International Journal of Engineering, Science and Mathematics
Vol. 6 Issue 8, December 2017 (Special Issue)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Design, Static & Dynamic Analysis of roll-cage an All Terrine Vehicle Chassis on different materials

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Abstract

the purpose of designing of this four wheeled all terrine vehicle for the transportation in hilly areas, farming fields and. It is designed for off-road uses and for endurance of rough hilly areas. The skeleton of the off road vehicle is called roll cage. The total load of the vehicle acting over the roll cage only. The design fully depends upon the material selection, frame design, cross section determination, and strength & analysis report. We studied all the parts of the roll cage to analyse the efficiency. We used high end software's like solid works & action for roll cage designing purpose & ANSYS for analysis. We made different type of designs of an ATV & analyse the deformations occurred.

Keywords:

CATIA,
SOLIDWORKS,
ANSYS,
front impact,
rear impact,
static analysis,
dynamic analysis.

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1. Introduction

An all-terrain vehicle (ATV), also known as a quad, quad bike, three-wheeler, four-wheeler, or quadricycle as defined by the American National Standards Institute (ANSI) is a vehicle that travels on low-pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. As the name implies, it is designed to handle a wider variety of terrain than most other vehicles. By the current ANSI definition, ATVs are intended for use by a single operator, although some companies have developed ATVs intended for use by the operator and one passenger. These ATVs are referred to as tandem ATVs.

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To be successful at fast trail riding, an ATV must have light weight, high power, good suspension and a low center of gravity. These machines can be modified for such racing disciplines as motocross, woods racing (also known as cross country), desert racing (also known as Hare Scrambles), hill climbing, ice racing, speedway, Tourist Trophy (TT), flat track, drag racing and others.

The main objective of the study carried out stress strain analysis (front impact, rear impact, side impact, roll over, torsional rigidity deformation & bumping deformation) of different type of design of roll-cage having different type of material composition of an All-Terrain Vehicle (ATV).

The 3D model of different type of roll cage are prepared on Solid Works software by using weldment feature & then we analyzed them on ANSYS software, by which we know the deformations occurred on the roll-cage design.

II. DESIGN METHODOLOGY:

We have designed the roll cage keeping in view the safety and aesthetics. These are the two factors which matters us the most, therefore they are given utmost consideration.

II.1.1Roll cage design:

Roll Cage can be called as skeleton of a vehicle, besides its purpose being seating the driver, providing safety and incorporating other sub-systems of the vehicle, the main purpose is to form a frame or so called Chassis.

II.1.2Material for roll-cage:

Material selection of the chassis plays crucial part in providing the desired strength, endurance, safety and reliability to the vehicle. To choose the optimal material we did an extensive study on the properties of different carbon steel. The procurement team was directed to get the quote of those steel pipes. We found 3 types of materials i.e. AISI 1018, AISI 4130, and AISI 1026. We first considered AISI 1018 steel. The strategy behind selecting the material for roll cage was to achieve maximum welding area, good bending stiffness, minimum weight and maximum strength for the pipes. So, after market analysis on cost, availability and properties of these two alloys, we finalized AISI 1018 of the following dimensions:

Outer Diameter: 26.54 mm

Wall Thickness: 3 mm

Then analyses of the roll cage considering AISI 1018 pipes of shown dimensions was done and we got the safe factor more than 2, which justified the selection Then we made a different design by using AISI 4130 & done analysis.

II .1.3 Vehicle dimensions:

A wider track width at the front than at the rear will provide more stability in turning the car into corners decreasing the tendency of the car to trip over itself on corner entry and more resistance to diagonal load transfer. Wheel Base is 1600mm and Track Width is 1550mm. This has been chosen to ensure better balance and straight-line stability. This has also created ample space for the driver and other systems.

II. 2Roll cage components:

The components used to design the Roll Cage, their functions and designing procedure is mentioned below:

II.2.1 Rear Roll Hoop (RRH):

The RRH was the first section of the chassis to be designed. It is angled back at 100° angle to provide the driver with the most natural sitting position possible. It consists of four sections of tubing welded on the ends. The Rear Roll Hoop Lateral Diagonal Bracing (LDB) keeps the RRH from deforming and increases overall stiffness of the chassis. Two lateral members have been used for support and mounting points for seat belts and engine.

II.2.2 Roll Hoop Overhead (RHO):

The RHO is welded to the RRH. The RHO provides the appropriate head room for a 6 feet 3 inch driver with additional 6 inch clearance.

II.2.3 Lower Frame Side Members (LFS):

The LFS is welded at the bottom of the RRH as shown in Fig. 1. The width of LFS keeps on decreasing along the length. This provides maximum driver space and at the same time it reduces the size of the vehicle. The Lateral Cross (LC) Member joins the LFS in the front. The width of the LC member is selected so as to accommodate the three pedals comfortably.

