Journal of Analysis and Computation (JAC)
(An International Peer Reviewed Journal), www.ijaconline.com, ISSN 0973-2861
Volume XVI, Issue IV, Jan-June 2022

STRUCTURAL ANALYSIS OF 3600 ROTATING VEHICLE CHASSIS

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ABSTRACT

Chassis is a part of automobile vehicle which is used to support various components such as DC Motor, Microcontroller, Sensors, Different Mechanism, Battery etc. It is used to propel the vehicle. It carries all the necessary load and weight of the components; hence it should be strong enough to uphold the shock, twist, vibration and other stresses. This paper aims at the research work carried out, in the area of chassis with the constraints of maximum stress, deflection 103Mpa and 0.566mm. For finite element analysis solidwork simulation is used and after result concluded that better material is Mild steel. Various material was changed to check their effect on weight and Stresses (ranges between 101Mpa to 103Mpa) also Static and Modal Analysis are done to get results.Mild steel material results are better than other materials.

Keywords: Chassis, Stress, Deflection and Vibration Analysis, FEA.

1. Introduction:

The chassis for an automobile is like a skeleton to the human body. Various parts of an automobile like the engine, transmission system, suspension, axles, etc. are mounted to the chassis. So, chassis is also called as a carrying unit of an automobile. Depending on the structural requirements and cost involved in manufacturing, the type of chassis is selected for the vehicle. Modern vehicles typically have one of two different styles of chassis: Unibody or body-on-frame. Unless you drive a pickup truck or large SUV, there's a great chance that your vehicle has a unibody chassis. This means that the body—the thing that gives the car its exterior shape—and the chassis or frame are all part of the same assembly. Unibody designs help save weight and provide a smoother ride. They can also prove beneficial in crash safety and reduce production costs if they can be adapted for other vehicles in a manufacturer's lineup. Automobile frames are manufactured from aluminum and steel which make it heavy and directly affects the efficiency of the vehicle. So now a day the lightweight composite material like carbon fiber, epoxy glasses etc. are used as a manufacturing material for chassis.

By analysing the limited feature of the SX360 dump trucks, the authors identified the location of the high-pressure frame and its rules for the deviation of the two-dimensional and intermediate distribution and the temporary dynamic analysis of node areas, and concluded that: vertical analysis of the framework sub-frame with supporting components, and the normal rigidity and rigidity of the frame area may meet the safety frame performance requirements. a very stable frame structure. [1] With the construction of a car chassis, the development is very important in the modern environment. This work is aimed at analyzing the ladder chassis and the chassis design of the space frame. Analysis of designed models involves the use of three different materials. In this study two different car loading conditions are considered non-loaded (except for passengers who are CURB car weight) and loading conditions (with passengers and the gross weight also called gross weight). [2] This paper presents an analysis of the heavy-duty chassis of trucks. Pressure analysis is important in studying fatigue and predicting the survival of parts in order find an important point with very high pressure. An analysis was performed in the truck model using a limited-edition commercial item packed with ABAQUS. [3] In this study, the pressure analysis of the truck chassis with integrated components was performed using FEM. The commercial goods package ANSYS version 5.3 has been used for problem solving. Determination of the pressure of the truck chassis before production is important due to the development of the design. To achieve a decrease in the magnitude of the pressure near the folded joint of the chassis frame, the thickness of the lateral part, the thickness of the connecting plate and the length of the connecting plate have varied. Numerical results have shown that side joint stress can be reduced by increasing the size of the side joint in the area. If a thickness change is not possible, increasing the length of the connecting plate may be another good option.[5] The project is about a 360-degree rotating car. This car goes everywhere. This makes the car ready to work on narrow roads and sharp corners. Ordinary motor vehicles face many problems such as parking, U-turn and very time consuming. Therefore, a 360-degree spinning wheel is designed to reduce and eliminate problems they occur in the handling of industrial assets. In this system, each 4-wheel drive provided driving with stepper motor, so it can rotate 360 degrees. There are 4 Dc motors drive to move the car in the forward directions. 360-degree rotating wheel controlled by RF remote. As such, we will be using this 360-degree rotating car for the various ideas we wish to make transporting items in excess bags and in addition by vehicles, which can help reduce gridlock hour and free time. [6] In the modern development age, there are many types of vehicles built in this community, yet there are many places in this program have very few parking spaces and there may be a difficult parking and retrieval challenge a parked car. We have therefore developed a new way of parking cars as a 360-degree car parking project. Rotating the car with the trunks. This project hopefully helps to park cars like cars easily in the parking lot as well can also return cars to them. In this project we use a spur gear and a worm gear with a car mechanic for the purpose of lifting and rotating. Introducing the prototype model of a revolving car system that can help cars to park and take off` a small space in a short time. In our system it contains 2 Dc motors, one for lifting a car and the other for locking. Change one is used to lift the car and rotate the car clockwise or counter clockwise. Switch 2 is used for locking. [7]

