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Static Analysis of Leaf Spring Made of Composite Material

Ankit Gaur[1] , Prabhash Jain [2]

[1]*Ankit Gaur, M. Tech Scholar, Dept. of Mechanical Engineering, BUIT, Bhopal*
[2]*Prabhash Jain, Professor & Head, Dept. of Mechanical Engineering, BUIT, Bhopal*

***Abstract* - In this paper, we have proposed the composite materials for manufacturing the leaf spring of a vehicle in place of the traditional metals. Composites are not only good in strength but also less in weight and corrosion resistant. Due to high fuel prices in the market, the automobile industries are showing keen interest in replacing the heavy metallic parts with the lighter weight materials. This work shows the comparison of the performance of a composite spring and the traditional metallic spring. Composite leaf springs are not only lighter in weight but also less noisy than the metallic leaf spring. The leaf spring model is made in the CATIA software and the analysis was done using ANSYS 14. The composite material taken for the study is E glass epoxy which is an advanced composite.**

***Keywords*- Leaf Spring, E Glass Epoxy, ANSYS, CATIA, Equivalent stress, Elastic strain and Total deformation.**

I. INTRODUCTION

A spring is an elastic body whose main function is to distort when loaded and regain its shape and size when load is removed. Leaf springs are commonly used in the suspension system of vehicles. The use of the leaf spring goes back even to the medieval times. The spring are made up of the flat rectangular plates of slender arc shape stacked on top of each other. The center of the leaf contains the axle , while tie holes called eyes are provided at either end for attaching to the vehicle body. For heavy spring number of leaves are stacked on each other with progressively shorter leaves. It consist of full length and graduated leaves. Multi leaf spring carries lateral loads, brake torque, driving torque in addition to shock absorbing. Advantages of leaf spring over helical spring are that the ends of the springs are guided along a definite path and it is act as a structural member.

The strain energy of the materisal becomes a major factor in designing the springs. The relationship of the specific strain energy can be expressed as

$$U = \sigma^2 / 2 \rho E$$

Where σ is the strength,

ρ is the mass density

E is the Young's modulus of the spring material.

Leaf spring serves damping as well as springing functions. leaf spring can be attached with the frame from both ends or the front end attached directly and the rear end with the help of a shackle. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness.

A composite is any material that have been physically assembled to form one single bulk without physical blending to form a homogeneous material. The resulting material still have the constituent of different materials. Advantage with composite material is that different material could be combined to take the advantage of the characteristics of each constituent. The construction of

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automotive components with the composite materials helps in conserving natural resources and economize energy. As there is direct proportionality between the weight of the vehicle and its fuel consumption the advanced composite materials such as Graphite, Carbon, Kevlar and Glass with suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/density).

Advanced composite material can easily be used for the suspension in the vehicles, as their elastic properties can be easily tailored to increase strength and reduce the stress induced while suspension.

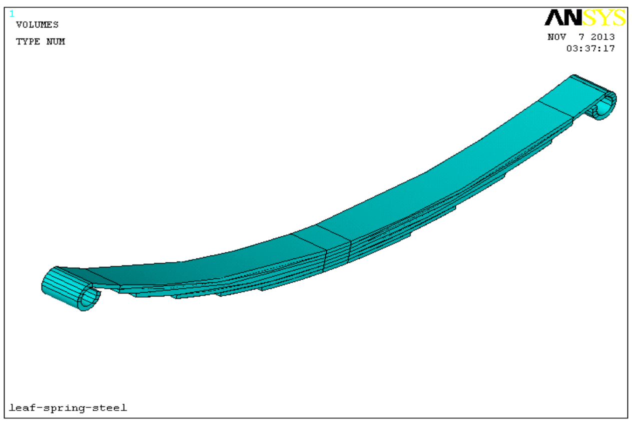

Fig 1.1 Leaf Spring

II. OBJECTIVES

In this work we analyze a spring of E-Glass /Epoxy composite by making a model of leaf spring with the help of a CAD and CAE packages. This is done to achieve the following objective-.

