DESIGN AND FABRICATION OF CHASSIS FOR ELECTRICAL VEHICLE

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ABSTRACT: Automotive chassis can be considered as the backbone of any vehicle. The main purpose of chassis is to hold all the essential components of the vehicle, like engine, suspension, braking system, propeller shaft, differential etc. In order to sustain various loads under different working conditions chassis should be robust in design. Moreover chassis should be stiff and strong enough to resist several twisting and bending moments. This paper presents the static load analysis of cast iron chassis of electrical vehicle using ANSYS. Different cross sections for the chassis design are evaluated and C section chassis with cast iron is fabricated as it was found to be economical when compared cost and weight of the chassis.

Keywords— Chassis, Design, ANSYS.

1. INTRODUCTION:

Chassis usually denotes the basic frame that decides the overall shape of the vehicle. It holds the important components of the vehicle. The chassis of electrical vehicle being changed is of ladder frame type which has two side members or longitudinal members of C- cross section and five transverse members called cross members with same cross section. The chassis has been modeled in pro-e Wildfire 2.0 and Analysis was done using ANSYS.

Sandip godse Patel [1] studied static analysis to determine key characteristic of a chassis. The static load analysis of the chassis of TATA ace zip was performed Stress optimization was done using reinforcement technique of optimization by adding stiffeners. Ashutosh dubey and vivek dwivedi [2] considered the load cases & boundary conditions for the stress analysis of chassis using ANSYS software. C angular is used for chassis fabrication.

Hemant Patil, and Sharad Kachave[3] conducted experimentation on “Stress Analysis of Automotive Chassis with Various Thicknesses. Filho et. al [4] have investigated and optimized a chassis design for an off road vehicle with the appropriate dynamic and structural behavior, taking into account the aspects relative to the economical viability of an initial small scale production. The design of an off-road vehicle chassis has been optimized by increasing the torsional stiffness, total weight of structure and simpler geometry for reduction of production cost.

Roslan Abd Rahman et al [5] carried out stress analysis of heavy duty truck chassis by utilizing a commercial finite element package ABAQUS, to determine critical point so that by design modifications the stresses can be reduces to improve the fatigue life of components. Cicek Karaoglu et al [6] performed stress analysis of heavy duty truck chassis with riveted joints by utilizing a commercial finite element package ANSYS version. In this study, they examined the effect of the side member thickness and connection plate thickness with length change, the side member thickness is varied from 8 to 12 mm.

Tulasiram Nasikai and Charyulu[7] performed the Design and Analysis on Vehicle Chassis Frame using different chassis angulars like L,C and I.

2. DESIGN CALCULATIONS:

Estimation of Electrical Vehicle Weight, Assuming a motor speed of 3000 rpm and power of 3KW and Maximum velocity of 30km/hr.

$$\text{Power} = \frac{2\pi NT}{60} \quad \text{---------- Equation (1)}$$

$$T = \frac{60*P}{2\pi*3000}$$

$$= \frac{60*3*750}{2*\pi*3000}$$

=7.16 N-m.

Velocity of the vehicle = 30km/hr

$$= 30*\frac{5}{18}.$$

= 8.33 m/s

Velocity (V) = R*ω. ---------------Equation (2)

ω = V/R, Here R is radius of wheel= 15cm

$$\omega = \frac{8.33}{0.15}$$

ω =55.55 m^2/s

ω = axle speed

$$\omega = \frac{2*\pi*N}{60} \quad \text{-----------Equation (3)}$$

$$55.55 = \frac{2*\pi*N}{60}$$

$$N = \frac{55.55*60}{2\pi}$$

Motor Speed N = 530 rpm

$$\text{Available torque on shaft } T = \frac{60*3*750}{2\pi*530}$$

T= 40.53 N-m

With 30% loss of torque, T=40.53*0.7 =28.37 N-m

$$\text{Force } F=\frac{T}{R_s} \quad \text{---------Equation (4)}$$

$$F=\frac{28.37}{0.15}$$

F = 189 N.

$$\text{Weight (W)} = \frac{F}{\mu} \quad \text{--------Equation (5)}$$

Assuming rolling friction between vehicle tire and road as 0.02

$$W = \frac{189}{0.02}$$

W = 9456.66 N.

