UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF SPACE FRAME CHASSIS FOR SOLAR CAR CHALLENGE

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

by

NOOR AZREEN BIN HAMZAH

B071110129

921112-03-6195

FACULTY OF ENGINEERING TECHNOLOGY

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DESIGN AND ANALYSIS OF SPACE FRAME CHASSIS FOR SOLAR CAR CHALLENGE**

SESI PENGAJIAN: **2014/15 Semester 2**

Saya **NOOR AZREEN BIN HAMZAH**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	TIDAK TERHAD	

Disahkan oleh:

_____ _____

Alamat Tetap:

Lot Pt 601, Lorong Delima, Jalan

Kuari, 16600 Pulai Chondong,

Kelantan.

Cop Rasmi:

Tarikh: _____ Tarikh: _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled “Design and Analysis of Space Frame Chassis for Solar Car Challenge” is the results of my own research except as cited in references.

Signature : …….

Author’s Name : ……

Date : ……

APPROVAL

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

……

(Project Supervisor)

ABSTRAK

Asas projek ini adalah untuk mereka bentuk dan analisis kerangka ruang casis untuk pertandingan kereta solar. Cabaran utama dalam membangunkan casis kereta solar adalah untuk memaksimumkan kekuatan dan mengurangkan berat kerangka. Reka bentuk untuk rangka mestilah ringan dan juga memenuhi keperluan peraturan pertandingan. Objektif projek ini adalah untuk mewujudkan satu kajian awal bagi kemungkinan reka bentuk rangka kereta solar. Satu kajian reka bentuk rangka kereta solar dijalankan untuk melihat sama ada penyelesaian yang boleh diperolehi daripada jurnal, kertas kerja teknikal dan penyelidikan mengenai sistem kereta solar. Tiga model reka bentuk casis dihasilkan dengan menggunakan perisian komputer CATIA. Kemudian reka bentuk casis dimasukkan ke dalam perisian CATIA juga untuk dianalisis. Hasil kajian daripada reka bentuk model yang telah dianalisis digunakan untuk memilih model dengan ciri-ciri terbaik daripada reka bentuk rangka kereta solar. Pilihan reka bentuk dilakukan berdasarkan pelaksanaan spesifik kerangka dan sifat-sifat teknikal dari reka bentuk tersebut.

ABSTRACT

The basis of this project is to design and analysis of space frame chassis for solar car challenge. The main challenge in developing effective solar car chassis is to maximize the strength and minimize the weight. The design for the frame must be light in weight as well to meet the competition regulatory requirement. The objective of this project is to establish a preliminary study for possible solar car frame design. A study of the solar car frame design is carried out to see whether a solution can be obtained from journals, technical papers and research on solar car system. Three design of the model will be done using appropriate software CATIA. Then the design included into the CATIA software to analyse the chassis. Results from the design that had been analysed is used to choose the best performance and the best characteristics of solar car frame design. Design selection is carried out based on specific performance of the frame and technical attributes for design.

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time. Engr. Nur Rashid Bin Mat Nuri has been the ideal thesis supervisor. His sage advice, insightful criticisms, and patient encouragement aided the writing of this thesis in innumerable ways. I would also like to thank my fellow friend whose steadfast support of this project was greatly needed and deeply appreciated.

ACKNOWLEDGEMENT

I am using this opportunity to express my gratitude to everyone who supported me throughout the course of this BDP project. I am thankful for their aspiring guidance, invaluably constructive criticism and friendly advice during the project work. Above all, I would to express my warm thanks to supervisor Engr. Nur Rashid and my co-supervisor Mr. Mohd Faruq and also to Mr. Muhammad Zaidan and Mr. Mohd Suffian from Faculty of Engineering Technology, University Technical Malaysia Melaka (UTeM) for their support and guidance. I am sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to the project.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al	-	Aluminium
CAD	-	Computer Aided Drawing
cm	-	Centimetre
Hz	-	Hertz
Kg	-	Kilograms
Km	-	Kilometre
m^3	-	Cubic metre
M	-	Mega
mm	-	Millimetre
N	-	Newton
>	-	More than
<	-	Less than
σ	-	Stress
ϵ	-	Strain
τ	-	Torque

CHAPTER 1

INTRODUCTION

Photovoltaic or solar powered automobiles found in backgrounds today are composed involving costly, lightweight products for instance titanium composites. These kinds of supplies tend to be helpful to produce jet fighter jets. Fiberglass and carbon fiber are also be used most of the actual bodywork.