2. Objectives:

- To study basic principle of working of chassis.
- To investigate the problems occurs in the chassis.

- To prepare 3D CAD model of chassis geometry and doing static analysis.
- To perform Finite element analysis of chassis geometry with natural boundary conditions.
- To suggests the remedial actions, new material for chassis geometry to solve the failures.

3. Methodology:

1. The Chassis frame is the basic framework for car work. It supports everything car parts attached to it. It is made of stainless steel. Everything car-related parts are attached to it only. All systems are related to vehicle such as powerplant, transmission, steering, suspension, braking system etc. are attached and only supported by it.
2. Due to variety of loads and pressure acting on the chassis body some problems occurs at the time of working. a sturdy chassis provides a solid foundation for your car suspension. By reducing the flex on the chassis, the suspension takes control to keep the tires connected to the road surface.
3. Required parts are first modeled in CATIA V5 which is excellent CAD software's, which makes the modeling easy and user friendly. The model is then transferred in DXF format and exported into the Solidworks.
4. The chassis is analyzed in Solidworks in three steps. Preprocessing: The geometry (physical bounds) of the problem is defined. The mesh may be uniform or non-uniform. The physical modelling is defined. Boundary conditions are defined. This involves specifying the chassis behavior and properties at the boundaries of the problem. Then different materials are applied to the chassis and analysis was done.

3.1 Need of Chassis Analysis:

It is crucial to determine the material's strength, as well as the strength of the join to ensure that it can take the forces in such an impact. Chassis in vehicles are tested to ensure durability throughout the product lifecycle.

3.2 Design Calculations:

Let us consideration,

Aluminum material for sample calculation:

Table 1: Aluminium Properties

Sr.No.	Material	Aluminium
1	Tensile Strength	68.9×10^4 kg/m^2
2	Yield Stress	27.5×10^4 kg/m^2
3	Allowable Stress	1.01×10^3 kg/m^2
4	Young's Modulus	6.79×10^{11} kg/m^2
5	Density	2700 kg/m^3
6	Poisson's ratio	0.33

Weight: 2.23kg

Load acting on chassis: 21 N (Considering weight of different materials attached with chassis)

Length of Chassis: 600 mm (suitable for prototype modelling)

Uniform Distributed Load: load/length: 0.035 N/mm

M(max) = wl/4 = 334.5 kg-mm … (Equation i)

Z = Moment(max) / σ = 15.92 mm^3 … (Equation ii)

3.3 Boundary Conditions:

Following Boundary conditions are applied while doing analysis. External Four side of chassis are fixed. Atmospheric pressure are applied on the chassis. Bearing Force are applied at the bearing slot.

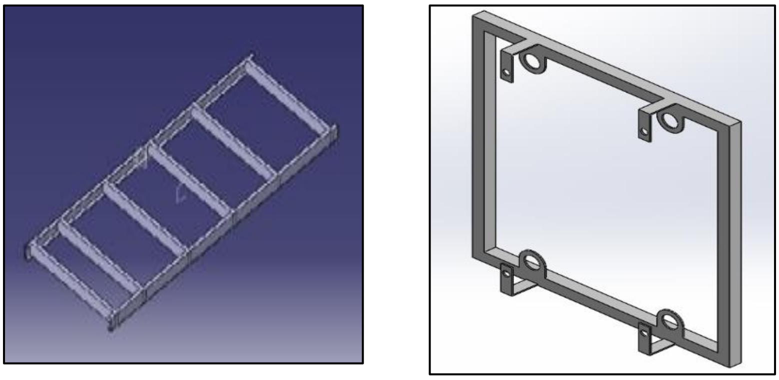
BC1	External side of chassis are fixed
BC2	Atmospheric Pressure are applied on the body of chassis
BC3	Bearing Force are applied at the bearing slot