W = 945.66 kg.

$$\text{Without loss of torque, force is, } F = \frac{T}{R_s} \quad \text{-----------Equation (6)}$$

$$= \frac{40.53}{0.15}$$

F = 270.2 N

$$\text{Weight (w)} = \frac{F}{\mu} \quad \text{---------Equation (7)}$$

$$W = \frac{270.2}{0.02}$$

W= 13510 N.

W = 1351kg.

Similarly the calculation is made for 25%, 20% and 10% loss of torque and results are tabulated in the table 2.1.

Table 2.1.Chassis weight comparison table with %loss of torque.

Loss of torque	Force N	Weight kg
30%	189.13	945.66
25%	216.16	1080.8
20%	229.66	1148.35
10%	243.18	1215.9

2.1 CALCULATION OF PRESSURE LOAD TO BE APPLIED:

Gross vehicle weight (G.V.W) = 1000kg. This load (G.V.W) is applied in the form of pressure.

Hence the total area of application of load as calculated from chassis dimensions = 5676.9cm.

Hence the total load to be applied = 1000*9.81

= 9810N.

Pressure to be applied = 9810/5676

P= 1.73 N/cm^2 .

2.2 TYPES OF CHASSIS:

Ladder Chassis: Ladder chassis is considered to be one of the oldest forms of automotive chassis that is still used by most of the SUVs till today. As its name connotes, ladder c resembles a shape of a ladder having two longitudinal rails inter linked by several lateral and cross braces.

Monocoque Chassis: Monocoque Chassis is a one-piece structure that prescribes the overall shape of a vehicle. This type of automotive chassis is manufactured by welding floor pan and other pieces together. Since Monocoque chassis is cost effective and suitable for robotized production, most of the vehicles today make use of steel plated Monocoque chassis.

Backbone Chassis: Backbone chassis has a rectangular tube like backbone, usually made up of glass fiber that is used for joining front and rear axle together. This type of automotive chassis or automobile chassis is strong and powerful enough to provide support smaller sports car. Backbone chassis is easy to make and cost effective.

2.3 PROBLEM SPECIFICATIONS:

The objective of the present work is to design and analyze the cast iron chassis frame with two different cross sections. The chassis model was created in pro-e software and it is imported into ANSYS, static analysis is performed. Original TATA ACE ZIP chassis is shown in Fig. 2.1

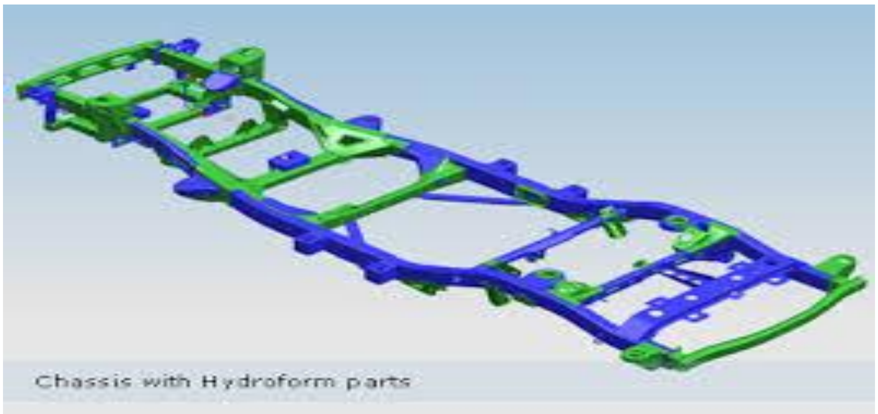

Fig. 2.1: Tata ACE ZIP chassis

3. STRUCTURAL ANALYSIS OF ELECTRICAL VEHICLE CHASSIS:

Dimensions of electrical vehicle chassis are taken from Tata ace as shown in the fig 3.1. 3-D model of chassis is used for analysis in ANSYS. The loading conditions are assumed to be static. The element chosen is Solid 186, a higher order 3-D 20-node solid element that exhibit quadratic placement behavior. The element is described by 20 nodes having three degree of freedom per node: translations in the nodal X, Y, and Z direction. The element supports plasticity, hyper elasticity, creep, stress stiffening, larger deflection, and large stain capabilities.

