A Review on Design and Analysis of Chassis Frame using Graphene, Carbon Fiber and Aluminium Alloy as Composite

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Abstract – This paper represents design and analysis of chassis frame using graphene, carbon fiber and aluminium alloy as composite. In automobile a chassis frame is structure that forms the foundation of all important components of a vehicle like Engine, transmission, differential, axles etc. all these components together form a chassis. In this project a jeep wrangler's chassis frame is modelled in solidworks and further static analysis is going to be performed in Ansys to determine areas of deformation and equivalent stresses.

***Key Words*: Solidworks, Ansys, Jeep wrangler, static analysis, chassis frame.**

1. INTRODUCTION

Chassis is a French word which translates to "Base frame of an automobile" Chassis frame is the basic frame work of the automobile. It supports all the parts of the vehicle attached to it and gives it a structural support. The main function of a chassis is not only to maintain the structural integrity but to also provide safety to the occupants of a vehicle in case of a collision therefore selection of material is also very crucial. A chassis frame must be strong enough to withstand all the static, dynamic, torsional and bending stresses acting on it. There are many different types of chassis frame such as ladder frame, monocoque chassis, space frame chassis, backbone frame chassis etc. among these a ladder frame chassis is mostly used in trucks and SUVs like, Toyota Land Cruiser, Jeep wrangler, Ford F-150 etc. ladder frames are robust and strong they're also easy to design and cheaper to build, but ladder frames are also very heavy this is where composites like aluminium alloys, carbon fiber and graphene comes into equation.

1.1 Graphene Trends and Development

Graphene is a two-dimensional sheet of graphite arranged in a honeycomb hexagonal structure when you put these structure one on top of the other we get 3D graphite. Graphene, the wonder material is strongest material that has ever been measured it has excellent mechanical, electrical and chemical properties. But this wonder material alone cannot be used to manufacture 3 dimensional objects. A group of scientists from Pennsylvania State University came up with something known as Graphene-reinforced carbon fiber they came up with a new way of creating the material that not only makes the process cheaper but also strengthens the fibers. Using a mix of laboratory experiments and computer simulations, the researchers added graphene to carbon fiber and analyzed its properties. The researchers added trace amounts of graphene (0.075 to 0.1 wt %) to traditional carbon fiber and saw a 225% increase in tensile strength and 184% increase in young's modulus when compared to PAN based Carbon fibers. Carbon fiber is an excellent material but with current cost of manufacturing at 15 USD per pound it makes it very expensive to bring PAN based carbon fibers into mainstream production but with this breakthrough the cost is expected to reduce to 5 USD/pound

1.2 Finite Element Analysis

Finite element analysis or FEA is a simulation program used to solve complex engineering models numerically in a virtual environment The static analysis of mechanical parts is intended to calculate the effects of constant loads on the structure ignoring the effects of inertia and shock that are commonly found when the applied loads change rapidly A static structural analysis is used to calculate the areas of deformation and equivalent stresses in a structure due to application of force. After the analysis is performed, we will get minimum, average and maximum deformation along with equivalent stresses.

2. Literature review

[1] Kenji KARITA, Yoichiro KOHIYAMA, Toshihiko KOBIKI, Kiyoshi OOSHIMA, Mamoru HASHIMOTO (2003) From this study authors found that the Aluminium chassis meets the target of weight reduction, strength and rigidity. Also they concluded that the remaining technical issues will be addressed to enable commercial adoption of the aluminum frame.

[2] William F. Milliken, Douglas L. Milliken has suggested a book "Chassis Design" and explained the principle to design chassis and analysis of chassis.

[3] Sanchit Shrivastava, Roopesh Tiwari, Suman Sharma "Design and analysis of Heavy commercial vehicle chassis through material optimization" (2019) from this paper authors explains how different materials affects the weight reduction and critical areas in the chassis by performing static structural analysis.

[4] Patel Vijaykumar V, Prof. R. I. Patel "Structural Analysis of Automotive Chassis Frame and Design Modification for Weight Reduction" In this paper authors perform structural analysis to determine weather the design is safe or not they also focused on weight reduction and modifications required before manufacturing

[5] Keith J. Wakeham has suggested a Paper on "Introduction to chassis design" and explained various technical and non technical factors that influences the design of chassis.

[6] Dr.R.B choudary written a book "Introduction to Ansys 10.0" This book explains the basics of Ansys and how to get into ANSYS as a beginner.

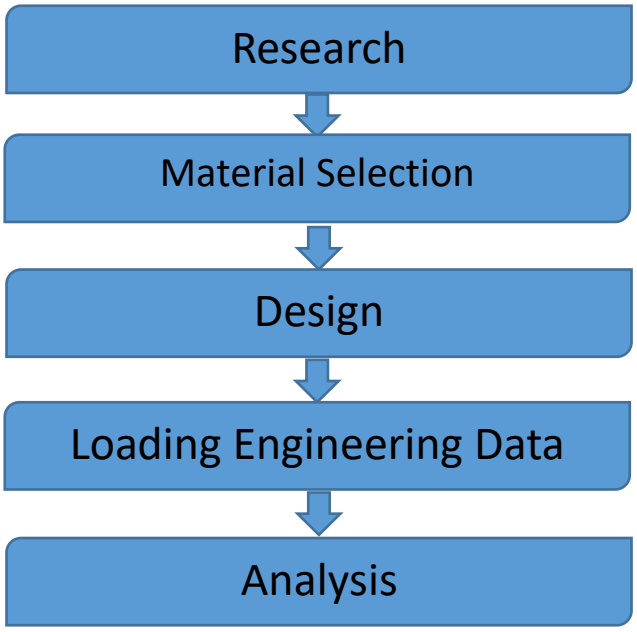
3. Aim of the project

- To calculate Deformation with equivalent stresses
- To calculate weight of chassis with different materials
- To design a simple yet robust chassis frame
- To compare results of analysis and determine the best material

4. Problem Definition

Traditionally the most commonly used material for manufacturing chassis frame has been steel. Steel has some decent properties, it's cheap and is readily available but over the years a lot of automobile manufacturers are experimenting with new and improved material technologies such as carbon fiber, aluminium, graphene, glass epoxy etc. conventional materials like steel are heavy and during high speed head on collisions they may deform beyond their crumple zones so we wanted to compare latest gen material technologies to previous gen materials and see how they perform when subjected to forces which they experience during realistic high speed crashes.

