FRAME BODY STRUCTURE FOR SOLAR CAR

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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Date: 06 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This report presents about the frame design structure for solar car. Solar car has been invented to find an alternative energy that can be replaced the common energy that being used right now which is fuel energy. The condition to design for this frame design is lightweight in term of weight, low displacement on frame when accident due to tensile strength of the material and the high natural frequency of that design. Objective of this report is to create a preliminary study for possible design of solar car frame.A research about solar car frame design is conducted to see whether the solution for the parameter can be obtained from the journal, technical paper and also the research about solar car system. The answers from the design will be analysed in order to choose the best model and features of the three wheel solar car frame design. The design of the final model will be done by using SolidWork software which is suitable for making the 3D model of the car. Then the design will included into ALGOR software to analyse about natural frequency and also the roll bar testing and got the results that the third chassis of the solar car is the best chassis that can be use inside the solar car to optimize the solar energy used.

ABSTRAK

Kajian ini menyajikan tentang struktur rekabentuk rangka untuk kereta suria. Kereta suria dicipta untuk mencari tenaga alternatif yang boleh menggantikan tenaga umum yang telah digunakan sekarang yang merupakan tenaga bahan bakar fosil. Syarat yang ditetapkan untuk rekabentuk rangka ini ialah ringan dalam hal berat rangka, keteguhan bar perlindung ketika kemalangan kerana kekuatan bahan bina rangka dan juga frekuensi yang tinggi untuk rekabentuk rangka tersebut. Matlamat kajian ini adalah untuk mengkaji sebuah rangka yg berupaya memenuhi syarat yang ditetapkan sebelum ini. Sebuah kajian tentang rekabentuk rangka kereta tenaga suria dilakukan untuk melihat apakah penyelesaian untuk parameter tersebut boleh diperolehi daripada jurnal, kertas teknikal dan penyelidikan tentang sistem kereta suria. Jawapan dari kajian tersebut akan dianalisa untuk memilih model terbaik dan ciri dari rekabentuk rangka tiga roda kereta suria. Rekabentuk model akhir ini akan dilakukan dengan menggunakan software Solidwork yang dimana sesuai untuk membuat model 3D dari kereta suria ini. Kemudian rekabentuk tersebut akan dimasukkan ke dalam perisian ALGOR untuk menganalisis mengenai ujikaji besi penghadang, gelombang semulajadi dan mendapatkan keputusan yang dimana kereta suria yang ketiga adalah rangka terbaik yang boleh digunakan di dalam kereta suria untuk mengoptimumkan tenaga matahari digunakan.

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LIST OF SYMBOL

E	Modulus of Elasticity
d_o	Outer Diameter
d_i	Inner Diameter
^{o}	Degree
e	Exponential
I	Moment of Inertia
Π	Pi Number

LIST OF ABBREVIATIONS

Hz	Hertz
mm	Milimeter
N	Newton
MPa	Mega Pascal
Dia	Diameter
lb	Pound
In	Inch
F	Fahrenheit
Max	Maximum

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Solar energy is some alternative energy that we retrieved from the sun light and we convert it into energy. Many researches have been made to apply this solar energy into human daily life. Nowadays this solar energy has been used in many ways, like to generate electrical energy into human application, for example water heater and so on. This solar energy is radiant energy which scientifically called electromagnetic radiation. It been produced by nuclear reactions at the core of the sun.

After that, this energy streams from the surface of the sun in waves of many different wavelengths. There are invisible wavelength and also a visible wavelength which can be seen by our eyes. For invisible wavelength, it is consists of the shortest and the longest wavelength. For visible wavelength, it is consist of medium wavelength which can be seen by our eyes that we called it as sunlight. Most of the sun's energy is in this visible wavelength.

Mostly, the sun emits electromagnetic radiation of all wavelength whether is invisible wavelength or visible wavelength. The sun produces over 90% of its radiation in the visible and infrared region of the spectrum with the sun surface temperature which is in about 6000°C. On the atmospheric earth space, the small amount of harmful ultraviolet and other high- energy radiation emitted by the sun will be effectively screened. But still, visible light reaches the earth's surface with little filtering, and that was the medium wavelength that will be converted into electrical energy.