3.1 CHASSIS MODEL DIMENSIONS:

Chassis was model based on the Tata ace zip chassis dimensions, from that dimensions based on the project requirement the values are taken as ration down from the original values of Tata ace zip. Based on the ratio following vales are taken as,
Total length of the chassis =300cm
Total width of the chassis =130cm
And in this chassis design, chassis have 5 cross members and three lateral members.

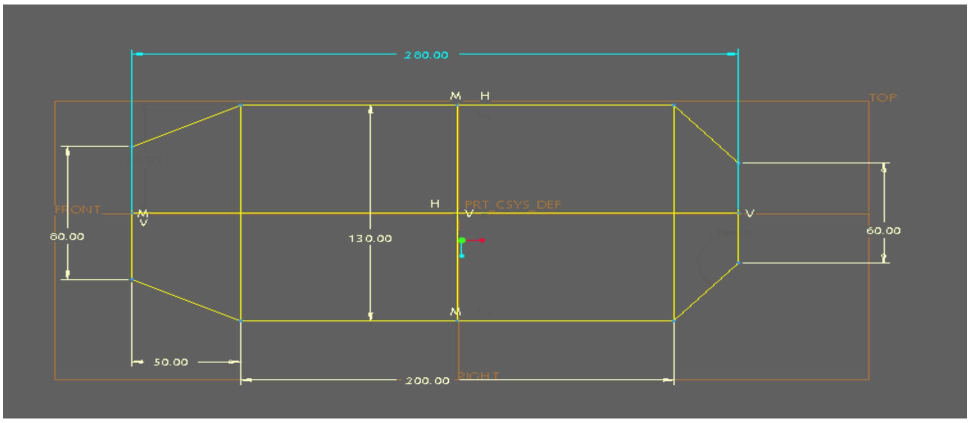

Fig 3.1: Line diagram for C section chassis.

Stress analysis is done using ANSYS, 20 noded solid 186 element was used. First boundary condition is fixed at 1/3 of 100 cm i.e.33.3 cm from first cross member of chassis back side as shown in Fig. 3.1 and second boundary condition is based on the leaf spring design that is the total length of the leaf spring 50cm,this is same at another side of wheel arrangement. And final fixed node is at middle node of the first cross member from front side. The pressure load of 1.73 N/cm^2 is applied on top of the surface area.

3.2 STRUCTURAL ANALYSIS FOR I-SECTION CHASSIS:

I section chassis frame forms the backbone of a heavy vehicle, its principle function is to safely carry the maximum load for all designed operating conditions. The processes of analyzing for I cross section chassis is same like L-type cross section chassis. Figure 3.2 represents the I-cross section line diagram with same dimensions given to the L angular cross section.

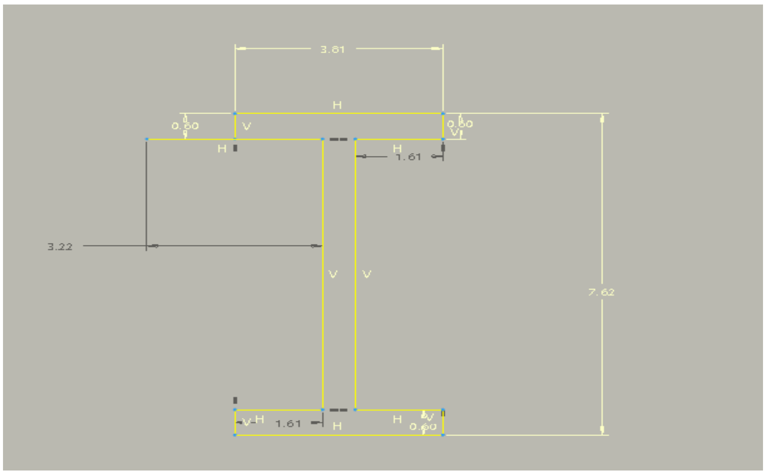

Fig 3.2: I-type cross Section with dimension

Following are the I-type cross section dimensions taken for chassis design and analysis.

Width =3.81cm.

Height =7.62 cm.

Thickness =0.6 cm.

The above values are taken based on the vehicle weight consideration and availability of cross section dimensions in the market.

3.3 Meshing:

Meshing is the process used to fill the solid model with nodes and elements, i.e, to create the FEA modal. Meshing is done with 20 noded solid 186 element and performing the meshing processes. Meshing is consider as a area mesh, areas are meshed with edge length of 3. Meshing model helps to get accurate results in the ANSYS. Meshing model for I section chassis shown in Fig.3.3.