II.2.4 side impact members (SIM):

The SIM increases chassis stiffness and is a major member that provides protection to the driver in a side-on collision. It is a single piece of tubing with two bends as shown in Fig. 1. The SIM extends straight up to the driver's elbows and then converges in the front. The LC connecting the SIM in the frontis a very important member because it is the first member of chassis to be hit in case of frontal impact. It not only protects the driver from frontal impacts but also increases the stiffness of the Roll Cage.

II.2.5 Rear Bracing:

The Rear Bracing encloses the engine, transmission, and rear drive assembly. The rear bracing also incorporates an independent rear suspension. The main properties of the rear chassis are all constrained by the driveline. Before the base of the rear was designed, the length of the drive axle was considered. Also the height of the lower rear roll cage is defined by the rear suspension mounting points. From this point the rest of the rear roll cage is designed. To check the accommodation of driver in the roll cage design made, the team took two more days to make a dummy cockpit using Poly Vinyl Chloride pipes. The driver was seated to check out the comfortably and front visibility from the vehicle. After this test two major changes were done in the design.

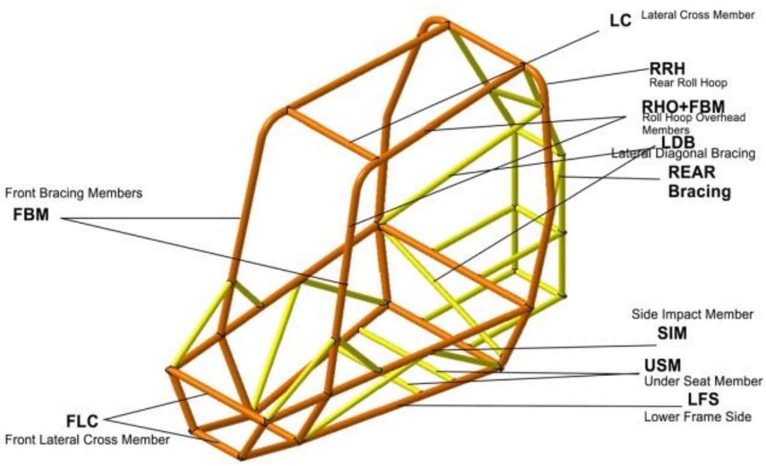


Figure 1

PROPERTIES	AISI 1018 OD-1in W/T- 3mm	AISI 1020 OD-1in W/T- 3mm	AISI 4130 OD-1in W/T- 3mm
Density(g/cc)	7.87	7.9	7.9
Poisson's ratio	0.29	0.29	0.29
Elastic modulus(Gpa)	210	210	210
Tensile strength(Mpa)	470	450	1040
Yield strength(Mpa)	365	320	720
Bending stiffness(Nm^2)	3791.1	3791.1	3791.1
Bending strength(Nm)	391.3	370.2	467.4
Elongation (%)	26	28	25
Reduction in area (%)	40	40	40
Hardness(HB)	130	130	280
Thermal conductivity (micron/mk)	12	12	12
Cost in Rupees/metre	500	420	700
Weight per metre(Kg)	1.4	1.7	1.25

III. DESIGN ON DIFFERENT TYPE OF MATERIAL & ANALYSIS REPORT

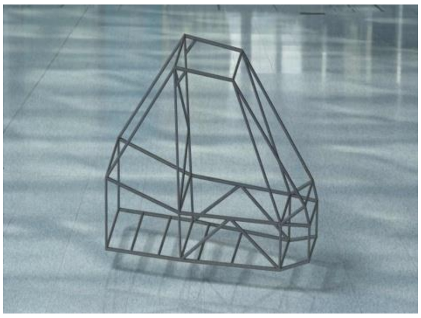


Figure 2

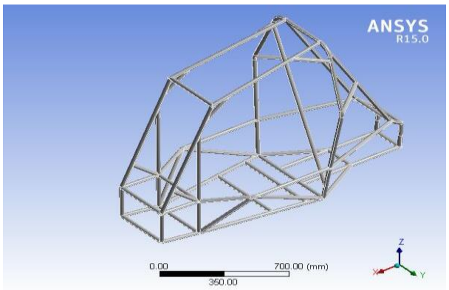


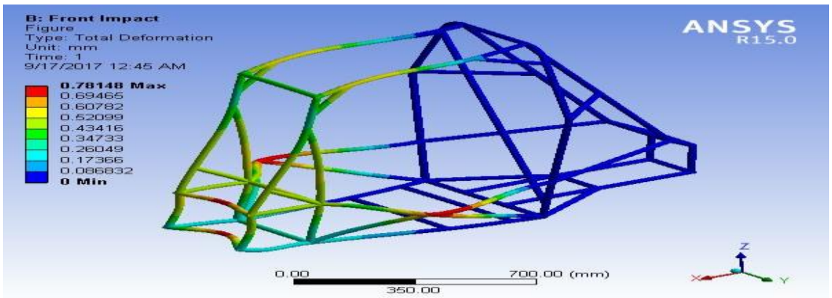
Figure 3

III .1 Front Impact

Front impact test is established by taking assumption of total weight of the vehicle in which the Weight of the driver is included, and maximum acceleration of vehicle colliding with any objects which have eight times weight of the curb weight.