Nowadays, many applications was created based on applying solar energy into the application, but usually not as a primary energy source, only as supporting to minimize the consumption of the primary energy (usually electrical energy). For example, 4 Times square which the tallest skyscraper built in New York City using the building-integrated photovoltaic (BIPV) panel on the 37th through 43rd floor to incorporate more energy-efficient building techniques than other commercial skyscrapers (Kiss + Cathron, 1999).

In automotive section, there are some races authorized to some organization to encourage corporate organization like university or college team to create their own solar car and compete each other in term of speed and also the energy efficiency of solar car. The most notable solar car races in present time are the World Solar Challenge and the North American Solar Challenge which been contested by a solar car from variety university and corporate team.

For solar car, solar energy was main power source which can be stored into battery charger after charged it under sunlight in certain period by convert the solar energy into electrical energy. The amount of energy stored in the battery charges is depend on area of photovoltaic panel on the car which can directly convert the solar energy into electrical energy.

The first solar car who had won World Solar Challenge in 1985, Sunraycer was a big step towards solar car technology. 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 completed the 1,950-mile course from Darwin to Adelaide, Australia in five days by averaging 43.5 miles an hour and covering the distance in 42 hours and 50 minutes on the road. Built mostly by General Motors and its Hughes Aircraft subsidiary, the Sunraycer easily outpaced 24 other cars entered or partly sponsored by Ford of Australia, Volvo, Mitsubishi, the Massachusetts Institute of Technology and other organizations (Malcolm W. Brownie, 1987).

The source of the car's power is an array of 7,200 photovoltaic cells developed by Spectrolab, a subsidiary of Hughes Aircraft to power advanced communications satellites in space. Electronics experts have described these cells as phenomenally efficient; they convert 16.5 percent of the power of the sunlight striking them into electrical power. By comparison, most of the solar cells used to power remote unmanned weather observatories convert only 2 or 3 percent of solar energy they absorb into usable electricity.

1.2 PROBLEM STATEMENT

In Malaysia, solar car research not really popular compared to the others research. Although Malaysia is tropical nation which is receive a direct sun light 12 hour all the year but this solar energy does not fully utilized by Malaysia people. As a solar car part, frame design is important because solar car can be crushed easily if the framework part is not strong enough to hold the impact after collision. Also frame body need to strong to support a load from engine, mass of driver and other parts that contributed to the solar car operation. Driver safety needs to be considered if the accident occurs by front collision which must no easily bend due to collision force.

1.3 RESEARCH OBJECTIVE

The main objective of this research is to create a preliminary study for possible design of solar car frame. As a common knowledge, frame body for solar car is created to give a shape of the solar car and also to withstand the load from the solar panel body, driver, actuator and also the suspension. The rigidity of frame body will greatly affected the solar car speed because the more rigid the frame body, more faster the solar car will go but they must have a accurate setup to make sure the car will get faster as it could be. Also another objective is to determine the proper dimension of solar car to make sure the maximum performance of solar car can be achieved and also the maximum solar energy collected by the solar panel during race. The rigidity and the dimension will be the subject of this research.

1.4 SCOPE OF THE RESEARCH

There are some scopes that must be included in this research. One of the scopes is sketch and designsthe body frame of solar car by using software. For example, draftsketching the chassis design by using ALGOR or SolidWork software. Then next scopes is to compose the body frame analysis of solar car in term of static conditionsuch as roll bar testing when collision or rollover during solar car operation. And last scopes for this research is tofind the suitable size of frame material by comparing with various sizes during ALGOR analysis such as natural frequency, and roll bar testing.

1.5 LIMITATION

In this preliminary study there are certain limitation that being counter such as there are limited types of aluminium steel that been sold in local market. Also not all size of tubes been sold in local market. Although that not been a big problem because there are international market that sold the required aluminium but still the price to get it is really high. This price included shipment price and also the present price of steel according to world price.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Body frame is creating to support the upper body, engine, driver and also other component which make up the vehicle. Rigidity and can lends the whole vehicle support is the main factor that decide the structure of body frame. Body frame usually includes a multiple transverse cross members and a pair of longitudinally extending channels. In order to allow for longitudinally extending storage space, the transverse frame body members have a reduced cross section.