Table 2: Specification of Material

Material	Yield strength (N/m^2)	Density (kg/M^3)	Weight (N)	Elastic modulus (N/m^2)	Poisson's ratio
Aluminium	**2.76E+07**	2700	21.9476	**6.90E+10**	**0.33**
Carbon steel	**2.83E+08**	7858	63.8766	**2.05E+11**	**0.29**
AL alloy 6063	**2.15E+08**	2700	21.9479	**6.90E+10**	**3.30E-01**
Steel AISI4130	**4.60E+08**	7850	63.8115	**2.05E+11**	**2.85E-01**
Titanium	**8.27E+08**	4480	36.4173	**1.10E+11**	**3.10E-01**
MS	**3.70E+08**	7860	63.8928	**2.00E+11**	**0.303**

4. Structural Analysis Chassis Model :

The model of chassis is as shown in Figure 1 having length of 550mm and width is 600 mm respectively. Various material is applied for the analysis of chassis as like Aluminium, Titanium, Carbon Steel, Mild steel. Static analysis on various cross sections (External body, Bearing Slots, Rod Slots) was carried out to check deformation and stress.



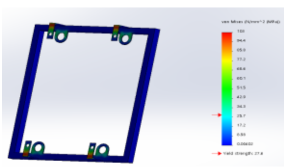
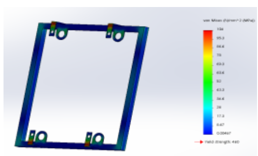
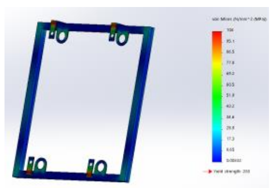
a.Existing model[18] b. New model

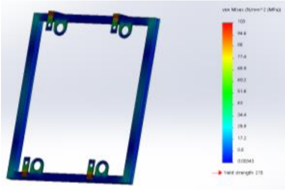
Figure 1: Model of Chassis

CAD model of chassis was designed in Solidworks and also analysis was carried out in Solidwork Simulation. Meshing was done in Solidwork software. Using Solid meshing 7593 number of elements were formed as fine meshing was used. After meshing structural analysis were done. The results of static structural and analysis were compared with mentioned materials of chassis. To check the more efficient material for chassis two types of analysis is done i.e., Static and Modal Analysis. In static analysis stress, strain, displacement, young's modulus, density, tensile strength values for different materials are compared. In modal analysis weight, stress, displacement, frequency for different materials is compared.

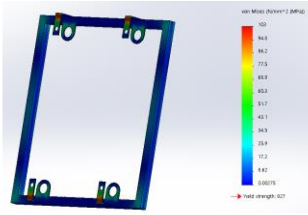
For static and modal analysis different materials are used like Aluminum alloy, Carbon steel, Mild Steel, Titanium.

4.1 Static structural analysis: A static structural analysis calculates the effect of steady (or static) loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can include steady inertia loads (such as gravity and rotational velocity and accelerations), and time varying loads that can be approximated as static equivalent loads having 214.839and point load. A static structural analysis was used to calculate displacements, stresses, strains and forces in a structure due to the application of load.

