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Design and Development of Chassis for Solar Vehicle

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Abstract: The aim of the concern work is to design, develop and fabricate the chassis for solar vehicle. A chassis is a skeleton of vehicle. The chassis not only forms the structural base but also a 3-D shell surrounding the occupant which protects the occupant in case of impact and roll over incidents. The design and development process of the roll cage involves various factors; namely material selection, frame design, cross-section determination and finite element analysis. The frame modeling is done with CATIA software. All frames structure is analyzed in static test using ANSYS software. The static tests are conducted using ANSYS to determine if the vehicle frame could support a total weight of all vehicle components and one driver.
Keywords: *Chassis, Frame modeling, Finite element analysis, ANSYS,*

I. Introduction

The chassis is the main structure that supports the vehicle weight and absorbs impact energy in a crash event. The chassis also adds to the aesthetics of a vehicle. It is designed to incorporate all the automotive sub-systems [1]. The design and development process of the roll cage involves various factors; namely material selection, frame design, cross-section determination and finite element analysis. As the vehicle mass, the moments of inertia, and the centre of gravity (COG) position can change significantly during operation, which could affect the performance of an active system. The mass of a vehicle is potentially the most crucial parameter for any kind of dynamics of a road vehicle, as it directly affects the longitudinal, lateral, power train, and suspension dynamics hence considering all these factors the design should be made. In material selection the material with carbon percentage of 0.18% is selected. While designing chassis for the golf kart in terms of the propulsion system, the vehicle was designed to drive on a flat road and climbing hill at a maximum velocity of 45 kilometers per hour (km/hrs) and acceleration from zero to maximum speed within twelve seconds [2].

Therefore the concern work deals with the development of chassis of solar vehicle with maximum velocity of 45kilometers per hours.

II. Chassis Frame

1.1 Space frame

Space frame considered to be one of the best chassis methods 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 Formula SAE competitions to project cars and even low volume sports cars. An example is shown in figure1. Anyone who has ever designed a space frame knows 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. This seems like a tall order but the first thing to understand is that even though these aspects are important it is still subjected to tubular theory that was presented earlier. Therefore making it as wide as possible which makes it more rigid. This is normally difficult to do but through making side pods structural it is possible to added strength. The biggest problem of any design is that it will require openings for entry and exit from the cockpit area and these will not be filly triangulated. This will be the weak spot for the chassis and care must be taken to ensure this area is of sufficient strength.

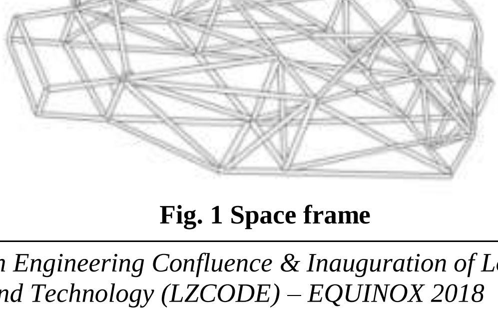

Fig. 1 Space frame

1.2 Design Methodology

The design methodology is categorized in to two parts; namely theoretical calculations and design optimization. The theoretical calculation process is started with an automotive dynamic calculation in order to determine the minimum required drive force. The design process included the chassis and exterior designs. In chassis design, the static analysis is only focused on the yield strength of the structure. After finalizing the frame along with its material and cross section, it is very essential to test the rigidity and strength of the frame under severe conditions. The frame should be able to withstand the impact, torsion, roll over conditions and provide utmost safety to the driver without undergoing much deformation. Frontal impact test, rear impact,torsion test and rollover test are performed on the chassis.

1.3 Theoretical Design calculations

The design and development process of the chassis involves various factors; namely material selection, frame design, cross-section determination and finite element analysis. Material with the carbon percentage of 0.18% is required hence the 1018 material is selected. Space frame is selected for chassis design which is made up of tubes. Hence for the tubes cross section determination is done.

To check factor of safety of chassis two main lateral members are considered as simply supported beams. Forces acting on the beam are assumed according to weight of the subassemblies. In front section steering assembly weight is to be located. In the central part driver's cabin is considered and at the rear portion transmission assembly is considered. The loading diagram considering the three different loads is shown in the figure 2.

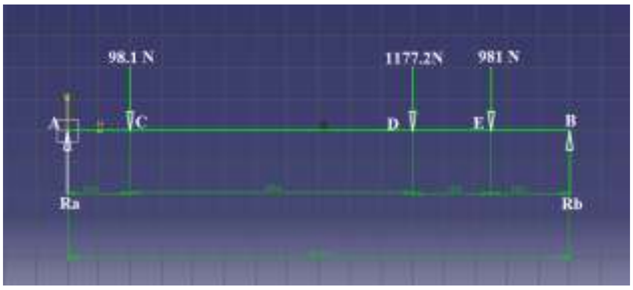

Fig. 2 steering assembly weight, driver's cabin weight and transmission assembly weight distribution diagram

Shear forces and bending moments calculations are carried out with help of Steering assembly weight = 98.1 N, driver's cabin weight = 1177.2 N and transmission assembly weight = 981 N. The maximum bending moment (M) is equal to 579.4023 KN-mm. This bending moment i.e. bending strength is calculated for two beams of the chassis. Therefore for one beam i.e. one cross-section, bending strength is M/2 =289.70115 KN-mm.