The body frame has to base around a driver's cockpit to make sure the safety of the driver and also as a core of the vehicle. The safety of the chassis is a major aspect in the design, and should be considered through all stages. Generally, the basic body frame type consists of backbone, space frame, ladder frame, monocoque, combination. This different type of frame design will result the different performance of each framework.

A backbone chassis is the simplest structure design. It consists of a sturdy tubular backbone that joints the front and rear axle. These chassis is fully enclosed to be rigid structure and handle all loads (Wakeham.K.J, 2009). It should be noted that the backbone chassis can be built through many types of construction. The space within the structure is used to place the driveshaft. Further, the drive train, engine and suspensions are all connected to each of the ends of the chassis. Almost rear wheel drive and front engine vehicles use backbone chassis.

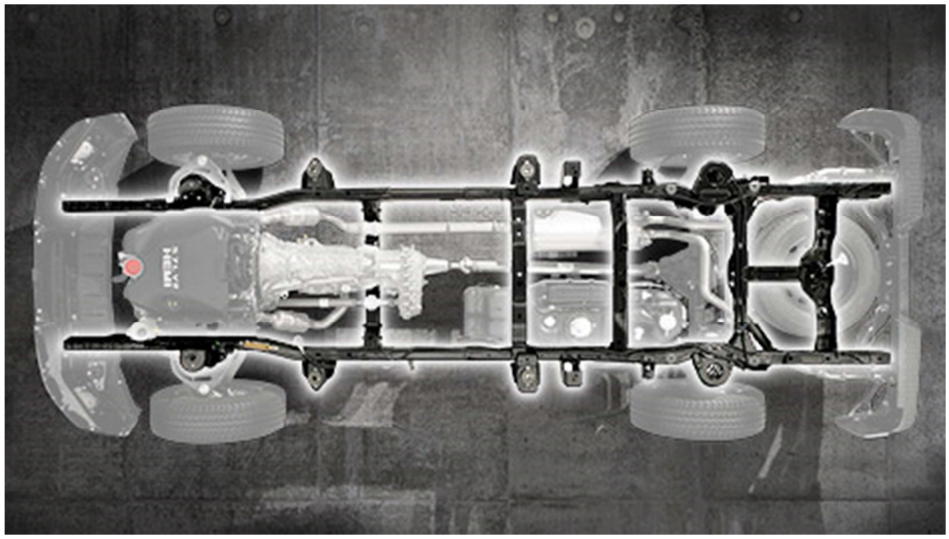

Figure 2.1: Backbone frame

Source: Lamar P 2001

Most modern cars use the monocoque chassis. A monocoque chassis can be refer to the vehicle where the external body is load bearing (Wakeham.K.J, 2009). These chassis type basically build from a single piece of framework that gives shape to a car. It built by welding several pieces together. Some parts of the skin like the grill, the bumpers, the fenders, front wing and rear diffuser are so far away from any load paths that they only hold themselves. The doors and the hood can only transfer a limited amount of load across their gaskets, hinges, and bolts in normal driving situations. The rear door is both far away from any load paths and separated by a gasket. The rear door is a mini-monocoque made of the glass window and the metal frame. (Lamar,P. ,2001).

Monocoque designs are favored among high-performance cars and racing cars today for their overall structural integrity and the fact that one can design a monocoque out of lightweight materials such as carbon fiber and expect the resulting vehicle to be light, stiff, and stable at high speeds and in tight corners. These types of particularly advanced monocoques can even be molded to create diffusers and ground effects which generate huge amounts of downforce (Lamar,P. ,2001).