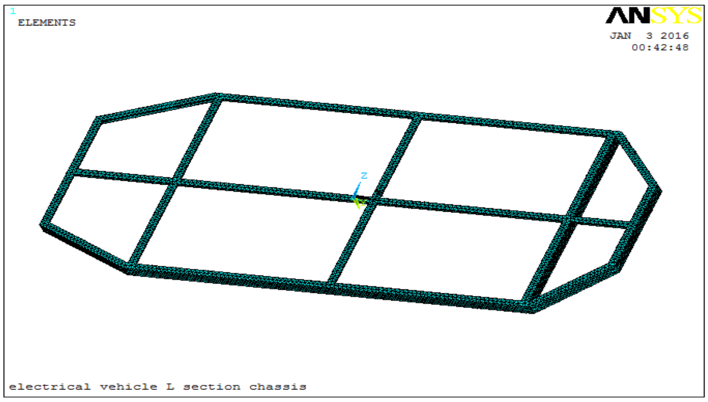

Fig .3.3: Meshed mode**l**

3.4 Load and B**oundary conditions:**

Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by steady loads that do not induce significant inertia and damping effects. Boundary condition involves application of load and defining constraints in the model. In this project Model is fixed in all degrees of freedom. The boundary conditions are fixed at supports and pressure load of 1.73 N/cm^2 are applied on the chassis areas as shown Fig.3.4.

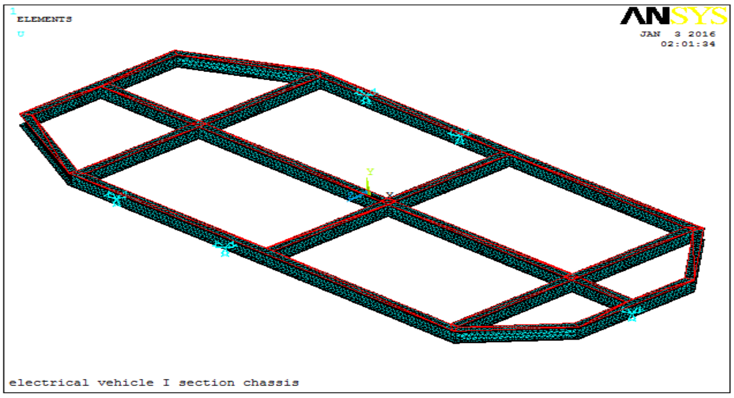

Fig.3.4: Load and boundary conditions

3.5. Deformed shape:
After completion of applying boundary conditions and pressure load of 1.73N/cm^2 on chassis area, the model get deformed as shown in Fig.3.5.

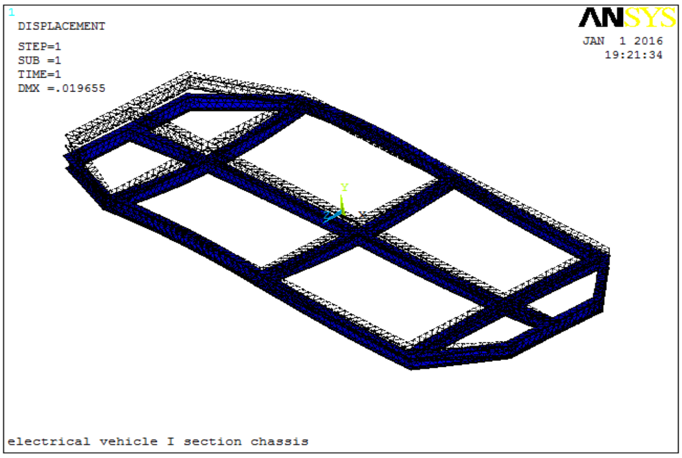

Fig .3.5: Deformed shape

3.6 Stress intensity:
Stress Intensity Factor, K, is used in fracture mechanics to more accurately predict the stress state ("stress intensity") near the tip of a crack caused by a remote load or residual stresses. When this stress state becomes critical a small crack grows ("extends") and the material fails. Fig.3.6 shows the stress intensity values.

