PERFORMANCE ANALYSIS OF COMPOSITE LEAF SPRING

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ABSTRACT: Reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue. In this project we have done design and analysis of composite leaf spring. Current research in Automobile Industry undergoes the replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio and good corrosion resistance. The material selected was glass fiber reinforced polymer (E-glass/epoxy) is used against conventional steel. In our project we have modeled the leaf spring in CREO and the analysis was done using ANSYS software.

Keywords: E-glass, composites, creo, ansys, leaf spring.

1.INTRODUCTION

Conventionally called laminated or carriage spring a leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times. An advantage of a leaf spring over a helical spring is that the end of the leaf spring may be guided along a definite path. Sometimes referred to as a semi-elliptical spring or cart spring, it takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The centre of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body.

For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled and results in stiction(Any solid objects pressing against each other but not sliding will require some threshold of force parallel to the surface of contact in order to overcome static cohesion). Stiction is a *threshold*, not a continuous force in the motion of the suspension. For this reason manufacturers have experimented with mono-leaf springs.

A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. Some springs terminated in a concave end, called a spoon end (seldom used now), to carry a swivelling member.

Materials constitute nearly 60%-70% of the vehicle cost and contribute to the quality and the performance of the vehicle. Even a small amount in weight reduction of the vehicle, may have a wider economic impact. Composite materials are proved as suitable substitutes for steel in connection with weight reduction of the vehicle. Since, the composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel, multi-leaf steel springs are being replaced by mono-leaf composite springs.

2.FIBRES SELECTION

The commonly used fibres are carbon, glass, kevlar, etc. Among these, the glass fibre has been selected based on the cost factor and strength. The types of glass fibres are C-glass,S-glass and E-glass. The C-glass fibre is designed to give improved surface finish. S-glass fibre is design to give very high modular, which is used particularly in aeronautic industries. The E-glass fibre is a high quality glass, which is used as standard reinforcement fibre for all the present systems well complying with mechanical property requirements. Thus, E-glass fibre was found appropriate for this application.

2.1RESINS SELECTION

In a FRP leaf spring,the inter-laminar shear strengths is controlled by the matrix system since these are reinforcement fibres in the thickness direction, fibre do not influence inter laminar shear strength. Therefore, the matrix system should have good inter laminar shear strength characteristics compatibility to the selected reinforcement fibre. Many thermo set resins such as polyester, vinyl ester, azpoxy resin are being used for fibre reinforcement plastics (FRP) fabrication. Among these resin systems, epoxies show better inter laminar shear strength and good mechanical properties. Hence, epoxide is found to be the best resins that would suit this application. Different grades of epoxy resins and hardener combinations are classifieds, based on the mechanical properties.

3. DESIGN AND ANALYSIS RESULTS

3.1 THREE DIMENSIONAL FINITE ELEMENT ANALYSIS

The general purpose of finite element analysis software ANSYS is used for the present study. Using the advantage of symmetry in geometry and loading, only one-half of the leaf spring is modelled and analyzed. The three dimensional structure of the leaf spring is divided into a number eight-nodded 3D brick elements in order to get accurate results, more number of elements are to be created. Hence, an aspect ratio of three is maintained in the finite element model. The variation of bending stress and displacement values are predicted. The composite leaf spring from undeformed shape, it is observed from the results that the composite leaf spring functions equally as the conventional leaf spring under similar loading conditions.

CAD Modelling of any project is one of the most time consuming process. One cannot shoot directly from the form sketches to Finite Element Model. CAD Modelling is the base of any project. Finite Element software will consider shapes, whatever is made in CAD model. Although most of the CAD Modelling software have capabilities of analysis to some extent and most of Finite Element software have capabilities of generating a CAD model directly for the purpose of analysis, but their off domain capabilities are not sufficient for large andcomplicated models which include many typical shapes of the product. The model of the multi leaf spring structures also includes many complicated parts, which are difficult to make by any of other CAD modelling as well as Finite Element software and the analysis of complete Multi leaf spring is not possible in ANSYS. Therefore, a single main leaf is taken and the design is drawn using CAD modelling software “CREO”.The CAD model of main single leaf spring used for analysis is shown in Fig-3.1.1 below:-

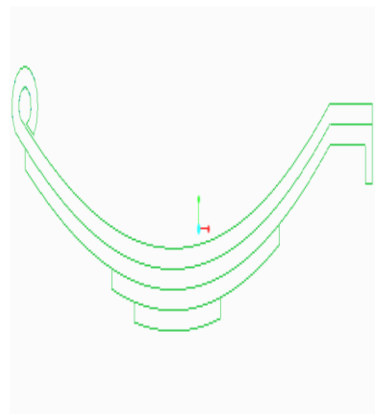


Fig 3.1.1 Design of leaf spring (2D model)

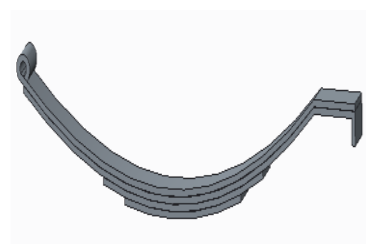


Fig 3.1.2 Design of leaf spring (3D model)

