International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-2 Issue-2, January 2013

Optimization of Chassis of an All-Terrain Vehicle

D. Nagarjuna, Junaid Mohammed Farooq, A.S.N. Saiteja, P. Siddhartha Sri Teja

Abstract— In the case of vehicles, the term chassis means the frame plus the running gear like engine, transmission, driveshaft, differential, and suspension. An all-terrain vehicle (ATV), also known as a quad, quad bike, three-wheeler, or four-wheeler, is defined by the American National Standards Institute (ANSI) as 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. This paper deals with design of chassis frame for an All Terrain Vehicle and its Optimization. Various loading tests like Front Impact, Rear Impact, Side Impact, Roll over test etc have been conducted on the chassis and the design has been optimized by reducing the weight of the chassis.

Index Terms— Differential, Driveshaft, ATV, Transmission, Quad Bike.

I. INTRODUCTION

A. All Terrain Vehicles (ATV):

As the name implies, an All Terrain Vehicle (ATV) is designed to handle a wide variety of terrain than most other vehicles. Although it is a street legal vehicle in some countries, it is not street legal vehicle within most states and provinces of Australia, The United States, Canada or the United Kingdom. In UK, a recent variant class of ATV is now road legal, but there are only a few models available in this class.

Fig1. All Terrain Vehicle

Manuscript published on 30 December 2012.
***Correspondence Author(s)**
D.Nagarjuna, Department of Mechanical Engineering, K.L.University, Guntur, Andhra Pradesh, India.
Junaid Mohammed Farooq, Department of Mechanical Engineering, K.L.University, Guntur, Andhra Pradesh, India.
A.S.N.Saiteja, Department of Mechanical Engineering, K.L.University, Guntur, Andhra Pradesh, India.
P.Siddhartha Sri Teja, Department of Mechanical Engineering, K.L.University, Guntur, Andhra Pradesh, India..

By the current ANSI definition, ATV's are intended for use by a single operator, although some companies have developed ATV's intended for use by the operator and one passenger. The rider sits on and operates these vehicles like a motorcycle, but the extra vehicles give more stability at slower speeds. Although equipped with three wheels, six-wheel models exist for specialized applications. ATV's are used as racing models. Sports models are built with performance in mind. To be successful at fast trail riding an ATV must have light weight, high power, good suspension and a lower center of gravity.

B. Chassis or Frame Work:

A chassis consists of an internal framework that supports a man-made object. It is analogous to an animal's skeleton. Chassis is a French term which was initially used to denote the frame parts or basic structure of the vehicle. It is the back bone of the vehicle. A vehicle without body is called chassis. An example of chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery. For commercial vehicles chassis consists of an assembly of all the essential parts of a truck (without the body) to be ready for operation on the road.

Fig2. Chassis of a sports car

The design of a pleasure car chassis will be different than one for commercial vehicles because of the heavier loads and constant work use. The components of a vehicle like a Power Plant, Transmission system, Axels, Wheels and Tyres, Suspension, Controlling systems like Braking , Steering etc , and also electrical system parts are mounted on the chassis frame. It is the main mounting for all the components including the body. So it is also called as a carrying unit. The main components of a chassis are frame, engine or power plant, clutch, gear box, U joint, propeller shaft and the differential.

II. DESIGN CONSIDERATIONS

The initial design of frame has been performed as per the guidelines set by SAE (Society of Automotive Engineering).

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

These include not only the design features but also the tools to be used in the design.

Before designing the frame it was important to make several global design decisions. The frame geometry has been designed as per SAE rules for an ATV. The design of car suspension will be unequal length A-arms in the front and a swing arm in the rear. The frame was designed using CATIA package and analysis was performed in ANSYS. The three dimensional sketching was important as it involved too many bent numbers.

A. Initial Design:

Some notable features of the initial design were

1. Roll Hoop
2. Horizontal Hoop
3. Two Perimeter Hoop

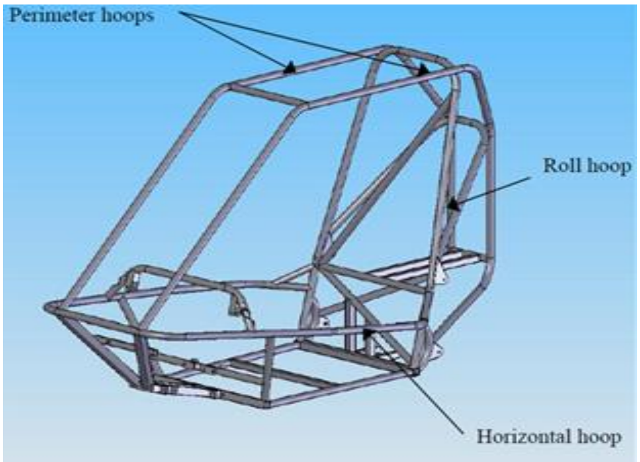


Fig3. Initial Design

B. Types of Materials Used:

Analysis test has been conducted on different materials to be used for manufacturing of the chassis frame. Properties of materials under different loading conditions and deformations have been tested by using ANSYS. The results of material testing have been listed below.