Permissible bending strength (σ_{bper}) is equal to

$$\sigma_{bper}=\frac{Sut}{3}$$

$$\sigma_{bper}=\frac{440}{3}$$

σ_{bper}= 146.666 N/mm2

Induced bending stress (σ_{bind}) is calculated to determine factor of safety of chassis

$$\frac{\sigma b}{y}=\frac{M}{I}$$

$$\frac{\sigma b}{12.7}=\frac{289.70115\times10^3}{26957.2}$$

σ_{bind}. = 136.483 N/mm2

$\sigma_{bper}>\sigma_{bind}$

Factor of safety is given by

$$\frac{\sigma bper}{\sigma bind}=\frac{146.66}{136.483}$$

= 1.1

The calculated factor of safety is 1.1

All the dimensions taken for chassis are dependent on ergonomic purposes.

III. Design Optimization

The scenario which everyone tries to avoid is having an accident. During a car accident on a road there is more emphasis put on decelerating a vehicle through structural deformation absorbing the impact with crumble zones. An accident on the track is more concerned with having a very rigid enclosure with devices attached to dissipate the energy. A driver is also very securely connected to the chassis through multipoint harnesses and head restraints.

3.1 Front Impact

The frontal impacting force is calculated by Newton's second low. For the frontal collision considering m as mass of the vehicle and u, v as the initial and final velocities respectively and t is taken as collision time.

$F = \frac{m \times (v-u)}{t}$

In automotive industry, the impact time is of the range 0.15 to 0.2 s. Taking time of impact as

t = 0.18

$F = \frac{230 \times (12.5-0)}{0.18}$

F = 15972.2 N

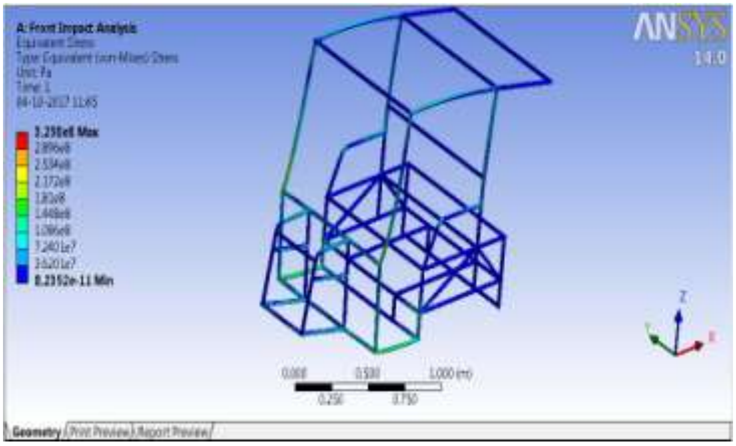

Fig. 3 Front Impact Analysis for Stress

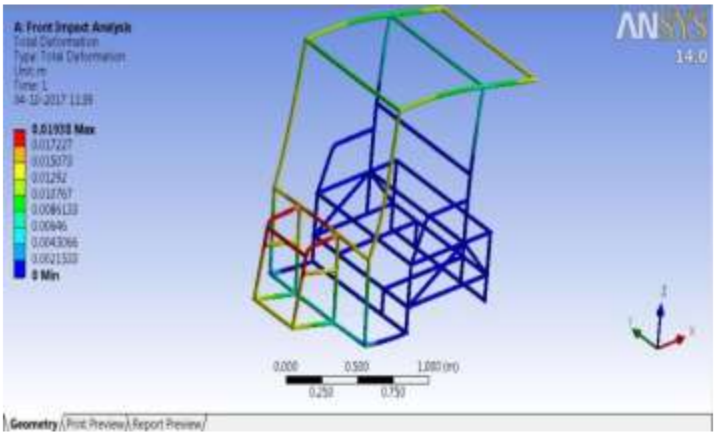

Fig. 4 Front impact analysis for total deformation

Maximum deformation in case of frontal impact is seen as 19.38mm&Maximum Stress is 3.25*108 pa. Shown in the figure 4 and figure 3