Front Impact load calculation:

Using the projected vehicle + driver mass of 300 kg, the impact force was calculated based on a G-load of 8. F = ma 300*8*10 = 24000 N (approx.). We apply 24000 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.



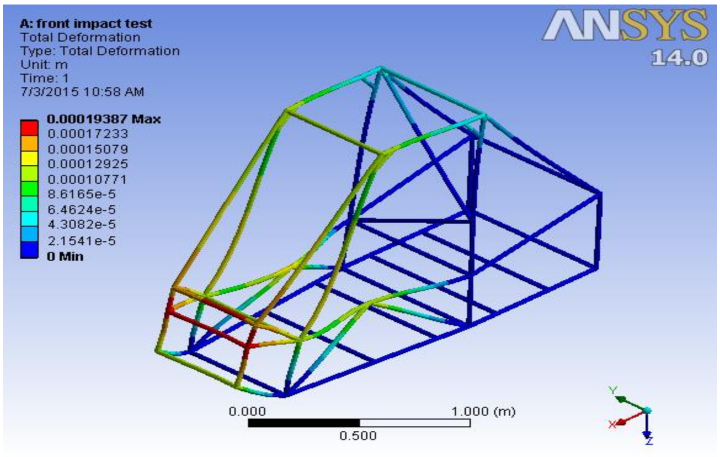


Figure 5

Maximum Stress-214
Factor of Safety-1.5(>1, Design is safe)

Side impact	4G
Maximum Deformation	3.33mm
Maximum Stress	130 Mpa
Factor of Safety	3.53(>1,Design is safe)

Front impact	8G
Maximum deformation	1.9mm
Maximum Stress	214
Factor of Safety	1.5(>1,Design is safe)

III.3Rear Impact Test

Rear Impact test is performed by taking assumptions that total curb weight (driver plus ATV weight) is equal to 300 Kg, and maximum travelling speed of ATV is 58 km/hour colliding with any heavy object which have eight times weight of our curb weight. It is known as 8G impact test. In rear impact test 8G force is applied because when the driver wants to takeover there is more chances of accident if the vehicle is unbalanced.

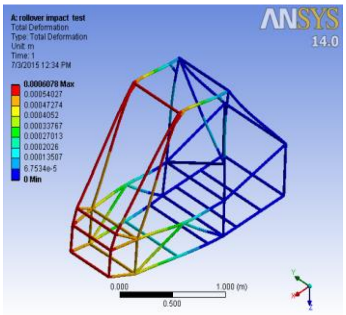


Figure 6

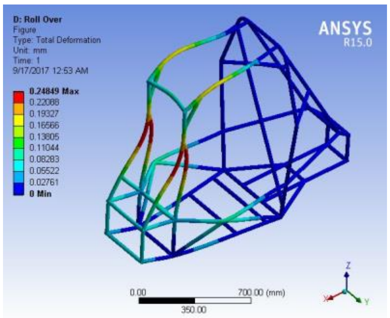


Figure 7

Rollover impact	2G
Maximum Deformation	6.4mm
Maximum Stress	147 MPa
Factor of Safety	3.09>1,Design is safe

Rollover impact	2G
Maximum Deformation	6.4mm
Maximum Stress	147 MPa
Factor of Safety	3.09>1,Design is safe

The total deformation 2.6 mm and maximum stress is 214 Mpa. Hence the factor of safety is around 2.1.so the design of roll-cage is safe.

IV Conclusion

These are the analysis reports of the chassis on different type of materials i.e., AISI 1018 & AISI 4130 steel tube. Both materials are having same thermal properties but mechanical properties differ. From this analysis we conclude that AISI 4130 steel tube is having more strength, hardness and corrosion free than AISI 1018. Due to presence of Chromium (Cr), Molybdenum, Silicon (Si) it is corrosion and oxidation free and having good hardenability and machinability.

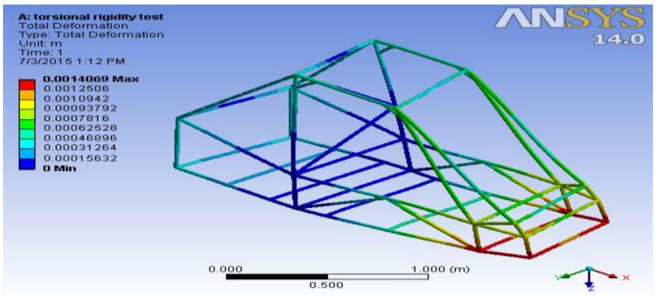


Figure 9

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