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# Modeling and Analysis of Monochromatic Composite Leaf Spring Using FEM

C.Madan Mohan Reddy*, G.Guru Mahesh ** M.Tech

* Dept. of mechanical engineering, Madanapalle institute of Technology & science Madanapalle
** Assistant Professor Madanapalle institute of Technology & science Madanapalle

## ABSTRACT:

In this present work is carried out on modeling and analysis of mono chromatic composite leaf spring to replace the earlier conventional steel leaf spring. The work is to reduce the overall weight of suspension system and improve load carrying capacity of the leaf spring by using the composite material. The design considerations for this study are stress and deflection. The composite materials used for this leaf spring are polymer epoxy as matrix phase and glass fibers as reinforcement phase. The some of the glass fibers used for this are E-glass epoxy, graphite-epoxy, Kevlar-epoxy. The comparison is made between steel leaf spring of light weight vehicle and composite leaf spring in terms of strength and stiffness. The static analysis is done and compare with theoretical values with ansys. The modeling is developed on proe-5 and analysis is carried out on ansys-14.

KEY WORDS: composite materials- leaf spring-modeling- static analysis- comparison.



## 1. INTRODUCTION:

Composite materials are the one of the main applications of the aerospace, automobiles and marine Industries. Because of their less weight, good stiffness and less corrosive properties. Weight reduction is one of the major factors of that one. It results in less fuel consumption; economize maintenance of vehicle and optimum utilization of natural resources. The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the un sprung weight. This helps in achieving the vehicle with improve good riding qualities. As we know that springs, are designed for absorb and store energy after it releases slowly. Hence, the strain energy of the material becomes a major factor in designing the springs. The conventional steel leaf spring is replaced with composite material, because of their more elastic strain energy storage capacity, good strength to weight ratio, good riding properties and, density good modulus of elasticity.

## 1.2 LEAF SPRING:

Leaf springs are also known as flat springs or carriage springs .Leaf spring is an elastic body, whose functions to distort when load applied and to recover its original shape, after load is removed. Applications of leaf springs are as follows to cushion, absorb or control energy due to either Shock or vibration as in automobiles. The leaf springs suppose to carry loads, brake torque, driving torque. The leaf springs used are single or multi leaf springs are there. Today leaf springs are still used in commercial vehicles such as cars, vans and trucks, and railway carriages. For heavy vehicles, they have the advantage of spreading the load more widely over the vehicle's chassis. The main importance of leaf spring is to carry bump loads (i.e. due to road irregularities), supports the chassis weight, controls axle damping, controls braking forces, and to provide better suspension. Leaf springs are designed in two ways:

1. Multi leaf

2. Mono leaf.

The multi-leaf spring is made up of several steel plates of different length stacked together, while mono-leaf spring is made up of single steel plate. During normal operation, the spring compresses to absorb road shock. The leaf spring bends and slide on each other allowing suspension movement. Leaf springs can serve locating and to some extent damping as well as springing functions. The leaf spring absorbs the vertical vibrations and impacts due to road irregularities by means of vibrations in the spring deflection so that the potential energy is stored in spring as strain energy and then released slowly.

## 1.3 SPECIFICATIONS OF MONO LEAF SPRING

The mono leaf steel spring specifications as follows. The chemical composition of the material is 0.565C, 1.8%Si, 0.7%Mn, 0.045%P and 0.045% S.

Table 1shown various parameters of steel leaf spring.

| Si.No | Parameter | value |
|---|---|---|
| 1. | Total length of the spring(Eye to Eye) | 965 mm |
| 2. | Free camber (At no load condition) | 68 mm |
| 3. | No. of full length leave (Master Leaf) | 01 |
| 4. | Thickness of leaf | 10 mm |
| 5. | Width of leaf spring | 50 mm |
| 6. | Maximum load given on spring | 794.54 N |
| 7. | Young's Modulus of leaf spring | 2.1e5 N/mm2 |

Table No 1

## 1.4THE ANALYTICAL CALCULATIONS FOR STEEL LEAF SPRING:

The maximum deflection of the mono leaf spring is limited to 34mm, and then the allowable load on the spring is given by

Deflection

δ = 12*W*L3 / E*b*t3*(2nG+3nF)

