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# A PERFORMANCE EVALUATION OF LEAF SPRING REPLACING WITH COMPOSITE LEAF SPRING


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**Abstract -** The automobile industry has shown increased interest in the replacement of steel spring with fibre glass composite leaf spring due to high strength to weight ratio. Therefore the aim of this work is to reduce the weight and low cost fabrication of complete mono composite leaf spring and mono composite leaf spring with bonded end joints. Also, general study on the analysis and design. A single leaf with variable thickness and width for constant cross sectional area of unidirectional glass fibre reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf spring, was designed, fabricated (hand- layup technique) and tested. The results showed that an spring width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat. The finite element results using ANSYS software showing stresses and deflections were verified with analytical and experimental results. The design constraints were stresses (Tsai-Wu failure criterion) and displacement. Compared to the steel spring, the composite spring has stresses that are much lower, the natural frequency is higher and the spring weight is nearly 85 % lower with bonded end joint and with complete eye unit.



***Keywords:-*** *composite, glass fibre reinforced plastic (GFRP),*


## I. INTRODUCTION

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. 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 unsprung weight. This helps in achieving the vehicle with improved riding qualities. It is well known that springs, are designed to absorb and store energy and then release it. Hence, the strain energy of the material becomes a major factor in designing the springs.

The relationship of the specific strain energy [3] can be expressed as

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

Where, $\sigma$ is the strength

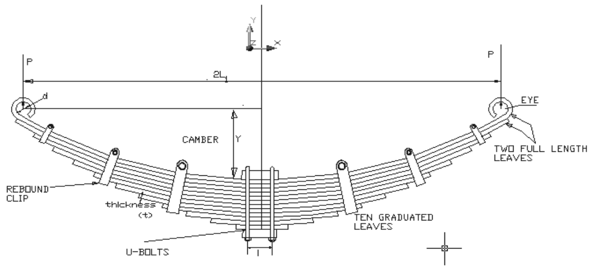
$\rho$ is the density

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

It can be easily observed that material having lower modulus and density will have a greater specific strain energy capacity. The introduction of composite materials was made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness [1].

In every automobile, i.e. four wheelers, trucks the leaf spring is one of the main components and it provides a good suspension and it plays a vital role in automobile application. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device [2].

## II. GEOMENTRY OF SPRING




## III. LITERATURE SURVEY

- Rajendran studied the application of composite structures for automobiles and design optimization of a composite leaf spring. Great effort has been made by the automotive industries in the application of leaf springs made from composite materials.
- S. Vijayarangan showed the introduction of fibre reinforced plastics (FRP) made it possible to reduce the weight of a machine element without any reduction of the load carrying capacity. Because of FRP materials high elastic strain energy storage capacity and high strength-to-weight ratio compared with those of steel, multi-leaf steel springs are being replaced by mono leaf FRP springs .

- H.A. Al-Qureshi study on the analysis, design and fabrication of composite springs. From this viewpoint, the suspension spring of a compact car, “a jeep" was selected as a prototype. A single leaf, variable thickness spring of glass fiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf steel spring, was designed, fabricated (moulded and hoop wound) and tested. The testing was performed experimentally in the laboratory and was followed by the road test. Comparison between the performance of the GFRP and the multi leaf steel springs is presented. In addition, other relevant parameters will be discussed [8].

- Mouleeswaran Kumar This paper describes static and fatigue analysis of steel leaf spring and composite multi leaf spring made up of glass fibre reinforced polymer using life data analysis. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle are taken and are verified by design calculations. Same dimensions of conventional leaf spring are used to fabricate a composite multi leaf spring using E-glass/Epoxy unidirectional laminates. The load carrying capacity, stiffness and weight of composite leaf spring are compared with that of steel leaf spring analytically and experimentally.

*A. DEFINITION*

**Composite** A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the *reinforcing phase* and the one in which it is embedded is called the *matrix* [3]. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibers, etc [2].

