UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF SPACEFRAME CHASSIS OF SHELL ECO-MARATHON CHALLENGE URBAN CAR USING SHAPE OPTIMIZATION METHOD

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with honours.

by

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DECLARATION

I declare that this thesis entitled “Optimization of Spaceframe Chassis of Shell Eco-Marathon Challenge Urban Car Using Shape Optimization Method” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : .....

Name : .....

Date : .....

DEDICATION

I would like to dedicate this research to my treasured supervisor, Mr. Mohd Suffian Bin Abdul Razak who provides extra knowledge and assist me thoroughly in completing this research and also highly appreciated to my beloved parents for supporting me all the time while making this research.

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion, this dissertation/report is sufficient in terms of scope and quality as partial fulfillment of Bachelor of Mechanical Engineering Technology (Automotive Technology) with honours.

Signature :……..

Supervisor Name :……..

Date :……..

ABSTRACT

Chassis is known to be the vehicle's most essential component. Vehicle chassis provide the mainframe to support the body and various components of the vehicle. However, many urban car concept chassis in the previous Shell Eco-marathon event do not optimally design in ergonomic while maintaining its strength, durability, and stability. The material used is not suitable and easy to break in order to minimize the car's weight. Also, driver comfort and safety during the design process are not carefully considered. Suitable engineering software did not been used when designing and simulating. The purposes of this project are to design an urban car chassis for Shell Eco-marathon challenge that focuses on lightweight design and strength using engineering design software. Then, simulate and analyze the urban car chassis of the Shell Eco-marathon challenge car using engineering software. The lower part of the chassis has been optimized by using Solid Thinking Inspire until it got the desired shape. Then, the entire chassis is designed by using CATIA V5 and finally simulates it by using Altair Simsolid until got the desired result. Overall the result data is satisfying and passed the durability test, so the chassis design is considered safe and can be implant in actual chassis fabricating to compete in the Shell Eco-marathon Challenge.

ABSTRAK

Casis dikenali sebagai komponen paling penting dalam sesebuah kenderaan. Casis kenderaan berfungsi sebagai rangka utama untuk menyokong badan dan pelbagai komponen lain. Walaubagaimanapun, banyak casis berkonsepkan kereta bandar dalam acara Shell Eco-marathon Challenge sebelumnya tidak direka dengan baik dari segi ergonomik dan tidak dapat mengekalkan kekuatan, ketahanan dan kestabilannya. Bahan yang digunakan juga tidak sesuai dan rapuh untuk meminimakan berat kenderaan. Selain itu, keselesaan dan keselamatan pemandu tidak dititik beratkan dengan teliti semasa proses reka bentuk. Perisian kejuruteraan yang sesuai tidak digunakan ketika proses mereka bentuk dan simulasi. Tujuan projek ini adalah untuk mereka bentuk casis kereta bandar untuk acara Shell Eco-marathon Challenge yang memberi tumpuan kepada reka bentuk dan berat yang ringan menggunakan perisian reka bentuk kejuruteraan. Kemudian, proses simulasi dan analisis dilakukan pada casis menggunakan perisian kejuruteraan. Lantai casis telah dioptimumkan dengan menggunakan perisian Solid Thinking Inspire sehingga mendapat bentuk yang dikehendaki. Kemudian, seluruh casis direka bentuk dengan menggunakan perisian CATIA V5 dan akhirnya mensimulasikan dengan menggunakan perisian Altair Simsolid sehingga mendapat keputusan yang diinginkan. Keseluruhannya, data yang terhasil adalah berjaya dan melepasi ujian ketahanan, jadi reka bentuk casis dianggap selamat dan boleh diterapkan dalam proses fabrikasi casis yang sebenar untuk pertandingan Shell Eco-marathon Challenge.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
3D	-	3-Dimensional
SUV	-	Sport Utility Vehicle
SAE	-	Society of Automotive Engineer
FV	-	Formula Varsity
ASEAN	-	Association of Southeast Asian Nations
UTeM	-	Universiti Teknikal Malaysia Melaka
CAE	-	Computer-Aided Engineering
CAD	-	Computer-Aided Design

CHAPTER 1

INTRODUCTION

This chapter presents the explanations and objectives of this project. The purpose and goals will be represented in this chapter by background, problem statement, objectives, and scope.

