Weight Optimization of Mono Leaf Spring Used for Light Passenger Vehicle

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Abstract **-** The leaf spring is widely used in automobiles as major part of suspension system. These springs are intended to bare jerks and vibrations during traveling on uneven roads. The suspension leaf spring is one of the potential items for weight reduction in automobiles. The reduction of weight will achieve Fuel efficiency. The emphasis of this paper is on the application of FEA concept to compare three materials for leaf spring and proposed the material having best strength to weight ratio among them. Three materials used for comparing are the conventional steel, composite E-Glass Epoxy and Carbon Epoxy. This present work is to estimate and compare the deflection, bending stress induced in the leaf spring by these materials. The leaf spring, which is used for analyzing, is a mono leaf spring of Light passenger vehicle. A model of such leaf spring has been designed from actual steel leaf spring and analyzed using ANSYS in this paper. Theoretical calculations and Testing is done for validation of results.

Keywords: *Finite element analysis, Leaf spring, Composite material.*

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1. INTRODUCTION

A spring is an elastic body whose function is to absorb and release energy when needed. The automotive suspension system connects the road wheels to the frame or body of the vehicle. The primary function of the suspension system is to support the weight of the vehicle. It also isolate the vehicle body and the passengers within from the road shocks and vibration. Reduction of weight of mechanical parts can save energy in automobiles. Weight reduction can be achieved by the introduction of better material, improved design and better manufacturing processes. The strain energy of the material becomes a major factor in designing the springs. The introduction of composite materials made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness. Composite Materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel. [1]

2. LEAF SPRING

Mono Leaf spring used for this work is spring of Maruti 800 car. Dimensions are measured from the actual spring. The steel leaf spring use in this work includes total length (Center to eye) 487.5mm. The height of axle seat is 200 mm & width of leaves are 49 mm. In actual Condition the leaf spring is simply supported at the end. One end of leaf spring is fixed while other end of the spring is sliding suspension movement. The center is attached to the vehicle axle. For Calculation and FEA, only half leave is considered which is working as a Cantilever beam.

3. MATERIAL SELECTION

The fibers used in composite materials are glass and carbon. E-glass fiber is a high quality glass fiber, which is used as standard reinforcement. Carbon Fiber has better strength as compare to glass fiber.[2] Among all the easily available resins epoxies show better inter laminar shear strength and good mechanical properties..

4. MECHANICAL PROPERTIES

Properties	Value	Unit
Young's modulus	200000 - 200000	MPa
Tensile strength	650 - 880	MPa
Elongation	8 - 25	%
Fatigue	275 - 275	MPa
Yield strength	350 - 550	MPa
Density	7700	Kg/m3

Table 1 Mechanical Properties of Steel [2]

Properties	Value
Tensile modulus along X-direction (Ex), MPa	34000
Tensile modulus along Y-direction (Ey), MPa	6530
Tensile modulus along Z-direction (Ez), MPa	6530
Tensile strength of the material, MPa	900
Compressive strength of the material, MPa	450
Shear modulus along XY-direction (Gxy), MPa	2433
Shear modulus along YZ-direction (Gyz), MPa	1698
Shear modulus along ZX-direction (Gzx), MPa	2433
Poisson ratio along XY-direction (NUxy)	0.217
Poisson ratio along YZ-direction (NUyz)	0.366
Poisson ratio along ZX-direction (NUzx)	0.217
Mass density of the material (ρ), kg/mm3	2.6·106
Flexural modulus of the material, MPa	40000
Flexural strength of the material, MPa	1200

Table 2. Properties of E-Glass Epoxy[2]

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Value	Properties
177000	EX(MPa)
10600	EY(MPa)
10600	EZ(MPa)
0.27	PRXY
0.02	PRYZ
0.02	PRZX
7600	GX (MPa)
2500	GY(MPa)
0.0000016	ρ (kg/mm³)

Table 3. Properties of Carbon Epoxy[3]