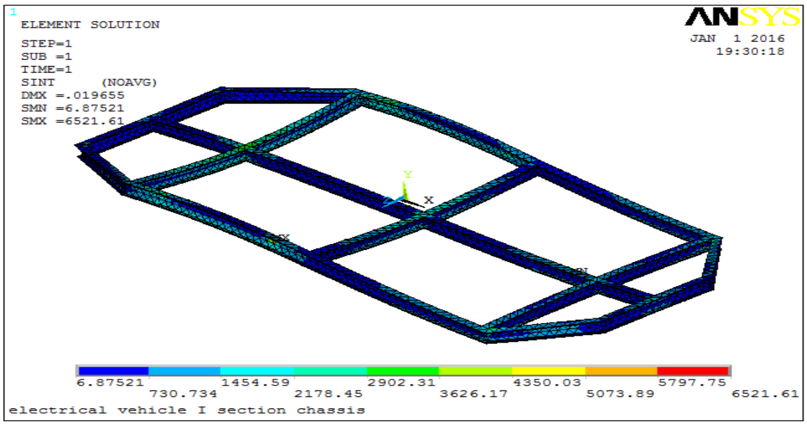

Fig .3.6: Stress intensity

3.7 Von mises stresses:

Von Mises stress is considered to be a safe haven for design engineers. Using this information an engineer can say his design will fail, if the maximum value of Von Mises stress induced in the material is more than strength of the material. It works well for most cases, especially when the material is ductile in nature. Fig.3.7 shows the von mises stresses values.

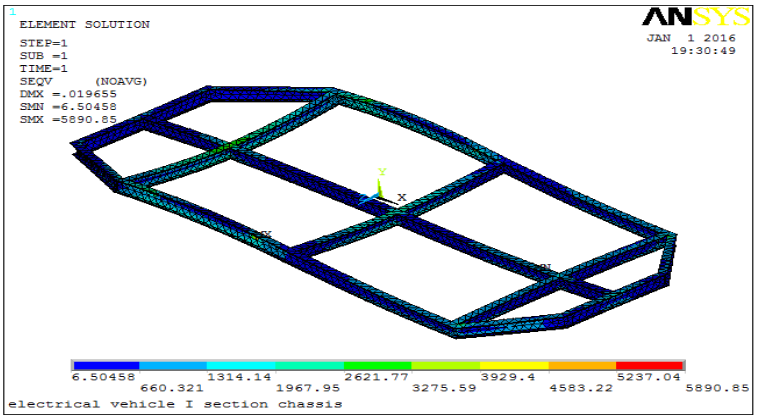

Fig .3.7: Von mises stresses.

3.8. Nodal solutions:

The output from the solution consists of the nodal solution (or the primary degree of freedom solution) and the element solution (or the derived solution)

The nodal solution from an analysis consists of:

- the degree of freedom (DOF) solution, such as nodal displacements, temperatures, and pressures
- the reaction solution calculated at constrained nodes - forces at displacement constraints Fig.3.8 represents the nodal solutions of chassis.

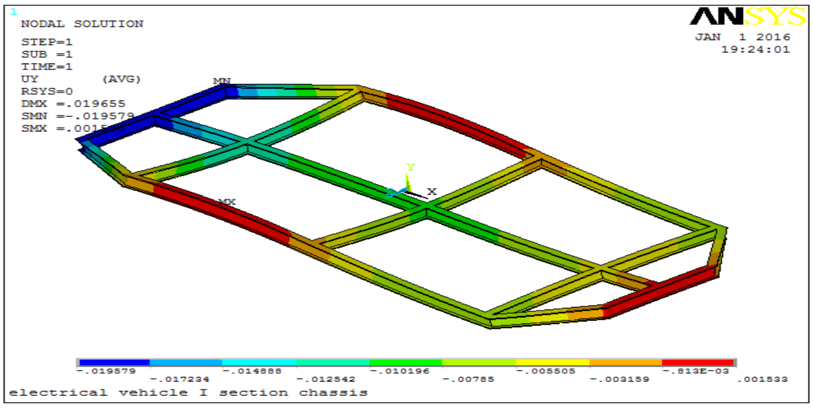

Fig .3.8: Nodal solution for I section chassis

4. CHASSIS WITH C-TYPE CROSS SECTION:

Now a day's C-type cross section chassis are used in most of the auto mobile chassis. Static analysis is done as like above two section. Structural analysis is done using ANSYS for C section chassis, line diagram with dimensions is shown in figure 4.1.

