

Design and Analysis of Leaf Spring of an Automobile Using Composite Materials

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ABSTRACT: The Industrial revolution is the reason for the competition between industries, which brought many new improved technologies into existence, which are often used for advancements and customer satisfaction by automobile industries, like replacing the conventional materials by more reliable and a good alternatives to achieve rigidity, weight reduction, cost reduction, etc. Composites has higher specific stiffness, good corrosion resistance and high strength. Leaf spring is one of the oldest suspension systems that is used even after many advancements, as it is more suitable for the heavy load carrying vehicles. This work deals with finding a suitable composite material that can be a replacement for conventional steel leaf spring. The composites chosen are E-Glass/ Epoxy and Carbon/ Epoxy and are analyzed for minimizing weight of the composite leaf spring compared to that of conventional steel leaf spring. The leaf spring is modeled in NX CAE and analyzed using NX NASTRAN software.

KEYWORDS: Suspensions, spring, leaf spring, composites, weight reduction.

I. INTRODUCTION

Automobile industry is one of the most competitive industries. Innovations in automobiles help the industrialists to gain more profit and the customers to buy the product that satisfies their needs. Many innovations are carried out in the suspension system of vehicles regularly in order to bring up more comfortable and effortless drive to the customers. Leaf spring is one of the type of suspension systems which is a dependent suspension system, which normally has a beam that holds wheels parallel to each other and perpendicular to the axle. When the camber of one wheel changes, the camber of the opposite wheel changes in the opposite manner, i.e., if at one side it is a positive change then in the opposite side it is a negative change. The road may not be smooth and these irregularities causes vibrations and impacts which are absorbed by the leaf spring and this energy is stored as strain energy and then released slowly. The specific strain energy is inversely proportional to the density and Young's modulus of a material, which is higher for composite material which can be used for such applications. The introduction of composite materials has made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity. Hence, steel leaf springs are being replaced by composite leaf springs.

II. SOFTWARE TOOL

The modeling software used here for modeling leaf spring is NXCAE 8.5, which is more comfortable, flexible and advanced platform for modeling complex shapes and machineries. The analysis of leaf spring is performed using NX NASTRAN, which is a finite element analysis program for solving various numerical mechanical problems. The leaf spring on steel and composites is analysed and the results are tabulated and observed.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

III. DIMENSIONS AND CALCULATION

The dimension values that are taken from the steel leaf spring of the Maruti Omni van with SM45C as material are as follows;

Weight of the automobile	=	800 kg = 7848 N
Load exerted over a leaf spring(P)=	=	$\frac{7848}{4} = 1962 \text{ N}$
Span of the master leaf (2L)	=	939.8 mm
Number of leaves (n)	=	5
Width of a leaf (b)	=	55 mm
Thickness of a leaf (t)	=	6.35 mm
Weight of the leaf spring	=	13.53 Kg

Theoretical calculation for steel leaf spring,

Maximum bending stress

$$\sigma_{b \text{ max}} = \frac{6 P L}{n b t^2}$$

$$= \frac{6 \times 1962 \times (939.8/2)}{5 \times 55 \times (6.35)^2}$$

$\sigma_{b \text{ max}}$	=	498.85 MPa
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Maximum deflection

$$y_{\text{ max}} = \frac{4 P L^3}{E n b t^3}$$

$$= \frac{4 \times 1962 \times (939.8/2)^3}{5 \times 2 \times 10^5 \times 55 \times (6.35)^3}$$

$y_{\text{ max}}$	=	57.82 mm
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IV. COMPOSITE MATERIAL SELECTION

Composite materials have been in use in many recent inventions as it gives higher strength for lesser weight when compared to many metals. E-Glass/Epoxy and Carbon/Epoxy materials are more common composite materials used for their higher strength to weight ratio. Thus this project considers these two materials and compares for the most suitable one. The thickness of a leaf for composite leaf spring is found using the formula $b=6t$ and the number of leaves for each composite materials is found by comparing each with the maximum deflection value of steel leaf spring.

V. ANALYSIS OF LEAF SPRING

The steel leaf spring is imported to NX NASTRAN and is analysed for the maximum bending stress and the maximum deflection values. The resulting values are tabulated. The constraints are given at the central holes, where the bolt and nut is used. The load P is given at the ends of the master leaf. The same procedure is repeated for E-Glass/Epoxy and Carbon/Epoxy leaf springs.