5. FINITE ELEMENT ANALYSIS

Model of mono leaf spring is designed in CATIA V5R20 and imported in ANSYS 14.0 workbench for FEA analysis. Mono leaf spring which is acting as cantilever beam is fixed at a centre end and load is applied at the eye end. Load is gradually increased from 500N to the maximum 2875N with the intervals of 500 N. Deflection is measured at the eye end and stresses calculated at the centre. For the validation of results theoretical calculation are done by using following formulas: [3]

Deflection $\delta = 4 \times W \times L^3 / n \times E \times b \times t^3$

Stress $\sigma = 6 \times W \times L / n \times b \times t^2$

The load acting on the vehicle is determine by the following formula,

Total weight acting downward by Vehicle:

=gross vehicle weight*gravity*F.S

=1000 kg *10* 1.15

= 11500/4 =2875N

Since the vehicle is 4-wheeler, a single leaf spring corresponding to one of the wheels takes up one fourth of the total weight.

Gross vehicle weight calculate as,

=Weight of vehicle + Weight of persons(80 kg x 5 person)

=600kg+400kg

=1000kg

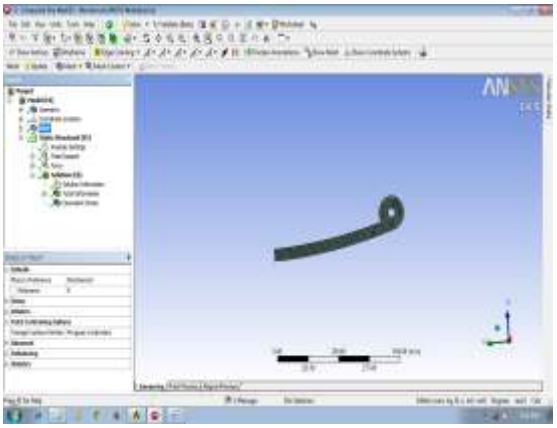

Fig.1 Meshing of Steel Spring

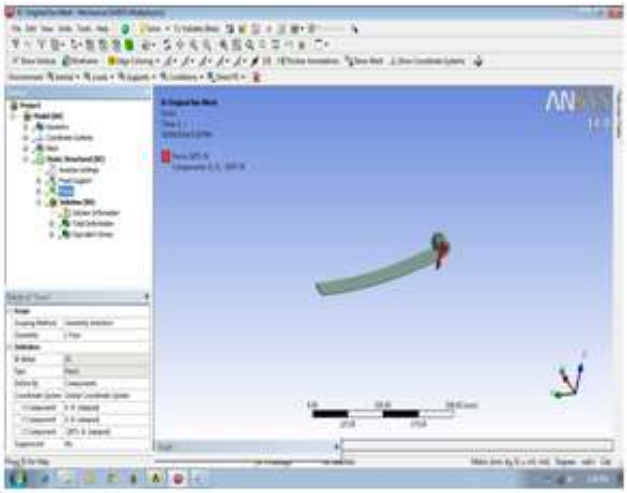

Fig.2 loading of spring

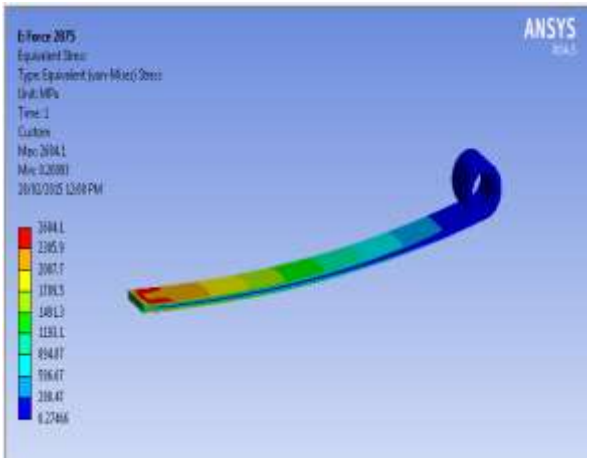

Fig.3 Stress (Steel) at Maximum load

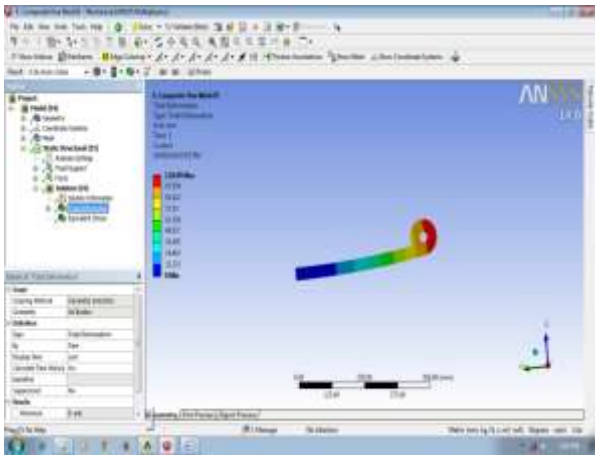

Fig.4 Deformation (E-Glass Epoxy) at Maximum Load

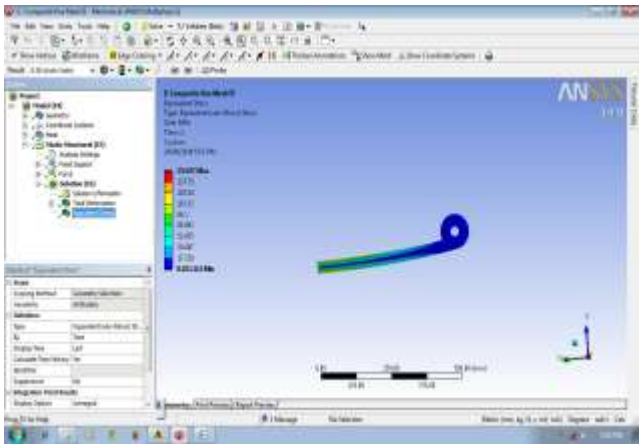

Fig.5 Stress (E-Glass Epoxy) at Maximum Load

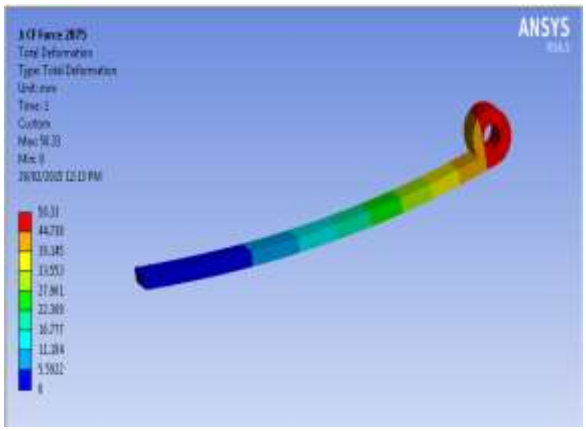

Fig.6 Deformation (Carbon Fiber) at maximum Load

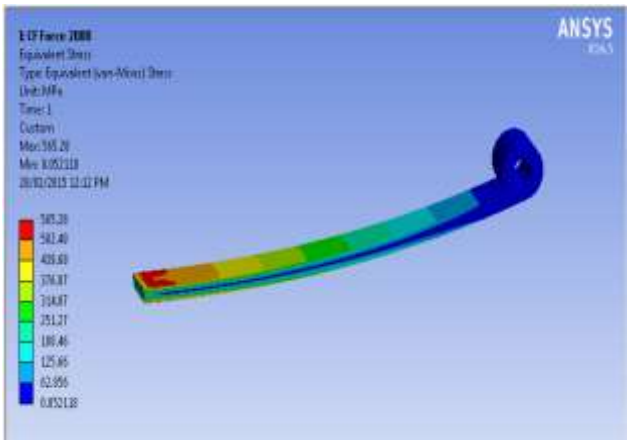

Fig.7 Stress(Carbon Fiber) at Maximum Load

6. MANUFACTURING AND TESTING

Hand layup technique is suitable for manufacturing of composite leaf spring. In this process a mould cavity made up with the help of green sand mould, after manufacturing cavity of require size optical gel coating of suitable thickness layer is made in the boundary of cavity then after this resin in liquid form is poured in that cavity and for getting require shape the consolidation roller rolls over the two layer of resin and dry reinforcement fabric layer of given thickness.[2]

