Design And Analysis of Roll Cage on Single Seater Buggy

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Abstract- *RCDC – Rally Car Design Challenge is an intercollege competition organized by AMZ Automotive in which we Design, Build and race off-roader single seater buggy. Roll cage is a structure developed by joining individual roll bar by welding or bolting together to protect passenger from being injured in an accidental conditions. The objective of the study is to compare different materials used in a roll bar to form a frame Structure in the vehicle. In this paper we are going to compare ASTM A106 grade B, AISI 1018. We have designed our vehicle based on the RCDC 2019 Rulebook. In this paper we are analyzing respective materials at different static and dynamic conditions for different loading conditions by using AnSYS workbench. In this we study materials under different loading conditions to select a better and efficient material.*

Keywords*:* Material, RCDC, Roll cage, Strength.

I. INTRODUCTION

This project was aimed to develop the design of a roll cage which is safe, ergonomic and has the lowest possible weight. Competitiveness of the vehicle in terms of ruggedness and manuverability had also been kept in mind at the virtual and final working model of the vehicle. A preliminary design was first prepared keeping in mind the guidelines issued by SAE. Indian standards for driver space have been incorporated and a PVC mock-up was developed to evaluate the driver ergonomics. The CAD modelling of the frame and other components was done. This design was checked by Finite Element Analysis after estimating the load and the weight of the frame optimized.

II. DESIGN METHODOLOGY

Design of any component is consists of five major principles: 1.objectives 2.Parameters 3.safety 4.comfort 5.Function.

2.1 DESIGN OBJECTIVES

The primary objective of the Roll cage is to provide a 3-dimensional protected space around the driver that will keep the driver safe. The secondary objectives are to provide reliable mounting locations for components, be appealing, low in cost, and low in weight. In addition roll cage must support all operator control systems, front and rear suspension systems, and engine and drive train. Other design factors included durability and maintainability of the frame.

2.2. DESIGN PARAMETERS

Table 1

Parameters	**Properties**
Shape	Circular
Material Elongation	High
Strength to weight ratio	High
Factor of safety	High (more than 1.25)
Centre of gravity	Low
Attractive design	Aesthetically pleasing
Cost	Low or reasonable
Manufacturability	Easy
Weld ability	Good
Overall vehicle length	Less than 180 inches
Ride height	More than 10 inches
Overall vehicle height	As low as possible
Overall vehicle width	Less than 64 inches
Crash sustainability	Very high
Roll over sustainability	Very high

2.3 ROLL CAGE SAFETY

An all-terrain vehicle is mostly undergoes rough terrain accidental scenarios. In general the crash of the vehicle is a normal phenomenon. The main function of the roll cage is to protect the driver from any intrusion primarily and vehicle major components secondarily. The FEA analysis is to study and obtain a good result of a roll cage that will survive the worst crash. And another one of the worst scenario of the all-terrain vehicle is that roll over. Due to the inconsistent terrain

the vehicle roll over upside. It has a very major impact on driver's safety. FEA analysis is done to ensure roll over safety. Driver with such an all-terrain vehicle must be able to drive comfortably.

2.4 COMFORT

It is dependent upon not only the suspension but ride height, vision of the driver, ride height, vibration, etc. driver comfort ability was given paramount importance. The roll cage should be able to accommodate a person of height comfortably. The tallest member in the group was selected as the driver and the roll cage was designed taking the tallest member into consideration. The first task of the is to decide the seating position and then, using the anthropometric charts to further make the posture further suitable from ergonomics point of view.

2.5 ROLL CAGE FUNCTION

The main function of the roll cage frame is to provide the mechanical support to different parts of vehicle like engine, tires, suspension systems etc. It provides dynamic stability, strength, strength against vertical bending, Safety of driver against accidents and also acts as a vibration harness agent.

