Design and Development of Roll Cage for ATV Vehicle

Prof. H.R.Mahale[1],Prof.V.A.Revaskar[2],Ajinkya Girish Mande[3],Prasanna Vasant Patil[4],Sahil Vijay Sable[5]
[1,2]Prof. Mechanical,JES'ITMR, Nashik, Maharashtra, India
[3,4,5]B.E.Students, JES'ITMR,Nashik,Maharshtra, India

ABSTRACT

MEGA ATV is an all-terrain vehicle competition which gives under graduate students a practical experience in engineering sciences. In this event we can get more practical knowledge in automobile field. This project deals with modeling. of roll cage of an automobile (MEGA ATV) and analyzing it to give an optimum design. ATV is most economical off- road vehicle can be used in rugged environment, so we haveanalyzed the impact forces of terrain environment. Considering Ergonomics and aesthetics of the vehicle Roll-cage design is made with the help of CATIA V5 software. Roll-cage in primary defines against roll over and other unknown accidents happening in the terrain environment. We have analyzed impact resistance of roll-cage design under various conditions like front impact, self-weight impact during jumping over uneven surface and endurance in varying road conditions, while considering safety, ergonomic condition, comfort of driver and aesthetics. This makes roll-cage economic and efficient one. The Main objective of the work is to determine non concurrency in production of a product. It deals with non-concurrency in designing and manufacturing of automobile roll cage and rectifying it to meet aoptimal design and sequel in manufacturing a product.

Keywords: *ATV, Roll cage, Weight, Strength, and analysis, etc.*

1. INTRODUCTION

Roll cage is a skeleton on which all assembly is done. This is not only a structural base but also 3D surrounding of driver which provide safety from impact and roll overs. The frame should be strong enough to withstand shock, twist, vibration and other stresses. In this we have considered ergonomics and aesthetics of driver but mostly concerned about driver safety.We have designed our roll cage in CATIA V5 and impact
Analysis is done using ANSYS Workbench for different collisions.
It is very important to check all failure modes of roll cage, Bharat Kumar Sati et al.[1], Denish S. Mevawala et al.[2], Amal Tom Kumbiluvelil et al.[3] have done static analysis of predicting failure modes on roll cage. This research discusses about the static analysis of all possible impact cases during event site.

Fig.No.1.Virtual Model of ATV

The objectives of the study considers design factor such as safety, easy manufacturing, ergonomics design and light weight.

2. DESIGN CONSIDERATION

The initial design of frame has been performed as per the guidelines set by SAE (Society of Automotive Engineering). The frame geometry has been designed as per SAE rules for an ATV. The main design focuses of vehicle to provide rigid construction, versatile drive train, suspension design with optimize weight. With gained easy access to a tube bender the team was able to increase the number of bends in the vehicle and in turn use more continuous members. Similar robust and durable designs were adopted in suspension, transmission and brakes system. Selection of proper material for fabrication of roll cage is very important. There are various materials available

	AISI 1018	AISI 1040	AISI 4130	AISI 5130	AISI 1020
Density kg/m²	7700	7845	7700	7700	7700
Ultimate Strength N/mm²	634	518.08	560	580	394.7
Yield Strength N/mm²	388	353.4	480.8	430	294.8
Young's Modulus Gap	200	200	200	200	200
Hardness (BHN)	197	149	156	379	111

Table No.2.1. Comparison of various materials

in market depending upon their property as shown in Table No. 2.1

From above comparison we use two types of material in roll cage to reduce the weight of vehicle.

	Material	Outer Diameter (mm)	Inner Diameter (mm)	Wall Thickness (mm)
Primary (member)	AISI 4130	31.75	28.54	1.6
Secondary (member)	AISI 1018	25.4	22.098	1.6

Table No.2.2.Selection of Material

3. FINITE ELEMENT MODELING

3.1. CAD Model

After selection of material next step is to draw 3-D model of roll cage with all considering set parameters of various systems and sub systems and according to rules of MEGA ATV Rulebook. For the start of the design, we have used CATIA V5 software in which we have drawn the line drawing of roll cage. The next step after the line drawing of roll cage is piping of roll cage by using one of the features which is Framework. By using this feature, piping of roll cage can be done with the various cross sections required.