1. To study the behavior of composite spring in comparison with the traditional steel leaf spring.
2. To check the results of deflection in composite leaf spring in comparison with the traditional steel leaf spring.
3. To find out the frequency change in composite leaf spring.
4. To reduce the weight of spring to increase the efficiency of the vehicle.

COMPOSITE MATERIALS

Composite Material are generally made up of two and more materials with significant different physical and chemical properties that when combined to form a material which are different from the constituents.

In this analysis the material of the composite leaf spring is E- glass epoxy. There are four layers of material is layup in following manner:

- The E glass Epoxy is also type of fiber.
- SiO_2 54wt%
- Al_2O_3 14wt%
- CaO+MgO 22wt%
- B_2O_3 10wt%
- Na_2O+K_2O less then 2wt%.

The following are the properties of E-glass epoxy used for the analysis which are as follows.

S. No.	Properties	Values
1.	Tensile modulus along X-direction	34000MPa
2.	Tensile modulus along Y-direction	26530MPa
3.	Tensile modulus along Z-direction	36530MPa
4.	Tensile strength of material	4900MPa
5.	Compressive strength of the material	450MPa
6.	Shear modulus along XY-direction	2433MPa
7.	Shear modulus along YZ-direction	1698MPa
8.	Shear modulus along ZX-direction	2433MPa
9.	Poisson ratio along XY-direction	0.217MPa

10.	Poisson ratio along Y Z direction	0.366MPa
11.	Poisson ratio along ZX-direction	0.217MPa
12.	Mass density of the material	2.6×103Kg/mm3
13.	Flexural modulus of material	40000MPa
14.	Flexural strength of material	1200MPa

Table 2.1 Properties of E-Glass Epoxy

Parameter	Specification
Material	Steel(55Si2Mn90)
Tensile Strength	1962N/Sq. mm
Yield Strength	1470N/Sq.mm
Young's Modulus	2.1e5 N/Sq.mm

Table 2.2 Steel Properties

III. METHODOLOGIES

FEA uses a complex system of points called nodes which make a grid called a mesh as shown in fig.3.1. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those awhich experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

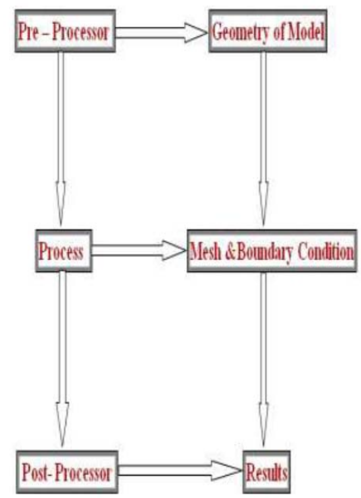

Fig.3.1 Block diagram of CAE

A 3D model design of multi-leaf spring has created in software.CATIA software having special tools in generating surface design to construct typical surfaces, which are later, converted into solid models. Solid model of all parts of the structures are then assembled to make a complete structure.

The 3D model of multi leaf spring is used for FE Analysis . The multi leaf spring model for conventional leaf spring and composite leaf springs has imported in to the ANSYS-14 workbench.

A stress-deflection analysis has performed using finite element analysis (FEA). The complete procedure of analysis has done using ANSYS-14 Workbench. Generally to conduct finite element analysis process is divided into three main phase's pre-processor, solution and post processor.

IV. DESIGN OF LEAF SPRING

The leaf spring used for the study was taken from Bajaj loading auto. Various dimension of the spring has carefully measured with help of precise measuring instruments. The dimensions of the leaf spring is shown b the fig.

The cross section is considered according to the real spring and not altered. For ease in manufacturing a uniform rectangular cross section is considered and analyzed with CAE Package.

