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Structural Analysis of an ATV Frame

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Abstract- All-terrain vehicles (ATVs) are motorized vehicles with large, low pressure tyres. ATVs are designed to carry one rider on uneven surfaces. ATVs weigh up to 600 pounds and can reach speeds of 75 mph.

The uses of ATVs are increasing day-by-day and it is spreading across worldwide. As the use of ATV is increasing day-by-day, there is a black side also which increases number of accidents and injuries happened during riding.

The main objective of this research work is to perform a structural analysis on an ATV frame considering mainly the safety features including total safety of driver during any crash or any accident, to have a compact structure with less weight and with good aesthetics as well.

To achieve this objective the material selection for roll cage structure is based on good strength to weight ratio as compared between various tubing international grades. The numerical analysis of the frame is accomplished in ANSYS software using structural model prepared in CREO software. The frame is analysed under various type of crash tests like front impact, side impact etc. to check its strength and required safety features of the frame. The Impulse-momentum equation is considered for the forces which act on the body during any collision.

Index Terms- ATV, ANSYS, FRAME, DESIGN.

I. Introduction

All-terrain vehicles (ATVs) have been popular recreational vehicles since their introduction in the United States in the 1970s. They have experienced increased use worldwide since the early 1990s and newer models weighs up to 600 pounds and can reach speeds of 75 mph [1]. They have widely used for agricultural purposes on farms. Since 1983, there have been about 190 scientific papers and technical reports written about ATV-related injuries and deaths, associated costs, effectiveness of laws, various prevention strategies, and identification of high-risk groups. As the no. of accidents is increasing day-by-day on ATV hence safety of the particular ATV is the most important concern and there may be some extra safety precautions from manufacturer side to buyer and rider.

To check the strength and safety features of an ATV frame, structural analysis is performed. Structural analysis is the determination of the effect of loads on physical structures and their components. Structural analysis incorporates the fields of applied mechanics, material science and applied mathematics to compute a structure's deformation, internal forces and stresses etc. There are three approaches to the analysis: the mechanics of materials approach, the elasticity theory approach and the finite element approach. The finite element approach is a numerical method for solving differential equations generated by theories of mechanics.

II. LITERATURE REVIEW

A great amount of published literature and various project & design reports are reviewed for this research. Few of them highlight the importance of topic. The literature review indicates that much of the published research about ATVs and ORVs (Off-road vehicle) has focused on their use and impacts. Most of them mainly concerns about the safety of children (younger than 16 years), because 40-50 % accidents or injuries happened with children under 16 years age not with adults elder than 18 years or more. Jo Annette David (CPSC 1998) collects reports of ATV-related incidents resulting in death from a variety of sources [2]. A report prepared by MIRA Ltd. emphasized on the seating position of rider on the ATV and also check performance of the ATV during different Rollover scenarios [3]. RIRDC (Australian Govt.) Emphasized on to setup a national framework for development and to reduce the no. of deaths and serious injuries happened during operation with ATV [4].

Delta-V Experts team concerned on Simulation of a quad bike in rollover condition for reducing no. of injuries happened during accident [5]. Various ATV safety summits have been held in U.S. also emphasized on safety of rider under the age of 16 years.

III. ATV FRAME MODELLING

a) Modelling introduction

With the advent of powerful computers and robust software, computational modelling has emerged as a very informative and cost effective tool for material design and analysis. Modelling often can both eliminate costly experiments and provide more information than can be obtained experimentally. A wide variety of software, for e.g. CREO, CATIA, SOLIDWORKS, FEMPRO, ANSYS etc. are commercially available and can be used to model and analyse the ATV frame. In this research Creo2.0 is used for modelling and ANSYS 14.5 is used as a tool for analysis.

This ATV frame is made according to BAJA SAEINDIA 2015 rules and regulations [6].

b) Material properties

The material selection will be based on various researchers in literature and by considering some important points like carbon content, density, weight to strength ratio, tensile strength etc. The material was chosen AISI 4130 and AISI 1018 for fabrication of roll cage frame as per our requirements.

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Material properties [7, 8]

S.NO.	Parameters	AISI 4130	AISI 1018
1.	Carbon content	0.3%	0.18%
2.	Young's modulus	205 GPa	205GPa
3.	Poisson ratio	0.29	0.3
4.	Tensile strength	435 MPa	365 MPa

Analysis of the frame is done under static conditions.

c) Analysis

The structural analysis was performed on the roll cage frame. The roll cage frame is tested under various impact (crash) tests such as frontal impact test, rear impact test, side impact test, torsion test, drop test etc. The frame is a distributed mass system. The analysis was conducted by providing proper boundary conditions and applied forces at on specified locations.