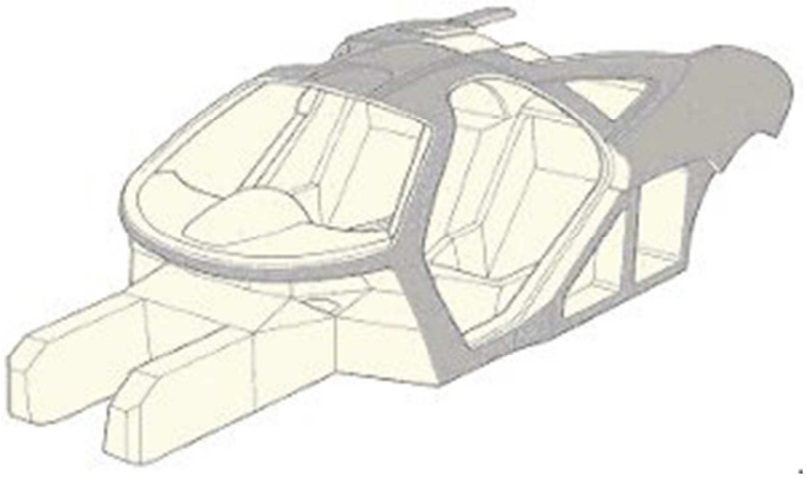

Figure 2.2: Monocoque Frame for McLaren F1 GT

Source: Shanahan R 2005

So named for its resemblance to a ladder, a ladder frame is the simplest and oldest frame used in modern vehicle construction. It consists merely of two symmetrical rails, or beams, and cross members connecting them. Originally seen on almost all vehicles, the ladder frame was gradually phased out on cars around the 1940s in favor of perimeter frames and is now seen mainly on trucks. It was originally adapted from “horse and buggy” style carriages as it provided sufficient strength for holding the weight of the components (Wakeham.K.J, 2009). This design offers good beam resistance because of its continuous rails from front to rear, but poor resistance to torsion or warping if simple, perpendicular cross members are used. Also, the vehicle's overall height will be higher due to the floor pan sitting above the frame instead of inside it. (Wakeham.K.J, 2009). The lateral and cross members provide rigidity to the structure. Most SUV’s are still use ladder chassis (Automotive Online, 2008).

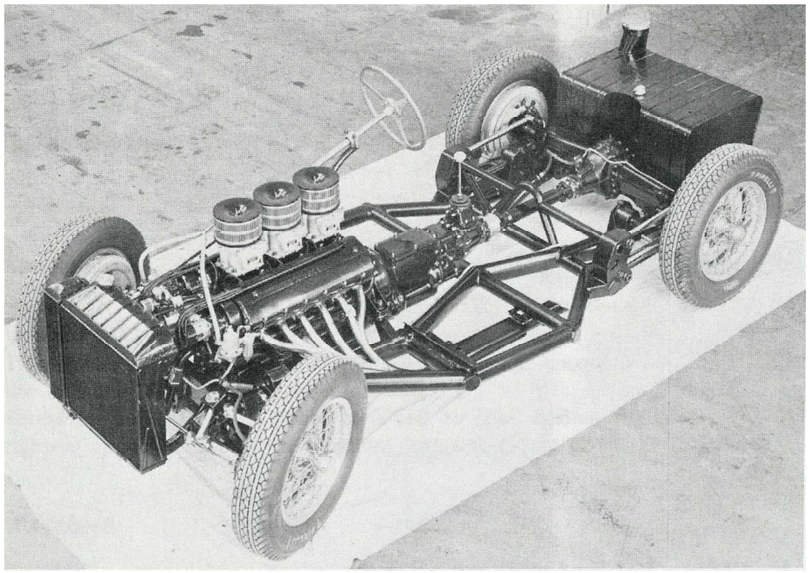

Figure 2.3: Ladder Frame for 1952-Ferrari.

Source: Lamar P 2001

Now days, mostly there are two main types of chassis used in race cars which are tubular spaceframes and composite monocoque (Christopher, 2004). Space frames have been used in the construction of racing car chassis, since the introduction of car racing in the 1940's (Christoper, 2004). Most often their geometry is based on platonic solids. The simplest form is a horizontal slab of interlocking square pyramids built from aluminium or tubular steel struts. In many ways this looks like the horizontal jib of a tower crane repeated many times to make it wider. A stronger purer form is composed of interlocking tetrahedral pyramids in which all the struts have unit length. More technically this is referred to as an isotropic vector matrix or in a single unit width an octet truss. More complex variations change the lengths of the struts to curve the overall structure or may incorporate other geometrical shapes. Space frames chassis have been used since the start of the motor sport scene. A space frame consists of steel or aluminum tubular pipes placed in a triangulated format to support the loads from the vehicle caused by suspension, engine, driver and aerodynamics (Christopher, 2004).

