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# A Review Paper on Design & Analysis of LeafSpring

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***Abstract: This paper reviews some of the general study on the design, analysis and fabrication of composite leaf spring. Leaf springs are one of the oldest suspension components they are still frequently used, especially in commercial vehicles. The literature has indicated a growing interest in the replacement of steel spring with composite leaf spring.The suspension system in a vehicle significantly affects the behavior of vehicle, i.e. vibration characteristics including ride comfort, stability etc. Leaf springs are commonly used in the vehicle suspension system and are subjected to millions of varying stress cycles leading to fatigue failure. A lot of research has been done for improving the performance of leaf spring. Lot of materials are used for leaf spring .but it is found that fiberglass material has better strength characteristic and lighter in weight as compare to steel for leaf spring. In this paper the author is reviewed few papers on use of alternate materials and effect of material on leaf spring performance.***

***Keywords: steel leaf spring, ANSYS, PRO-E software.***

## I. INTRODUCTION

Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. The main function of leaf spring assembly as suspension element is not only to support vertical load, but also to isolate road-induced vibrations. The behaviour of leaf spring is complicated due to its clamping effects and inter-leaf contact etc. It carries lateral loads, brake torque, driving torque in addition to shock absorb. Springs are crucial suspension elements on cars, necessary to minimize the vertical vibrations, impacts and bumps due to road irregularities and create a comfortable ride. The suspensionleaf spring is one of the potential items for weight reduction inautomobile as it accounts for ten to twenty percent of the unsprung weight. The introduction of composites helps in designing a better suspension system with better ride quality ifit can be achieved without much increase in cost and decrease in quality and reliability. In the design of springs, strain energy becomes the major factor. In the present scenario the main focus of automobile manufacturers is weight reduction of the automobile. Weight reduction can be achieved mainly by introducing the better material, design optimization and better manufacturing processes. In automobiles, leaf spring is one of the potential parts for weight reduction as it accounts for 10% - 20% of the unsprung weight. Composite materials have made it possible to reduce the weight of leaf springwithout any reduction in load carrying capacity and stiffness. Composite materials are now used extensively in place ofmetal parts. Several papers were devoted to the application of composite materials for automobiles.

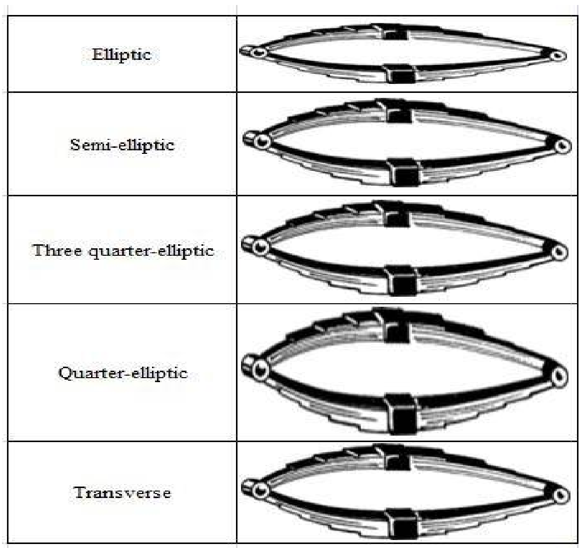


Figure1.1 Types of leaf spring

The figure shows a laminated semi- elliptic spring. The top leaf is known as the master leaf. The eye is provided forattaching the spring with another machine member. The amount of bend that is given to the spring from the centralline, passing through the eyes, is known as camber. The camber is provided so that even at the maximum load the deflected spring should not touch the machine member towhich it is attached. The central clamp is required to hold the leaves of the spring.