All the forces are calculated by using impulse-momentum equation which is as-

$$M_1 V_1 = M2V2$$

S.No.	Crash test type	Magnitude(N)
1.	Frontal impact	16700
2.	Rear impact	8600
3.	Side impact	8600
4.	Rollover	7400
5.	Torsion test	4905
6.	Drop test	7100
7.	Front bump	4905
8.	Rear bump	4905
8.	Lozenging	1406

c) Meshing

Any continuous object has infinite degrees of freedom. Finite element method reduces this from infinite to finite by means of Meshing. Meshing is a process of creating nodes and elements on a particular object.

ANSYS Meshing is a component of ANSYS Workbench. It's a next generation meshing platform. Meshing provides a wide range of highly robust automated meshing tools-from tetrahedral meshes to pure hexahedral meshes, inflation layers and high quality shell meshes .The roll cage frame is meshed using the mesh tool. The mesh tool provides a convenient path to many of the most common mesh controls, as well as to the most frequently performed meshing operations. The frame throughout this project is subjected to simply supported boundary conditions.

IV. RESULT

In this section we present several numerical simulations, in order to assess the behaviour of the roll cage frame subjected to various impact conditions.

Deflection, von-mises stress, von-mises strain, safety factor etc. are some tools which are used as a resulting tool to show the behaviour of the roll cage frame as per the applied load conditions. Following table shows the results of various tests-

S.No.	Impact test	Max. Stresses (MPa)	FOS
1.	Front impact	273.35	1.5914
2.	Rear impact	**322.87**	**1.3473**
3.	Side impact	165.91	2.6219
4.	Rollover	215.79	2.0159
5.	Torsion test	244.79	1.7771
6.	Drop test	126.8	3.4306
7.	Front bump	191.38	2.2729
8.	Rear bump	235.72	1.8454
9.	Lozenging	32.523	13.375

ANSYS DIAGRAMS

In this section we present several numerical simulations diagram of von-mises stresses in following figures for different type of impact condition to assess the behaviour of the roll cage frame.

