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DYNAMIC ANALYSIS & SHAPE OPTIMIZATION OF ELECTRIC CAR CHASSIS

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ABSTRACT

This paper deals with the analysis of chassis frame for improving its payload. The FEM analysis has been carried out with various alternatives. This paper analysed the backbone frame for both dynamic and static load condition with the stress deflection bending moment on the electric car chassis frame. The finite element analysis over ANSYS is performed by considering the load cases and boundary conditions for the stress analysis of the chassis. The electric car chassis is being modelled in CATIA V5 and then it is being imported in the finite element analysis software-Ansys. At present the weight of the chassis is 40 kg in this project we have reduce the weight of chassis by 50% and load capacity is still same. This has been carried out with the help of shape optimization. Different types of material were taken into consideration for electric car chassis.

KEYWORDS

Finite Element Analysis, ANSYS, Shape Optimization, CATIA V5 R18, load analysis, weight reduction

1. INTRODUCTION

The chassis of car is the backbone of vehicles and integrates the main component systems such as the axles, suspension and is usually subjected to the weight of cabin, its content, and inertia forces arising due to roughness of road surfaces etc. (i.e. static, dynamic and cyclic loading). The stress analysis is important as it will help us to analyze the maximum load that can be applied on the vehicle. The load point is thus important so that the mounting of the components like engine, suspension, transmission and more can be determined and optimized, Finite Element Method (FEM) is one of the method to locate the load point. Design of chassis using CATIA V5 R18. Various load condition and calculation on the chassis. analysis of chassis for (structural steel, magnesium & aluminum alloy) in shape optimization.

2. Design of chassis using CATIA V5 R18

To design an electric vehicle, the chassis must be designed based on the requirements and the ability of the electric energy to move it. The components involved in building the electric vehicle must be considered. The main components that will give an effect to the design of the chassis are the electric motor and the battery. The size, weight and the position of these components must be considered before designing the chassis.

- Ground clearance-160 mm, Net weight - 420 kg
- Chassis Dimensions -(L x W) 275 x 60 cm
- Upper chassis dimensions - 224 x 112 cm

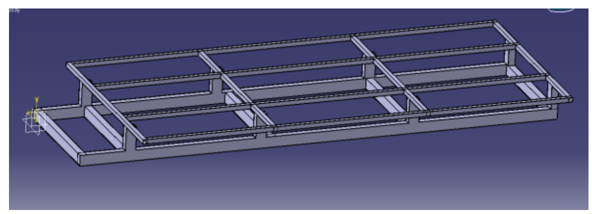

Figure 1. 3-D model of electric car chassis in Catia V5

2.1. Material

The choice of materials for a vehicle is the first and most crucial factor for automotive design. There is a variety of materials that can be used in the automotive body and chassis, but the purpose of design is the main challenge here. The most important criteria that a material should meet are lightweight, economic effectiveness, safety, recyclability and life cycle considerations.

Table 1. Properties of material

Property	Structural Steel	Aluminium Alloy	Magnesium Alloy
Mass (kg)	39.969	14.104	9.165
Density (kg/mm^3)	7.85*10^6	2.77*10^-6	1.8*10^-6
Poisson's Ratio	0.3	0.33	0.35
Young's Modulus (MPa)	2*10^5	71000	45000
Bulk Modulus (MPa)	1.6667*10^5	69608	50000

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3. CALCULATION

Basic calculation for chassis frame

Side bar of the chassis are made from rectangular tubular channels with 275×60×60cm

CASE 1: Considering the weight of batteries

Capacity of electric car = 600kg
Capacity with 125% = 750kg
Weight of body and motor = 420 kg
Weight of single Battery = 35 kg
Total number of batteries = 5

Total load acting on chassis = capacity of chassis + weight of body and motor + Weight of batteries =

750 + 420 +(35×5) = 1345 kg or 13181 N

Chassis has two beams, so load acting on each beam is half of the total load acting on the chassis on the single frame = 13181/2 = 6590.5 N

Uniformly distributed load is assumed on the chassis. Hence, UDL is 6590.5/2750 = 2.39 N/mm

Table 2. Calculation of stress and deflection

Stress produced on the beam –	Maximum Deflection of Chassis –
$\sigma = \frac{M}{Z}$ $= \frac{9037187.5}{23740.8}$ $= \mathbf{380.66\ N/mm^2}$	$\delta = \frac{5wl^4}{384EI}$ $= \frac{5\times2.39\times2750^4}{384\times2\times10^5\times7.122\times10^5}$ $= \mathbf{12.49\ mm}$

4.1. Load applied

In this load is applied on to the chassis udl is applied. There are 6 points fixed – 2 in front for macpherson strut bar and 4 at back 2 for each semi-leaf elliptical leaf suspension. analysis is done by applying different load at different point. The meshing is done on the model with 17929number of nodes and 9683numbers of tetrahedral elements. The EV chassis model is loaded by static forces from the EV body and load. For this model, the maximum loaded weight of vehicle plus body is 670 kg = 6572.7 N. the load is multiplied by factor of 3 (18000N).

