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Research Article

Static Analysis of ATV Roll Cage

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Abstract

All-terrain vehicles (ATV's) are nowadays one of the most popular vehicles with its extraordinary capability of travelling through all terrains. ATV was first made in USA and is defined by (ANSI) as the vehicle that travels with low-pressure tires. Only a single person can sit in these vehicles and also used for racing events and many applications. With the increase in use there are major accidents and deaths recorded due to failure of roll cage therefore careful and optimum designing of Roll cage is very important. The safety can be determined by performing various types of analysis on roll-cage which is most dominating part of ATV since it is responsible to take all the force acting on it. In this paper we have performed the static analysis on Roll cage with help of ANSYS-16 by applying the forces on it, we have performed front impact, rear impact, side impact, torsion and bump analysis from these analysis we have calculated the magnitude of stress developed and deformation .

Keywords: *ATV's, ANSI etc.*

1. Introduction

All-terrain vehicles are one of the most famous vehicles and which was first made in USA in the early 70's and since then the use of these vehicles has being increased significantly. The speed of these vehicles varies with the engine displacement as per use these vehicles are used in farms, off-road applications, hilly region etc. there are number of papers and reports on ATV cost, its performance, safety of ATV vehicle, designing, etc. With this there have been also number of accidents because of failure of roll cage causing injuries and deaths of people in ATV's and hence safety of vehicle is very essential parameter to deal. Therefore, to check the safety of vehicle various analyses are performed on various parts out of this structural analysis are performed on the roll-cage of vehicle. In this various loads are applied and the required parameters are observed under the acting load. Ansys workbench provides a great platform for analysis and gives us approximate numerical solution to the problem.

With the increase in number of high configuration computers and the number of advanced software designing of particular vehicle has become very simple thus reducing time and cost required. Design and analysis of the model reduces the time of iteration and experimentation thus saving a large capital which needs to be invested. This software with their advanced tools can determine number of parameters and exact values which cannot be determined experimentally like CATIA, ANSYS, SOLIDWORKS, HYPERMESH, and PRO-E are some examples of software available to the users. In this research work CATIA V5 is used for developing CAD Model of vehicle and ANSYS 16 is used to carry out the CAE part like meshing and static structural analysis. The ATV roll-cage modeling is done according to the BAJA SAEINDIA-2016 rulebook (SAE BAJA Rulebook 2016).

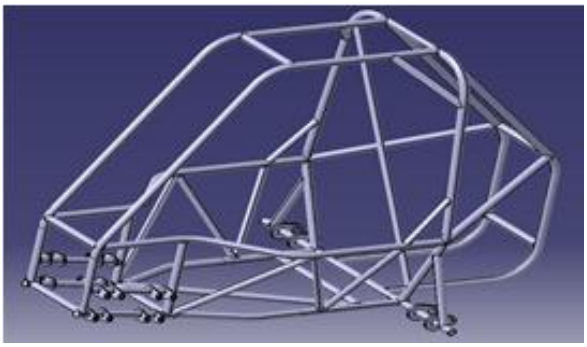

Fig.1 3-d Modeling

2.1 Material Selection

Material was selected considering various parameters like percentage of carbon, tensile strength of material, Young's modulus, compressive strength, Poisson's ratio, Density etc. comparing various material *viz*. AISI 1018, AISI 1020, AISI 4130 in the table given below.

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Table 1 Properties of materials

S. No	Properties	AISI 1018	AISI 1020	AISI 4130
1	Carbon Content	0.14%	0.18%	0.28%
2	Poisson's ratio	0.3	0.3	0.3
3	Young's modulus	205GPa	205GPa	205GPa
4	Tensile Strength	370MPa	350MPa	460MPa

2.2 Meshing

After the modeling of the geometry the most important part is meshing, it appears as the net like structure consisting of elements and nodes connected to each other. The model has infinite degree of freedom with the help of meshing the infinite degree of freedom is reduced to finite degree of freedom. Meshing is nothing but creating nodes and elements on the model thus capturing the entire geometry. ANSYS is used as meshing tool since it provides good platform for meshing the model, it has global and local meshing systems which are very user friendly, and ANSYS generates the number of elements and nodes on the basis on element size given to it as input. Number of element and nodes can also be controlled by making changes in global system. ANSYS default produces hexahedral mesh but on the complex curvature it produces tetrahedral mesh. After meshing the model analysis were performed by giving boundary conditions as input from user.