*B. CLASSIFICATION*

Matrix Based [5]

- Polymer Matrix Composites
- Metal Matrix Composites
- Ceramic Matrix Composites

Reinforcement Based

- Fiber Reinforced Composites
- Whisker Reinforced Composites
- Particle Reinforced Composites

## III. LEAF SPRING

The spring is a machine part used to absorb sudden loads and to accumulate elastic energy [3]. There are different mechanical designs and forms of springs [2]. The spring under consideration is called a *leaf spring.* A typical leaf spring is shown in Figure shows the leaves hold together by a (1) centre bolt and (2) clamp. Fig. show different spring ends used in practice. The top leaf is designated as the main leaf. fig. shows various parts of the of leaf spring

Leaf spring:
(a) Spring (1, centre bolt; 2, clamp),
(b) Eye spring end, and
(c) Plain spring end.

## IV. DESIGN PARAMETER OF STEEL LEAF SPRING

Parameters of the steel leaf spring used in this work are shown in Table 1

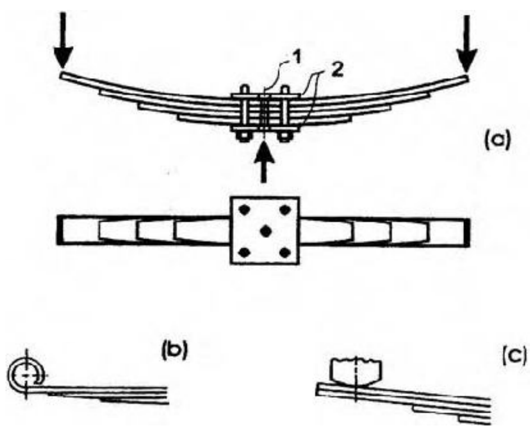
The expression for bending stresses [6],

The deflection, given by

Appro. Mass of spring is given by

M = (one half of spring length *SF) (Unit mass from table)/1000

TABLE 1



## V. ANALYSIS OF COMPOSITE LEAF SPRING

| Parameter | Value |
|---|---|
| Material selected-Steel | 55Si2Mn90 |
| Tensile strength (N/mm$^2$) | 1962 |
| Yield strength (N/mm$^2$) | 1470 |
| Young's modulus E (N/mm$^2$) | 2.1*10$^5$ |
| Design stress ($\sigma_b$) (N/mm$^2$) | 653 |
| Total length (mm) | 1190 |
| The arc length between the axle seat & the front eye(mm) | 595 |
| Arc height at axle seat (mm) | 120 |
| Spring rate (N/mm) | 32 |
| Nominal static loading (N) | 3850 |
| Available space for spring width (mm) | 60-70 |
| Spring weight (kg) | 26 |

To design composite leaf spring, a stress analysis was performed using the finite element method done using ANSYS software. Analysis carried out for composite leaf spring for Glass/Epoxy, Graphite/Epoxy and Carbon/Epoxy composite materials and the results were compared with steel leaf spring.

**For steel leaf spring**
Boundary condition: - In this analysis is one end is assumed to be fixed and loading is
applied at other end. A finite element stress analysis is performed under full bump loading [9].

- Element type & density:- every leaf with eight-node 3D brick element (solid 45)
- five-node 3D contact element (contact 49)

**For composite leaf spring**
Element type & density for mono composite leaf spring [5]: - eight-node 3D SOLID46.
(For multi leaf spring to establish contact between the leaves, the interface elements
CONTACT174 and TARGET170 are chosen.)
Figs. represent FEA results for steel and mono composite leaf spring (Glass/Epoxy) [5].

