

ANALYSIS OF A AN EFFICYCLE ROLL CAGE

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ABSTRACT

Efficycle is an intercollegiate design competition for undergraduate and graduate engineering students where teams have to design and fabricate an energy efficient Hybrid-human powered- three wheeled-electric vehicle organized by the Society of Automotive Engineers, India.

The vehicle supposed to be aerodynamic, highly engineered, safe and ergonomically designed. The design should be commercially viable as a product and should be attractive to the consumers because of its visual appearance, performance, reliability and ease of operation.

The purpose of the event is for setting up a trend of using eco-friendly vehicles in India and come up with some innovative designs.

The Competition includes designing, fabricating and validating a three wheeled vehicle driven by two drivers. The vehicle would be evaluated for its design, performance, safety, durability and the teams compete against each other. Vehicles entered into competitions must be conceived, designed, fabricated and maintained by the student team members without direct involvement of professionals, automotive engineers, racers, professional fabricators, technicians, machinists or related professionals.

General Terms

EFFICYCLE, CATIA V5, ANSYS

Keywords

Strength, factor of safety, deformation, load, support, impact

1. INTRODUCTION

A roll cage is a skeleton of an efficycle. The roll cage 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 roll cage also adds to the aesthetics of a vehicle. So determining strength requirements of roll cage, stress analysis is carried out using FEA software ANSYS workbench.

This paper focus on various loading tests like Front Impact, Rear Impact, Side Impact, Roll over to check whether our chassis can bear all types of impacts

2. DESIGN METHODOLOGY

Design of any component is consists of three major principles: 1.optimization 2.safety 3. comfort. The primary

objective of the roll cage is to provide a 3-dimensional protected space around the driver that will keep the driver safe. Its secondary objectives are to provide reliable mounting locations for components, be appealing, low in cost, and low in weight.

Once modeling of the roll cage structure is done by using CATIA V5, this design is checked by Finite Element Analysis.

We have focused on every point of roll cage to improve the performance of vehicle without failure of roll cage.

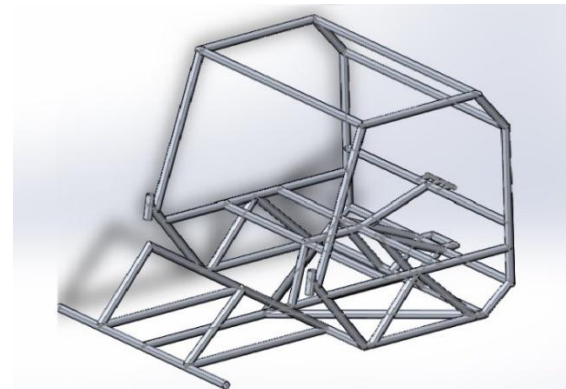


Fig.1: 3-D Model of Roll Cage Structure

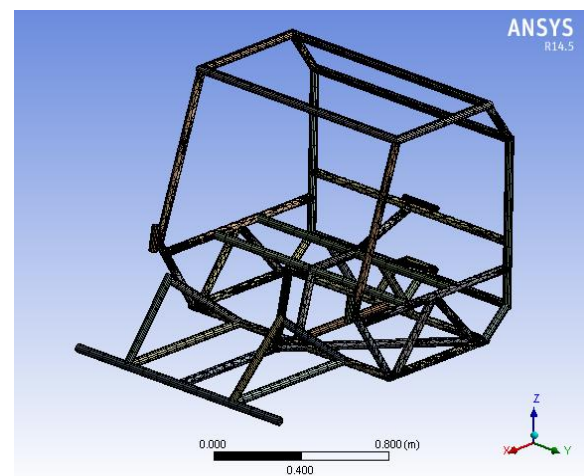


Fig.2: Meshing

3. MATERIAL USED:

Table 1. Mechanical Properties of Aluminium alloy 6061-T6

Subject	Property
Material	AA-6061 T6
Density	2700 Kg/m ³
Ultimate Tensile Strength	310 Mpa
Yield strength	276 Mpa
Young's modulus	69 Gpa
Poisons ratio	0.33
Roll cage weight	20.38 Kg

Table 2. Dimensions of pipe section

Pipe dia.	38.1mm
Wall thickness	2mm

4. FINITE ELEMENT ANALYSIS

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. Following tests were performed on the roll cage.

- (i) Front impact
- (ii) Rear impact
- (iii) Side impact
- (iv) Roll Over

4.1 Front impact analysis

Impact load calculation:

Using the projected vehicle/driver mass of 300 kg, the impact force was calculated base on a G-load of 3.

$$\text{Force} = \text{mass} * \text{acceleration} \dots (1)$$

$$= 300 * 3 * 10 = 9000 \text{ N}$$

$$\text{Impulse time} = \text{weight} * (\text{velocity} / \text{load}) \dots (2)$$

$$= 300 * (6.94 / 9000) = 0.23 \text{ seconds}$$

We apply 9000 N from the front for the test of front impact of the roll cage structure of the vehicle for determining strength at the time of front collision.