34= 12*W*L3 / E*b*t3*(2nG+3nF)

Weight W=795N

Stress

σ = 6*W*L / n*b*t2

= 6*794.5*483 / 1*50*102

Stress σ=451.5Mpa

## 1.5 COMPOSITE MATERIALS:

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Composite materials are composed of inclusions suspended in a matrix. The constituents retain their identities in the composite. In general the components can be physically identified and there is an interface between them. Some of the composite materials offer a combination of strength and modulus that are either comparable to or better than any traditional metallic materials which we have earlier. Because of their low specific gravities, strength weight-ratio and modulus of elasticity. These composite materials are better than those of metallic materials. The fatigue strength and weight ratios as well as fatigue damage tolerances of composite laminates excellent. For this reasons, fiber composite have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries. Some other characteristic of many fiber reinforced composites is their high internal damping. This results to better vibration energy absorption within the material and results in reduced transmission of noise and vibration to neighboring structures. High damping capacity of composite materials can be beneficial in many aerospace, automotive applications in which noise, vibration, strength and hardness is a critical issue for passenger comfort. Among the other environmental factors that may cause degradation in some of the mechanical properties of some polymeric matrix composites are elevated temperatures, corrosive fluids, and ultraviolet rays. In many metal matrix composites, oxidation of the matrix well as adverse chemical reaction between fibers and matrix are of great concern at high temperature applications.

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## 1.6 THE SPECIFICATIONS OF COMPOSITE MATERIALS:

Table 2shown various parameters of composites.

| Material properties | E-Glass Epoxy | Graphite Epoxy | Kevlar Epoxy |
|---|---|---|---|
| E11 | 34 | 142.6 | 80 |
| E22 | 65.3 | 96.0 | 55 |
| G12 | 24.33 | 6.00 | 2.2 |
| G23 | 16.98 | 3.10 | 1.8 |
| V12 | 0.217 | 0.25 | 0.34 |
| V23 | 0.366 | 0.25 | 4 |

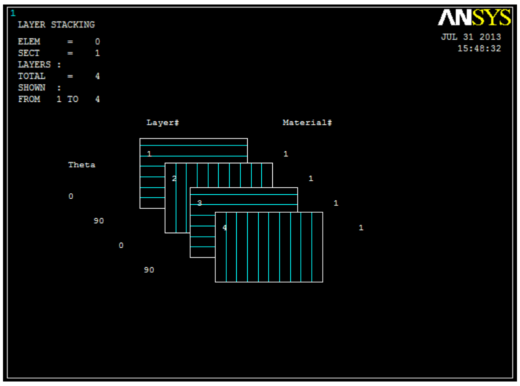
Table 2

## 1.7 FINITE ELEMENT ANALYSIS

Finite element structural analysis is a method of predicting the behavior of a real structure under specified load and displacement conditions. The finite element modeling is generalization of the displacement or matrix method of structural analysis to two and three-dimensional problems and three -dimensional problems. The basic concept of FEM that structure to be analyzed is considered to be an assemblage of discrete pieces called "elements" that are connected together at a finite number of points or nodes. The finite element is a geometrically simplified representation of a small part of the physical structure. Discretising the structure requires experience and complete understanding of the behavior of the structure can behave like a beam, truss, plate, and shell.

### 1.7.1 Analysis of Steel, Composite Leaf Spring

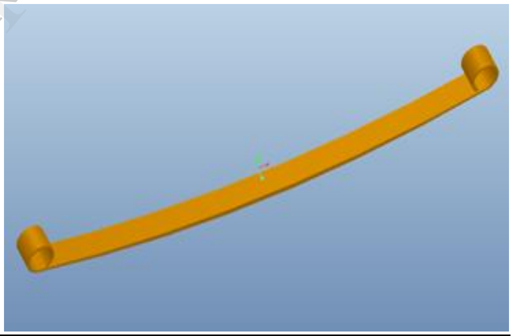
The analyses are carried out on steel leaf spring by considering as cantilever beam. The cantilever beam is fixed at one end and load is acting at another end. The analyses of composites are also considered as cantilever. The selected material for composite is SHELL181.This capability of modeling laminar composites up to 255 layers. We can modify the properties of each layer in the Section Properties section. The advantage of using layered shell elements is great since a complex CAD model with fibers need not be constructed. We can store the results of each layer from the Top, Middle, and Bottom Lamina in SHELL181.Since we have 4 layers. The orientation of e-glass, graphite, Kevlar fibers to matrix phase is considered as (0-90°).