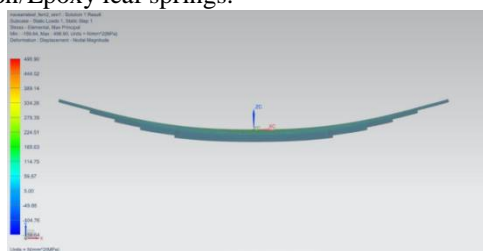


Fig. no. 1 Stress analysis (steel)

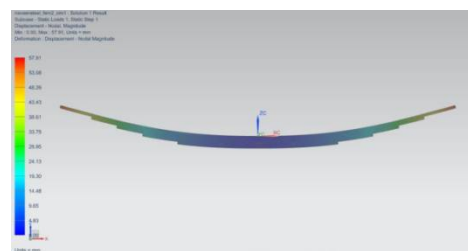


Fig. no. 2 Deflection analysis (steel)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

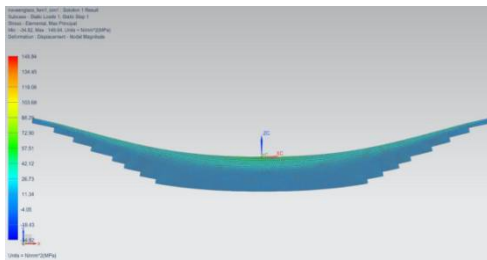


Fig. no. 3 Stress analysis(E-Glass/Epoxy)

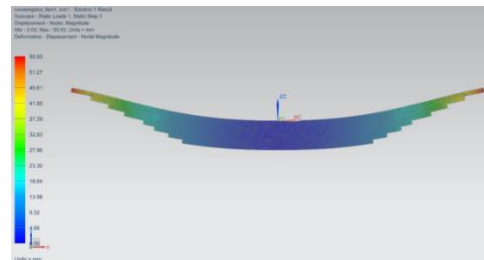


Fig. no. 4 Deflection analysis(E-Glass/Epoxy)

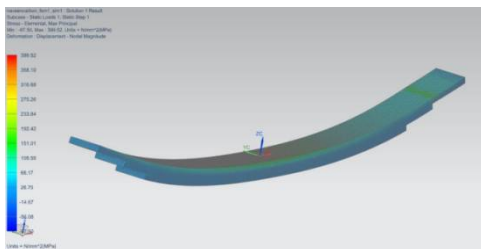


Fig. no. 5 Stress analysis(Carbon/Epoxy)

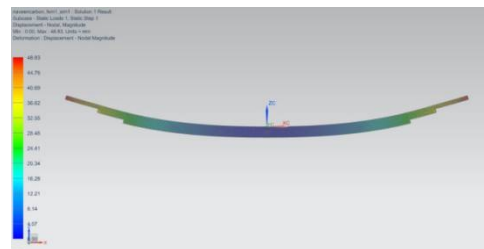


Fig. no. 6 Deflection analysis (Carbon/Epoxy)

VI. RESULTS AND COMPARISON

Materials	Maximum Bending Stress (MPa)		Maximum deflection (mm)		Weight (Kg)	No. of leaves
	Theoretical	FEA	Theoretical	FEA		
Steel (SM45C)	498.85	498.90	57.82	57.91	13.53	5
E-Glass/Epoxy	149.834	149.84	55.609	55.93	31.38	8
Carbon/Epoxy	399.558	399.52	48.792	48.83	8.68	3

Table no. 1 Theoretical and FEA results for steel and composite leaf springs

VII. CONCLUSION

The theoretical and the software analysis result values that has been calculated in this work are tabulated, according to the materials selected. From the tabulated results E-Glass/Epoxy leaf spring has lesser stress value than the conventional steel leaf spring but the number of leaves is higher than the others and thus the weight is larger. Carbon/Epoxy leaf spring has higher stress value than that of E-Glass/Epoxy but lesser than that of steel and lesser number of leaves than the same, thus lesser weight compared with other materials. Considering the weight of each leaf springs, Carbon/Epoxy leaf spring is more suitable and 64.15% weight reduction is possible.

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