

Design and Analysis of Mono-Composite Leaf Spring for Light Weight Vehicles

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ABSTRACT: Suspension system in an automobile determines the riding comfort of passengers and the amount of the damage to the vehicle. The main function of the leaf spring assembly as suspension element is not only to support vertical. The main function of leaf spring assembly as suspension element is not only to support vertical load, but also to isolate road induced vibration .the introduction of composite leaf spring has made it is possible to reduce the weight of spring without any reduction on load carrying capacity and stiffness. The achievement of weight reduction with adequate improvement of mechanical properties has made and composite a very good replacement material for conventional steel spring. The behaviour of leaf spring is complicated due to its clamping effects and inter leaf contact etc. The objective of this work is to estimation of liner stress, strain and deformation of composite leaf spring in truck by linear static structural analysis and replace the multi-leaf steel spring by mono composite leaf spring for the same load carrying capacity and stiffness. In this work, Mono leaf spring is designed by using the software CATIA V5 R20. It is then imported into FEM package of NASTRAN in HYPERMESH. And various analysis is done such as modal analysis (vibration analysis), static analysis i.e., impact force analysis stress analysis and strength analysis. The materials used for this analysis are Glass fibre reinforced plastic and epoxy resin having the composition 60% of GFRP and 40% of epoxy resin. The results are then compared with the conventional material such as steel. From all these analysis and comparison, it can be concluded that the composite materials GFRP and Epoxy-resin are suitable.

KEYWORDS: Mono leaf spring, Impact analysis, Static analysis, Nastran, Catia.

I. INTRODUCTION

Now a days, Better fuel efficiency, emission issues and reducing weight has become main focus in automobile sector. In that issue, weight reduction can be done by implementing better material, optimizing an appropriate design and quality manufacturing. In automobile sector, leaf spring is used suspension in most of the vehicles. So reducing weight of leaf spring get beneficial and can help to achieve the objective as per demands. For better material , composites are get closure to achieve weight reduction without any change in load carrying capacity , stiffness parameters. Composite materials are having good elastic strain energy, good strength to weight ratio, less weight than steel leaf spring.

I. LEAF SPRING

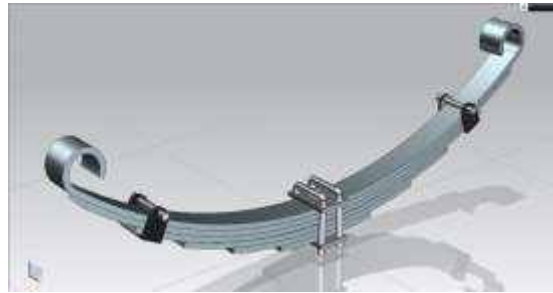


Fig 1: Leaf Spring

Leaf springs are a basic form of suspension made up of layers of steel of varying sizes sandwiched one upon the other. Most leaf spring setups are formed into an elliptical shape through the use of spring steel which has properties that allow it to flex as pressure is added at either end, but then returning to its original position through a damping process. The steel is generally cut into rectangular sections and then once held together by metal clips at either end and a large bolt through the center of the leaves. It is then mounted to the axle of the vehicle using large U-bolts, securing the suspension in place.

II. PROBLEM IDENTIFICATION

In present time the main issue of automobile industry are weight reduction. The need is to reduce the weight of the vehicles that is of leaf spring for the same load carrying capacity and stiffness the objective of the project is to replace the multi leaf spring by mono composite leaf spring. Estimation of stress and deformation of steel and composite material by static analysis. And also to evaluate whether the design is safe or not. Modal analysis to find the different modes and their natural frequencies in vibrational condition. Comparison of both the materials.

III. METHODOLOGY

We have newly designed the front car bumper using the CATIA V5 R19 software and it is then finely meshed using the HYPER MESH software and then imported the mesh model to the ANALYSIS workbench to perform the modal analysis, static analysis and impact analysis by giving the corresponding Boundary conditions.

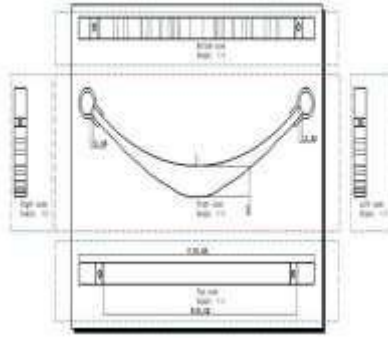
1. MODEL DESCRIPTION

The 2D view of the designed model is shown below with the dimensions specified. The data required for designing this model are:

- THICKNESS
- TOTAL LENGTH

: 8mm

: 1115mm



IV.RESULT AND DISCUSSION

1. GEOMETRY

The below figure shows the 3D model of the designed Mono Leaf Spring which is created using the CATIA V5 R20 software.