III. ROLL CAGE MEMBERS

- Primary member
- Secondary member

3.1. Types of primary member

- Rear roll hoop
- Roll hoop overhead members
- Front bracing members
- Aft lateral cross member
- Overhead lateral cross member
- Front lateral cross member
- Upper lateral cross member
- SIM lateral cross member
- Lower frame side members

3.2. Types of secondary members

- Lateral diagonal bracing
- Side impact members
- Fore/aft bracing members
- Under seat member
- Rear lateral cross member

IV. ROLL CAGEDESIGN

4.1. Roll cageIsometric view

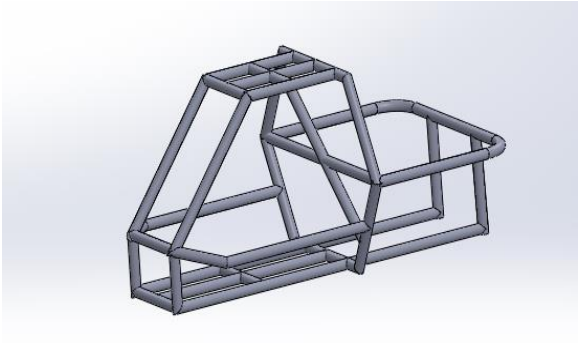

Fig 1. Isometric view

4.2. Roll cage front view

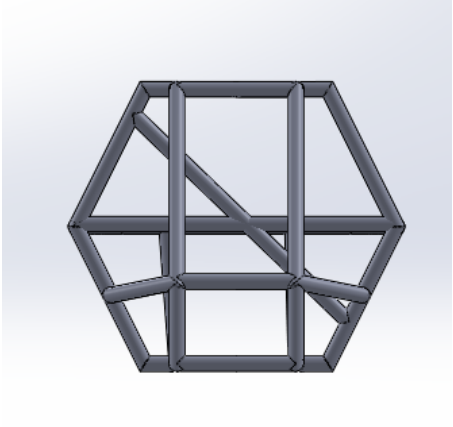

Fig 2. Front view

4.3. Roll cage side view

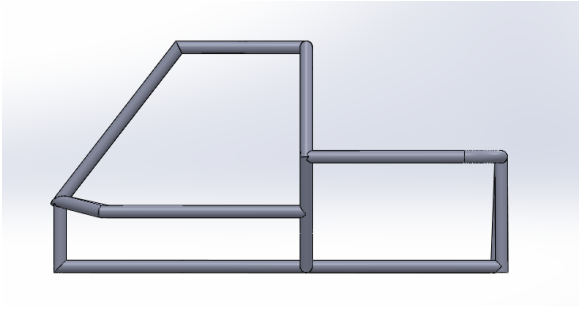

Fig 3. Side view

4.4. Roll cage Top view

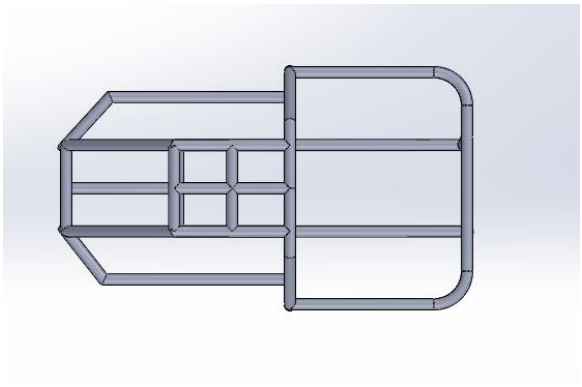

Fig 4. Top view

V. ROLL CAGE ANALYSIS

The whole analysis of the design is done by using ANSYS R15.0. By using this software we sorted out various failures with respect to the deformation of the roll cage model. The analysis of the roll cage is done according to the selected parameters such as front analysis, rear analysis and torsion analysis. Following are the results of various analysis performed while keeping in mind the resultant of failures

5.1. IMPACT TEST:

As given in rulebook for brakes the speed is 45km /hr. Based on this we calculating the forces for impact analysis. Due to euro norms and we taken the ratio to compare with euro norms of impact and then we get the values of speed.