Roll cage have been supported with all possible triangular structure so that forces acting on members can be distributed uniformly throughout the members. Shock absorber has been mounted passing through the center line of triangle.

Fig.No.2 shows the actual Roll Cage model of the vehicle by considering aesthetics, ergonomics and dynamics of the vehicle.

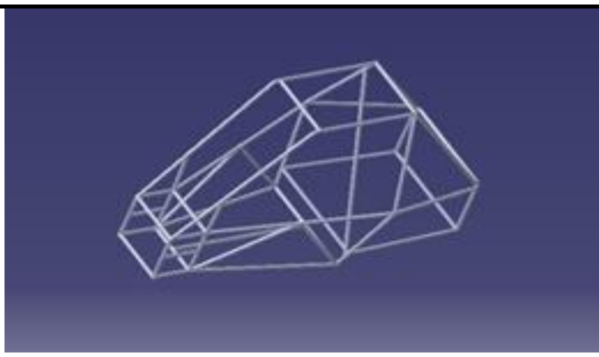

Fig.No.2.Isometric view of Roll Cage

3.2. Analysis of Roll Cage

Using the solid modeling in CATIA V5 and Finite Element Analysis (FEA) in ANSYS 15.0 roll cage is designed and optimized to maximize strength and minimize weight. Static analysis is carried out for all cases front impact, side impact and roll over impact shown by following figures.

A. Front Impact Analysis:-

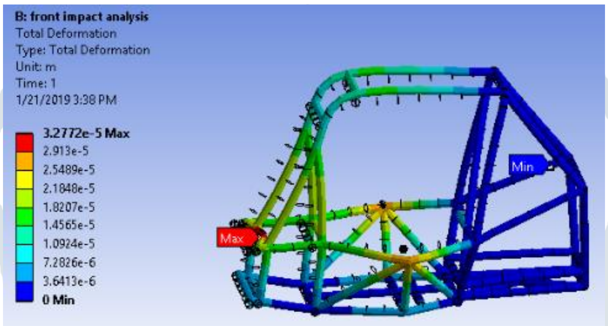

Fig.No.3.Static Structural Analysis with Total Deformation of FIA

B. Side Impact Analysis:-

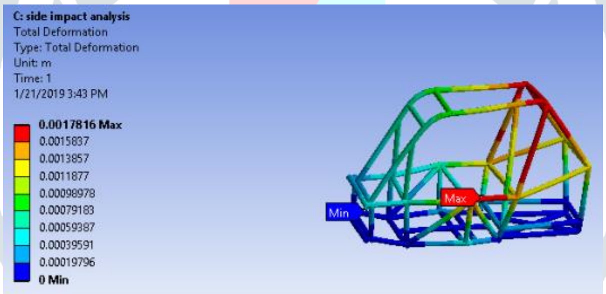

Fig.No.4.Static Structural Analysis with Total Deformation of SIA

C. Roll Over Analysis:-

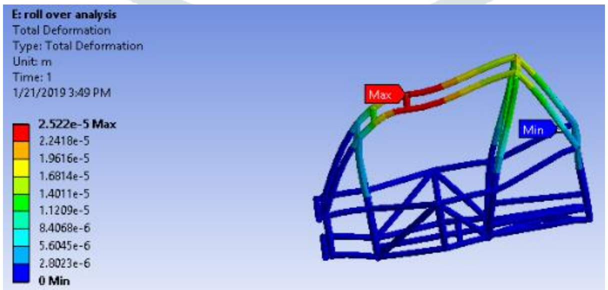

Fig.No.5.Static Structural Analysis with Total Deformation of ROA

4. CALCULATIONS

Calculations of material strengthDefinitions-
E =Modulus of elasticity
I = second moment of inertia