1.1 Project Briefing

A major move in direction solar car technology is when the first solar whom attained the World Solar Challenge in 1985. This solar car managed to finish the race 600 miles ahead than a nearest rival in that race. The Sunraycer is a 360-pound single-seated solar car finished the 1,950-mile passage from Darwin to Adelaide, Australia in five days by around 43.5 miles an hour and covers the distance in 42 hours and 50 minutes on the path. General Motors and its Hughes Aircraft subsidiary mostly build the Sunraycer easily outpaced 24 other cars entered or partially sponsored by the Massachusetts Institute of Technology, Ford of Australia, Volvo, Mitsubishi, and other organizations. (Malcolm W. Brownie, 1987)

This project presents about design and analysis of space frame chassis for solar car. Main purpose of this project is to design and analysis the elements of chassis of a race type solar car to achieve lightweight. Moreover, mounting points need to be allocated in design to attach different components such as the battery package, electronics, suspension parts, body panels, etc.

Besides, the chassis has to perform a support of all components and loads that manifest forces during acceleration, deceleration and cornering. The finite element modelling and analysis will use 3D CAD design software CATIA. The maximum displacement magnitude, max Von Mises stress will was compare between several design solar car chassis solar car chassis from different design. All the designs of solar car chassis were analysed using CATIA software. Diverse framework resources can certainly reduce the bodyweight in the car, increasing the automobile capacity to bodyweight relation. Material selection can offer advantages by reducing member deflection, growing chassis strength and can conclude the total of support required. At the end, the best design for chassis is determined.

1.2 Problem Statement

(a) The solar car chassis must be designed to follow the regulations set by competition authorities.

(b) Frame body have to sturdy to support lots from motor and mass connected with new driver along with components of which offered towards Solar Car operation.

(c) Driver safe practices needs to be considered and enhanced the car accident takes place by the front impact which in turn not easily bends as a result of impact force.

1.3 Objective

The main target of the analysis is to make an early study regarding probable design and style connected with solar car frame by means of:

(a) Design a lightweight and low material cost of chassis space frame for the race type solar car as well to meet the regulatory requirement.

(b) Analyse the space frame chassis of a solar car that can withstand the load from the solar panel body, driver, actuator and the suspension.

1.4 Scope

This specific challenge is actually concentrating on design and also development the space frame chassis of a solar car utilizing computer software far more within aerodynamics and also in a position to travel in long distance.

(a) Design and analysis a space frame chassis of solar car using 3D CAD design software CATIA.
(b) Chassis design must be adapted to safety and withstand force generated from loads and components and within the regulatory parameter requirements.
(c) Perform material selection analysis to achieve lightweight chassis.

1.5 Project Significant

Being a typical understanding, frame body for a solar car is made to supply a shape of a solar car as well as withstand the load from the solar panel body, driver, actuator and also the suspension. The rigidity regarding frame body may tremendously affected the solar car speed for the reason that more rigid the frame body, faster the solar car should go. The best dimension associated with solar car challenge rules is considered to be in range so that the solar car had been designed may be involved numerous challenge as possible.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Space frame chassis have been around in use since the beginning of the motorsport arena. Some sort of space frame consists of aluminium or steel tubular pipes positioned in a triangulated for-mat to backing the loads from the vehicle produced from driver, engine, aerodynamics and suspensions.

Essentially chassis is regarded as being a platform or framework to support the engine, upper body as well as other part to compliment the vehicle. Framework lends the entire vehicle assistance in addition to hardness. Chassis generally includes some longitudinally stretching out channels in addition to a number of transverse cross members which intersect the channels. The actual transverse members use a diminished cross section as a way to support a new longitudinally stretching out storage space.

The protection of the chassis is a major aspect in the design, and should be considered through all stages. The framework should consist of the various components necessary for the race car as well as being based around a driver's cockpit. Normally, the basic chassis types consist of backbone, ladder, space frame and monocoque. Diverse types of chassis design will result the different performance of every chassis.

Steel space frame and composite monocoque are major varieties of chassis utilised in race cars. While space frame include the traditional the traditional style

there are nevertheless quite popular nowadays throughout beginner motorsport. The popularity maintains because of the ease, the only real tools necessary to build a space frame can be a saw, welder and measuring device. Space frame nevertheless provide advantages over the monocoque as it can certainly be fixed easily.