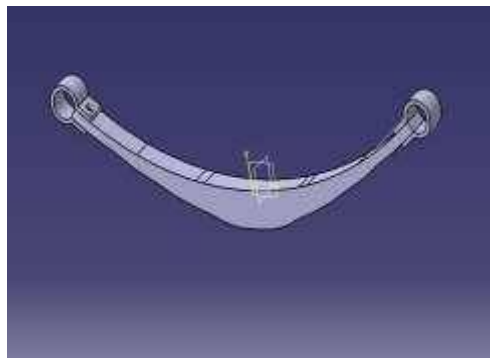


Figure 2: 3D model

2. MESHED MODEL

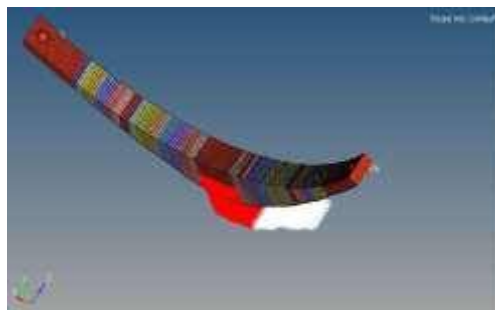


Figure 3: meshed model

3. FINITE ELEMENT MODEL DATA INFORMATION :

Total # of Grids (Structural)	: 2614
Total # of Elements	: 2372
Total # of Rigid Elements	: 2
Total # of Rigid Element Constraints	: 384
Total # of Degrees of Freedom	: 15672
Total # of Non-zero Stiffness Terms	: 404952

4. Element Type Information

CQUAD4 Elements	: 2370
CTRIA3 Elements	: 2

5. BOUNDARY CONDITIONS

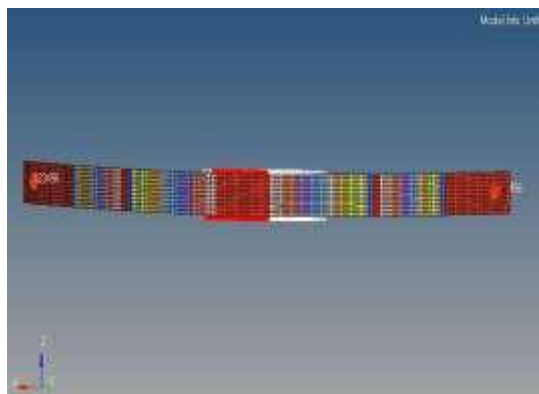


Figure 4: 2D model

- After the model is meshed, it is then subjected to different boundary Conditions.
- The model is fixed at the two ends of the mono leaf spring as shown in figure.

V. IMPACT ANALYSIS AND STATIC ANALYSIS

Firstly, we do the impact analysis and static analysis for the composite material i.e, GFRP when the mono leaf spring stationary.

There are 3 cases for impact analysis by applying varying loads i.e, 1KN, 1.5KN and 2KN.

1. In case 1: applying load of 1KN

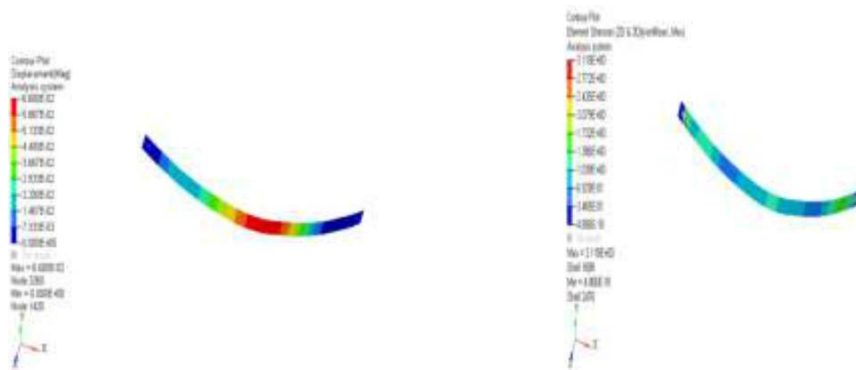


Figure shows the displacement by applying 1KN load. Figure shows the element stresses by applying 1KN load.

Maximum displacement is 0.660E-01 at grid 3260.

Maximum 2-D element stress is 3.12 in element 1689.

2. In case 2 : applying load of 1.5KN

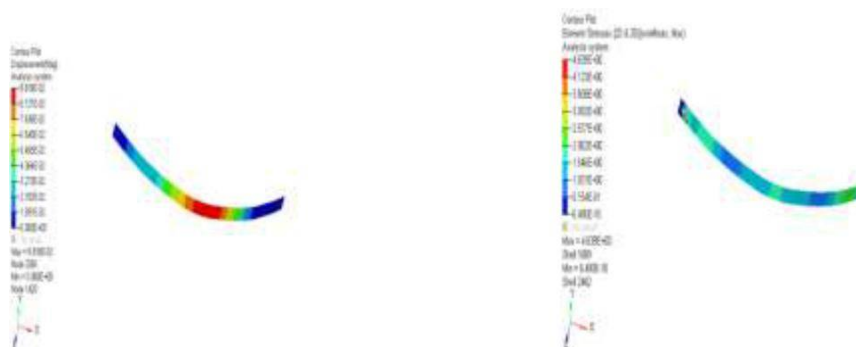


Figure shows the displacement by applying 1.5KN load. Figure shows the element stresses by applying 1.5KN load

Maximum displacement is 0.982E-01 at grid 3260.