- Static analysis (same load)
- Dynamic analysis (**3g load applied in Z direction)**

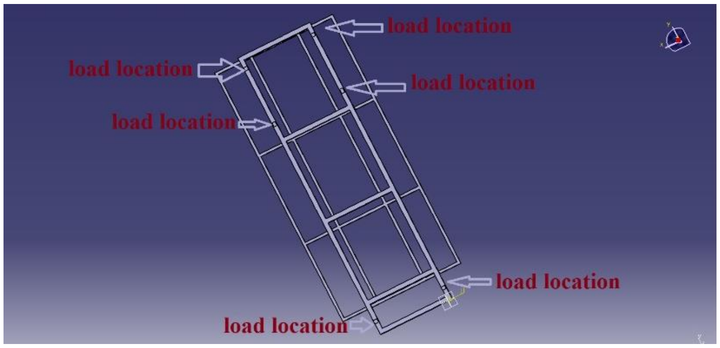

Figure 2. Load applied on various point

5. RESULT AND DISCUSSION

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. Static analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects.

TABLE 3.- Result of different material

Sl. No.	**Material**	**Stress (Mpa)**	**Deflection(mm)**
1.	**Structure Steel**	880.5	20.5
2.	**Magnesium Alloy**	1.8	.095
3.	**Aluminum Alloy**	2.9602	.0968

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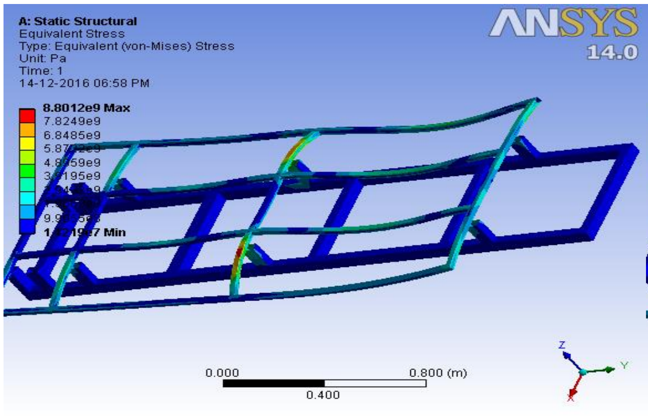
5.1. Analysis of structure steel



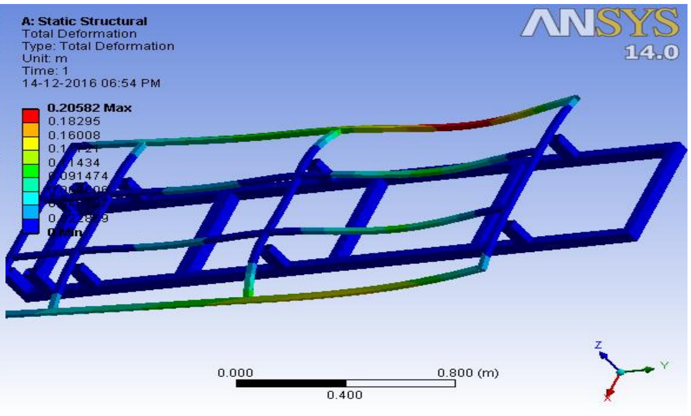
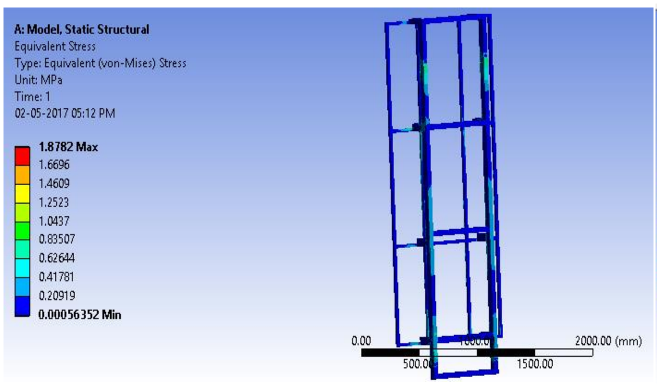


Figure 3. Maximum stress induced

Figure 4. Max deformation

5.2. Magnesium alloy (AS41)



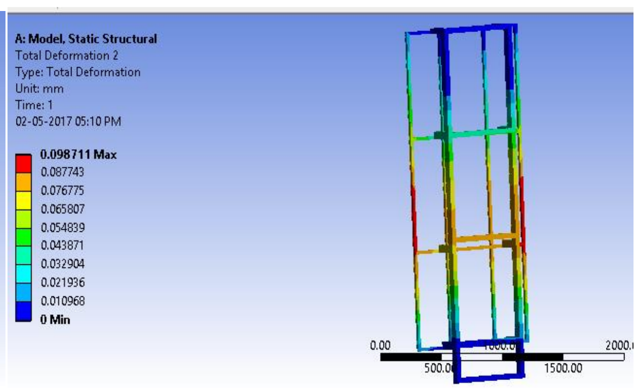
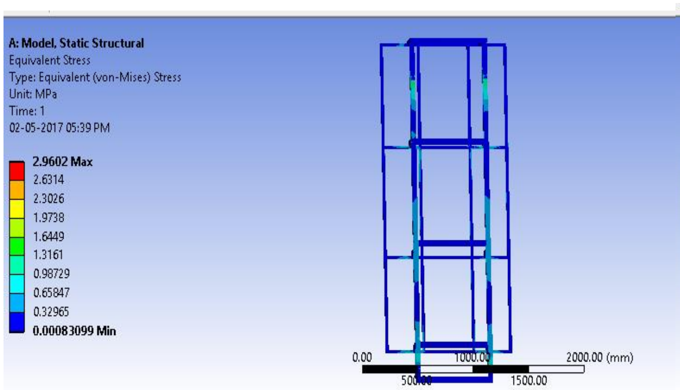