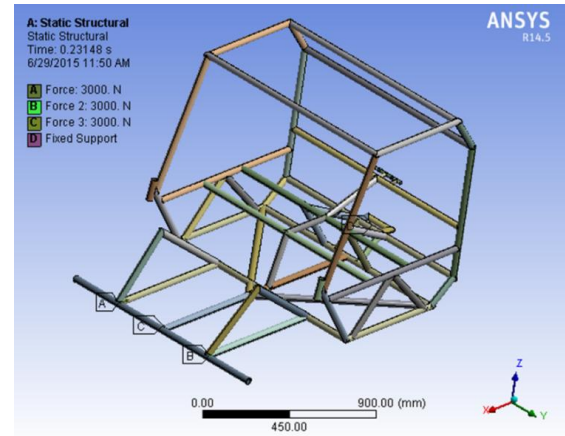


Fig.3: Load & Supports

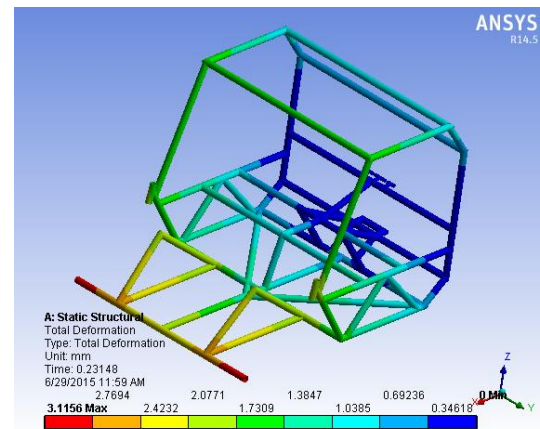


Fig.4: Front Impact Deformation

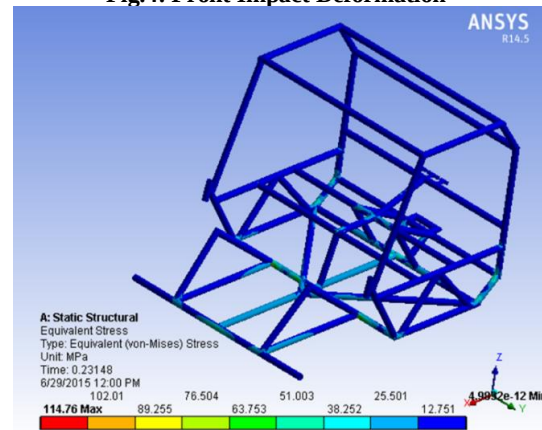


Fig.5: Front Impact Stresses

RESULTS:

Maximum deformation: 3.11 mm

Maximum Von-Mises Stress= 114.36MPa

4.2 Rear impact analysis

Impact load calculation:

Using the projected vehicle/driver mass of 300 kg, the impact force was calculated base on a G-load of 3.

Force = mass*acceleration

$$= 300 \times 3 \times 10 = 9000 \text{ N}$$

Impulse time = weight*(velocity/load)

$$= 300 \times (6.94/9000)$$

$$= 0.23 \text{ seconds}$$

We apply 9000 N from the front for the test of rear impact of the roll cage structure of the vehicle for determining strength at the time of rear collision.