Maximum 2-D element stress is 4.64 in element 1689

3. By Numerical Method :

Uniform constant stiffness is calculated by Differential equation of damped free vibration i.e,

$$m\ddot{x} + c\dot{x} + kx = F \quad \text{where } m\ddot{x} = \text{inertia force}$$

$$c\dot{x} = \text{damping force}$$

$$kx = \text{spring force}$$

there fore, $k=f/x$

In case 1- the displacement for 1KN is 0.0660

In case 2- the displacement for 1.5KN is 0.0982

In case 3- the displacement for 2KN is 0.1309

$$k=1000/0.0660=15.15 \text{ N/M}$$

$$k=1500/0.0982=15.27 \text{ N/M}$$

$$k=2000/0.1309=15.27 \text{ N/M}$$

This result shows the Uniform constant stiffness $F=KX$ for different loads of 1KN,1.5KN,2KN.

COMPARING BOTH FOR COMPOSITE MATERIAL GFRP AND CONVENTIONAL STEEL BY APLYING LOAD OF 3KN

1. FOR COMPOSITE MATERIAL

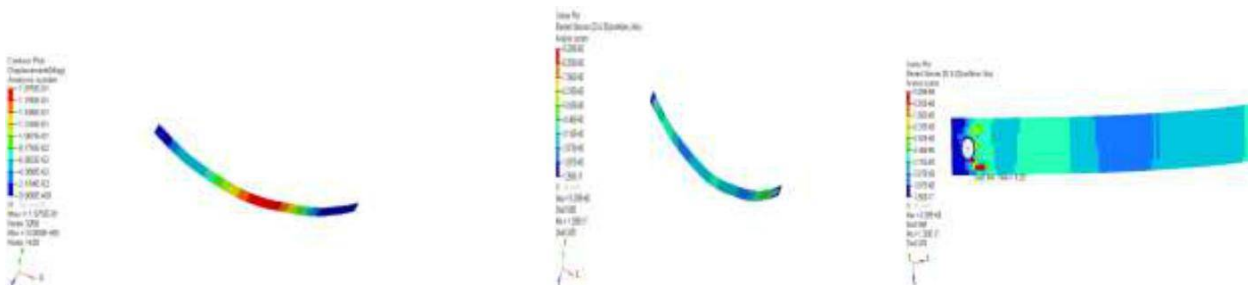


Figure shows the displacement, element stresses, stress section for 3KN

2. STRENGTH ANALYSIS

Strength Analysis of mono leaf spring using composite material.

Numerical method:

$$FOS = \frac{\text{ULTIMATE STRENGTH}}{\text{WORKING STRESS}} = \frac{140}{93.3} = 1.5$$

3. FOR STEEL MATERIAL

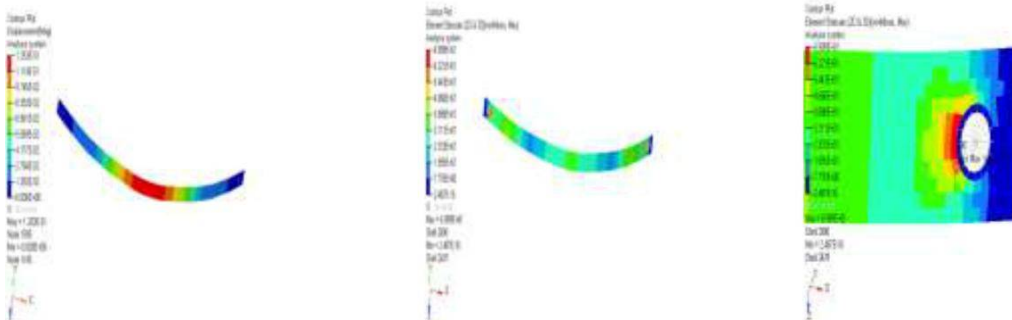


Figure shows the displacement, element stresses, and stress section for 3KN

VII. COMPARISION TABLE

Comparison of a Mono leaf spring of a composite material (GFRP) with steel material by static analysis

RESULTS	STEEL MATERIAL	GFRP(COMPOSITE MATERIAL)
Maximum principal stress	6.999E+01	9.329E+00
Minimum principal stress	2.467E-16	1.250E-17
Displacement	1.253E-01	1.975E-01
Mass	2.22480E-02	5.06917E-03
Factor of safety	3	1.5
Density kg/m ³	7.8e ⁻⁰⁹	2.0e ⁻⁰⁹

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