Figure 5. Maximum stress induced

Figure 6. Max deformation

5.3. Aluminum alloy (A5049)



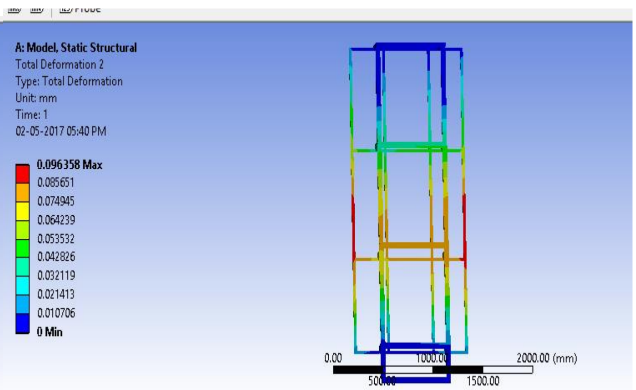


Figure 7. Maximum stress induced

Figure 8. Max deformation

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6. SHAPE OPTIMIZATION

It improves existing designs for more reliable and durable components. Minimize stress, strain, and durability or any combination of these by automatic simulation-driven modification of the surface geometry. 50% weight reduction, in this weight is reduced by 50 % of the original chassis weight. It defines the load path and unnecessary part is removed. The red part shown is to be removed as there is no important load path. The working of chassis will remain same.

Definition	
Target Reduction	50. %
Suppressed	No
Results	
Original Mass	3.9959e-002 t
Marginal Mass	1.6361e-004 t
Optimized Mass	2.2674e-002 t

Figure 9. WEIGHT REDUCTION

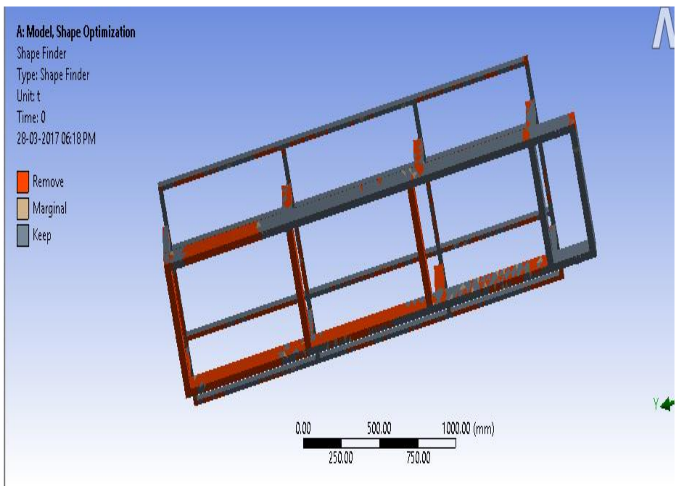

Figure 10. Shape Optimization

7. CONCLUSION

The existing electric car chassis was analyzed by the finite element analysis and the stress levels are found to be 880.5 MPa under dynamic loading for structure steel. After reduction, the weight of the chassis was reducing by 50 and still able to with stand same load and under same loading condition.

8. REFERENCE

[1] Stress Analysis of a Low Loader Chassis - Journal from Science Direct (2012) by Mohd Azizi Muhammad Nor, Helmi Rashid, Wan Mohd Faizul Wan Mahyuddinb, Mohd Azuan Mohd Azlan, Jamaluddin Mahmud

[2] Mechanical Engineering Design by Joseph F Shigley & Charles R.Mischke

[3] Stress and Dynamic Analysis of Optimized Trailer Chassis by Mehdi Mahmoodi-k, Iraj Davoodabadi, Vinko Visniic, Amir Afkar and V. Ramamurti

[4] Computer Aided Mechanical Design & Analysis, Tata McGraw Hills-2

[5] Ansys workbench software release 14.0 tutorial.

[6] I. Kutay Yilmazcoban, Yaşar Kahraman "Truck chassis structural thickness optimization with the help of finite element technique" TOJSAT the Online Journal of Science and Technology - Volume 1, Issue 3, July 2011.

[7] Patel Vijay kumar V, Prof. R. I. Patel "Structural Analysis of Automotive Chassis Frame and Design Modification for Weight Reduction" International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 1 Issue 3, May – 2012.