa pelanggaran. Dengan mencapai keputusan yang betul, proses reka bentuk yang dicadangkan telah diluluskan. Aliran reka bentuk meruapakan hasil akhir projek ini. Prosedur ini membawa kita untuk mereka bentuk casis yang ringan dan modular berdasarkan piawaian SAE.

ABSTRACT

Improvement of safety, reduction of energy consumption, and reduction of emission become one of the most highlighted issues for automotive industry in recent years. One of the most significant solutions, i.e. lightweight car body has been described in this project. Design, implementation, and characterization of parameters of lightweight car body are used as well. Moreover, modular structures enhanced the rate of purchase and production. Based on design specification, the new modular and lightweight chassis concept has been established. In the beginning of the simulation a beam model has used. Three primary simulations, bending stiffness, torsional stiffness, and modal analysis have implemented. Therefore, the confirmed results used as a baseline for making a more complex model. This model used shell element, which it can be used for performing second simulation that is more accurate and compatible with crashworthiness simulation. To get the reason appropriate results, proposed design process has been approved. This design flow is the last outcome of this project. Following this procedure leads us to design a lightweight and modular chassis based on SAE standard.

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U_1	-	Horizontal displacement
U_2	-	Vertical displacement
UR_3	-	Rotational displacement around Z-axis
K_T	-	Torsional stiffness
T	-	Torque
F	-	Applied load
B	-	Width track of car body
φ_d	-	Angular deflection of driver seat
φ_p	-	Angular deflection of passenger seat
φ_{ave}	-	Average of angular deflection
V_1	-	Velocity along X-axis
V_3	-	Velocity along Z-axis
g	-	Passengers foot well acceleration

CHAPTER 1.0

INTRODUCTION

1.1 Background of Study

The automotive industry has in recent years successfully attempted to build lighter vehicles with more energy efficient motors in order to significantly reduce fleet consumption in accordance with legal requirements. Significantly lower fuel consumption and CO_2 emissions have been the immediate compromised of such developments. On the other hand, demand for Electric Vehicles (EVs) has increased during the last years, especially after the peak oil prices experienced in the last few years. In spite of the technology that supports the EVs been well known since many years, vehicle manufactures have presented some reluctance to introduce it in the market [1]. However, the oil prices increase associated to the present pressure introduced by some national and regional authorities to reduce the environmental impacts of the transportation sector, is acting as a driver for vehicle manufactures changing the status-quo and start a regular production of EV models.

One of the major requirements to improve performance of a vehicle is the efficient design of the body and the structure. The chassis frame of the car is

expected to provide rigidity for accurate handling, provide mounting points for the suspensions, steering mechanism, gearbox, and seating for the occupant. While fulfilling these functions, the chassis should be light enough to reduce inertia and offer satisfactory performance. It should also be tough enough to resist fatigue loads that are produced due to the interaction between the driver, the engine and power transmission and the road. Reduced mass of the vehicle could be achieved through optimized design of the chassis or frame. Since the chassis is a critical load-bearing structure, such design is made possible with the aid of numerical simulation for displacement and stress analysis. In this respect, finite element (FE) analysis is an established versatile design tool readily available for engineers.

A direct weight reduction can also be accomplished by substituting the structural member with lightweight materials. Two common choices for the materials are aluminum and fiber-reinforced polymer (FRP) composites. Testing of critical components and full scale testing of the chassis structure prototype is indispensible both for validation of FE prediction and qualifying the parts for structural safety. The structure stiffness must be considered in relation to the weight to assess the efficiency of structure.

Performance of a vehicle is also evaluated in terms of ride comfort and handling. This vehicle dynamic behavior is primarily characterized by the response of the vehicle suspension system to road profile and distributed loading. Prediction of dynamic responses of the system (comprises of vehicle body and masses, suspension system and road surface profile) is commonly analyzed.

Modeling and analyzing the effect of the chassis framework for the electric vehicle is obtain through Finite Element software ABAQUS 6.9Ef. This tool is very important to identifying the structure failure before manufacturing and test. This software is used efficiently for calculating structure properties, such as static displacement and static stress, natural frequencies and mode shapes,

forced harmonic response amplitude. The finite element analysis is very useful tool to identify dynamic characteristics such as natural frequencies and mode shapes. A finite element stress analysis is carried out at the failure region to determine the stress distribution and possible design improvement [2].However; the finite element results are extremely sensitive to mesh refinement, especially with respect to singularities at the ends of the joint.

In this project, the electric vehicle uses an Azure Dynamics AC24LS 5.5 KW 4- pole, three-phase air-cooled AC electric motor. The corresponding digital motor controller DMOC445 has been suggested. The motor can spin up to a maximum of 11,000 rpm, and which offers 47 KW (63 hp) of peak power and 92 Nm of maximum torque, working with a single-gear transmission and a 15 KWh, 50Ah lithium-ion battery. The battery consists of eight separate modules, and each module is made up of 40 cells (in a four-in-parallel, 10-in-series configuration), and together the assembly weighs in at 240 kg. Incidentally, weight-wise, the Electric Vehicle has 150 kg .Weight more than a standard vehicle, with the battery being the hefty lad.

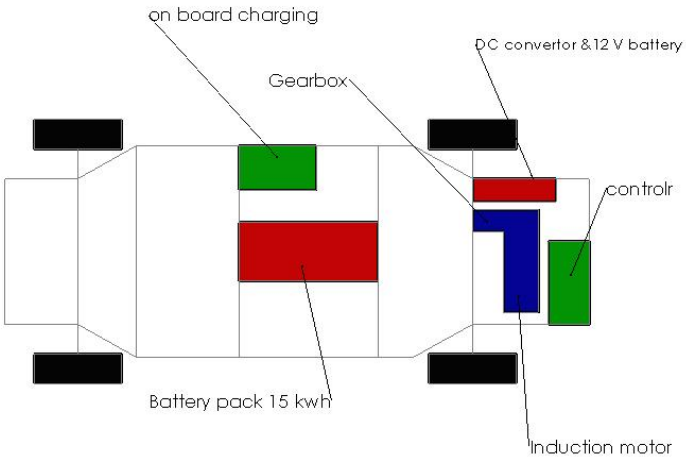

Figure 1.1 electrical components alignment

Figure 1.2 AC Motor/Controller Kit, 67 hp, 72/108 volt, 650 Amp

Figure 1.3 Unit Module Design-50Ah lithium-ion batteries

1.2 Research Objectives

The objectives of this project are as follows.

- To develop design methodology for modular and lightweight automobile body structures
- To design a prototype modular and lightweight body structure for an electric vehicle
- Establish structural crash response on the structure

1.3 Research Scopes

The first scope of this project focused on material properties. In this case, according to previous investigation the high strength steel choose as used material. Perform FE simulation of the structure for vibration response, deformation and stress analysis. Assess adequacy of the structure with respect to strength of materials and structural stability. Develop methodology for designing modular and lightweight automobile body structure, for a given set of design constraints. Establish the crashworthiness evaluation based on SAE standard, which it focused on four most important crash test simulation.

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