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Failure Analysis of Automobile Suspension Spring for Light Commercial Vehicle by Finite Element Approach

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Abstract: In automobile sector growing competition and innovation tends to change the existing products by new and advanced material products. This innovation is apply an area of suspension system of vehicle to achieve reduction in vehicle weight. Leaf springs are widely used as suspension components in automobiles. Laminated spring carries vertical loads, brake torque, driving torque in addition to shock absorbing. The main functions of the laminated springs for an automobile are to maintain a good control stability and to improve riding comfort. In this paper use light commercial vehicle as an object to reduce static parameter by using advance composite material like E glass- Epoxy UD.
Keywords: Automobile, composite, weight, Tools, ACP, FEM, ANSYS.

I. INTRODUCTION

A leaf spring is also called as suspension spring or laminated spring .Laminated is a simple form of spring commonly used for the absorbing vibration and sustain vertical load in wheeled vehicles. In the past called a carriage spring and most of the time referred to as a semi-elliptical spring or cart spring, it is widely used forms of shock aborbing, dating back to medieval times A design of leaf spring asa slender arc-shaped and length of spring steel is rectangular cross-section. In the popular common configuration is the chassis of vehicle attach at the end of eye and center of the arc of leaf spring provides location for the axle.The arrangement of leaves For very heavy vehicles, are in form of that several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs work springing and damping as well as can serve locating functions. Due to interleaf friction apply a damping action, and results in satiation in the motion of the suspension. So most of manufacturers have used mono-leaf springs. Composite materials are now used extensively in the automotive industry to take the place of metal parts. Several papers were devoted to the application of composite materials for automobiles. Some of these papers are reviewed here, with emphasis on those papers that involve composite leaf springs. Breadmore [1,2] studied the application of composite structures for automobiles. Moris [3] concentrated on using composites in the rear suspension system. Daugherty [4] studied the application of composite leaf spring in heavy trucks. Yu and Kim [5] designed and optimized a double tapered beam for automotive suspension leaf spring. Corvi investigated a preliminary approach to composite beam design and used it for a composite leaf spring.Vertical vibrations and impacts are buffered by 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 capabilityof a leaf spring ensures a more compliant suspension system. The amount of elastic energy that can be stored by a leaf spring volume unit is given by[6]
$s = \frac{1}{2}\frac{\sigma}{E^2}$Eq. (1) where r is the maximum allowable stress induced into the spring and E is the modulus of elasticity, both in the longitudinal direction. Considering that the dominant loading on leaf spring is vertical force [7], the Eq. (1)shows that 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 [8]. One of the most advantageous reasons for considering composites instead of steel is their weight. Another important characteristics of composites which make them excellent for leaf spring are: higher strength-to-weight ratio (up to five times that of steel), no interleaf friction, superior fatigue strength, ‘‘fail-safe’’ capabilities, excellent corrosion resistance, smoother ride, higher natural frequency, etc.In the present work, a four-leaf steel spring used inMahindra supro mini truck is replaced with a composite spring madeof glass/epoxy composites. The main objective was thereduction of static parameter.

II. EXPERIMENTAL WORK

In this paper author use light vehicle Mahindra Supro Mini Truck suspension spring .Specification of leaf spring is given in table 1 and material specification in table 2

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TABLE I
SPECIFICATION OF LEAF SPRING

Descriptions	Design 1
Materials	Structural Steel
1. Total Length of the spring (Eye to Eye)	1120mm
Front half (the arc length between the axle seat and the front eye)	559 mm
Axle height at axle seat	120.4mm
No. of full length leaves	2
No. of graduated leaves	4
Thickness	6mm
width	50mm
Spring rate	20.76N/mm
Normal static loading	2500 kg
Full bump loading	4500 kg
Nodes	466
Elements	1188

TABLE 2
MATERIAL SPECIFICATION

S. No.	Engineering Data Properties	E-Glass/Epoxy
1	Density (Kg/m^3)	1520
2	Young's Modulus X (MPa)	4500
3	Young's Modulus Y (MPa)	6500
4	Young's Modulus Z (MPa)	6500
5	Poisson's Ratio X	.23
6	Poisson's Ratio Y	.06
7	Poisson's Ratio Z	.06
8	Shear Modulus X (MPa)	4500
9	Shear Modulus Y (MPa)	4500
10	Shear Modulus Z (MPa)	4500
11	Specific Heat(J Kg$^-$	480

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	[1]C^{-1})	
12	ULTIMATE TENSILE STRESS (MPA)	135
13	TENSIL STRESS X (MPA)	289.5
14	TENSIL STRESS Y (MPA)	48.8
15	COMPRESSIVE STRESS X (MPA)	120
16	COMPRESSIVE STRESS Y (MPA)	450

III. FEA MODELING AND ANALYSIS

To design for static and simulation, structure steel leaf as well as composite leaf spring, stress analysis was performed on simplified equations and hit and trial and error method using FEA ANSYS Workbench software. The most common simulation setup for ANSYS software and divided into: pre-processing, solving, and post processing categories. Firstly, 3Dimentional geometric model of leaf spring is developed in solid Workbench and than Finite Element meshing. For better simulation result, quality of meshing is fine.