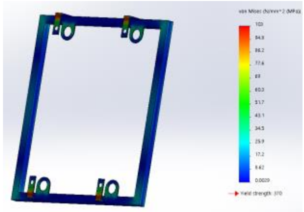
		
a. Von-Mises stress distribution of Aluminium Material	b. Von-Mises stress distribution of Steel Material	c. Von-Mises stress distribution of Carbon Steel Material



d. Von-Mises stress distribution of Aluminium alloy 6063 Material



e. Von-Mises stress distribution of Titanium Material



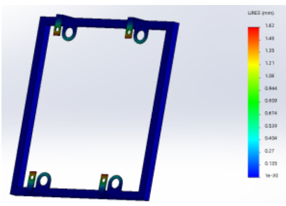
f. Von-Mises stress distribution of Mild steel Material

Figure 2 : Von Mises Stress distribution of Chassis

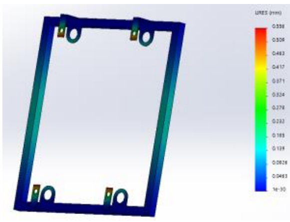
Table 3: Stress distribution of chassis

Material Type	Aluminium	Carbon steel	AL alloy 6063	Steel	Titanium	Mild Steel
Minimum Stress (Mpa)	0.00343	0.00332	0.00343	0.00467	0.00275	0.0029
Maximum Stress (Mpa)	103	104	103	104	103	103

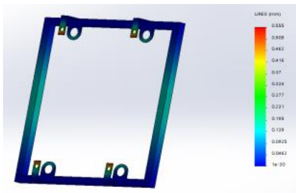
The above table represents the stress distribution results of given chassis. After applying mentioned Boundary Condition, the stress values obtained which is helpful for plotting results.



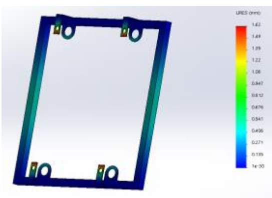
a. Deformation contour of Aluminium Material

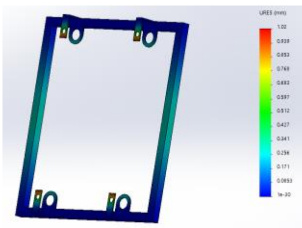


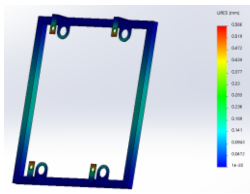
b. Deformation contour of Steel Material



c. Deformation contour of Carbon Steel Material







d. Deformation contour of Aluminium alloy 6063 Material	e. Deformation contour of Titanium Material	f. Deformation contour of Mild steel Material

Figure 3 : Deformation Contour of Chassis

Table 4: Deformation Results

Material	Aluminium	Steel	Carbon Steel	Aluminium alloy 6063	Titanium	Mild Steel
Deformation (mm)	1.62	0.555	1.62	0.556	1.02	0.566

The above table represents the Deformation results of given chassis. After applying mentioned Boundary Condition, the deformation values obtained which is helpful for plotting results.
Following are the different comparison to select the suitable material for chassis.

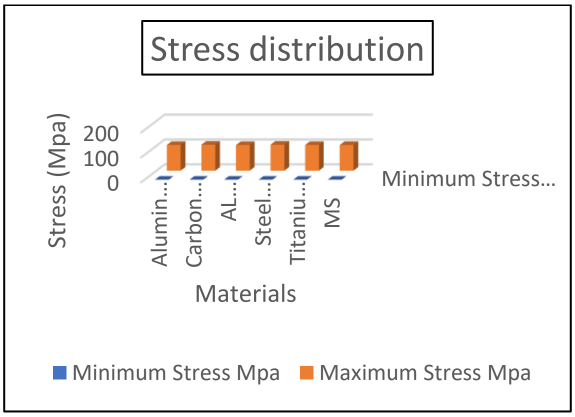


Figure 4 : Comparison of Stress Value against Different materials

Mechanical Stress is measure of internal resistance exhibited by a body or material when an external force is applied to it. The elastic limit of material is the limit where resisting force become equal to the applied force. Here stress values of different materials are varying from 102 to 104 unit, the MS and AL material having minimum stress.