Fig. 4.1 Meshed view of leaf spring

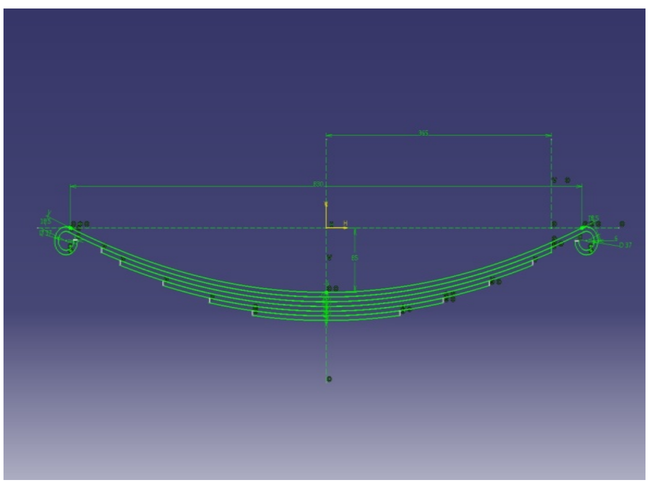

Fig. 4.2 Dimensioned view of leaf spring

STATIC ANALYSIS OF LEAF SPRING

The leaf spring modeled in the CATIA and then imported to the X_T format. As the spring is a solid , solid element named Solid 8 node 45 was used to mesh the model. Solid 45 element is a 8 node element. The solid 45 is well suited to modeling irregular meshes. The element has 8 nodes and three degrees of freedom at each node translations in the nodal x, y, and z directions. The element has plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities.

V. RESULTS AND CONCLUSION

As observed from the results the stress induced in both the steel and composite springs had little difference, but the deflection is more in composite spring than in steel spring.

Material	Weight of spring in Kg	Total Deformation in mm	Stress in MPa	Von mises Stress in MPa
Steel	7.1	0.693	22.973	52.023
Eglass Epoxy	2.34	7.5	22.42	55.774

Table 5.1 Comparison of Steel E Glass Epoxy

The weight of the composite leaf spring is significantly lesser than its steel counterpart. The composite leaf spring shows acceptable values of stress induced as that of steel leaf spring. Composite leaf spring can give good performance on good roads. But things will change on rough roads. Composite leaf spring also provides better corrosion resistance. But at rough roads performance of composite leaf spring may vary due to lower chipping resistance failure .