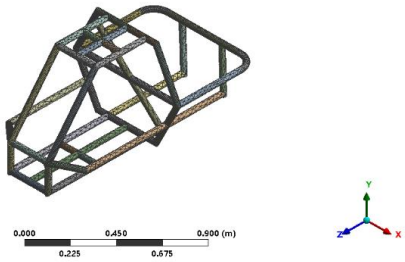

Fig 5. Mesh of Roll Cage

5.2. FRONT IMPACT:

During front impact, the ATV may hit a tree, another ATV or a wall. Time of impact will be greater for deformable bodies as compare to that of rigid bodies so impact force in the case of wall will be more than that in case of another ATV or tree. Impact time in case of impact with wall is taken as 1 second. For analysis, ATV is considered to be in static state and force corresponding to velocity 45km/h with impact time 1second is applied to front part of the roll cage of ATV keeping rear suspension members fixed.

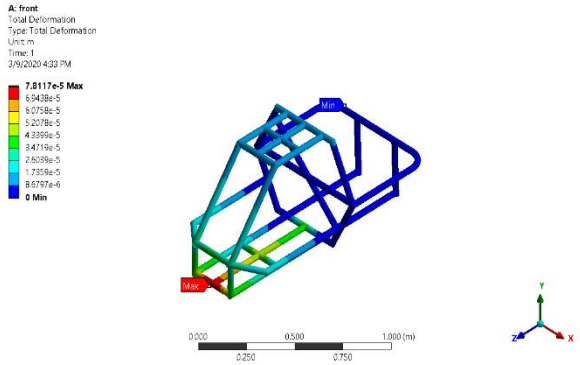

Fig. 6. Front Impact Analysis of Total Deformation

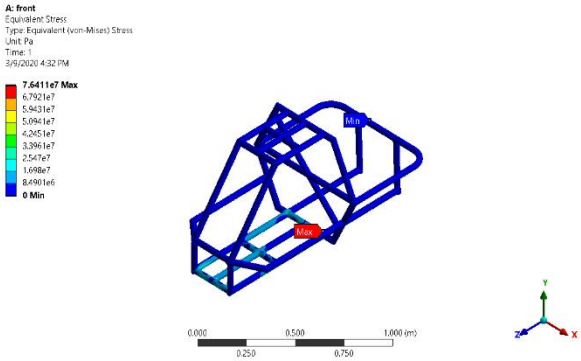

Fig. 7. Front Impact Analysis of Equivalent stress

5.3. REAR IMPACT:

In actual condition during rear impact, another ATV is going to hit ATV on its rear part. As the ATV is a deformable body so the impact time is taken as 1 second. For analysis, ATV is considered to be in static state and force corresponding to velocity 45 km/h with impact time 1 second is applied to rear part of the roll cage of ATV keeping front suspension members fixed.

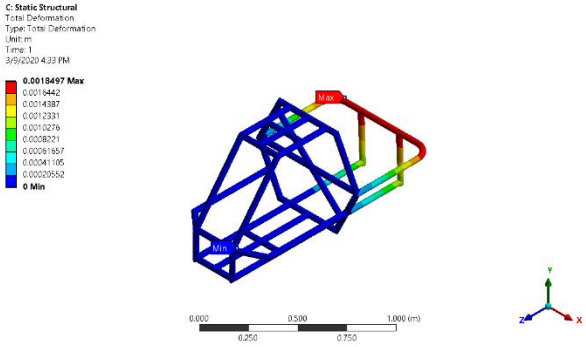

Fig. 8. Rear Impact Analysis of Total Deformation

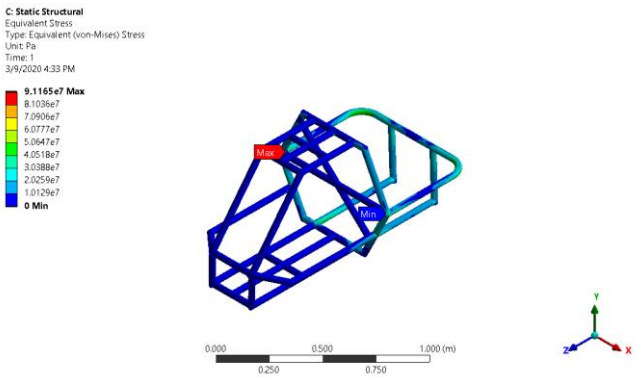

Fig. 9. Rear Impact Analysis of Equivalent Stress

5.4. SIDE IMPACT:

During side impact another ATV will hit ATV on side and as ATV is deformable body, so the impact time is taken as 1 second. For analysis, ATV is considered to be in static state and force corresponding to velocity 35km/h with impact time 1 second is applied to side of the roll cage of ATV keeping suspension members of other side fixed.