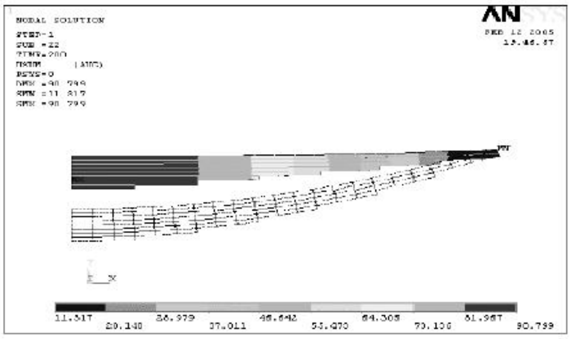


**Fig.5.1 Displacement pattern for steel leaf spring**

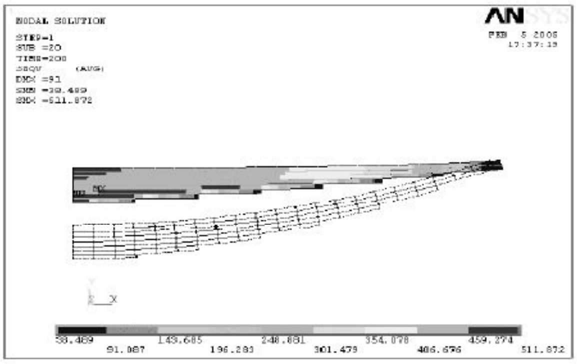


**Fig.5.2 shows Stress distribution for steel leaf spring [9].**

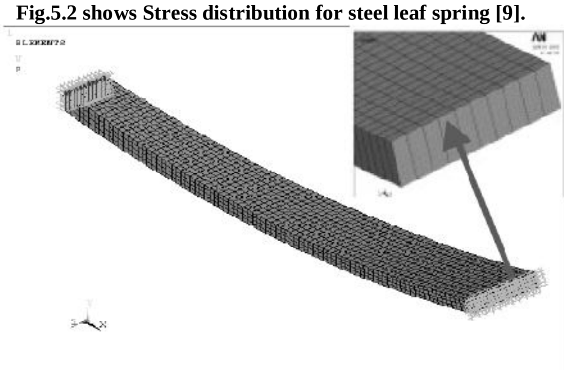


**Fig.5.3 show Boundary conditions and meshed model of mono Composite leaf spring [9].**

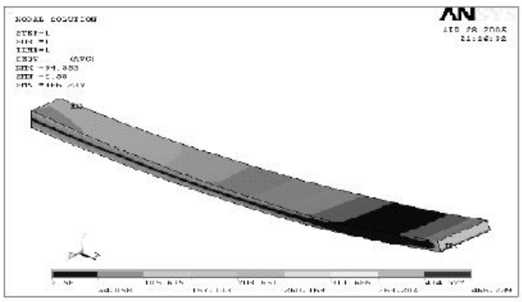


**Fig.5.4 shows Stress distribution for Glass/Epoxy composite mono leaf spring**

| MATERIAL | STATIC LOAD (N) | MAX.DEFLECTION (mm) | | MAX.STRESSES (Mpa) | | WEIGHT (Kg) |
|---|---|---|---|---|---|---|
| | | *FEA* | *Numerical* | *FEA* | *Numerical* | |
| Steel | 3980 | 90 | 107.5 | 511 | 653 | 26.0 |
| E-glass/ Epoxy | 4250 | 94 | 105.0 | 466 | 473 | 3.88 |
| Graphite/Epoxy | - | 68 | - | 422 | - | 2.33 |
| Carbon/Epoxy | - | 62 | - | 413 | - | 2.39 |

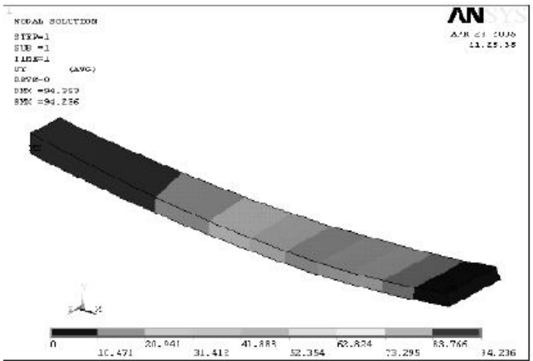



**Fig5.5 show Displacement pattern for Glass/Epoxy composite leaf spring [9].**

## VI. ESULT DISCUSSION

Numerical results of the leaf spring under static loading containing the stresses and deflection are listed in the Table. These results are also compared with FEA in Table. Since the composite leaf spring is able to withstand the static load, it is concluded that there is no objection from strength point of view also, in the process of replacing the conventional leaf spring by composite leaf spring. Since, the composite spring is designed for same stiffness as that of steel leaf spring, both the springs are considered to be almost equal in vehicle stability. The major disadvantages of composite leaf spring are chipping resistance.

- The weight of the leaf spring is reduced considerably about 85 % by replacing steel leaf spring with composite leaf spring. Thus, the objective of the unsprung mass is achieved to a larger extent. The stresses in the composite leaf spring are much lower than that of the steel spring.
- From the results, it is observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications.

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