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Design and Analysis of Solar Car Chassis

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Abstract. A solar car is a lightweight, low power vehicle designed and built with a single purpose in mind–racing with and only drive during the day. It has limited seating (one or two peoples) and usually has very little cargo capacity. However, it offers an excellent opportunity to develop future technologies that can be applied to practical applications. This study will focus on design and analysis solar car chassis part. The primary challenge in developing an effective solar car chassis is to maximize strength and safety while minimizing the weight. Every extra pound requires more energy to move down the road. However, safety is a primary concern and the chassis must meet stringent strength and safety requirements. The purpose of the study is to understand the concept design of solar car chassis in terms of calculation, material selection, chassis style selection and virtual analysis for chassis using CATIA software.

1. Introduction

A solar car is a lightweight and low power vehicle, built with a single purpose in mind - racing. It has limited seating (one or two people) with very little cargo capacity and only drives during the day. However, it offers an excellent opportunity to develop future technologies that can be applied to practical applications [1]. The design process of the chassis solar car started with the initial constraints of the racing rules and the requirement to fit the driver and all necessary components within the bodyshell of the car [2-3]. The car was actually designed from the outside with rough positions of the major components defining the constraints of the bodyshell, which is designed to maximize aerodynamic efficiency [4]. 3D Computer Aided Design (CAD) is the computer assistance in the engineering process was used to design and analysis the chassis, in this way gives significant benefits to the design with obtained to design and analysis the strength in chassis solar car [5-12]. A simple analysis shows the importance of aerodynamics above most other design factors for solar-powered vehicles and the aerodynamic design took precedence over the final designs of the suspension or chassis, although space was given to packaging each in the bodyshell [13].

In solar car racing, the most popular type of chassis is a space frame that is designed to be the load-bearing component of the car. In general, space frames are very lightweight, inexpensive, relatively easy to design, construct, analyze, test, and modify if need be [14-18]. Compared monocoque

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structures present a considerable engineering challenge. Monocoques are constructed of composites because of their high strength to weight ratio. The challenge is in regards to the material properties of composites with the strength and module differ depending on the piece's orientation and how the load is being applied [15].

2. Methodology

The main research is focused on designing a solar car chassis part to minimize weight and maximize strength [19-20]. Solar car chassis part must be designed and analyzed to best fit the chassis performance as well as an understanding of solar car chassis design concepts such as calculation, material selection, chassis style selection and virtual analysis. Figure 1 shows a flow process of designing solar car a chassis part.

Figure 1. Flow chart of research

2.1. Chassis Design

From 3D CAD design, the overall dimension for the chassis is a design based on anthropometric data collected from the selected driver and drawn using CATIA software [21]. This software was used to analyzed von misses stress before fabricated to know that the strength of structure design. Figure 2 shows the drawing of the chassis solar car by using CATIA software. Aluminum Square Tube 6063 T52, Aluminum Rectangular tubing 6063 T52 and Drawn Aluminum Tube 6061 T6 are chosen for the chassis frame design. Centroids of the chassis area are calculated using formula (1) and (2) and the total result are shown in table 1. Figure 3 shown Reference places of the Centroid of chassis area.

$$X \text{ bar} = \sum Ax / \sum A \quad (1)$$
$$Y \text{ bar} = \sum Ay / \sum A \quad (2)$$

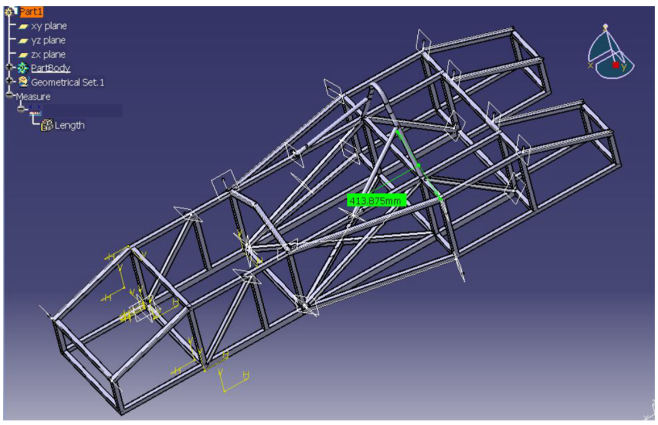

Figure 2. Proposed Specimen in 3D and 2D drawings

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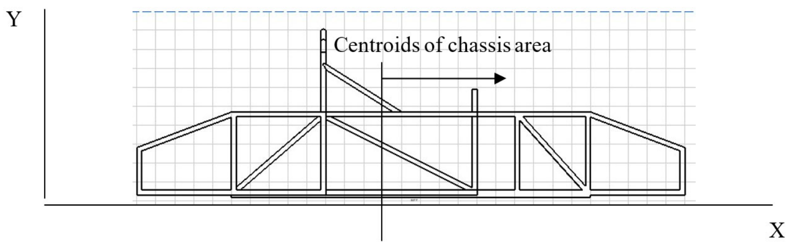