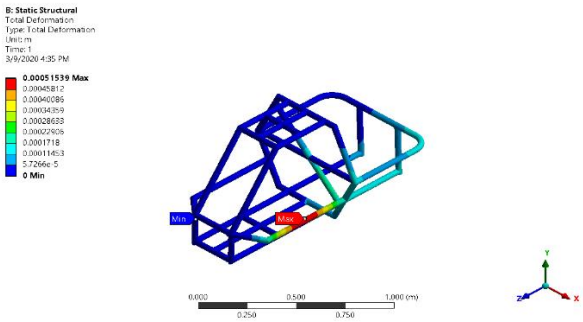

Fig. 10. Side Impact Analysis of TotalDeformation

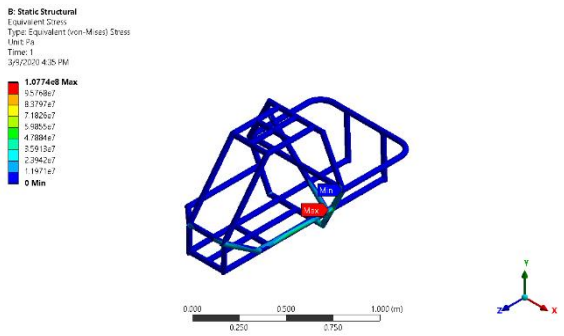

Fig. 11. Side Impact Analysis of EquivalentStress

5.5. ROLL OVER:

In roll over impact, ATV is considered to be dropped on its roof on road while it is suffered through skid. It is selected because it is sufficiently greater than anything expected at the event site. Since road and ground are non de formable bodies, so impact time is taken as 1 second. For analysis, ATV is considered to be in static state and force corresponding to the calculated velocity 40km/h for Roll over with impact time 1 second is applied to top of the roll cage of ATV keeping bottom members fixed.

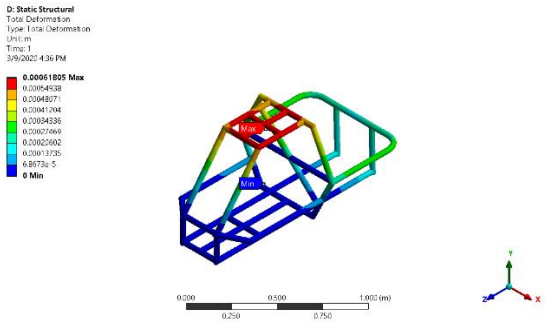

Fig. 12. Roll Over Analysis of Total Deformation

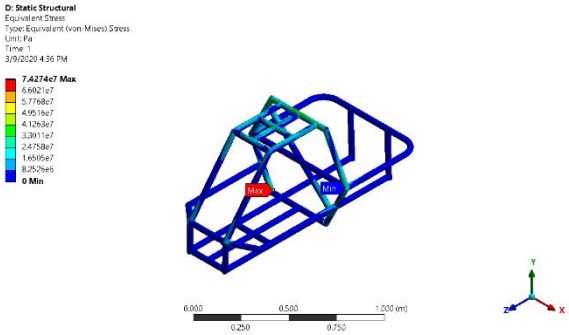

Fig. 13. Roll Over Analysis of Equivalent Stress

VI. CONCLUSION

The FEA Analysis showed that the vehicle can sustain in various condition and that the stress values are within the permissible limits. The basic need of an off-roader single seater buggy, which is lower weight to strength ratio, is also satisfied by the roll cage. Keeping the manufacturing in mind, the design of the car is kept very simple. Thus it can be concluded that this roll cage demonstrates good strengths in all tests and can be used to make an off-roader single seater buggy.

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