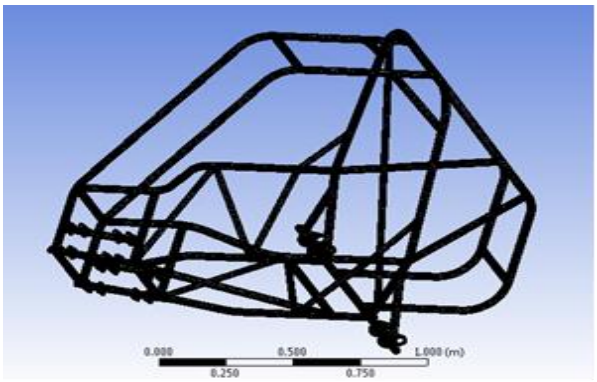

Fig.2 Meshed Model

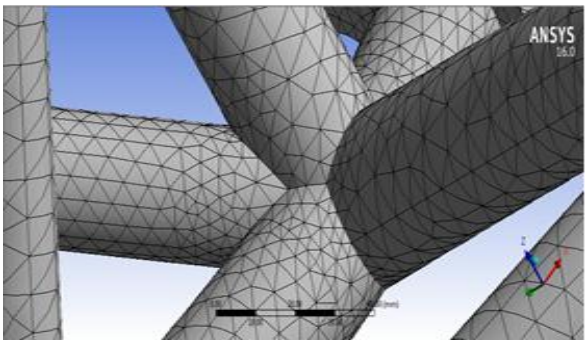

Fig.3 Magnified view of Mesh

2.3 Analysis and Result

Analysis was performed on the roll-cage designed and meshed by applying the boundary conditions. Initially the G-Force was calculated and as per industrial standards the forces were applied on the roll-cage. The roll-cage was tested for the front-impact analysis, rear impact analysis, side impact analysis, torsion analysis, and bump analysis on all of these analysis performed (2016) the behavior of the roll-cage was seen and the deformation, stress acting and FOS was calculated.

2.3.1 Front Impact analysis

In this analysis the front part of vehicle is subjected to force the force is acted on the point where the vehicle will first come in contact while facing an accident. In front impact analysis the force of 6G was applied, displacement was kept free in the direction of force and rear part of vehicle was fixed and the equivalent stress and deformation was calculated.

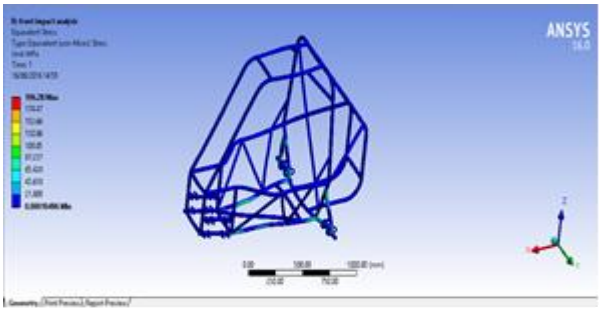

Fig.4 Front impact analysis (Equivalent stress)

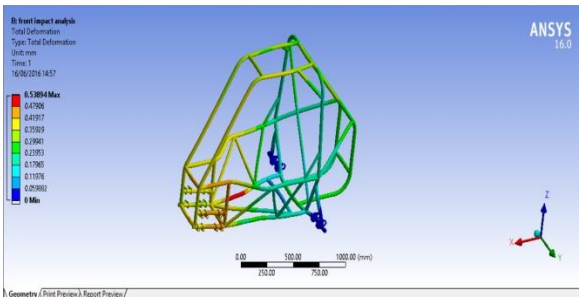

Fig.5 Front impact analysis (Total deformation)

2.3.2 Rear impact analysis

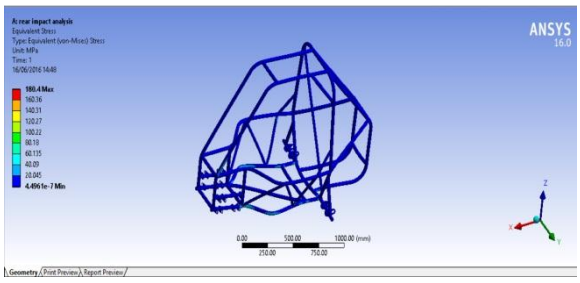

Fig.6 Rear impact analysis (Equivalent Stress)

Rear impact analysis is done in case the vehicle gets hit from behind. In rear impact analysis also the force of 6G was applied at the rear part and the displacement in the direction of the force acting was kept free as it was kept in front impact analysis and the front part of vehicle was fixed and therefore stress and deformation was calculated.

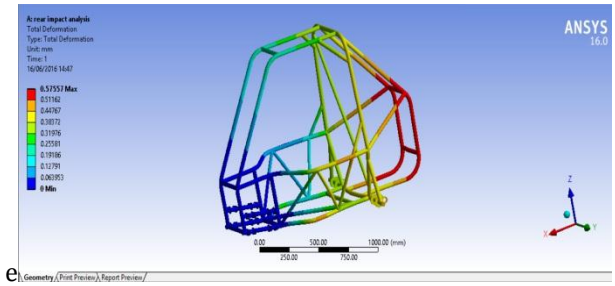

Fig.7 Rear impact analysis (Total Deformation)

2.3.3 Side impact analysis

This analysis is done to check that if the vehicle meets with an accident from side weather the vehicle can handle the maximum amount of force or it will fail. In side impact analysis the force of 3G was applied keeping other side of the ATV fixed and thus keeping the displacement free in the direction of applied force stress and displacement was calculated.