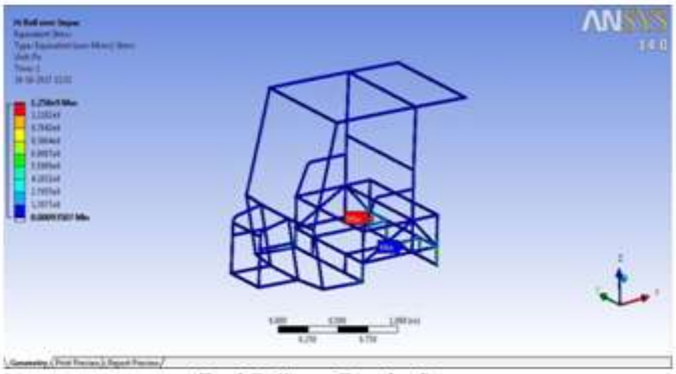

Fig.5 Rollover Test for Stress

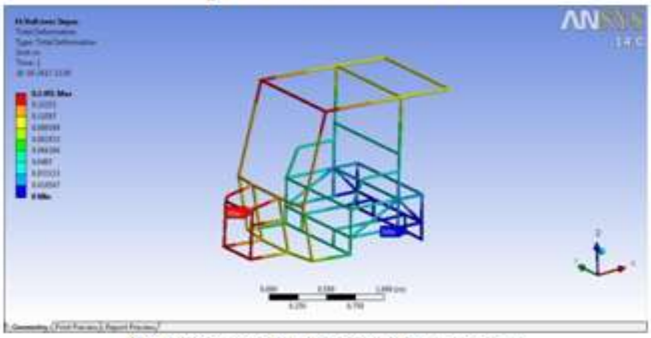

Fig.6 Rollover Test for Total Deformation

In Rollover test, forces are considered as per above mentioned formula. Deformation is seen 0.43mm & stress is 1.25*109 Pa. shown in the figure 6 and figure 5.

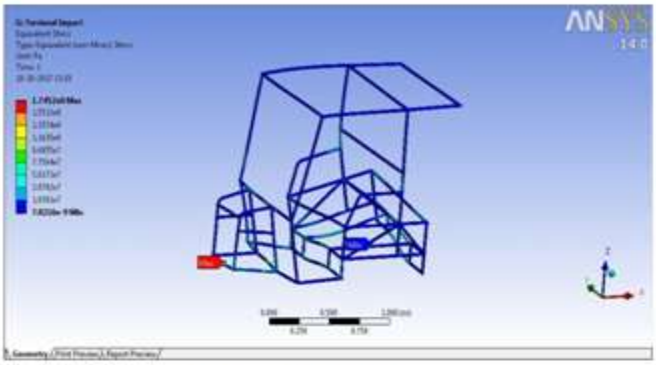

Fig.7 Torsional Test for Stress

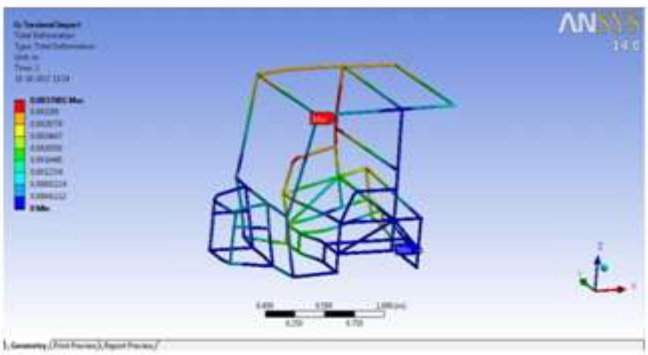

Fig.8 Torsional Test for Total Deformation

In Torsion test, Torque is calculated as per Torsion Formula.
(T/J) = (GΘ/L)= (τ/R);
T=4861.96 N-mm

Deformation is seen 3.7mm & stress is 1.74*108 Pa.

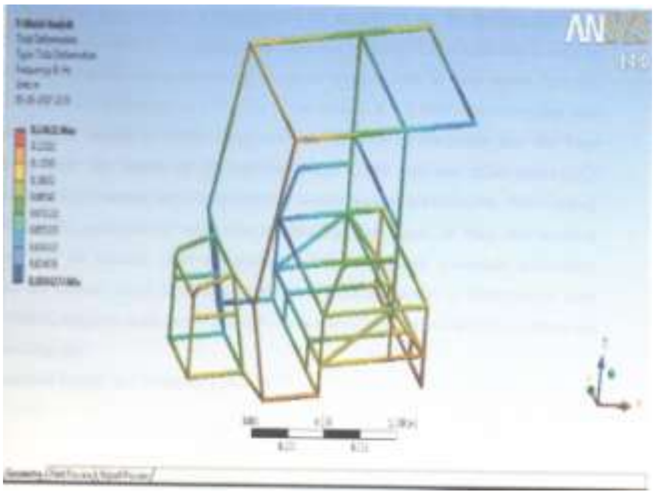

Fig.9 Modal Analysis

In the modal analysis maximum deformation is 14.62mm as shown in the figure 9.

IV. Conclusion

1. Designed space frame chassis has adequate factor of safety 1.1 for the loading conditions.
2. In the modal analysis maximum deformation is 14.62mm which provides safety for the cabinet of driver.
3. Frontal impact deformation is 19.38mm and driver is 500 mm from the deformed members.
4. Designed space frame is safe and satisfy ergonomic conditions.

Acknowledgements

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