2.2 Space Frame Background

A space frame chassis uses a sequence of straight small diameter tubes to achieve strength and rigidity with minimal weight. The particular technique was formalised during the Second World War, after they were employed for the structure associated with fug significant supports with fighter aircraft.

That design and style was first put together by Barnes Wallis who has been a British aviation industrial engineer. The huge benefits that this space frame offered on the airplane has been so it allowed this airplane to acquire a lot associated with destruction of certain locations even though even now holding onto full power to remain airborne.

Following the war within 1947, Doctor Ferdinand Porsche utilised the style to make the Cisitalia sports vehicle. Soon after primary vehicle companies including Lotus and also Maserati used the idea to create race cars; these kinds of autos ended up nicknamed birdcage sporting autos because of the great number of tubes. Current cars at the moment are built from single monocoque body produced from expensive fibre composite supplies.

2.3 Space Frame Chassis

The space frame chassis is to support the load from body panel, suspension, engine, and driver with its construction consists of steel or aluminium tubes placed in a triangulated format there would be great to withstand force. Space frame with their

simplicity make its popular today in amateur motorsport because. Space frames, unlike the monocoque chassis used in modern Formula 1 or CART, are easily repaired and inspected for damage.

In Figure 2.1 shows box with a bottom, top and two side while, its missing the front and back. The box collapses easily when pushed because there is no support in the front or back.

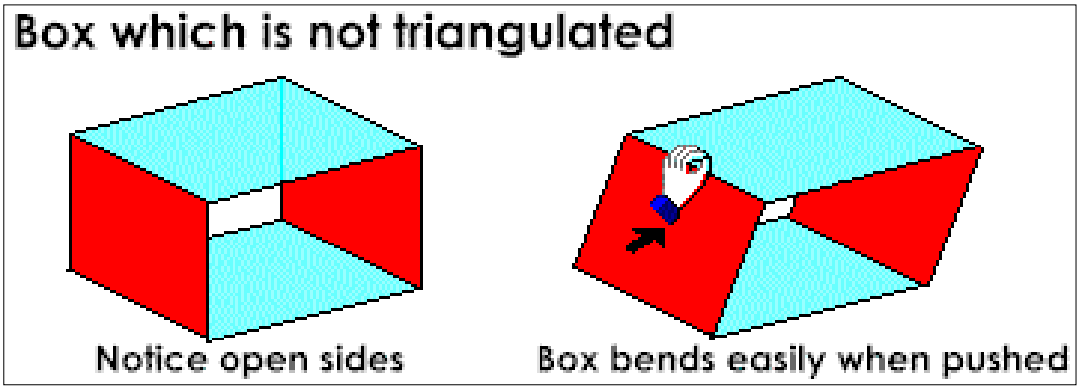

Figure 2.1: Box with open front and back

(Source: Matthew Gartner, 1999)

In order for solar cars operate properly, its need to be supported. So, triangulate the box by bracing it diagonally will bring this effectively adds the front and back which were missing, only instead of using panels, we use tubes to form the brace.

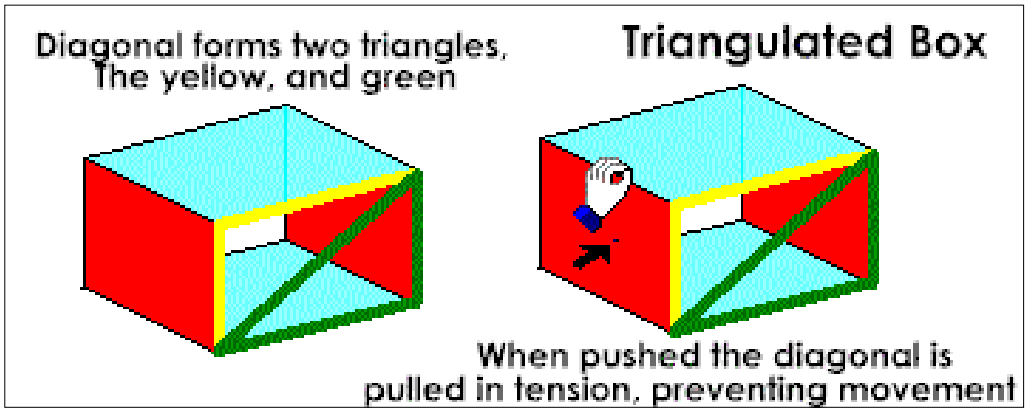

Figure 2.2: Box add with triangle at front.