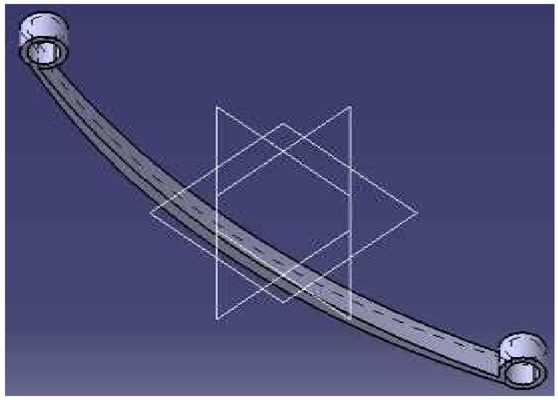

Fig: 1 Leaf Spring Designed in CATIA V5R20

To design composite leaf spring, a stress analysis wasperformed using the finite element method done using ANSYS software. Modeling was done for every leaf with CATIA V5R20 as shown in fig1.Also, analysis carried out for composite leaf spring with bonded end joints for Mild Steel, E-Glass/Epoxyand Jute E- Glass/Epoxy. The maximum and shear stresses along the adhesive layer were measured; represent FEA results for composite leaf springs of (Mild Steel E-Glass/Epoxy and Jute E-Glass/Epoxy). The maximum and shear stresses along the bonded adhesive layer for Mild Steel E-glass/Epoxy and Jute E-Glass/Epoxy were measured and plotted as shown in Figs.

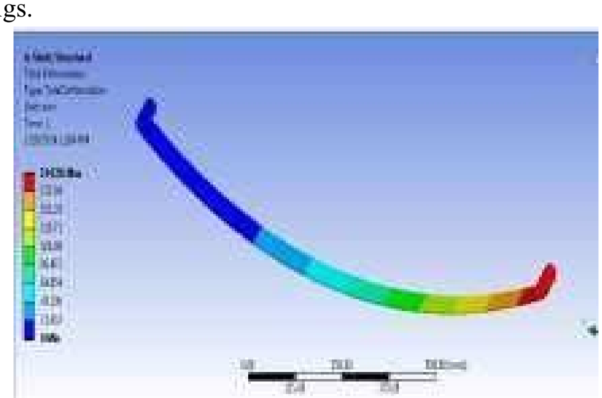

Fig: 2 Static Structural Analysis for Mild Steel

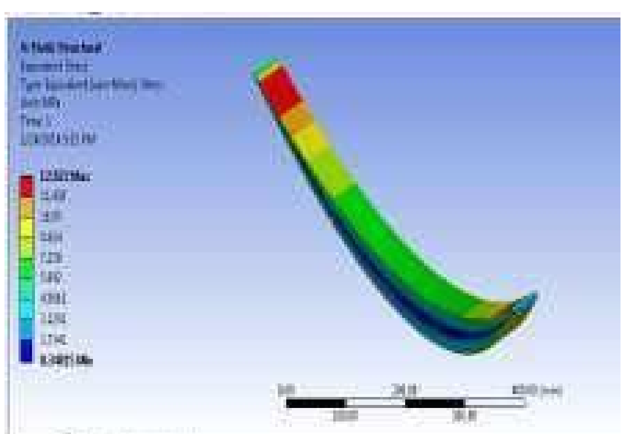

Fig: 3 Static Structural Analysis for E-Glass/Epoxy

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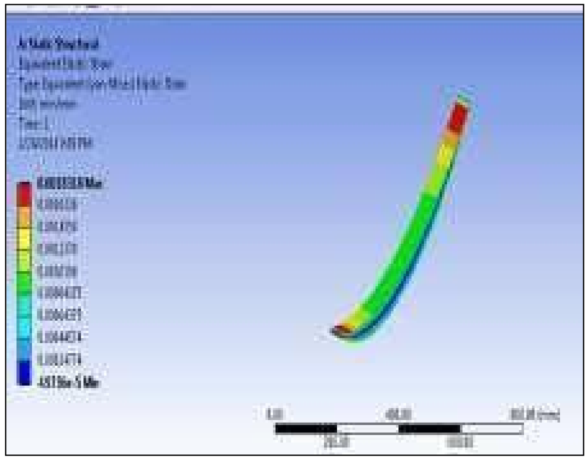