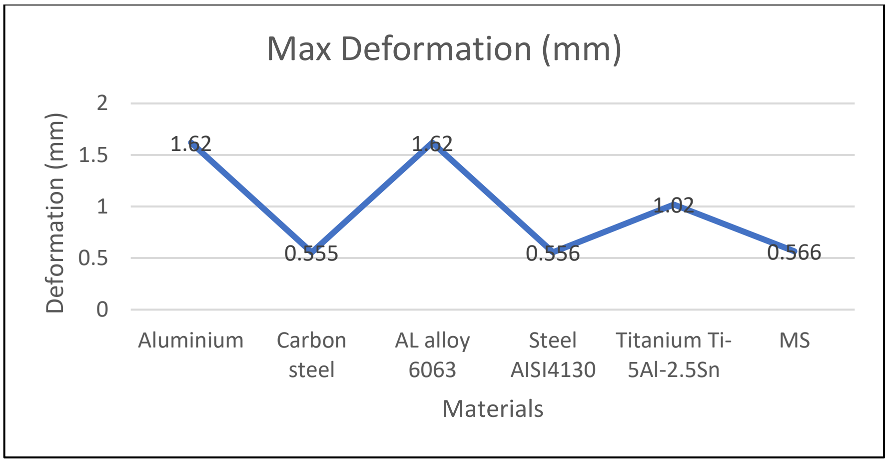


Figure 5 : Comparison of Deformation against Different materials

Deformation is a change of dimensions and in some cases shape of a body due to an applied external force. Here after analysis the deformation values ranges from 0.5mm to 1.62 mm. The maximum deformation is of Aluminium i.e. 1.62 and the minimum deformation is 0.5 the material is MS.

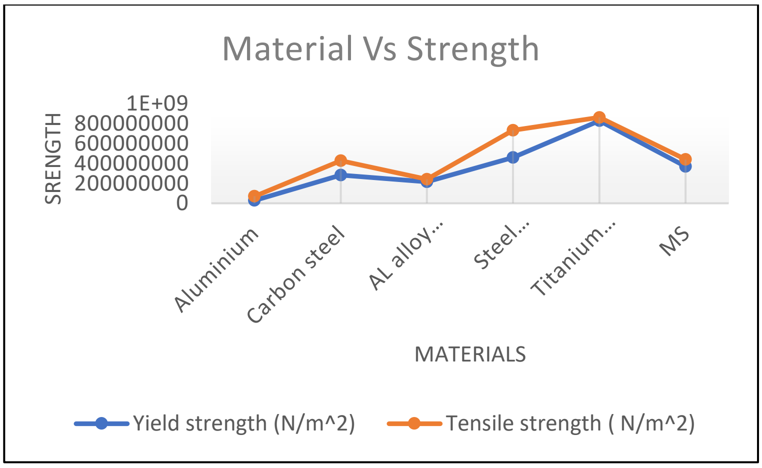


Figure 6 : Comparison of Strength against Different materials

Strength is the ability to withstand an applied stress or load without structural failure. In the graph comparison of material with yield and tensile strength. Yield strength is an indication of maximum stress that can be developed in a material without causing plastic deformation. Tensile strength is the maximum stress while being stretched or pulled before necking. After analysis the results proves that MS material will sustain maximum Strength as compared to other.

4.2 Modal Analysis: Modal analysis is the study of the dynamic properties of linear structures, based on structural testing or finite element analysis-based simulation. Modal analysis was used to determine the vibrational characteristics of a structure. [17]

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Volume XVI, Issue IV, Jan-June 2022

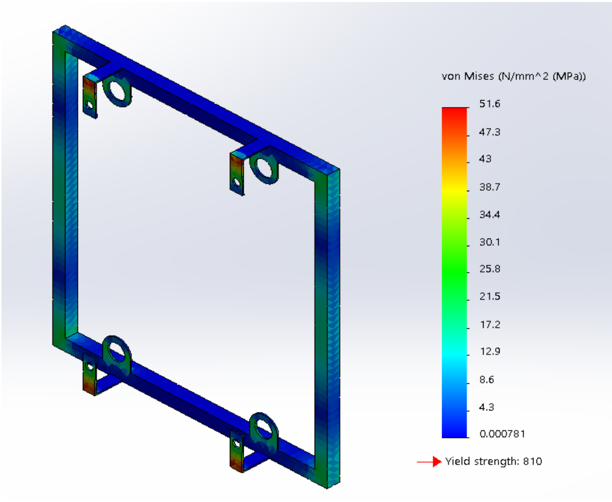

Figure 7 : Modal Analysis of Chassis

It calculates natural frequencies along with its mode shape. Natural frequencies and modes shape obtained in modal analysis were provided as input parameters for a transient and harmonic analysis. Static as well as dynamic analysis of frame was carried out by considering factor such as weight, frequency, etc.