4.1 Designed for Primary member

Diameter - 1.25” (31.75 mm)
Wall Thickness - 0.06299” (1.6 mm)
Material - AISI 4130 Steel
From tubing geometry
Modulus of elasticity (E) = 205 GPA

Outer diameter(D_o)= 31.75 mm
Thickness (t)= 1.6 mm
Inner diameter(D_i)= 28.54 mm
Second moment of inertia

$$I = \frac{\pi}{64} \times (D_0^4 - D_i^4)$$

$= 17.268\times e^3 mm^4$
Yield strength (S_y) =480.8 MPA
Distance From the neutral axis to extreme fiber
C=15.875 mm

4.1.1 Bending Strength:-

$$= \frac{(s_{y\times i})}{c} = \frac{(480.8\times 17.26e^3)}{15.875}$$

=522.74 N m

4.1.2 Bending Stiffness:-

= E × I
= (205×17.2688)
= 3540.104 N-m

4.1.3 Torsional stiffness per unit degree:-

$$= \frac{T}{\propto} = \frac{(G\times J)}{L} = \frac{(8.0e^{10})\times(3.4537e^{-8})}{1}$$

$=276.96 \frac{Nm}{Degree}$

4.2 Designed for Secondary member

Diameter - 1” (25.4 mm)
Wall Thickness - 0.06496” (1.65 mm)
Material - AISI 1018 Steel
From tubing geometry
Modulus of elasticity (E) = 205 GPA
Outer diameter (D_o)= 25.4 mm
Thickness (t)= 1.65 mm
Inner diameter (D_i)= 22.1 mm
Second moment of inertia

$$I = \frac{\pi}{64} \times (D_0^4 - D_i^4)$$

$= 8.722e^3 mm^4$
Yield strength (S_y) =388 MPA
Distance From the neutral axis to extreme fiber
C=12.7 mm

4.2.1 Bending Strength:-

$$= \frac{(s_y\times I)}{c} = \frac{(388\times 8.722e^3)}{12.7}$$

=266.40 N-m

4.2.2 Bending Stiffness:-

= E × I
= (205×8.722)
= 1744.4 N-m

4.2.3 Torsional stiffness per unit degree:-

$$= \frac{T}{\propto} = \frac{(G\times J)}{L} = \frac{(8.0e^{10})\times(1.744e^{-8})}{1}$$

$=1395.2 \frac{Nm}{Degree}$

5. CONCLUSION

We had successfully analyzed the roll cage structure for its strength against the collision from front, rear, and side impact. The analysis was helpful in finding out the maximum deformation, Von Misesstress and the factor of safety. Factor of safety is under safe limit. Roll cage designed is perfect for use in MEGA ATV event with all the system perfectly mounted on it.

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BIOGRAPHIES

	**Prof.Harshal Mahale** He has completed ME(Design) From Savitribai Phule Pune university. He has working experience of 4 years. He is currently working as a assistant professor, department of mechanical engineering, Jawahar education society's, institute of technology, management and research, (JES's ITMR, Nashik)
	**Prof.Viki A. Revaskar**. He has completed ME (Thermal) From Sant Gadgebaba Amravati university. He has working experience of 4 years. He is currently working as a assistant professor, department of mechanical engineering, Jawahar education society's, institute of technology, management and research, (JES's ITMR, Nashik)
	**Ajinkya G. Mande.** I am the students of BE Mechanical in the Jawahar education society's, Institute of Technology, Management and Research, (JES's ITMR, Nashik)

	**Prasanna V. Patil.** I am the students of BE Mechanical in the Jawahar education society's, Institute of Technology, Management and Research, (JES's ITMR, Nashik)
	**Sahil V. Sable.** I am the students of BE Mechanical in the Jawahar education society's, Institute of Technology, Management and Research, (JES's ITMR,Nashik)