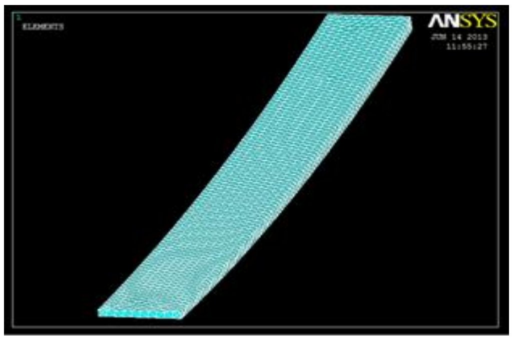

Fibers orientations on composite material



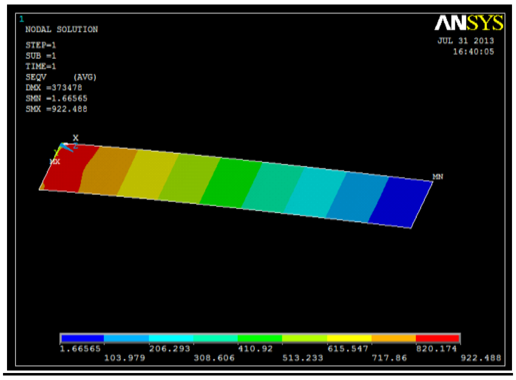
## The results obtained on ansys



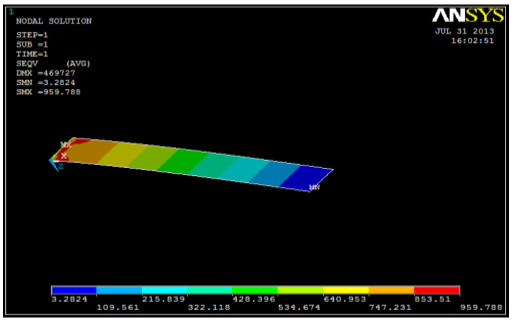
Leaf spring pro E model



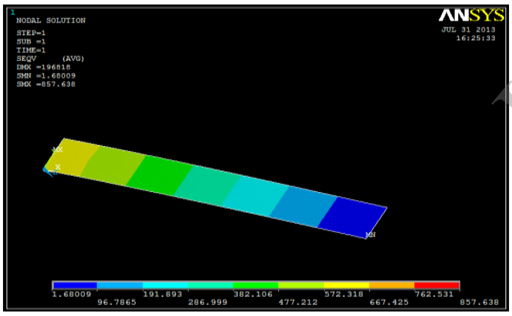

Leaf spring cantilever mesh



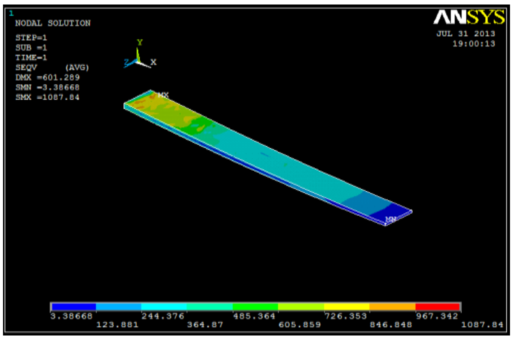

Kevlar epoxy vonmises stress




E glass epoxy vonmises stress




Graphite epoxy vonmises stress




Steel leaf spring vonmises stress

## The vonmises stress obtained as follows

| parameter | steel | E glass | Graphite epoxy | Kevlar epoxy |
|---|---|---|---|---|
| Vonmises stress (N/mm2) | 1087 | 959 | 857 | 922 |

## 1.8 CONCLUSION:

- The analytical study has been made between steel and composites.
- It is observe that the graphite epoxy having lower stress value with compare to steel and all other composites.
- By observing results composite leaf spring have good strength to weight ratio, good stiffness.

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