PARAMETER	IS3074CDS	1018 Stee	1020 DOI	4130 Chromol
yeild strength	4	2	4	4
COST	3	4	3	1
MANUFACTURABILITY	4	4	4	2
STRENGTH	4	1	3	4
TOTAL	15	11	14	11

PARAMETER	IS3074CDS	1018 Stee	1020 DOI	4130 Chromol
yeild strength	470 Mpa	365 Mpa	350 Mpa	435MPa
Bending stiffness	2390 Nm^3	1572.3Nm^3	1572.3Nm^3	1572.3Nm^3
Bending Strength	274.95Nm	223.96Nm	214.76Nm	266.92Nm
Weight	0.67	1.12	0.82	0.82
Cost/ft	Rs.62	Rs.22.5	Rs.74	Rs.205

Fig4: Material Properties under Loading

The results after comparison have shown that material IS3074 has more strength than others to withstand loading.

III. LOADING ANALYSIS ON CHASSIS

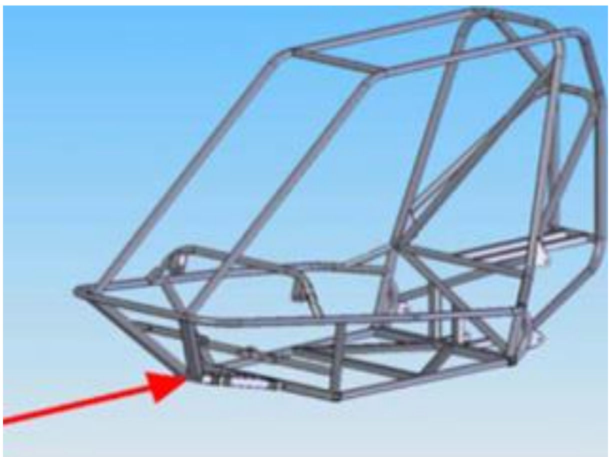
To properly approximate the loading the chassis can withstand, various accident test have been conducted on the chassis. Research has found that human body can withstand loads up to 9G only. Here in this case as per Indian Standards we have considered 7.5G. A value of 10G has been assumed as the worst case goal point. To validate this load an excel analysis has been conducted to find out crash pulse and decelerating time based on the maximum speed of the vehicle.

Crash pulse (s)	Load (lbf)	G force
0.18	7597.56494	10.13008746
0.181	7555.589443	10.07412013
0.182	7514.075216	10.01876782
0.183	7473.014695	9.964020456
0.184	7432.400485	9.909868171
0.185	7392.225347	9.856301316

Fig5. Crash Pulse result under various Loads

A. Front Impact:

In this case a deceleration of 10G was assumed as loading.



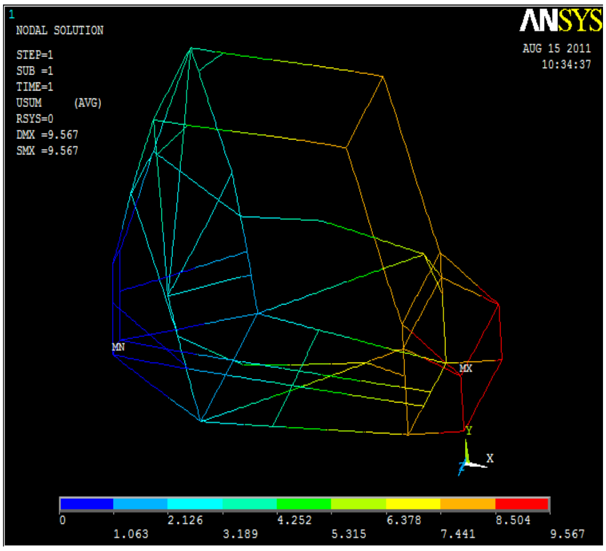


Fig6. Front Impact Loading & Deformation

B. Side Impact:

Side Impact load was conducted with 5G load on the chassis. This is equivalent to a load force of 3750 lbf. Similarly rear impact and Roll Over impact have been conducted at 5G and 2.5G respectively.

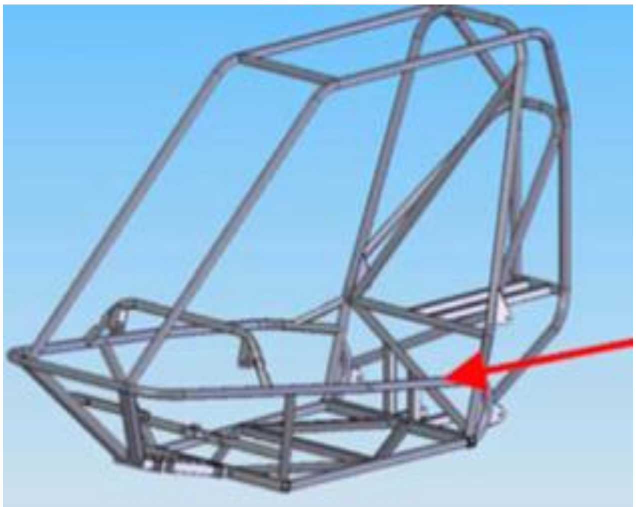
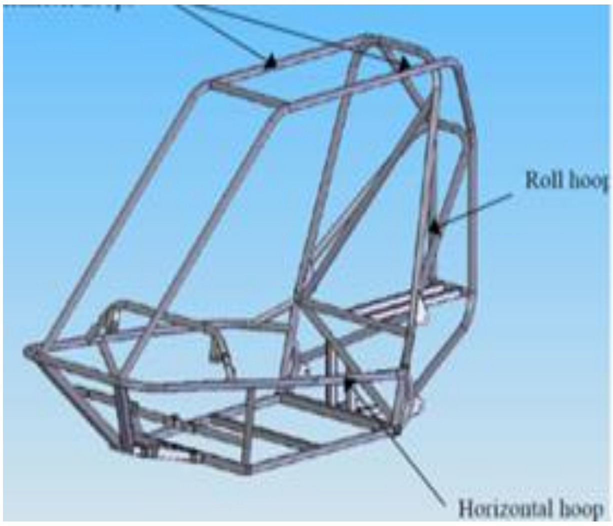


