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Automobile Leaf Spring from Composite Materials

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Abstract*—*Automobiles today are over 63% iron and steel by weight .With rising energy and environmental concerns, as well as increases in electronics and other on-board vehicle systems. Vehicle light-weighting continues to be a prominent concern for vehicle manufacturers. New structural materials - metals, ceramics, polymers or hybrid materials derived from these, called composites – open a promising avenue in automobile industries. This paper describes design and experimental analysis of composite leaf spring made of glass fiber reinforced polymer. The objective is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring and describes the significant economic potential of polymer composite and to replace automobile components (leaf Spring) against the steel.

***Keywords:* polymers, ceramics, composites, leaf spring.**

I. INTRODUCTION

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers 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 automobiles as it accounts for 10% - 20% of the unstrung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. 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. The composite material offer opportunities for substantial weight saving but not always are cost-effective over their steel counter parts. The leaf spring should absorb the vertical vibrations and impacts due to road irregularities by means of variations in the spring deflection so that the potential Energy is stored in spring as strain energy and then released slowly. So, increasing the energy storage capability of a leaf spring ensures a more compliant suspension system. According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring. Fortunately, composites have these characteristics.

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II. LEAF SPRING

Leaf springs also known as flat spring are made out of flat plates. Leaf springs are designed two ways: multi leaf and mono-leaf. The leaf springs may carry loads, brake torque, driving torque etc, In addition to shocks. The multi-leaf spring is made of several steel plates of different lengths stacked together. During normal operation, the spring compressed to absorb road shock. The leaf springs bend and slide on each other allowing suspension movement.

2.1 Construction of Leaf Spring

The leaves are usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaves are held together by means of band shrunk around them at the centre or by a bolt passing through center. Since, the band exerts stiffening and strengthening effect, therefore effective length of the spring for bending will be overall length of the spring minus width of the band. In case of a center bolt, two-third distance between centers of U-bolt should be subtracted from the overall length of the spring in order to find effective length. The spring is clamped to the axle housing by means of U-bolts. The longest leaf known as main leaf or master leaf has its ends formed in the Shape of an eye through which the bolts are passed to secure the spring to its supports. The other leaves of the spring are known as graduated leaves. In order to prevent digging in the adjacent leaves, the ends of the graduated leaves are trimmed in various forms. Rebound clips are located at intermediate positions in the length of the spring, so that the graduated leaves also share the stress induced in the full length leaves when the spring rebounds.

2.2 Materials for Leaf Springs

The material used for leaf springs is usually a plain carbon steel having 0.90 to 1.0% carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel products greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties.

III. COMPOSITE MATERIAL

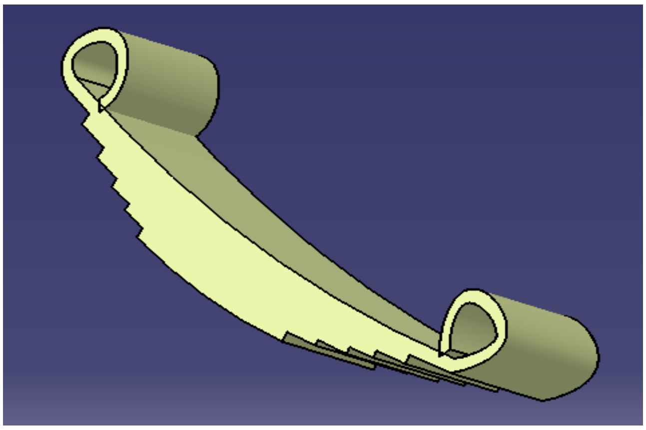
3.1 Characteristics

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds.

Typical composite materials are composed of inclusions suspended in a matrix. The constituents retain their identities in the composite. Because of their low specific gravities, the strength weight-ratio and modulus weight-ratios of these composite materials are markedly superior to those of metallic materials. The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates excellent. For these reasons, fibre composite have emerged as a major class of structural material are either used or being considered for metal in any weight critical components in aerospace, automobile and other industries.

IV. DESIGN ANALYSIS OF LEAF SPRING USING COMPOSITES

4.1 3D Model of a Leaf Spring



4.2 Analysis of Leaf Springs using ANSYS

All the analysis for the springs is done by using ANSYS 12.0. For composite leaf spring the same parameters are used as that of conventional leaf spring. For designing of leaf spring the camber is taken as 200 mm. Leaf spring is modelled in Catia software and it is imported in ANSYS 12.0. The constraint is given at the two eye-rolled ends. One of the ends is provided with translational movement so as to adjust with the deflection. This eye end is free to travel in longitudinal direction .This particular motion will help leaf spring to get flattened when the load is applied. The stress and deflection analysis is done for conventional and composite leaf spring using ANSYS software. The results for both composite and conventional leaf spring is compared and given below.