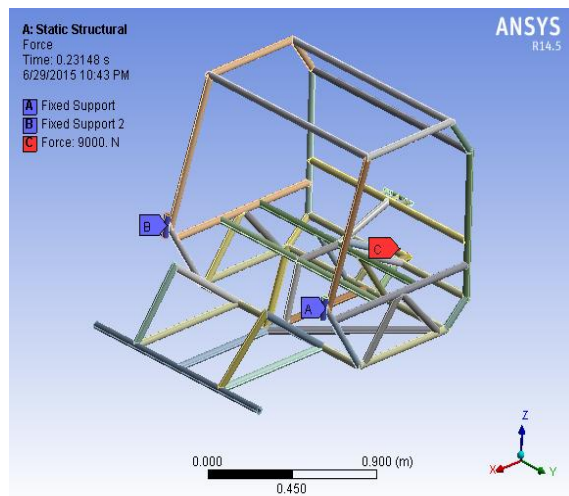


Fig.6: Load & Supports

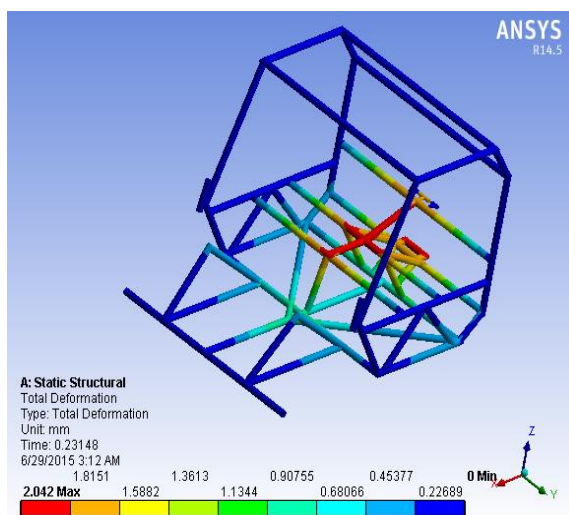


Fig.7 Rear Impact Deformation

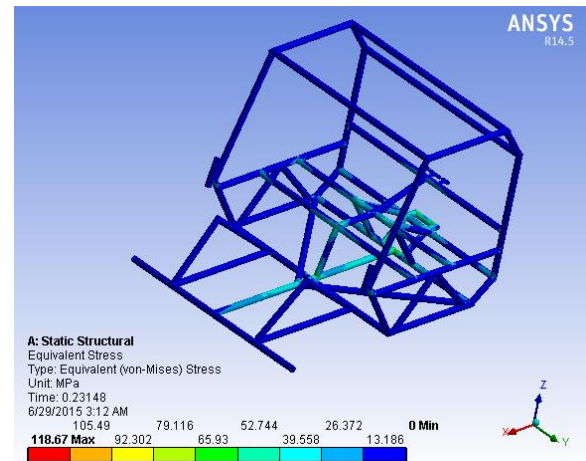


Fig.8 Rear Impact Stresses

RESULTS:

Maximum deformation: 2.04 mm

Maximum Von-Mises Stress= 118.67MPa

4.3 Side impact analysis

Impact load calculation:

Using the projected vehicle/driver mass of 400 kg, the impact force was calculated base on a G-load of 2.

Force = mass*acceleration

$$= 300 \times 2 \times 10 = 6000 \text{ N}$$

Impulse time = weight*(velocity/load)

$$= 300 \times (6.94/6000) = 0.34 \text{ sec}$$

We apply 8000 N from the side for the test of side impact of the roll cage structure of the vehicle for determining strength at the time of side collision.

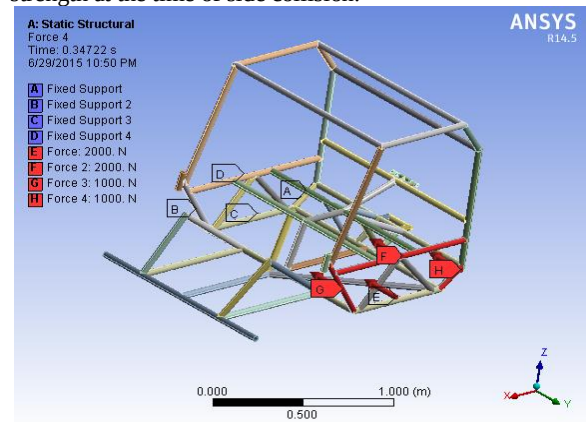


Fig.9 Load & Supports

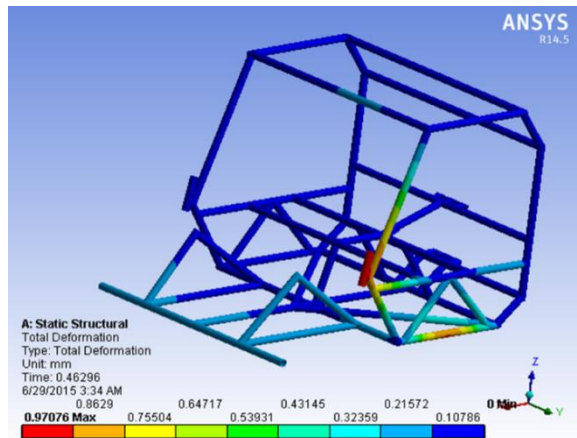


Fig.10: Side Impact Deformation

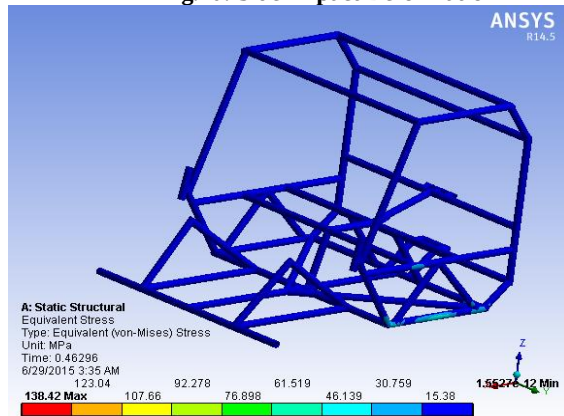


Fig.11: Side Impact Stresses

RESULTS:

Maximum deformation: 1mm

Maximum Von-Mises Stress=138.42MPa

4.4 Roll over analysis

Impact load calculation:

Using the projected vehicle/driver mass of 300 kg, the impact force was calculated base on a G-load of 2.