Fig7. Side Impact Loading

C. Rear Impact:



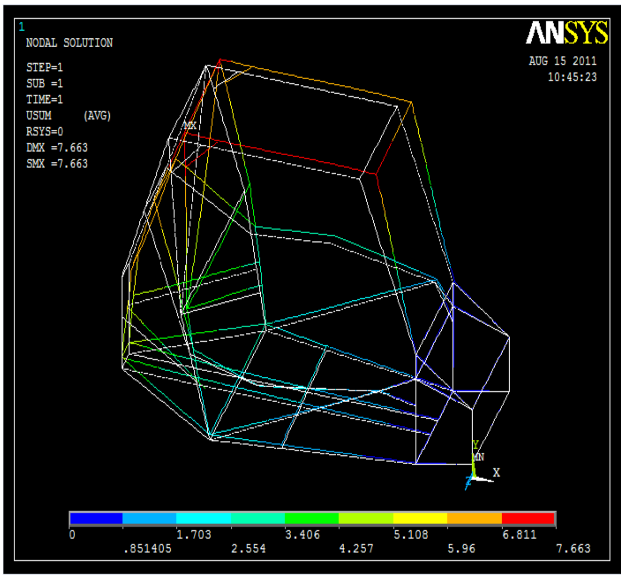


Fig8. Rear Impact Loading & Deformation

The shock absorber test has also been conducted on the suspensions of the vehicle. Based on obtained results optimization of chassis has been achieved.

IV. RESULTS & FINDINGS

Optimization of design has been achieved using IS3074 material. There has been considerable decrease in weight of roll cage which helps it in moving faster. Optimization has been achieved by reducing the diameter of chassis bar wherever less load is acting and where there are less deformations.

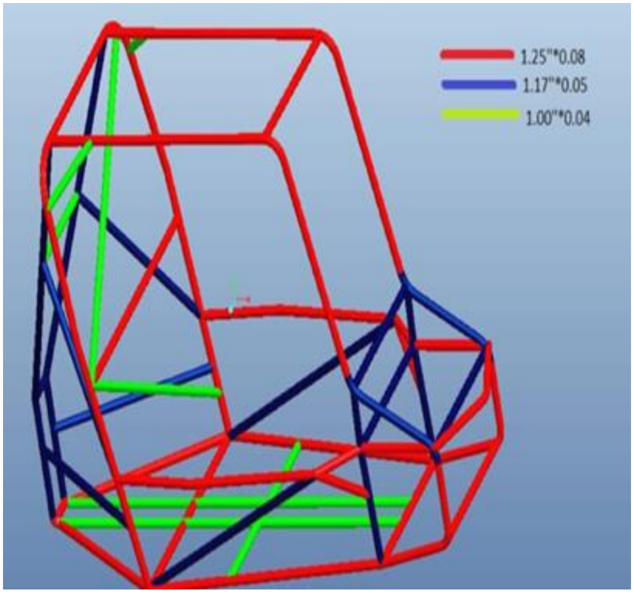


Fig9. Optimization of Roll cage

The bars in red color have higher diameter as they have to withstand more loads. The bars with blue color have less diameter than red ones and more diameter than the green ones. So, in this way the weight of chassis has been reduced from 84 kg to 64 kg by performing various loading analysis test on roll cage.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

V. CONCLUSIONS

The usage of finite element analysis was invaluable to the design and analysis of the frame for All Terrain Vehicle. The designing and analysis is a difficult part to carry on as so many tests are needed to be conducted with lot of constraints. The chassis was designed so as the vehicle can withstand all kinds of loads and is capable of moving on terrains like hilly areas, Rocky Mountains etc. This report thoroughly dealt with various load analysis on chassis and optimization has been achieved by reducing the weight of the chassis frame (roll cage).

REFERENCES

1. SAE Rule Book, 2011.
2. Auto Expo Magazine, 2010.
3. "Consolidated Rules for Mini Baja East, Midwest and Mini Baja 100", Society of Automotive Engineers, September 2004.
4. http://www.saeindia.org//
5. http://www.wikipedia.org//
6. ANSYS 11 Help.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)