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FINITE ELEMENT ANALYSIS AND EXPERIMENTAL STUDY OF COMPOSITE LEAF SPRING

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ABSTRACT

Leaf springs are the suspension components used in the automobile industry. For conservation of natural resources and to economize energy, weight reduction has been the focus of automobile Industries. Weight is the main issue related to the automobile industry. Thus automobile manufacturers are giving importance to reduction of weight. While reducing weight of the component designer has to think about increasing or maintaining strength of the component.
Composite materials are basically hybrid materials formed of multiple materials in order to utilize their individual structural advantages in a single structural material. The interest of the automobile industry in the replacement of steel spring with composite leaf spring has increased because of the better qualities of the composite materials. The weight of the leaf spring may be reduced by using composite materials without compromising the load carrying capacity and stiffness of spring. The current leaf spring is made up of multiple plates with steel material. Steel leaf spring has high weight, low natural frequency, high corrosion, more noise and the properties of material are changing when subjected to various loads. Thus current multiple leaf spring needs to be replaced or changed.
Various advanced composite materials offer significant advantages in strength, stiffness, high natural frequency and light weight relative to conventional metallic materials. In this paper the steel leaf spring is compared with composite leaf spring and the results are mentioned.

KEYWORDS: Suspension, Leaf spring, Steel material, composite material, Modeling,FEA.

INTRODUCTION

Leaf spring is also known as flat plate. Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and also in rail systems. 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. Function of the leaf spring is of spreading the load more widely over the vehicle's chassis, whereas coil springs transfer it to a single point.
Mono leaf spring is used for the lighter vehicle which consists of a single steel plate. While in the multi leaf spring a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves.

Composite material can be implemented for reduction of weight especially in automobile industries. The automobile manufacturers are focusing for weight reduction. It can be achieved primarily by introducing better materials, by better manufacturing processes or by optimizing the design. The suspension leaf spring is one of the potential items in automobiles as it accounts for nearly ten to twenty percent of the unsprung weight. The efficiency and the riding qualities will be improved with the reduction of weight of the vehicle. Composite materials will be used for this purpose without reduction in strength, load carrying ability and other properties also.

LITERATURE SURVEY

Jagbhooshan Patel and Veerendra Kumar [1] have worked on a leaf steel spring used in passenger cars. In this work regular leaf spring is replaced with a composite leaf spring made of glass/epoxy composites. B.Vijaya Lakshmi et al. [2] have concluded that composite material is better than using Mild-steel and epoxy is having good yield strength value and also epoxy material components are easy to manufacture and this having very low weight as compared to other composite material. M.Venkatesan and D.Helmen Devar [3] have compared the load carrying capacity, weight saving of steel and composite materials. Mahmood M. Shokrieh et al. [4] worked on four-leaf steel spring used in the rear suspension system of light vehicles is analyzed using ANSYS V5.4 software. He used optimization technique for reducing the weight. The objective was to obtain a spring with minimum weight that is capable of carrying given static external forces without failure. S.W. Burande, et al. [5] have worked on leaf spring of a commercial vehicle Tata Sumo. Work was aimed to carry out computer aided design and analysis of a conventional leaf spring. M. Vimal Teja et al. [6] carried out the research on Design and Analysis of Composite Leaf Spring for Tata sumo. He deals with the replacement of conventional steel leaf spring with a Mono Composite leaf spring using composite material. In this the design parameters like modulus of elasticity, density, poisons ratio were selected and analyzed with the objective of minimizing the weight of the composite leaf spring as compared to the steel leaf spring.

PROBLEM IDENTIFICATION AND PURPOSE OF STUDY

The conventional leaf spring is generally made of metallic steel material. It has high weight, low natural frequency, high corrosion, more noise and the material is changing its property when the load is acting. So there is a need of use of better material than the steel. Introduction of composite materials was made it possible to reduce the weight and cost of leaf spring without any reduction on load carrying capacity and stiffness. The composite leaf spring which has high strength, low weight, high strength and stiffness to weight ratio, good corrosion resistance, high natural frequency, low cost and flexibility in material and structure can be used.

So the problem selected for the project is to compare the composite material leaf spring with that of steel leaf spring with various parameters such as stresses, deflection, stiffness and weights.

SELECTION OF SUITABLE COMPOSITE MATERIAL

The selection of suitable composite material depends upon the material properties required for the component. For composite material proper selection of fibres and resins should be done in order to achieve the expected properties.