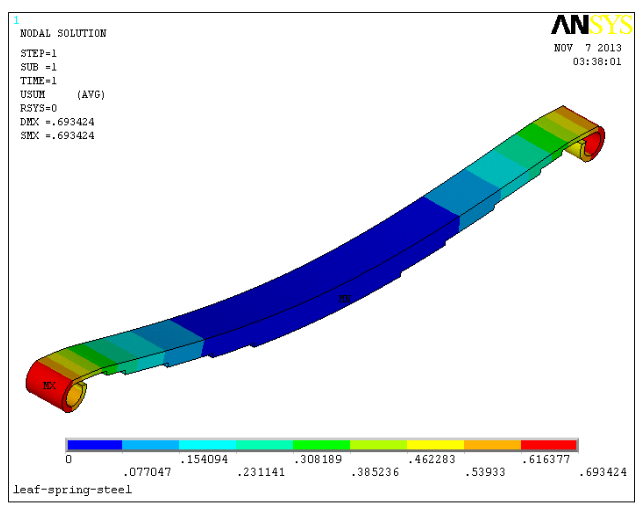

Fig. 5.1 Displacement diagram

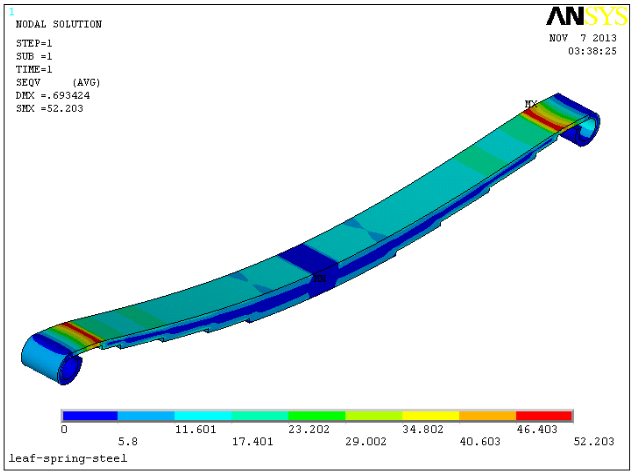

Fig. 5.2 Voin moises stress of Steel

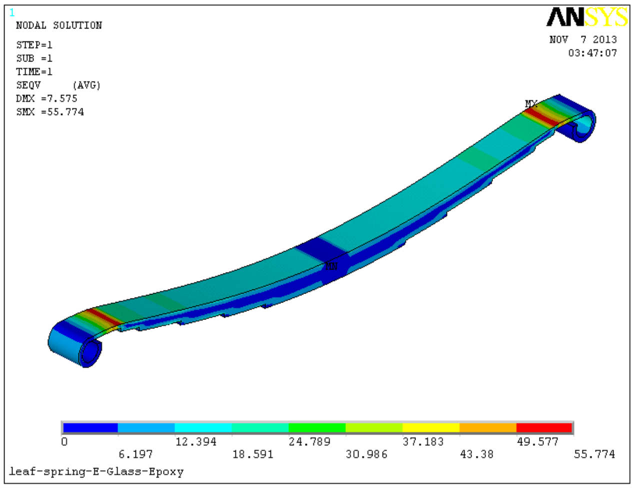

Fig. 5.3 Von moises stress in E Glass Epoxy

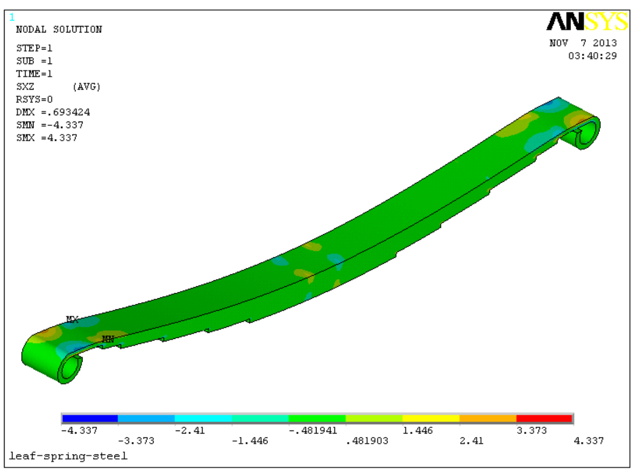

Fig. 5.4 Shear stress in XY direction (Steel)

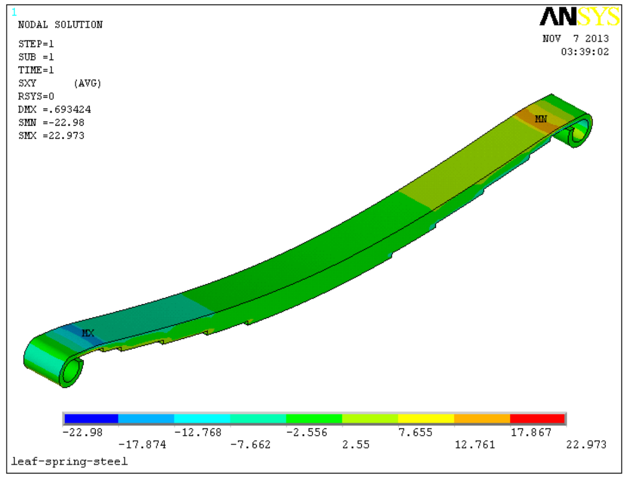

Fig. 5.5 Shear stress in XZ direction (Steel)