Figure 3. Reference of Centroid of chassis area

Table 1. Total Area X and Area Y

Shape		**Distance from**		**Area**	**Area**			
height (mm)	width (mm)	x	y		X	Y	AX	AY
250	25.4	0	25.4	6350	12.7	150.4	80645	955040
25.4	1000	0	25.4	25400	500	38.1	12700000	967740
38.1	1900	500	0	72390	1450	19.05	104965500	1379029.5
450	25.4	500	25.4	11430	512.7	250.4	5860161	2862072
450	25.4	1000	25.4	11430	1012.7	250.4	11575161	2862072
450	25.4	1800	25.4	11430	1812.7	250.4	20719161	2862072
450	25.4	2000	25.4	11430	2012.7	250.4	23005161	2862072
450	25.4	2400	25.4	11430	2412.7	250.4	27577161	2862072
450	25.4	2900	25.4	11430	2912.7	250.4	33292161	2862072
25.4	1900	500	412	48260	1450	424.7	69977000	20496022
140	25.4	1800	450	3556	1812.7	520	6445961.2	1849120
450	25.4	1000	450	11430	1012.7	675	11575161	7715250
			total	**235966**			**327773233**	**50534634**
						X/Y bar	**1389.07**	**214.16**

2.2. Analysis von misses stress.

Analysis of the chassis in the static case as shown in figure 4. From the analysis, it can see the maximum and minimum of deformation mesh; von misses stress and translation displacement. Von misses stress shows the results yield strength structure at chassis after place the load at chassis referring to the load such as driver, battery, motor, solar panel and etc. Yield strength from analysis must lower from the yield strength of the material used.

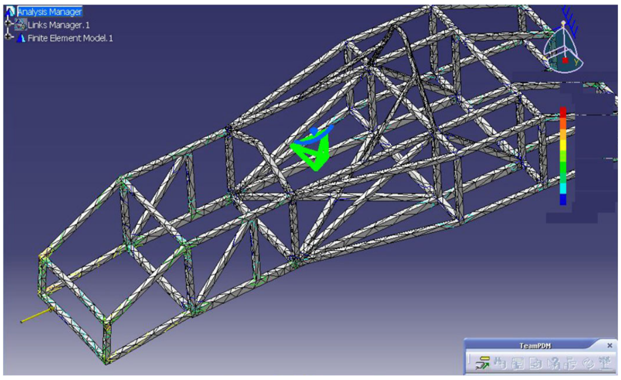

Figure 4. Chassis structure analysis

3. Results and Discussions

3.1. Result of FEA analysis

Table 2 shows results from FEA analysis - von misses stress on chassis design. It shows maximum and minimum von misses stress and translational displacement vector at the front, rear, side, and place load at the body (z Axis). The highest maximum load is from side about 145000N and yield strength is 1.44945e+008N_m^2 not over from yield strength of the material used 145e+008N_m^2.

According to the analysis that has been done, the analysis shows that no critical or dangerous point that happens at the chassis structure. In the analysis results, the load that applied on the chassis is 2075N and for analysis crash at the front, rear and side are 40700N. The load in 2075N, Analysis shows that the chassis is in a safe condition because it does not have a deformation or critical deflection on the chassis structure. In the analysis of load 40700N at the front, rear and side, it can show that driver position in a safe condition. After analysis, the result shows that the driver cage, not in critical damage. If the red colour sign appears on the chassis structure, it means the structure has a maximum von misses stress or maximum translational displacement vector. In addition, there have various factors to be considered such as the selection of material, restraint, and load before applied to the FEA analysis.

Table 2. Results of Analysis

Type of Load (N)	Von Misses Stress (N_m2)		Translational displacement vector (mm)	
	Maximum	Minimum	Maximum	Minimum
Front 40700N	7.22213e+007	104280	1.56289	0
Front Maximum load 81700N	1.44975e+008	209328	3.1373	0
Rear 40700N	6.72942e+007	123814	1.58798	0
Rear Maximum load 87650N	1.44922e+008	266641	3.41982	0
Side 40700N	4.18309e+007	254.473	0.665179	0
Side maximum Load 130600N	1.44945e+008	728.549	1.92119	0
Load at Body 2075N	3.53827e+006	37895	0.245243	0

By the way, from the results of the analysis, it shows the yield strength of the material is 1.45e+008 N/m^2. The maximum point of the analysis is 3.53827e+006 N/m^2 and the minimum point is 37895 N/m^2. According to the maximum and minimum points, yield strength from the analysis is below from the yield strength of the material used. It means chassis structure in a safe condition after place load on the chassis. From the results for analysis crash on load 40700N at the front, rear and side, it does show the yield strength analysis from the front, rear and side is below from yield strength of the material and the translational displacement vector have not a critical displacement at driver cage. It's mean the structure safety crash at the front, rear and side helps to protect the driver cage.

4. Conclusions

Chassis is an important part of solar cars, especially for racing. The primary challenge in developing an effective solar car chassis is to maximize strength and safety while minimizing the weight because every extra pound requires more energy to move down the road. However, safety is a primary concern and the chassis must meet stringent strength and safety requirements. The analysis was successfully achieving the objective.

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