SELECTION OF FIBRES AND RESINS

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

In fiber reinforcement plastics leaf spring, the inter laminar shear strengths is controlled by the matrix system used. Since these are reinforcement fibers in the thickness direction, fiber do not influence inter laminar shear strength. Thus, the matrix system should have good inter laminar shear strength characteristics compatibility to the selected reinforcement fiber.

For manufacturing of fiber reinforcement plastics (FRP), various thermo set resins such as polyester, vinyl ester, epoxy resin are being used. Among these resin systems, epoxies show better inter laminar shear strength and good mechanical properties. Therefore, for this particular application, epoxide is found to be the best suitable resins thus selecting particular grade from various grades of resins.

Therefore, mono composite leaf spring with fiber reinforcement plastics E-Glass/ Epoxy fiber having unidirectional laminates is found suitable for this application and thus selected for the study.

Table 1: Mechanical Properties of E-glass/Epoxy material

Sr. No.	Properties	Value
1	Tensile modulus along X-direction (Ex), MPa	43000
2	Tensile modulus along Y-direction (Ey), MPa	6500
3	Tensile modulus along Z-direction(Ez), MPa	6500
4	Poisson ratio along XY-direction(NUxy)	0.27
5	Poisson's ratio along YZ-direction(NUyz)	0.06
6	Poisson's ratio along ZX-direction(NUyz)	0.06
7	Shear modulus along XY-direction(Gxy), MPa	4500
8	Shear modulus along YZ-direction(Gyz), MPa	4500
9	Shear modulus along ZX-direction(Gzx), MPa	2500
10	Mass density of the material, MPa	0.000002

PROPOSED WORK AND METHODOLOGY

The dimensions of an existing conventional steel leaf spring of a light commercial vehicle have taken. Same dimensions of conventional leaf spring will be used to fabricate a composite leaf spring such as mono composite leaf spring using E- Glass/Epoxy fibre reinforced material with unidirectional laminates.

The behaviour of leaf spring with both the materials is studied by three methods that are analytical, software and experimentation.

MODELING AND ANALYSIS OF LEAF SPRING

The modeling of leaf spring with selected dimensions is done by using CATIA V5 and then ANSYS Workbench is used for analysis. The solid model is created in CATIA. Deflection and Stresses are found out by using ANSYS software. The CATIA file is imported in ANSYS software and the results are obtained. Figure 1 show the leaf spring modeled in CATIA.

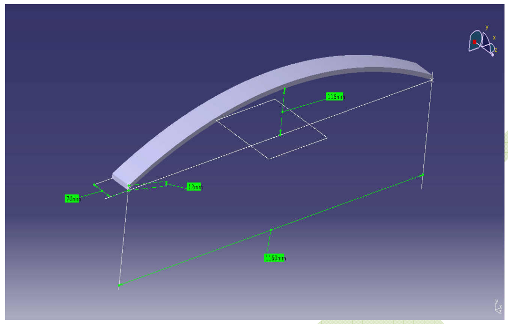

Figure No.1- Leaf Spring Model in CATIA

Deflection of steel material in Y direction:

i) For 490.5 N load

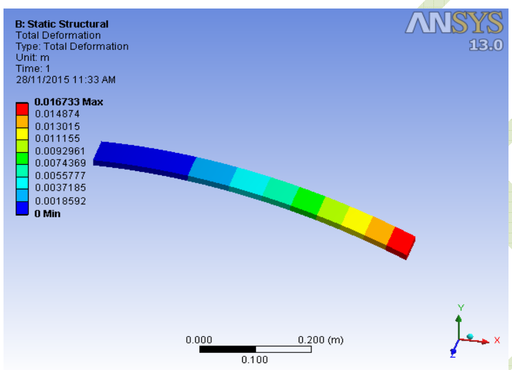

Figure No.2 - Maximum deflection is 16.73 mm

ii)For 981 N load

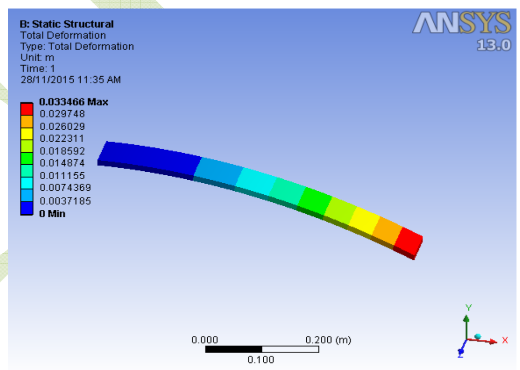

Figure No.3 -Maximum deflection is 33.466 mm

iii) For 1471.5 N load

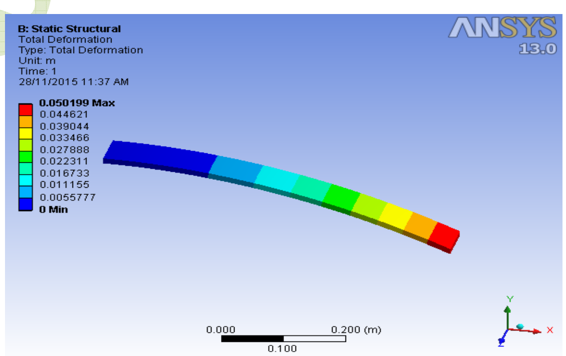

Figure No.4 -Maximum deflection is 50.199 mm

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Von-Mises stress of steel material in Y direction:

i) For 490.5 N load

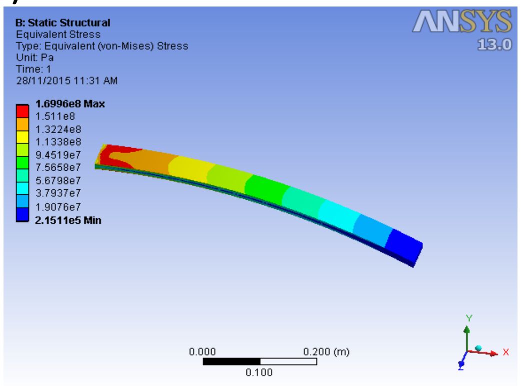

Figure No.5 - Von-Mises stress is 169.96 MPa

ii) For 981 N load

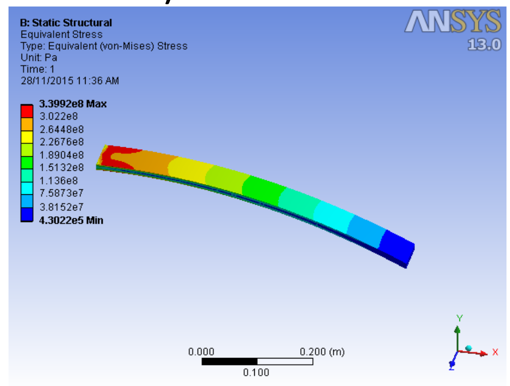

Figure No.6 - Von-Mises stress is 339.92 MPa

ii) For 1471.5 N load

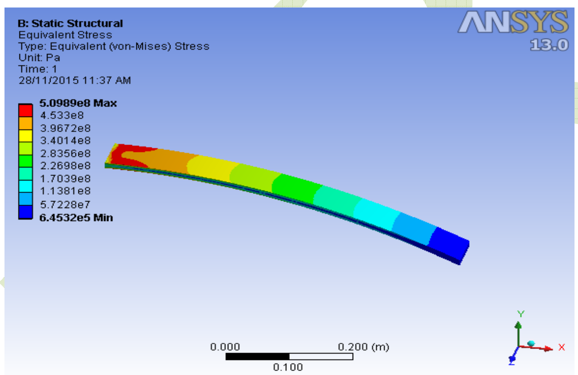

Figure No.7 - Von-Mises stress is 509.89 MPa

Deflection of composite material in Y direction:

i) For 490.5 N load

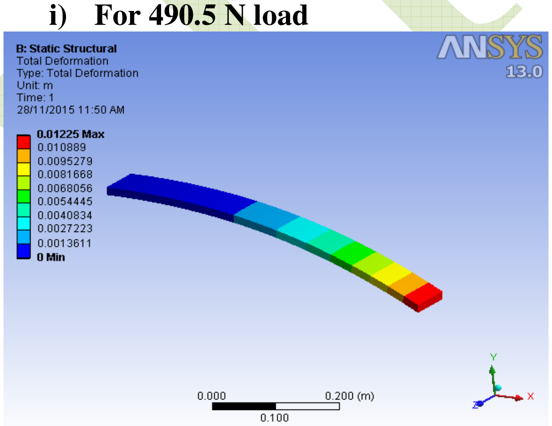

Figure No.8 - Maximum deflection is 12.25 mm

ii)For 981N load

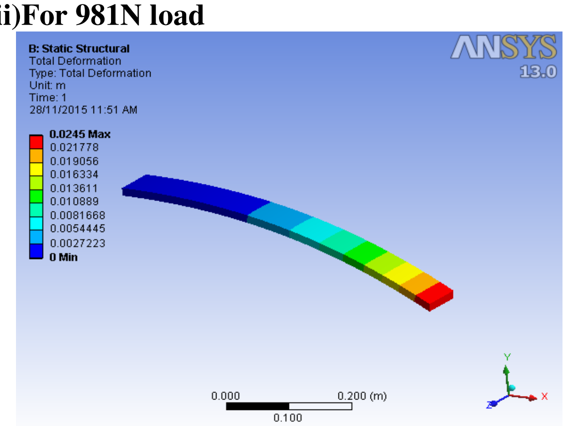

Figure No.9 - Maximum deflection is 24.5 mm

ii) For 1471.5 N load

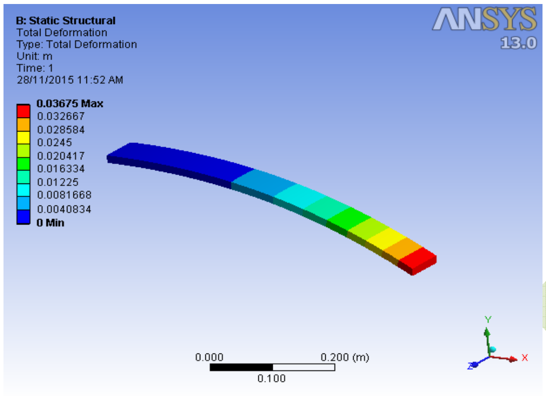

Figure No.10 - Maximum deflection is 36.75 mm

Von-Mises stress of composite material in Y direction:

i) For 490.5 N load

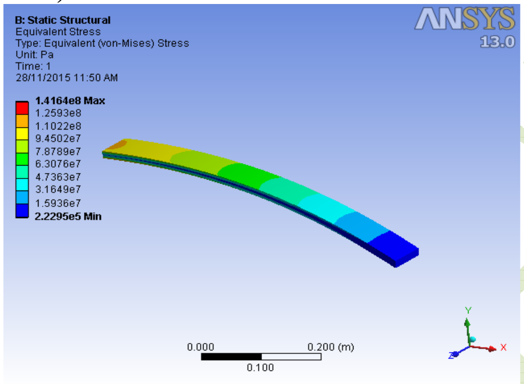

Figure No.11 - Von-Mises stress is 141.64 MPa

ii) For 981N load

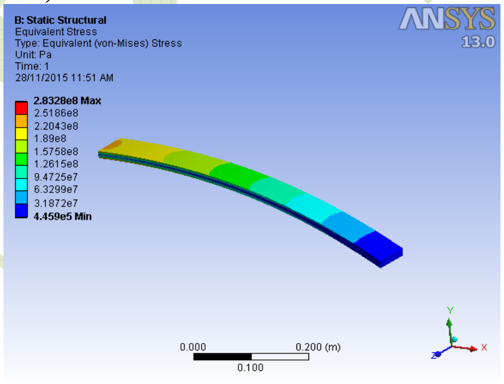

Figure No.12 - Von-Mises stress is 283.28 MPa

iii) For 1471.5 N load

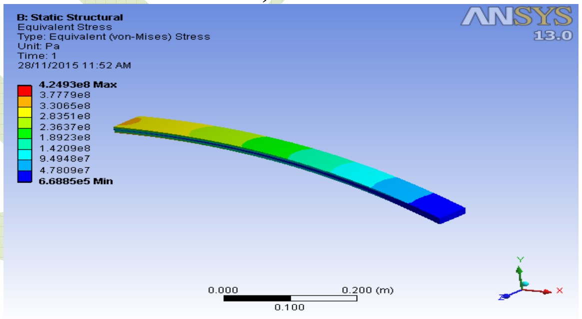

Figure No.13 - Von-Mises stress is 424.93 MPa

LEAF SPRING MANUFACTURING AND EXPERIMENTATION

The same dimensions were used for manufacturing of composite leaf spring. The process use is hand layup process. Plywood material is used for mould. The wax/gel is applied on the cavity surface and after glass fibres of desired length are cut and placed on mould layer by layer. Thereafter the solution of resin is placed on initial layer of glass fibre mat and then epoxy resin over the mat. After near about seven to ten minutes repeat the same procedure for subsequent layers till the desired thickness is achieved.