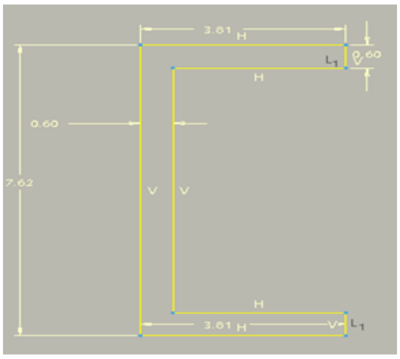

Fig .4.1: C-type cross-section of chassis

4.1. Solid model designed in pro-e software:
Based on the cross section and dimensions the chassis was designed in pro-e software as shown Fig.4.2.

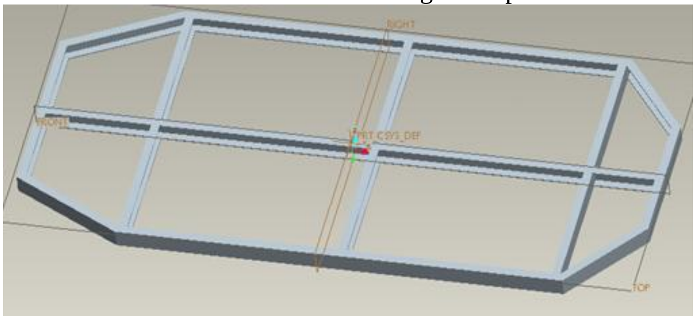
Fig .4.2: Chassis model in PRO-E

4.2. Meshed model and boundary condition:
Meshing model and boundary conditions are same as mentioned in Fig.3.4 and Fig.4.3 shows model for C section chassis. This meshing processes is same as earlier as described for I cross section chassis.

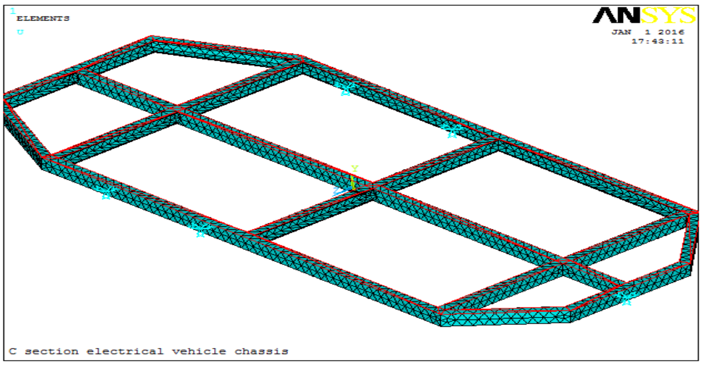

Fig .4.3: Meshed model and boundary condition

4.3. Deformed shape:
Chassis was deformed when pressure load of 1.73 N/cm^2 applied. Pressure load is same for this C section chassis also because the cross section dimensions are same for two cross section chassis there by area also same as 5676.9. So when pressure load is applied, the chassis deformation is shown in Fig.4.4