Table 5: Modal analysis Result

Mtl Type	Weight (N)	Minimum Stress Mpa	Maximum Stress Mpa	Displacement (mm)	Frequency (Hz)
AL alloy 6063	21.9476	0.000718	51.6	1.65	790.638
Carbon steel	63.8766	0.000623	52	0.564	795.516
Titanium	36.4173	0.000781	51.6	0.99	771.18667
MS	63.8928	0.000646	51.8	0.575	786.60867

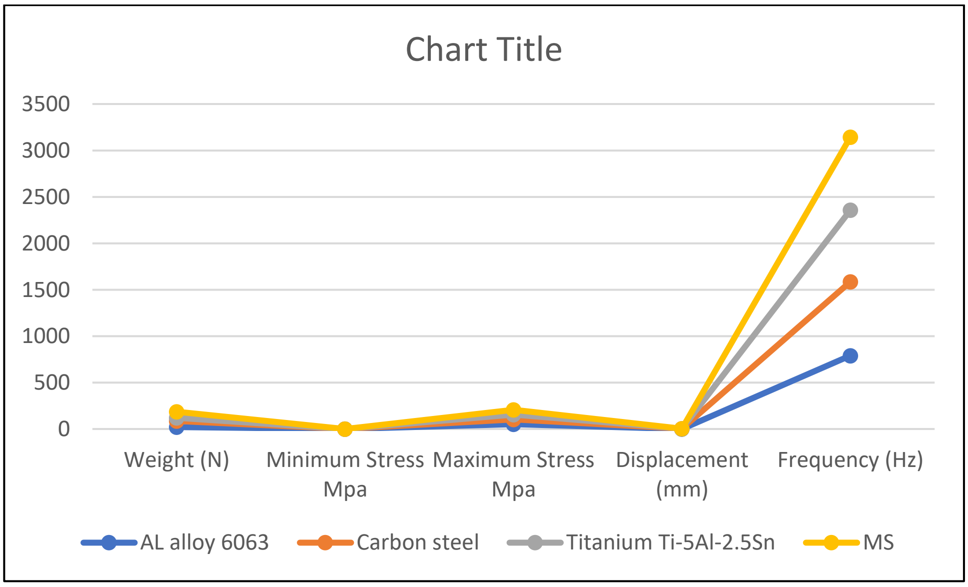

Figure 8 : Modal analysis of Displacement and Frequency against Different materials

The deformation and stress values varying with different material. Modal analysis graph gives the comparison between weight, stress, displacement and frequency. Above graph gives the detail information of different properties of different materials.

5. Result and Discussion

In the present work, 360^0 prototype vehicle chassis was analyzed using Solidwork software. Following are the results obtained from analysis,

1) Aluminium material having 103 Mpa stress and deformation of 1.62 mm.
2) Carbon Steel material having 104 Mpa stress and deformation of 0.555 mm.
3) Aluminium alloy material having 103 Mpa stress and deformation of 1.62 mm.
4) Steel material having 104 Mpa stress and deformation of 0.556 mm.
5) Titanium material having 103 Mpa stress and deformation of 1.02 mm.
6) Mild Steel material having 103 Mpa stress and deformation of 0.566 mm.

It is observed that the Mild steel material is having least deflection i.e.,0.566 mm and minimum von mises stress 51.8 Mpa. Yeild Strength of Mild Steel is 250 Mpa which is greater than maximum stress 104 Mpa.

6. Conclusion

Based on above discussion MS material is more advantageous as compared to other material. So for proper working of model MS material is good for Vehicle Chassis.

After studying the static and modal analysis the results are:

1. AL and MS material having equal stress values after applying external load.
2. After deformation the maximum deformation is happened in AL material and less deformation occurs in MS material.
3. In Strength also MS material having maximum capacity to sustain under maximum load.

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