Force = mass*acceleration

$$= 300 \times 2 \times 10 = 6000 \text{ N}$$

Impulse time = weight*(velocity/load)

$$= 300 \times (6.94/6000) = 0.34 \text{ seconds}$$

We apply 6000 N from the side for the test of side impact of the roll cage structure of the vehicle for determining strength at the time of roll over collision.

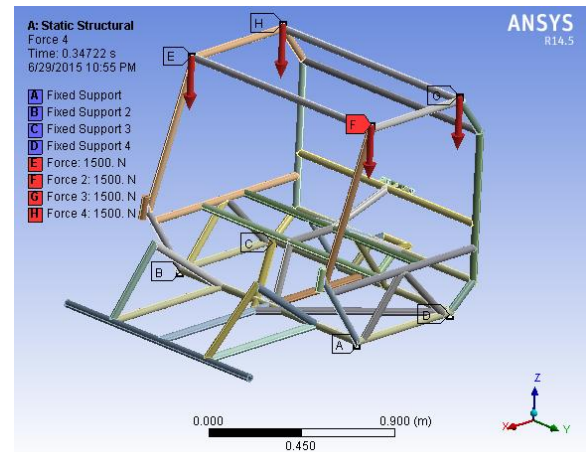


Fig.12: Load & Supports

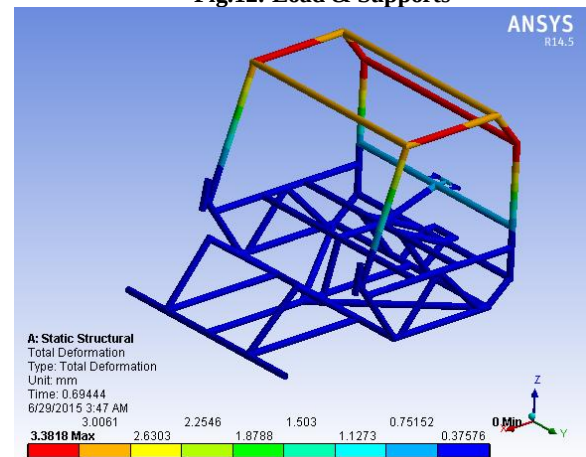


Fig.13: Rollover Deformation

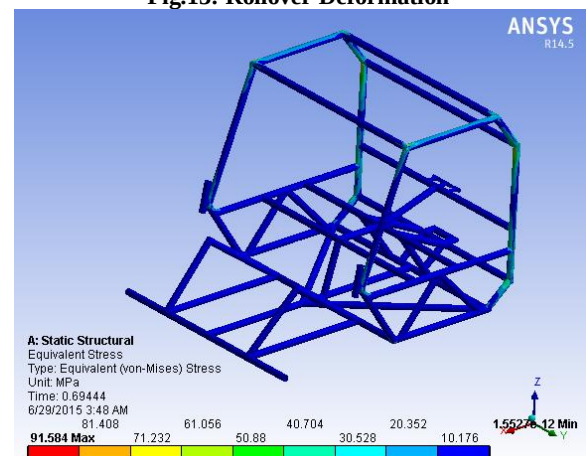


Fig.14: Rollover Stresses

RESULTS:

Maximum deformation: 3.38 mm

Maximum Von-Mises Stress=91.58MPa

5. CONCLUSION

Factor of Safety = $\sigma_{yt} / \sigma_{max}$

($\sigma_{yt} = 276 \text{ MPa}$)

CASE	STRESS (MPa)	DEFORMATION (mm)	Factor of safety
Front	114.36	3.11	2.40
Rear	118.67	2.04	2.32
Side	138.42	1	1.99
Roll over	91.58	3.38	3.01

Thus the roll cage structure is successfully analyzed for its strength against the collision from front, rear, side as well as roll over. Factor of safety is under the safe limit. The roll cage has sustained 3G force from front as well as rear & 2G force from side and rollover. Hence, deformation & stresses are under the limit.

6. ACKNOWLEDGMENTS

I want to thank team MAVERICK-DIT-our team in efficycle 2015.

7. REFERENCES

- [1] EFFICYCLE rulebook 2015
- [2] <http://www.matweb.com/search/datasheet.aspx?MatG UID=1b8c06d0ca7c456694c7777d9e10be5b>