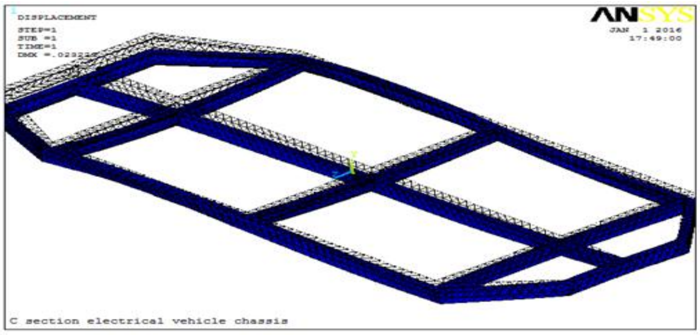

Fig .4.4: Deformed shape

4.4. Nodal solution:

The stresses induced in the chassis model are as shown in Fig.4.5

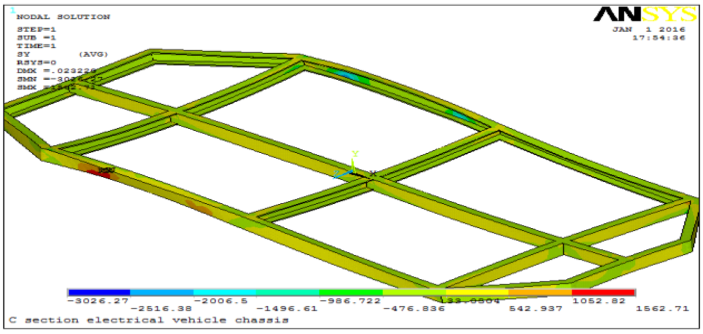

Fig .4.5: Nodal solution stress in Y- direction

4.5. C-type cross section Stress intensity:

Below Fig.4.6 shows the stress intensity. Load and boundary conditions are same as mentioned above. The value of stress intensity is 62.58 Mpa for this chassis.

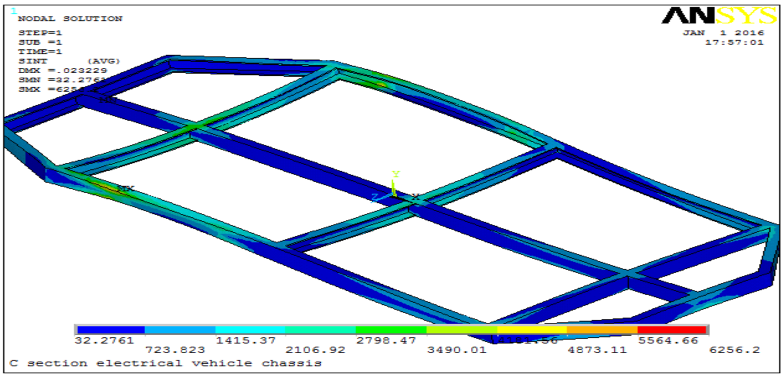

Fig .4.6: C-type cross section Stress intensity

4.6. C-type cross section von mises stresses:

Von mises stresses values are obtained based on chassis dimensions, pressure load, surface area and boundary conditions. The value of von mises stresses for C section chassis is 58.60 Mpa shown in Fig.4.6

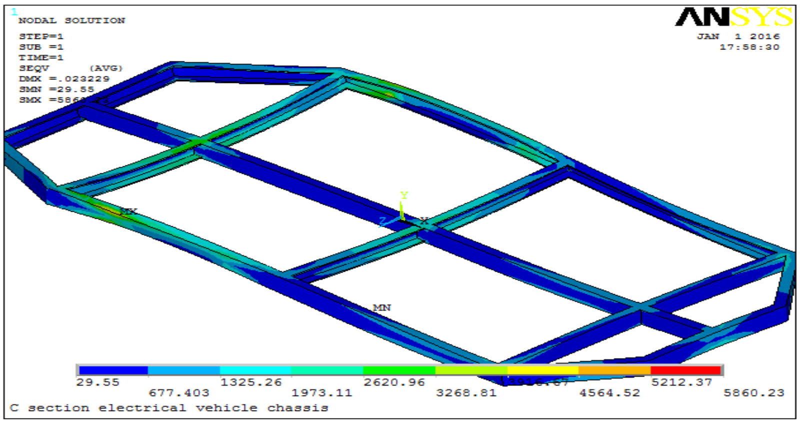

Fig .4.7: C-type cross section von mises stresses

5. RESULT SUMMARY:

Results are tabulated in the table, when the pressure load of 1.73N/cm^2, young's modulus 130Mpa, poisons ratio in between 0.2-0.3 and density is 0.0078N/cm^3 for cast iron material.

Table 5.1: Stress results

No	Type	Stress intensity (Mpa)	Von mises stresses (Mpa)	Total deformation (mm)
1.	I- type cross section	65.21	58.90	0.0001538
2.	C-type cross section	62.58	58.60	0.0001676

Based on the results the chassis was fabricated with cast iron and type of cross section is C

Fig .5.1: fabricated chassis with C cross section

6. CONCLUSION:

After observing the all results and comparing the I and C type cross sectional cast iron chassis frames, it is concluded that for I-type section von mises stresses is 58.90 N/mm^2 and C-type section von mises stress is 58.60 N/mm^2. So from the above values and based on the manufacturing cost, stresses induced in the chassis, strength of the chassis, it is better to consider the C-type cross section. Finally fabrication of chassis is made with C-type cross section with cast iron.

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