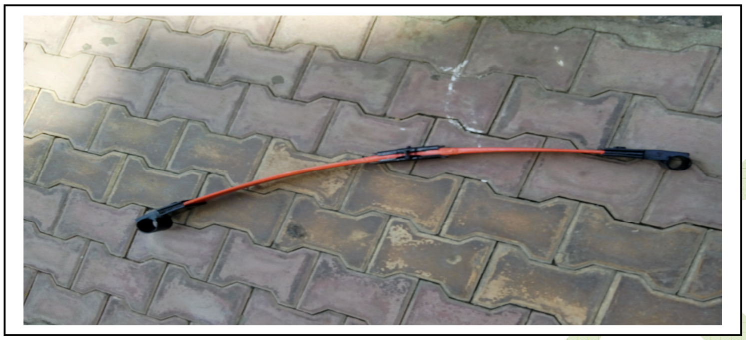

Figure No. 14- Composite material Leaf spring

The deflection of leaf spring is measured under static load conditions. One end of the leaf spring is made fixed and another end is kept free end. The loads are applied at the centre of spring and readings are recorded. The results are explained through graphs.

GRAPHS SHOWING RESULTS

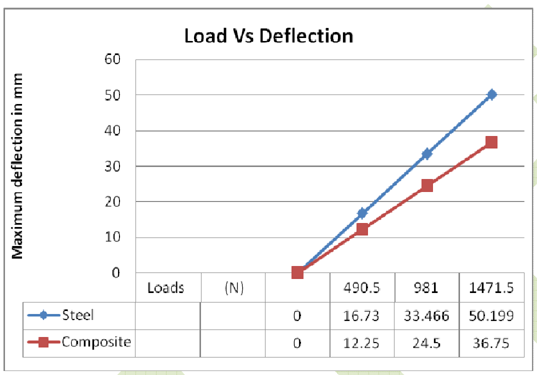

Figure No.15 – FEA results for Deflection For Steel and composite

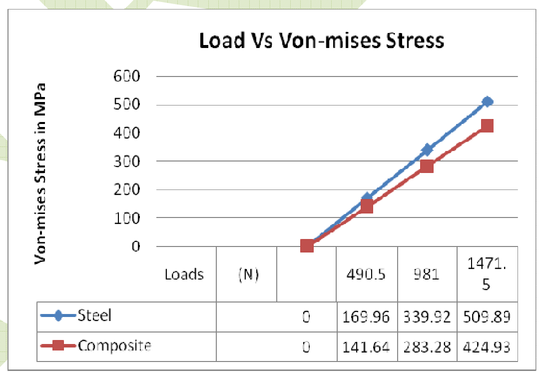

Figure No.16–FEA results for Von-Mises stress for Steel and composite

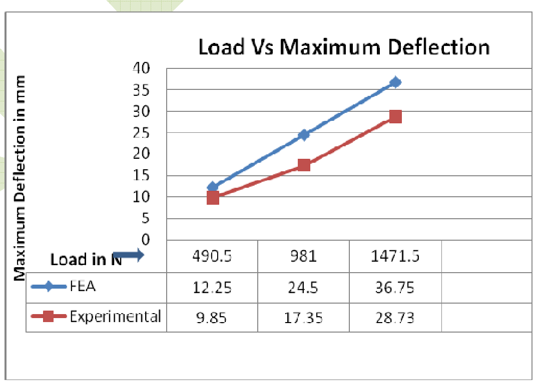

Figure No. 17- Comparison of FEA and Experimental results for Composite Leaf spring

From the results explained through graphs it is concluded that composite material leaf provides good performance over the metallic or steel leaf spring.

CONCLUDING REMARKS

In this work the performance of composite material leaf spring is compared with the performance of steel leaf spring with same specifications. From the results it is concluded that the deflection in the composite leaf spring is less than that of steel leaf spring. The stresses produced are also less than the steel material. It shows that composite material provides the better performance than the metallic material.

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