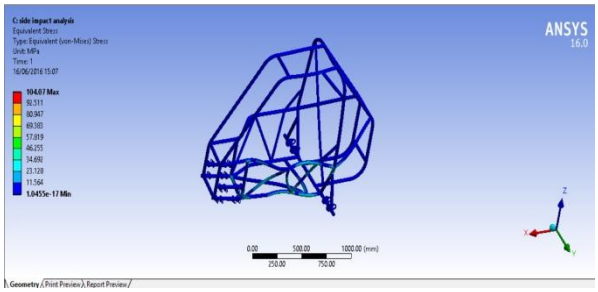

Fig.8 Side impact analysis (Equivalent Stress)

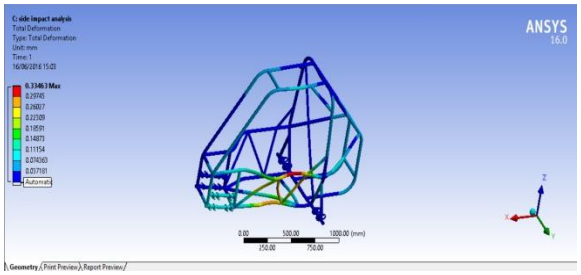

Fig.9 Side impact analysis (Total Deformation)

2.3.4 Torsion Analysis

Torsion analysis is done to see whether the vehicle can sustain the couple force that acts on front and rear part when driving on road. Torsion analysis was also done by applying the 3G this force acts as a couple on front and rear suspension points. The torsion analysis is carried at font as well as rear part of the ATV roll-cage.

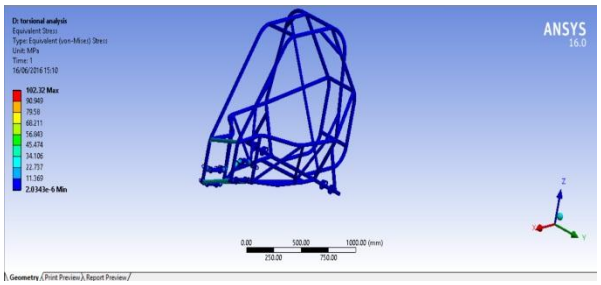

Fig.10 Torsion analysis (Equivalent Stress)

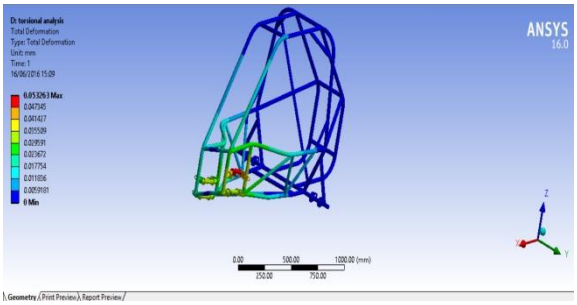

Fig.11 Torsion analysis (Equivalent Stress)

2.3.5 Bump Analysis

Bump analysis are done to see that the vehicle does not fail when its jumps from a height and thus remains in intact position. In bump analysis 3G force is applied. When the force is applied on front parts the rear parts are fixed and when it is applied on rear parts the front parts are fixed. The deformation and stress generated are compared and FOS is calculated.

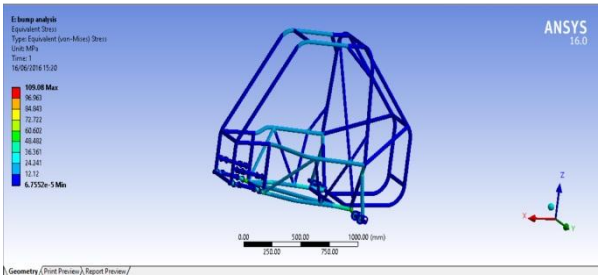

Fig.12 Bump analysis (Equivalent Stress)

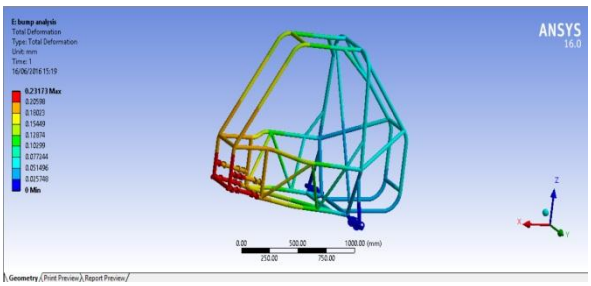

Fig.13 Bump analysis (Total Deformation)

The above analyses were performed by acting the force and resultant stress and deformation was seen the results are plotted in the table below:

Table 2 Results

S. No	Type of Analysis	Stress (MPa)	Deformation (mm)	FOS
1	Front Impact	196.28	0.5380	1.83
2	Rear Impact	180.40	0.5755	1.99
3	Side Impact	104.07	0.3346	3.44
4	Torsion	102.32	0.0532	3.56
5	Bump	109.08	0.2317	3.34

Conclusions

In this paper we have studied the modeling, material selection, meshing and static analysis of ATV.

We have performed number of analysis required for safety of vehicle i.e. front impact analysis, rear impact analysis, side impact analysis etc. We can conclude from above table that the vehicle is safe since the values of FOS (Factor of Safety) are greater than 1.

References

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