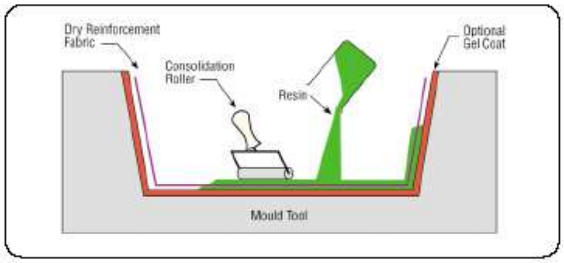

Fig.8 Hand Lay up technique [2]

After manufacturing leaf spring are kept for cooling at room temperature.

Fig.9 Steel and E-glass poxy spring

The steel and composite leaf springs are tested by using Hydraulic UTM. The experimental set up is shown in figures 9 and 10. The leaf springs to be tested are examined for defects. The spring is fixed at one end and one end is kept on slider for lateral movement of spring due to force. The load is applied from zero to the prescribed maximum load and back to zero. The spring is supported at center and hydraulic pressure is given from bottom to the spring..

Fig.10 Testing of Steel leaf spring

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Fig.11 Testing of composite leaf spring

7. RESULTS

From the Therotiacal calculation,FEA and Testing results are prepared.The Permissible stresses for the E glass Epoxy and cabon fibers are 2250 Mpa,3800 Mpa respectively.Remark are on the basis of maximum deformation occurred and Stresses as compare to Steel. Ratios of stesses induced and Max

imum permissible stress is also considered .

Sr.no		**Deformation (mm)**	**Stress(Mpa)**	**Remark**
	FEA			
1	Steel	288.49	2684.1	Present
2	E Glass epoxy	110.09	154.97	Good
3	Carbon Fibre	50.33	812.59	Best
	Therotical			
1	Steel	265.53	2681.56	Present
2	E Glass epoxy	95	140.49	Good
3	Carbon Fibre	45	762.755	Best
	Testing			
1	Steel	270	-NA	Present
2	E Glass epoxy	115	-NA	Good
3	Carbon Fibre	49	-NA	Best

8. PERCENTAGE WEIGHT SAVING

Table shows the % saving of weight by using composite materias

Sr.no	Materials	Actual weight	% weight savings
1	Steel	3500 gm	
2	E glass epoxy	2500gm	30%
3	Carbon epoxy	1600gm	55%