Although the space frame type are look like the traditional style, but they are still very popular today in amateur motorsport. Their popularity maintains because of their simplicity, the only tools required to construct a space frame is a saw, measuring

devices and welding equipments. The advantage of space frame compare to the monocoque type is it can easily be repaired and inspected for damage after a collision.

2.2 SPACEFRAME HISTORY

A spaceframe chassis uses a series of straight small diameter tubes to achieve strength and rigidity with minimal weight. Space frames were independently developed by Alexander Graham Bell around 1900 and Buckminster Fuller in the 1950s. Bell's interest was primarily in using them to make rigid frames for nautical and aeronautical engineering although few if any were realized. Buckminster Fuller's focus was architectural structures and has had more lasting influence. The technique was formalized during the Second World War, when they were used for the construction of large frames in combat aircraft. This design was first developed by Barnes Wallis who was an English aviation engineer. The advantages of the spaceframe offered to the aircraft, was that it allowed the aircraft to obtain large amounts of damage to certain areas while still retaining enough strength to remain airbone.

After the war in 1947, Dr Ferdinand Porsche used the concept to build his Cisitalia sports car. Soon after leading vehicle manufacturers such as Lotus, Maserati adopted the idea to produce race cars and these cars were nicknamed ‘birdcage’ racing cars because of the multitude of tubes. Modern race cars are now constructed out of a single monocoque frame made from expensive fiber composite materials. Figure 2.4 below shows an example of spaceframe chassis.

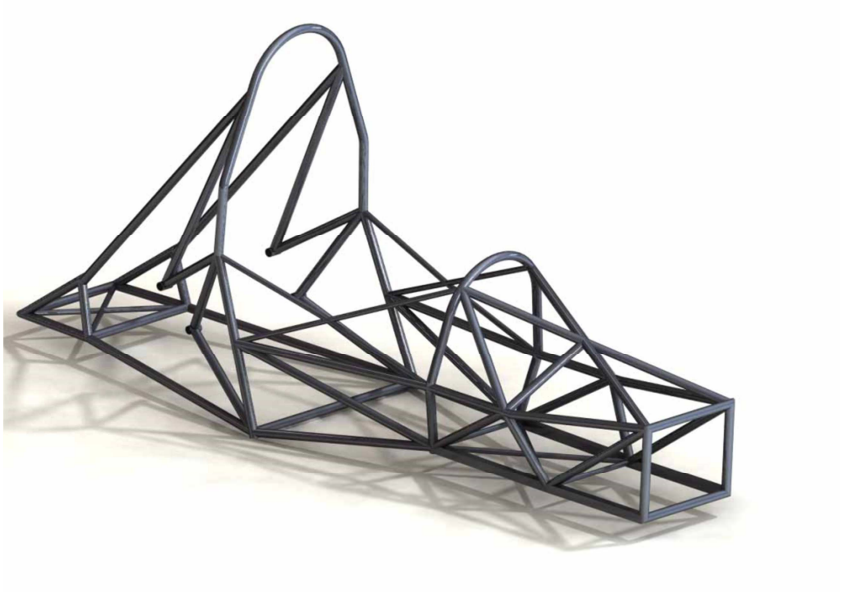

Figure 2.4: Space frame

Source: Christopher 2004

2.3 CURRENT SPACEFRAME

Lately, a spaceframe chassis is classify as a series of load bearing members which covered by panels that offer no load bearing support. This type of body frame offer greater flexibility in terms of one off production, and also allowing a wide choice of materials such as steel, aluminum or composites. When high demands of the productions required, spaceframes becomes very uneconomical compared to monocoque style frames. For mass production, monocogue seems to be the great choice other than space frame bodywork. Due to the phenomenon, significant research is being taken in spaceframe technology in order to increase the competitiveness level against monocoque frames. The construction techniques of spaceframe are expected to involve the modern composite materials and advance adhesives to form the spaceframe structure (Wakeham.K.J, 2009).

The advantage of this current spaceframe construction is that the overall mass of the vehicle is reduced and the construction process is more cost effective. This differs from a body-on-frame design in that the parts and smaller subassemblies are attached to