Fig: 4 Static Structural Analysis for Jute E-Glass/Epoxy

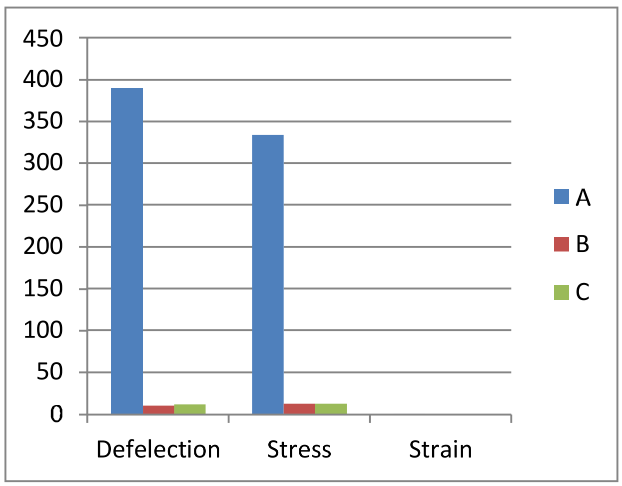


Fig: 5 Comparison of Materials Based on the Stress,Strain, Deflections with 1000N load

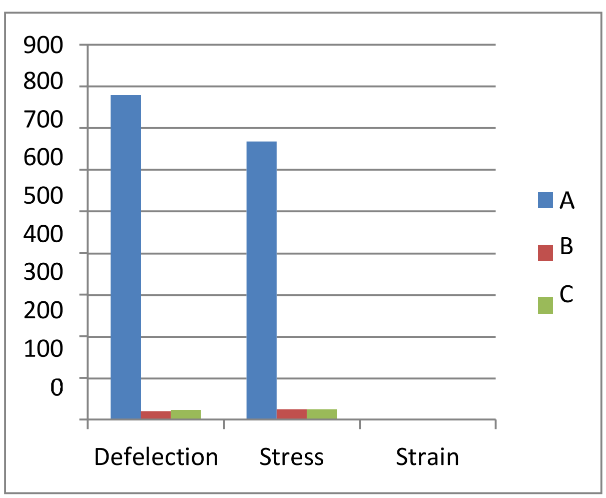


Fig: 6 Comparison of Materials Based on the Stress,Strains, Deflections with 2000N load

Note: a – steel leaf spring, b – e-glass/epoxy leaf spring,c - jute/e-glass/epoxy leaf spring

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| **Material** | **Young's modulus** | **Poisson's ratio** | **Tensile strength** | **Density** |
|---|---|---|---|---|
| Steel | 190-210 MPa | 0.27-0.30 | 572.3 MPa | 1000 kg/m$^3$ |
| E-glass /Epoxy | 24000 MPa | 0.3 | 205 MPa | 1520 kg/mm$^3$ |
| Jute/E-glass /epoxy | 21000 MPa | 0.22 | 185 MPa | 1460 kg/mm$^3$ |