9. GRAPHS

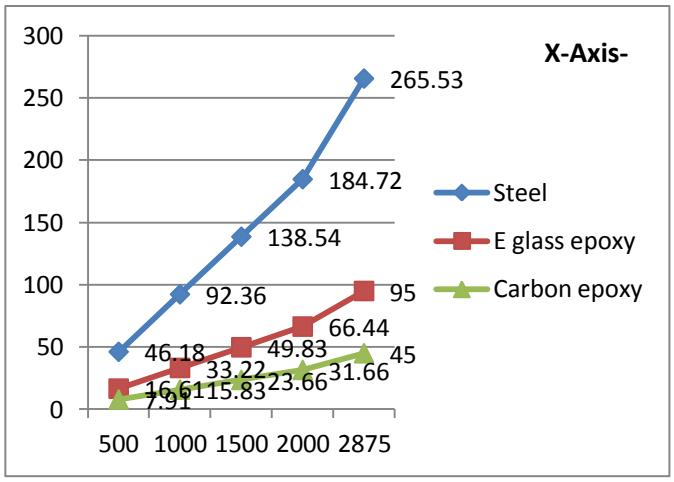

Fig.12 Theoretical Load v/s Deflection

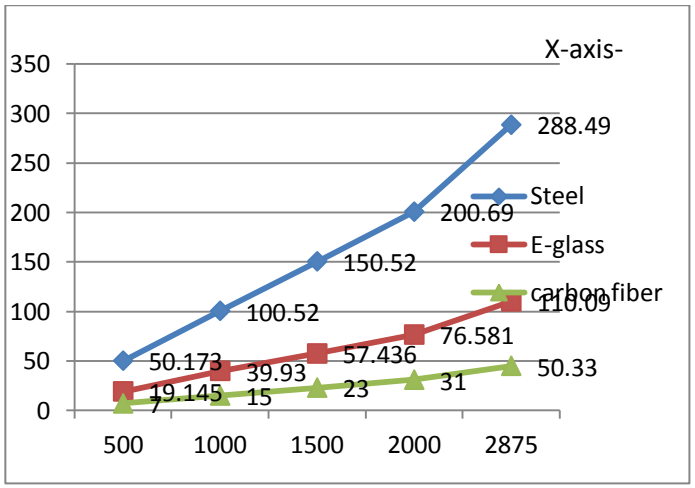

Fig.13 FEA Load v/s Deflection

As reducing weight and increasing strength of products are high research demands in the world, composite materials are getting to be up to the mark of satisfying these demands. In this project reducing weight of vehicles and increasing the strength of their spare parts is considered. The work involves the comparison of conventional EN47 and

composite material E-Glass Epoxy for leaf spring under static loading conditions the model is preferred of in CATIA V5R20 and then analysis is perform through ANSYS 14.0 .From The results obtained it is concluded that Bending stress and deflection of the composite leaf spring is less as compared to conventional steel spring. Results obtained through ANSYS are got validation from Theoretical calculations and Testing.

From the static analysis results it is found that there is a maximum displacement of 288.49 mm in the steel leaf spring and the Corresponding displacements in E-glass / epoxy, and carbon/epoxy's is 110.09 mm, 50.33mm.

From the static analysis results, we see that the von-mises stress in the steel is 2684.1 MPa. And the von-mises stress in Eglass/Epoxy, Carbon/epoxy's are 154.97MPa,812.59MPa respectively Among the two composite leaf springs no leaf spring has higher stresses than the steel leaf spring. E-glass/epoxy composite leaf spring can be suggested for replacing the steel leaf spring from stress and stiffness point of view. A comparative study has been made between steel and composite leaf spring with respect to strength and weight. Composite mono leaf spring reduces the weight by 30 % for E-Glass/E.poxy, and 55 % for Carbon/Epoxy over conventional leaf spring.

10. FUTURE SCOPE:

1) Analysis with Composite material having different grades.
2) Analysis by varying thickness.

11. REFERENCES

[1] Gulur Siddaramanna Shiva Shankar, Sambagam Vijayarangan,"Mono Composite Leaf Spring For Light Weight Vehicle – Design, End Joint Analysis And Testing" Issn 1392–1320 Materials Science (Medžiagotyra). Vol. 12, No. 3. 2006, Mechanical Engineering Department, PSG College Of Technology, Coimbatore-641004, India Received 20 June 2005; Accepted 07 April 2006

[2] Jadhav Mahesh V, Zoman Digambar B, Y R Kharde, R RKharde"Performance Analysis Of Two Mono Leaf Spring Used For Maruti 800 Vehicle"International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-1, December 2012

[3] M. Raghavendra, Syed Altaf Hussain, V. Pandurangadu, K. Palanikumar, "Modelling and Analysis of laminated composite leaf spring under the Static loading condition by using FEA." IJMER,vol2, issues. 4.July-Aug 2012pp 1875-1879,ISSN2249-6645