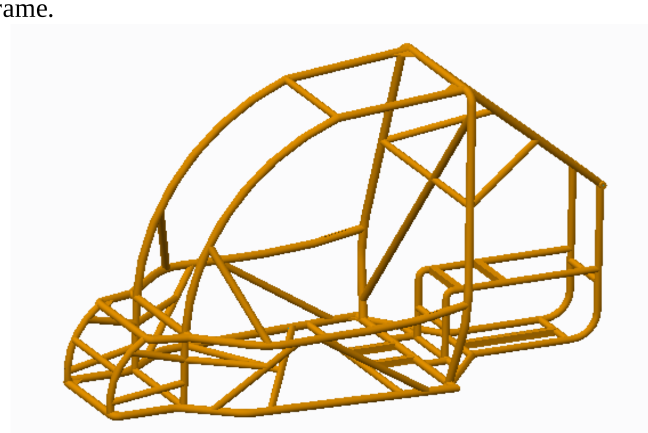

Fig 1- Isometric view of frame

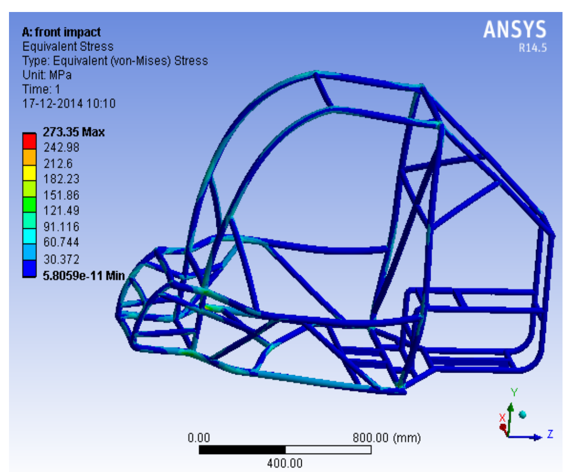

Fig 2- Frontal Impact

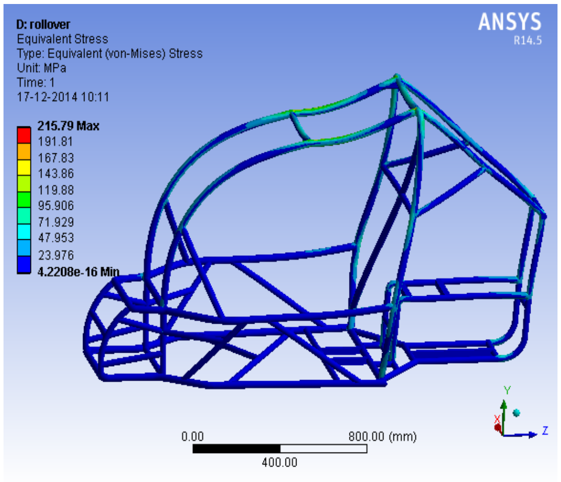

Fig 3- Rollover test

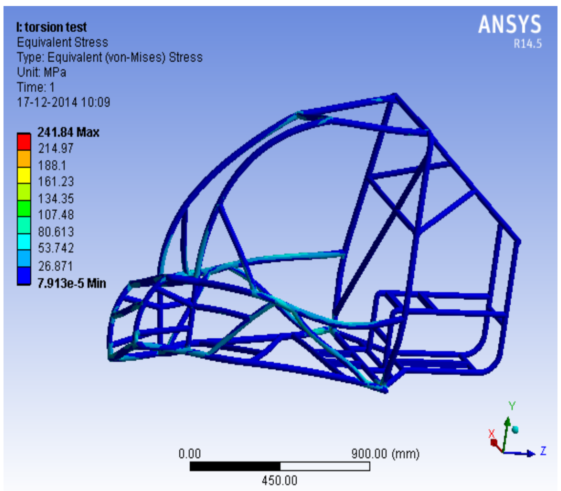

Fig 4- Torsion test

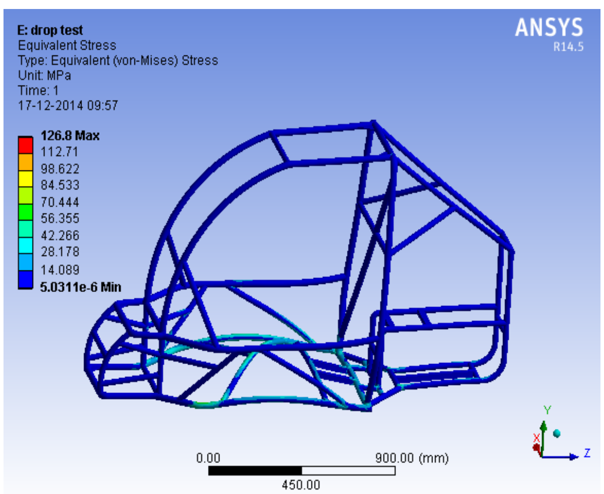

Fig 5- Drop test

V. CONCLUSION

In this research analysis is carried out on a roll cage frame made of AISI 4130 and AISI 1018 tubular sections. The structural response of this roll cage frame is studied with respect to load in various conditions.

A frame is designed that corrects weaknesses of previously designed frames. Upmost attention has kept on compactness of the frame as well as increased strength in critical areas to have the proper safety of driver during any impact. A complete analysis has done by ANSYS simulation software which will elevate the validity of the design.

It is observed that during all tests and calculations the minimum factor of safety achieved is 1.3473 (for rear impact), which is regards as safe as the result of maximum von mises stress is 322.87 MPa.

ACKNOWLEDGMENT

This project is resulted in design and fabrication of a frame that will allow us to compete in BAJA SAEINDIA-2015.

REFERENCES

[1] National Farm Medicine Center "All-Terrain Vehicle Safety" © 2003 Marshfield Clinic (910-053-01)

[2] Jo- Annette David (U.S. Consumer Safety Commission), "Report on AU-Terrain Vehicle-Related Deaths" April 1998.

[3] Jonathan Webb, Meng Ceng Mimeche (MIRA LTD.) "Mathematical modelling of the stability of passenger carrying tandem seat all-terrain vehicle (ATV)" Research report 223 for Health and Safety Executive 2004.

[4] Lyn Frager, Kirrily Pollock, John Temperley, "A National Strategy for Improving ATV Safety on Australian Farms", RIRDC Publication No 05/082, RIRDC Project No. US-122A, June 2005.

[5] Shane Richardson, Tia Orton, Andreas Sandvik, Chris Jones, Nikola Josevski and Wei Pei (Tandy) Pok (Delta-V Experts), "Simulation Of Quad Bike (ATV) Rollovers Using Pc-Crash To Evaluate Alternative Safety Systems", Paper No. 13-0286, 2012.

[6] Rulebook BAJA SAE INDIA 2015

[7] http://asm.matweb.com/search/SpecificMaterial.asp?bassnum=m4130r

[8] http://www.azom.com/article.aspx?ArticleID=6115

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