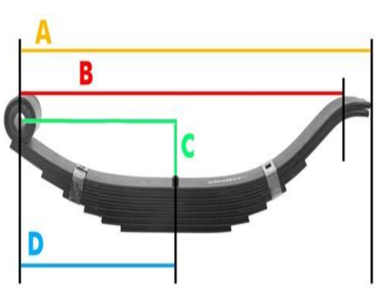
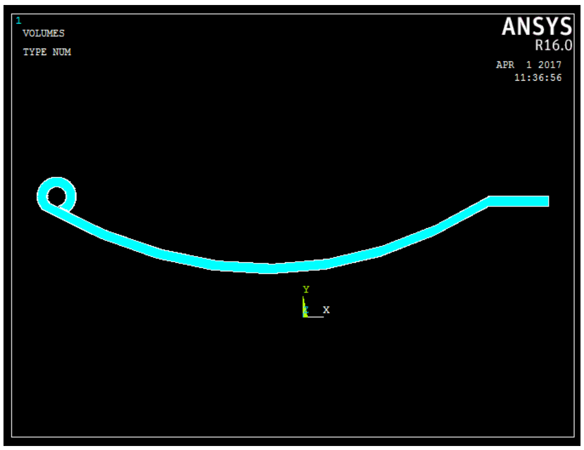


Fig. 3.1.2 Design of Hook Down Slipper Leaf Spring

where
A = 816mm
B = 716mm
C = 114mm
and D = 397mm



3.2 MESHED MODELS OF THE LEAF SPRING

The CREO model of leaf spring is now imported into ANSYS as shown below in Fig-3.2.1. All the boundary conditions and material properties are specified as per the standards used in the practical application. The material used for the leaf spring for analysis is structural steel, which has approximately similar isotropic behaviour and properties as compared to 65Si7.

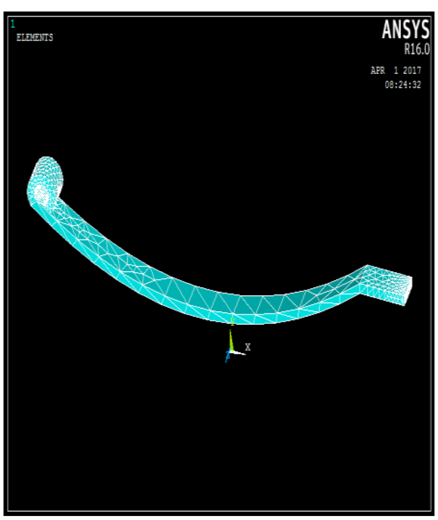


Fig 3.2.1 Meshed model in ANSYS (STEEL LEAF SPRING)

Similarly, the properties of the preferred composite material has been given as input and a desired meshed model of the composite material is created using ANSYS. The meshed model of the composite leaf spring is shown below in the Fig-3.2.2:-

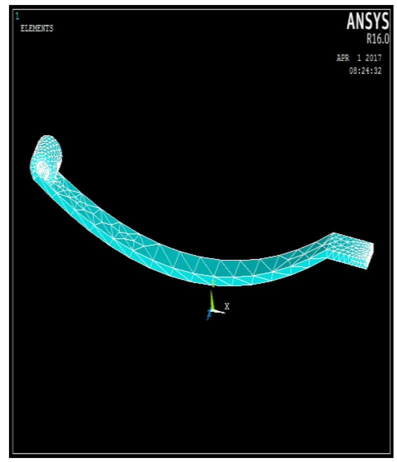


Fig3.2.2 Meshed model in ANSYS (COMPOSITE LEAF SPRING)

4. RESULTS AND DISCUSSIONS

Steel vs E-Glass Epoxy

Steel vs E Glass Epoxy (at point load 17,500 KN)				
	Steel at point Load		Composite at point Load	
	Minimum	Maximum	Minimum	Maximum
Displacement of sum vector	0	15.984	0	38.8545
Stress in X	-1788.67	908.357	-1664.63	855.208
Stress in Y	-1581.02	1491.79	-1442.56	1459.66
Stress in Z	-881.102	479.35	-647.212	397.074
Von Mises	11.0437	2646.56	10.0509	2699.67

Steel vs E-Glass Epoxy

Steel vs E Glass Epoxy (at point load 4,000 KN)				
	Steel at point load		Composite at point load	
	Minimum	Maximum	Minimum	Maximum
Von Mises	1.64101	309.071	1.50618	315.239

Steel vs E Glass Epoxy (at UDL 4,000 KN)				
	Steel at UDL		Composite at UDL	
	Minimum	Maximum	Minimum	Maximum
Von Mises	22,974.6	.389E+07	21,643.3	397E+07

5.CONCLUSION

1. The composite leaf spring is designed according to constant cross-section area method.
2. The 3-D model of the composite leaf spring is analyzed using finite element analysis.
3. A comparison chart on stress and displacement has been created based on the analysis results of the steel and composite leaf spring.
4. A comparative study has been made between composite and steel leaf springs with respect to weight, riding quality. From the study and analysis results, it is seen that the composite leaf spring are lighter and more economical than that of conventional steel leaf springs for similar performance. Hence, the composite leaf springs are the suitable replacements to the conventional leaf springs.

6.REFERENCES

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