(Source: Matthew Gartner, 1999)

In Figure 2.2 the box is added with triangle at front and by stressing the green diagonal in Tension, the triangulated box above imparts strength. Tension is the force trying to pull at both ends of the diagonal. Another force is called Compression. Compression tries to push at both ends of the diagonal and that is shown above in the horizontal yellow tube.

The monocoque chassis uses panels that are different from space frame just like the sides of the box in the Figure 2.3. Instead of small tubes forming the shape of a box, an entire panel provides the strength for a given side.

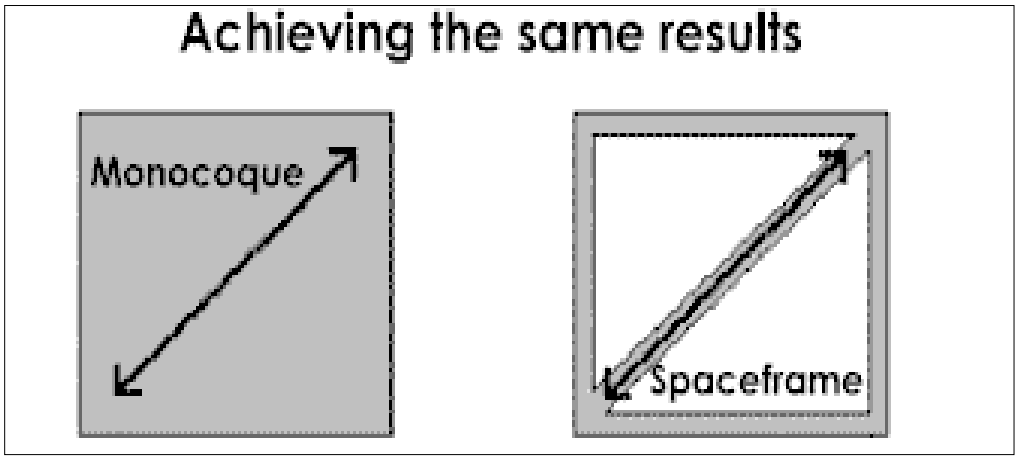

Figure 2.3: Different between monocoque and spaceframe.

(Source: Matthew Gartner, 1999)

In Figure 2.4, 'Cigar' shaped car of monocoque construction manufacture in 1999. The torsional rigidity is imparted with the help by the cylindrical shape. Torsional rigidity is the amount of twist in the chassis accompanying suspension movement.

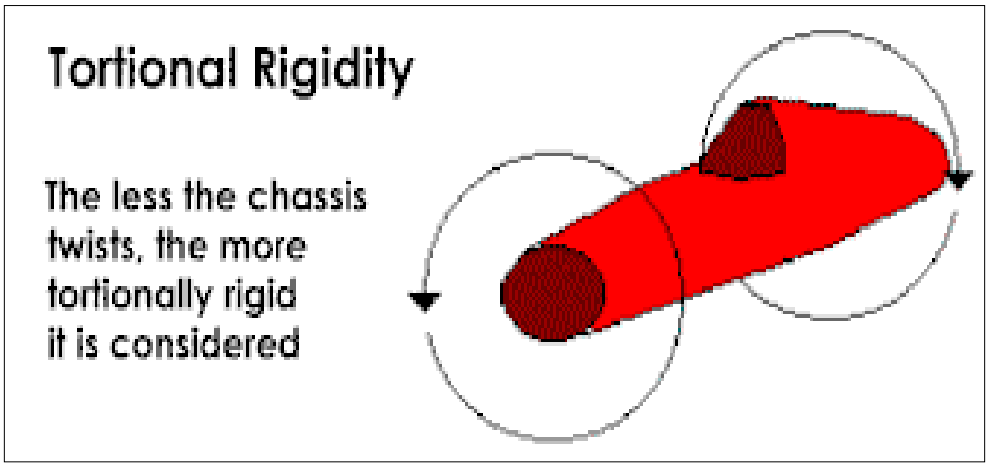

Figure 2.4: Shape of car 'cigar'.