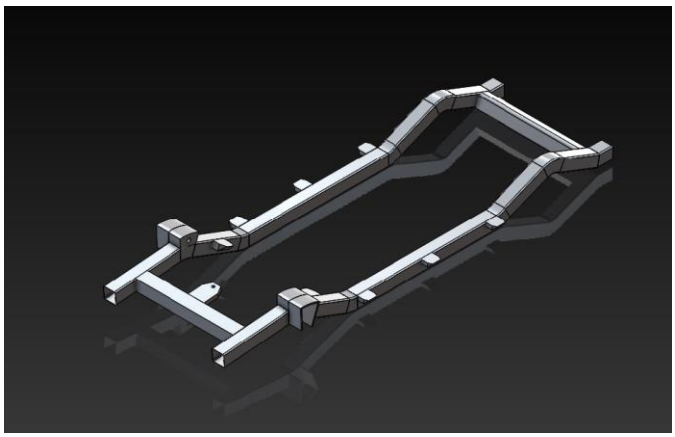
5. Proposed Methodology

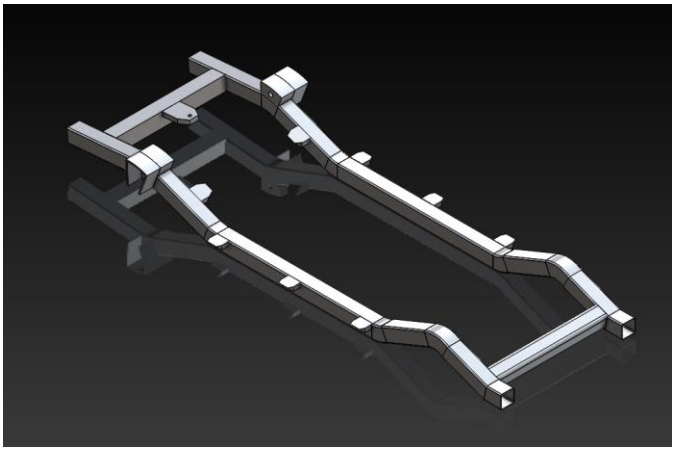


Research: After referring dozens of research papers and articles we have determined the various characteristics and properties of the materials along with the technical and non-technical aspects of designing and analysis.

Design:

In this project we've designed a ladder frame chassis inspired by the Jeep wrangler's frame. Most of the ladder frame members are C or I cross section type but, in this project, we are going to use a rectangular section type as it has higher strength and stiffness among the 3 types and is also easier to design. The dimensions of the frame will roughly be similar to Jeep wrangler. The ladder frame was modelled on designing software soildworks 2021 and like a typical ladder frame it has two long side member a few cross member and connection plates





Material selection:

Material selection in chassis frame plays an important role in maintaining structural integrity and safety of the vehicle. After extensive research on the current and future trends of material technology we shortlisted, a few materials based on their properties

Sr No	properties	Units	AA6063-T6	Carbon fiber	Graphene
1	Density	Kg/m^3	2700	2000	2270
2	Ultimate Tensile Strength	MPa	250	4000	130000
3	Poisson's ratio	MPa	0.33	0.38	0.4569
4	Youngs modulus	MPa	68.3e3	155e3	1000e3
5	Shear modulus	MPa	25.8e3	5.615e3	343.4e3
6	Yield strength	MPa	220	1000	14000

Static Structural Analysis:

A static structural analysis is performed to calculate the deformation and stresses in a structure due to application of force. In static structural analysis we are going to perform a front, side and rear impact analysis. This is important as it help us to determine how our frame will perform under forces which will be used as an input parameter. The forces will be calculated using the formula $F=1/2MV^2/d$ where, F= Force, M= Mass, V= Velocity and d= stop distance. After performing the analysis we will be able to determine the areas of deformation (minimum, average and maximum) along with equivalent stresses. After the analysis is done we will compare the materials based on deformation and equivalent stresses.

6. Conclusions

- In this project we focus mainly on comparing materials of different generations with different costs and see how they perform in analysis.
- Designing a ladder frame chassis with suitable parameters on solidworks.
- With static structural analysis we can determine minimum, maximum and average deformation along with equivalent stresses.
- This analysis will help us understand which material is most suitable based on strength and safety

7. References

- https://sciencing.com/calculate-force-falling-object-6454559.html
- https://www.engineeringtoolbox.com/impact-force-d_1780.html
- "Design & Analysis of Ladder Frame Chassis" by Yagyansh Mishra IRJET volume 7 issue 8 August 2020
- Jakub Šmiraus1, Michal Richtář2, "Design of motorcycle active chassis geometry Change system". Number 5, Volume VI, December 2011.
- Patil, Kamlesh Y., and Eknath R. Deore. "Stress analysis of ladder chassis with various cross sections." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 12.4 (2015): 1