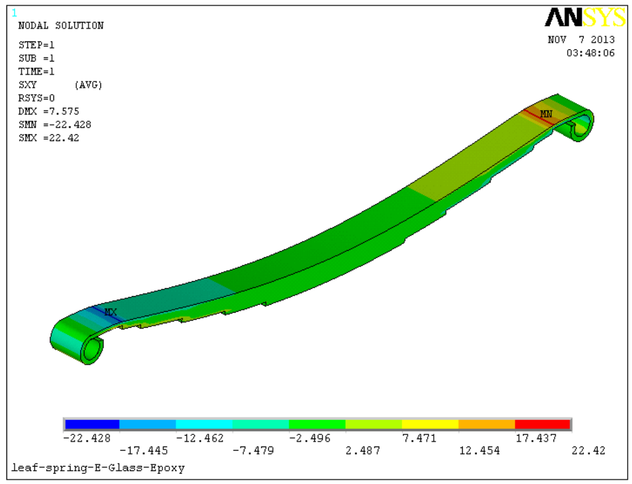

Fig. 5.6 Shear stress in XY direction (E Glass Epoxy)

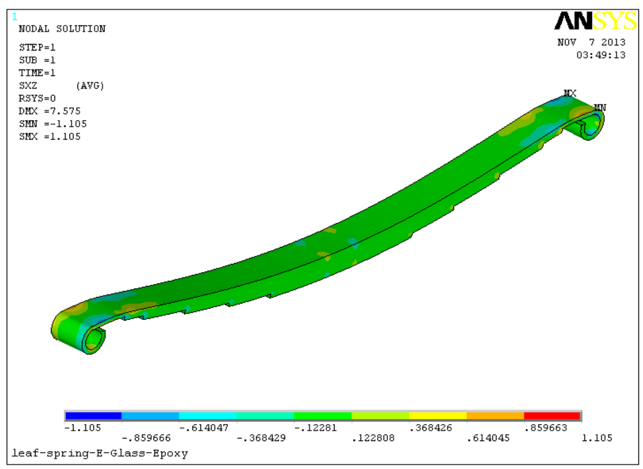

Fig. 5.7 Shear stress in XZ direction (E Glass Epoxy)

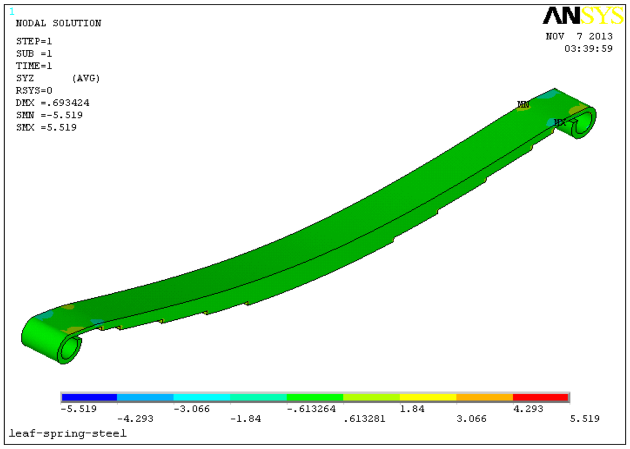

Fig. 5.8 Shear stress in YZ direction (Steel)

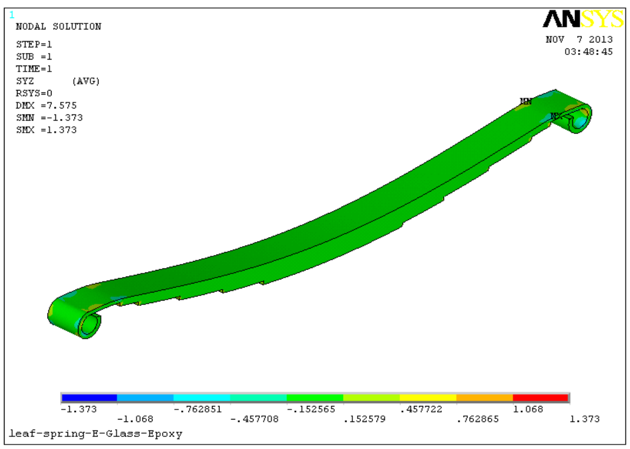

Fig. 5.9 Shear stress in YZ direction (E Glass Epoxy)

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