4.2.1 Conventional Leaf Spring

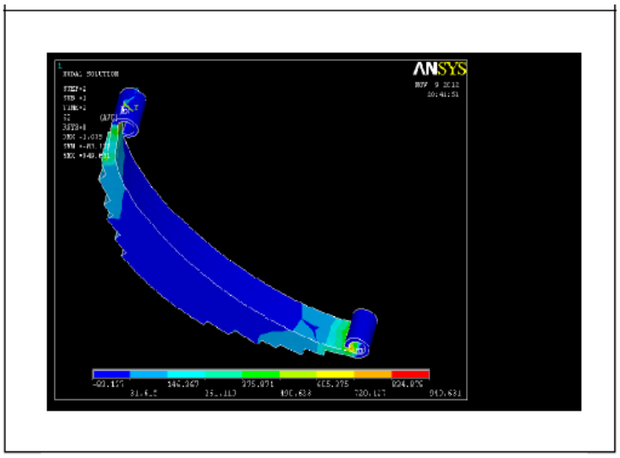


Fig. 4.1 Stress Analysis of Conventional Leaf Spring

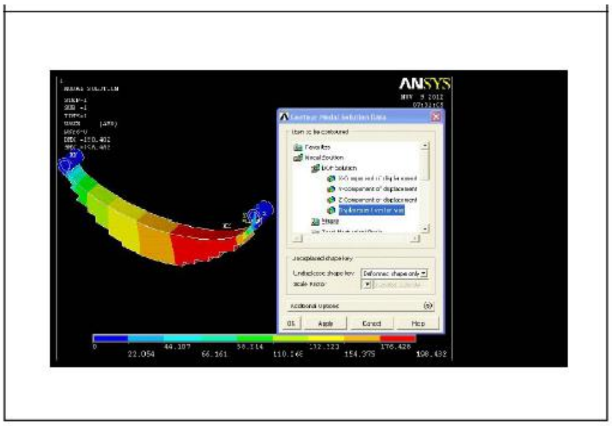


Fig. 4.2 Deflection Analysis of Conventional Leaf Spring

4.2.2 Composite Leaf Spring

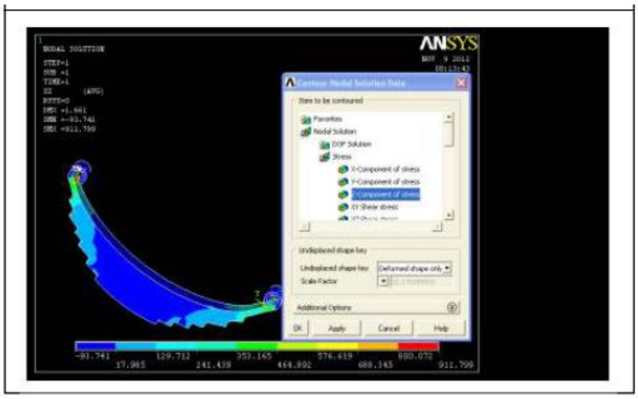


Fig. 4.3 Stress Analysis of Composite Leaf Spring

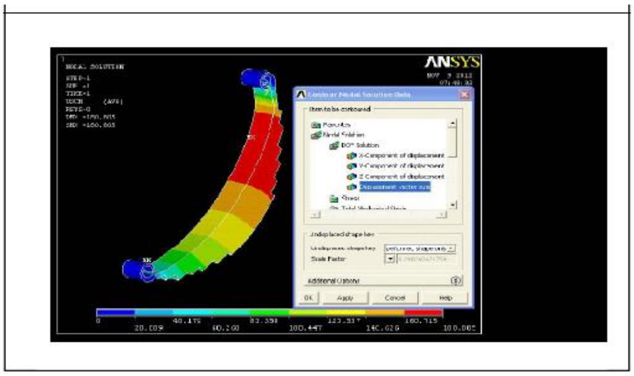


Fig. 4.4 Deflection Analysis of Composite Leaf Spring

Table 4.1 Comparision of Results

Material	Static Load (N)	Defection (mm)	Bending Stress (N/mm²)
Steel	4000	198.48	949.63
E-Glass/ Epoxy	4000	180.81	911.79

Table 4.2 Comparision of Weight

S. No.	Material	Weight(kg)
1	Steel	2.450
2	E – Glass/ Epoxy	0.700

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V. APPLICATIONS

Commercial and industrial applications of composite are so varied that it is impossible to list them all. The major structural application areas, which include aircraft, space, automotive, sporting goods, and marine engineering. A potential for weight saving with composites exists in many engineering field. The first major structural application of composite is the corvette rear leaf spring in Commercial. Other structural chassis components, such as drive shafts and road wheels, have been successfully tested in the laboratories and are currently being developed for future cars and vans. The metal matrix composites containing either continuous or discontinuous fibre reinforcements, the latter being in the form of whiskers that are approximately 0.1-0.5 μm in diameter and have a length to diameter ratio up to 200. Particulate-reinforced metal matrix composites containing either particles or platelet that ranges in size from 0.5 to 100 μm. Dispersion-strengthened metal matrix composites containing particles that are less than 0.1 μm in diameter and metal matrix composites are such as directionally solidified eutectic alloys.

VI. BENEFITS

i. Weight reduction.
ii. High strength.
iii. Corrosiveness.
iv. Low specific gravity.

VII. CONCLUSION

The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings. The future potential for composites in these types of applications is discussed in terms of the fabrication developments which appear likely in the next decade. It is necessary to study the usage of composites in improving the performance and efficiency of these automobile components. The 3-D modelling of composite leaf spring is done and analyzed using ANSYS. A comparative study has been made between composite and steel leaf spring with respect to weight, cost and strength. 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. Composite leaf spring reduces the weight by 85 % for E-Glass/Epoxy, over conventional leaf spring.

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