1.1 Background

Shell Eco-marathon is a special worldwide program, constructing super-energy efficient cars for science, technology, engineering and mathematics students and then taking them on the path in competition. The program motivates thousands of students across the world to work together in their university teams to evaluate their energy efficiency theories, using state-of-the-art technology, critical thinking and innovative ideas . This program seeks to see who can get around the track using the least amount of energy and also to prove that their vehicle is energy efficient by using the driver's proper plan, speed and agility to see who first passes the finish line without running out of their small energy allocation. The chassis frame is one of the essential components in all types of car. A vehicle frame, also known as a chassis, is the vehicle's main supporting structure, in which all parts are mounted together to form a new body. In the year of 1930, The structural frame of almost

every car was separate from its body (R. Hoppenstein, 2002). This design is referred to as body-on-frame as shown in Figure 1.1.

Figure 1.1: Body on Frame (https://en.wikipedia.org)

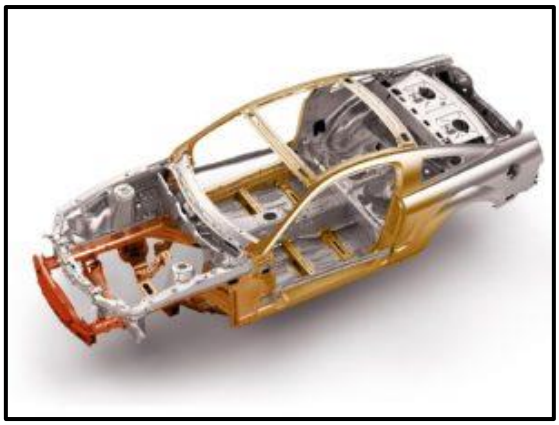

Figure 1.2: Unibody Frame (https://beamanbody.com/)

After 1930, almost all passenger cars have converted to unibody design, meaning that their chassis and bodywork are associated into one. Nearly all trucks, buses and most pickups are still using their chassis as a separate frame.The vehicle chassis can be divided into several

types such as monocoque, space frame, ladder and combination of these frame. These all types of chassis serve different purpose and function. It is a common type of frame used as a basis for vehicles for the ladder chassis, creating a solid basis from the shape as suggested by the name. Backbone chassis is a substantial central component required for a backbone car chassis that connects the front and back of the entire frame. Next, a monocoque car chassis is a structure which integrates body and chassis together to form a composite structure which has better stiffness as well as weight advantage as shown in Figure 1.3. A space frame chassis can also be referred to as a tubular frame, although in the true sense it is not tubular. To create a sturdy framework that includes some flexibility, the parts are welded together as shown in Figure 1.4. For the combination chassis, it uses a different type of frame and joints it together to make a single vehicle frame (A. Singh et al., 2008).

Figure 1.3: Monocoque Chassis (https://www.caranddriver.com/)

Figure 1.4: Space Frame Chassis (https://www.quora.com/)

Every chassis should be analyzed and evaluated before any physical build to predict the structural performance in various conditions. Previous researcher state that by reducing 10 percent of the vehicle mass, energy efficiency could be improved by 5 to 8 percent. Other than that, decreasing the vehicle mass can improve the overall vehicle dynamics (M. Suffian et al. 2017). In this project, engineering simulation software is very needed and necessary. Simulation software is based on the modeling process of a natural occurrence with a set of mathematical formulas. It is generally a program that enables the user to examine a simulation process without attempting to carry out that operation. Simulation software is commonly used to develop equipment so that the final result is as close to the specifications as possible without expensive and complex modification of the process. The most critical factors of designing the new chassis are the reduction of the weight, improvement of strength and stiffness and reduction of material and manufacturing cost (C. Tsirogiannis et al., 2017). This project focused on designing the optimized space frame chassis of an urban car using shape optimization method in the CATIA V5 software to make a lightweight chassis, stiff frame,

proper handling and stable urban vehicle as possible to minimize the fuel consumption and to improve the car safety. Once the appropriate method is established, the final prototype design of urban car space frame is tested by using simulation software to get the final analysis result.

Figure 1.5: CATIA V5 Software (https://www.google.com)

1.2 Problem Statement

The team of Universiti Teknikal Malaysia Melaka will participate in the Shell Eco-marathon challenge and designing an urban car with high energy efficiency is required. The type of design, material, and weight is the strongest factor that affected the performance, energy consumption and safety of the car. However, many urban car concept chassis in the previous Shell Eco-marathon event do not optimally design in ergonomic while maintaining its strength, durability, and stability. The material used is not suitable and easy to break in order to minimize the car's weight. Also, driver comfort and safety during the design process are not carefully considered.

There are many types of engineering software nowadays, and each of them has specific functions and tools. The correct engineering software must be taken into consideration and use suitable software for different types of simulation. The user should be able to identify a proper boundary condition setup with accurate material properties to prevent wrong or inaccurate simulation result.