(Source: Matthew Gartner, 1999)

Torsional rigidity applies to space frames too, but because a space frame isn't made from continuous sheet metal or composite panels, the structure is used to approximate the same result as the difficult to twist "cigar car". Below in Figure 2.5 show the 'cigar' chassis using space frame.

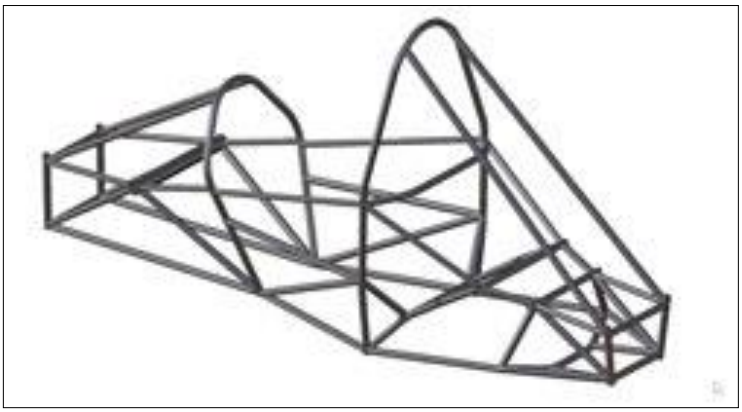

Figure 2.5: Space frame chassis.

(Source: Matthew Gartner, 1999)

2.4 Advantages of Space Frame

Space frame is considered to be one of the best chassis that can yield very good results for torsional rigidity, weight holding, and impact protection. It is also simple to design and only moderate in difficulty to build. This makes it perfect for

many applications from solar car competitions to project cars and even low volume sports cars. Anyone who has ever designed a space frame will know that triangulation is very important as well as making sure that it is comprised of nodes where the tube ends meet and not to have parts subjected to bending loads. The advantages of space frame chassis are described below:

(a) Space frame chassis systems are lighter than traditional steel. Therefore, it provides significant economy in foundation costs.
(b) Since the space frame systems are triangulated format, it will provide maximum strength and minimum deflection of the design compare to the other chassis types due to the support from tubular pipes.
(c) Using a space frame chassis in a race car, the high torsional rigidity can be achieved as well as its light weight. It means that, space frame chassis designs will enhance the rigidity/weight ratio.

2.5 Aluminium Review

The chassis undergoes various kinds of forces during locomotion, it has to stay intact without yielding, and it should be stiff to absorb vibrations, also resist high temperatures. The material property of the chassis is an important criterion while designing of the solar car. Different chassis materials can reduce the weight of the vehicle, improving the vehicle power to weight ratio. Material selection can also provide advantages by reducing member deflection, increasing chassis strength and can determine the amount of reinforcement required. The materials which used to build the space frame chassis in this project are aluminium and fiberglass.

Aluminium is a nonferrous material with very high corrosion resistance and very light material compared to steels. Aluminium cannot match the strength of steel but its strength-to-weight ratio can make it competitive in certain stress application. Aluminium can also be alloyed and heat treated to improve it mechanical properties, which then makes it much more competitive with steels however the cost increases dramatically.

Pure Aluminium is also a possible material and is reasonably affordable and very light but it is the weakest and will require extra reinforcement to produce a rigid chassis. Aluminium is very hard to work with as it requires very skilled welding and is an overall softer metal. Basically there are several types of Aluminium. For this project, I decide to use Aluminium Alloy 6063-T6. Aluminium alloy 6063 is one of the most extensively used of the 6000 series aluminium alloys. (Aalco. 2005)

Aluminium Alloy 6063 is the least expensive and most versatile of the heat treatable aluminium alloys. It has most of the good qualities of aluminium. It offers a range of good mechanical properties and good corrosion resistance. It can be fabricated by most of the commonly used techniques. In the annealed condition it has good workability. The typical properties of aluminium alloy 6063 include medium to high strength, good toughness, good surface finishing, excellent corrosion resistance to atmospheric conditions, good workability and widely available. It is welded by all methods and can be furnace brazed. (Aalco. 2005)

This aluminium type is used for a wide variety of products and applications from truck bodies and frames to screw machine parts and structural components. 6063 is used where appearance and better corrosion resistance with good strength are required.

Table 2.1, Table 2.2 and Table 2.3 below shows the typical composition, the physical properties and the mechanical properties of Aluminium Alloys 6063 respectively.