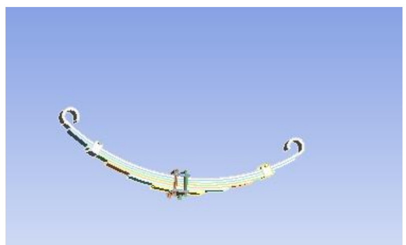

Fig.1.3D design of leaf spring

IV. RESULT AND DISCUSSION

A. *Static Analysis*

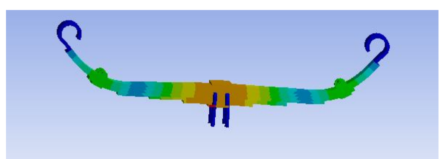

Fig.2.Deformation of leaf spring

Parameter	Material		Difference	%
	Structure steel	E glass-Epoxy		
Max load in N	25000	25000		
Max stress in MPa	1254.365	1215.546	38.819	3.09
Total deformation mm	64.33	56.23	8.1	12.59

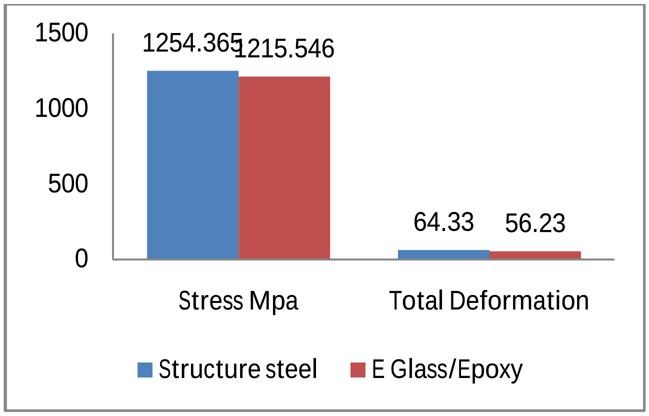

Fig.3.Grafical representation of FEA result

V. CONCLUSION

In application to Finite Element leaf spring models, linear elastic stresses from Finite element analysis can be used directly to calculate total deformation. It can be shown that, design and simulation stresses satisfying maximum stress failure criterion; hence design is safe. In ANSYS Workbench 16.0,Static analyzedusing ACP Tool predicting CAE result in terms of stress and Total deformation .Total reduction in max stress and deformation is respectively 3.09% and12.59%.

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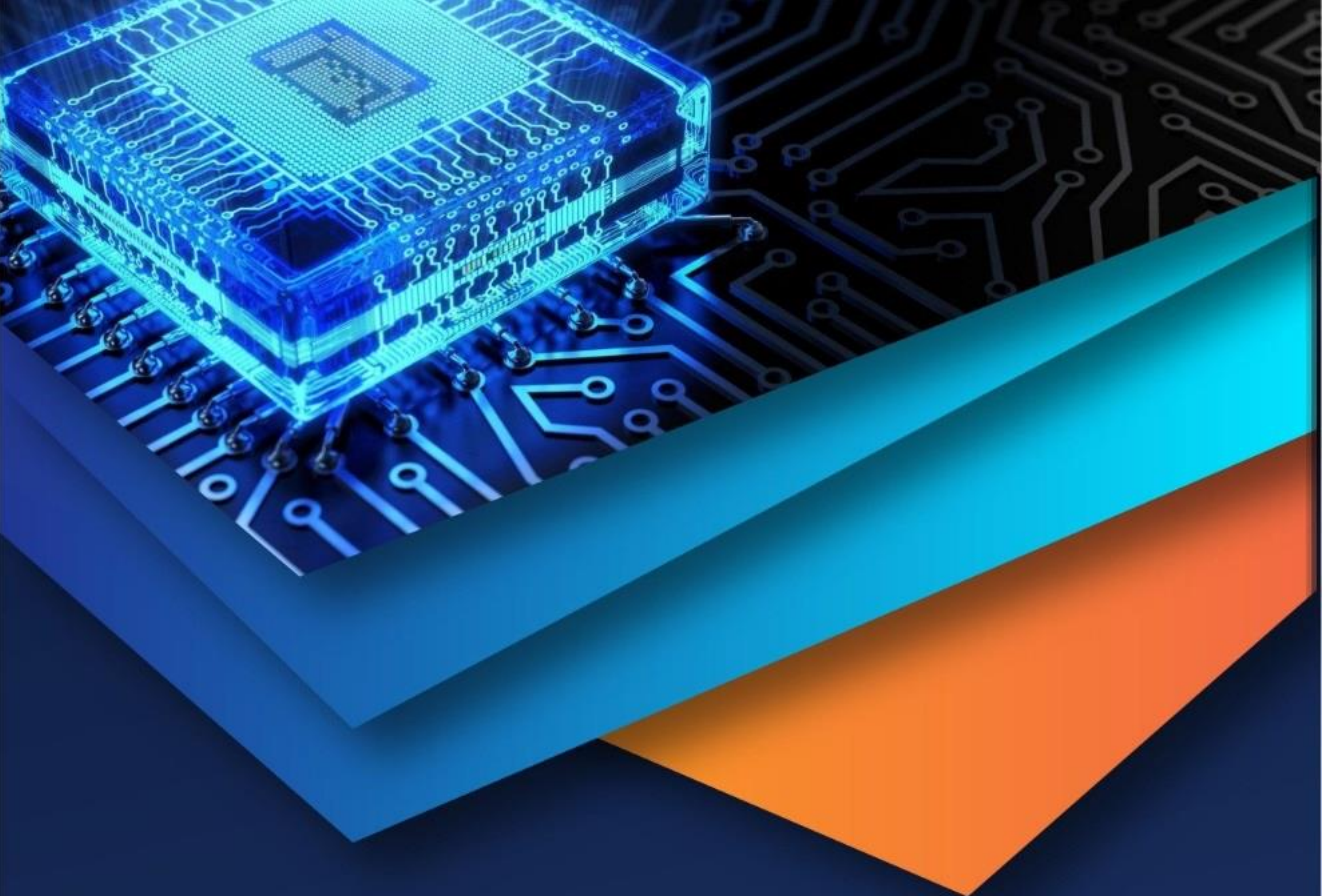

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