| Object Name | *SECOND-LEAF\|SECOND-LEAF* | *THIRD-LEAF\|THIRD-LEAF* | *FORTH-LEAF\|FORTH-LEAF* | *FIFTH-LEAF\|FIFTH-LEAF* | *SIXTH-LEAF\|SIXTH-LEAF* | *SEVENTH-LEAF\|SEVENTH-LEAF* | *2ND\|2ND* |
|---|---|---|---|---|---|---|---|
| State | Meshed | | | | | | |
| **Graphics Properties** | | | | | | | |
| Visible | Yes | | | | | | |
| Transparency | 1 | | | | | | |
| **Definition** | | | | | | | |
| Suppressed | No | | | | | | |
| Stiffness Behavior | Flexible | | | | | | |
| Coordinate System | Default Coordinate System | | | | | | |
| Reference Temperature | By Environment | | | | | | |
| Treatment | None | | | | | | |
| **Material** | | | | | | | |
| Assignment | E-Glass | | | | | | |
| Nonlinear Effects | Yes | | | | | | |
| Thermal Strain Effects | Yes | | | | | | |
| **Bounding Box** | | | | | | | |
| Length X | 1228.4 mm | 1000. mm | 700. mm | 580. mm | 430. mm | 300. mm | 1150. mm |
| Length Y | 264.01 mm | 139.05 mm | 68.451 mm | 48.18 mm | 28.825 mm | 16.981 mm | 187.85 mm |
| Length Z | 50. mm | | | | | | |
| **Properties** | | | | | | | |
| Volume | 4.6418e+005 mm³ | 3.1413e+005 mm³ | 2.145e+005 mm³ | 1.7649e+005 mm³ | 1.2999e+005 mm³ | 89524 mm³ | 3.6843e+005 mm³ |
| Mass | 100.26 kg | 67.852 kg | 46.332 kg | 38.123 kg | 28.078 kg | 19.337 kg | 79.581 kg |
| Centroid X | 3.4638 mm | -1.0377e-013 mm | 1.8814e-014 mm | 6.0243e-014 mm | -6.2385e-015 mm | 4.3346e-015 mm | 3.469 mm |
| Centroid Y | -99.67 mm | -163.74 mm | -193.73 mm | -206.59 mm | -219.16 mm | -229.17 mm | -141.07 mm |
| Centroid Z | -1.9061e-014 mm | 1.26e-014 mm | -1.3447e-014 mm | -3.2192e-014 mm | -9.8356e-015 mm | 1.9677e-014 mm | -1.6431e-014 mm |
| Moment of Inertia Ip1 | 7.3445e+005 kg·mm² | 1.2123e+005 kg·mm² | 25818 kg·mm² | 14067 kg·mm² | 7229.4 kg·mm² | 4292.2 kg·mm² | 2.5115e+005 kg·mm² |
| Moment of Inertia Ip2 | 1.6387e+007 kg·mm² | 5.8794e+006 kg·mm² | 1.9334e+006 kg·mm² | 1.0886e+006 kg·mm² | 4.4107e+005 kg·mm² | 1.495e+005 kg·mm² | 9.25e+006 kg·mm² |
| Moment of Inertia Ip3 | 1.7079e+007 kg·mm² | 5.9724e+006 kg·mm² | 1.9399e+006 kg·mm² | 1.0868e+006 kg·mm² | 4.366e+005 kg·mm² | 1.4573e+005 kg·mm² | 9.468e+006 kg·mm² |
| **Statistics** | | | | | | | |
| Nodes | 7029 | 6963 | 4752 | 3927 | 2904 | 2046 | 8151 |
| Elements | 3310 | 4200 | 2860 | 2360 | 1740 | 1220 | 4920 |
| Mesh Metric | None | | | | | | |

## II. CONCLUSION

The automobile chassis is mounted on the axles, not direct but with some form of springs. The stresses and deflection of steel leaf spring and composite leaf spring are found with great difference. Deflection of composite leaf spring is less ascompared to steel leaf spring with the same loading condition. Weight and cost are also less in composite leaf spring as compared to steel leaf spring with the same parameters. Conventional steel leaf spring is also found to be 5.5 times heavier then Jute E- Glass/Epoxy leaf spring. Material saving of 71.4 % isachieved by replacing Jute E-Glass/epoxy in place of steel for fabricating the leaf spring. Composite leaf spring can be used on smooth roads with very high performance expectations.

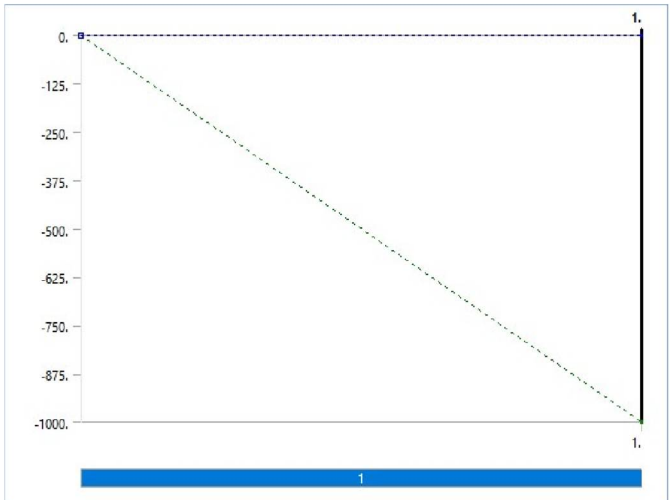


TABLE 15
Model (A4) > Static Structural (A5) > Solution

| | |
|---|---|
| Object Name | *Solution (A6)* |
| State | Solved |
| Adaptive Mesh Refinement | |
| Max Refinement Loops | 1. |
| Refinement Depth | 2. |
| Information | |
| Status | Done |
| MAPDL Elapsed Time | 28. s |
| MAPDL Memory Used | 955. MB |
| MAPDL Result File Size | 25.313 MB |
| Post Processing | |
| Beam Section Results | No |
| On Demand Stress/Strain | No |

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