The purposes of this project is to design a durable, reliable, lightweight and safe chassis using the CATIA V5, optimize it by using Solid Thinking Inspire and simulates it by using Altair Simsolid. At the same time, the human factor of the driver also will be put into consideration in designing a comfortable ride on the chassis during this challenge. The designed frame of the urban car concept for Shell Eco-marathon must contain all necessary elements to support the Universiti Teknikal Malaysia Melaka team car and the driver.

1.3 Objective

The purposes of this project are:

1) To design an urban car chassis for Shell Eco-marathon Challenge that focuses on lightweight design and strength using engineering design software.
2) To simulate and analyze the urban car chassis of the Shell Eco-marathon challenge car using engineering software.

1.4 Scope

This study will be focused on lightweight and sturdy urban car space frame chassis in order to minimize energy consumption while having enough chassis strength to compete in the

Shell Eco-marathon challenge. This space frame chassis will use the ASTM A500 hollow square steel as the primary part and study about the joint strength between the frames connection. Besides that, this study also focuses on designing an urban car chassis using CATIA V5 software, optimize it by using Solid Thinking Inspire and simulates it by using Altair Simsolid. Next, this study is focused on the optimization of the design chassis using shape optimization method.

CHAPTER 2

LITERATURE REVIEW

The whole chapter deals with the study of literature and research journals, reference book and related articles to this project. The journals have been thoroughly referenced since the articles contain several information and data that can be used and applied up to the end of this project. The study of literary works was a method that will finalize this project. The literature analysis sources are newspapers, books, research paper, as well as other online sources.

2.1 Vehicle Chassis

Vehicle chassis is an essential component of a car. Chassis is a vehicle's primary frame that has to convey every one of the segments and backing every one of the heaps. It forms as motor vehicle bones. The elements connected to the frame include the suspension system, the motor, the seat, the drive system and the braking system. This involves high loading of each component and the actual forces during speeding, cornering and declination. The automotive chassis is one of the most vital constructions of any self-propelled structure because of its multifaceted role on vehicle dynamic behaviour (Koumartzakis et al., 2016). The chassis provides as the mainframe to support the body and various components of the vehicle, it must

be sufficiently stiff to resist shock, bend, vibration and several other stresses and its main function are to safely handle the maximum load for all designed driving conditions. The chassis is known as the car's most essential component because it retains most of the parts and materials around each other (A. Singh et al., 2008).

The frame construction is vital for ensuring the engine performance, safety and reliability. In the event of an accident or collision, the chassis should be able to defend the passenger from injury. The designed chassis has to take fuel consumption into consideration. This can achieve by reducing the chassis weight. The development of the frame should be optimized to meet safety and fuel economy criteria. For a good handling feature, an important element in chassis construction is to have optimal twisting rigidity together with toughness. Maximum shear stress and distortion are often important factors for the construction of the chassis by analyse and optimize the vehicle frame with maximum shear stress limitations and chassis distortion under peak load (A. Singh et al., 2008).

Chassis is known to be the car's most essential component. Therefore, there are several types of chassis that can be taken into consideration in competing in the Shell Eco Marathon challenge like space frame, unibody, monocoque and ladder. All the these frame serve differents purpose, advantages, disadvantages and their characteristic between each other.

2.1.1 Space Frame

Space frame develops a 3D chassis using certain tubes or hollow bars. In certain areas, tubes are positioned to deal with the forces they have to endure. Those frames are typically designed for a specific reason. These pipes are jointly welded and it also uses rectangular-section tubes to create welding easier. However, the highest possible toughness is provided by

circular tubes. These tubes are typically used in a sports car. Optimizing the configuration makes it harder to place doors open positions for instance. Furthermore, the space frame makes it difficult to access the driver's seat such as high doors. An automobile space frame involves a body unit and the front unit to build a vehicle. The body unit consists of a couple of horizontally stretched, longitudinally prolonging major side rail frameworks and a couple of rearmost upright frameworks, each linked to a various major side rail framework and lengthening upwards to create a set of rearmost foundations. In automobile production, space frame layout is largely been used. The space frame is a construction of individual chassis elements that are joined together to create a cage-like framework in which a certain elements of an automobile are assembled, along with the motor, the drivetrain components, the suspension and the stick-on body parts of a car. Tubular hydroforming possibly provides several benefits in the development of space frames since it would allow manufacturing companies to improve frame stiffness, dimensional flexibility, fatigue life as well as collision value over non-hydroformed space frames thus lowering frame production and price (G. Jaekel et al., 2000).