A Review paper on comparative study of conventional and composite leaf spring for light weight vehicle

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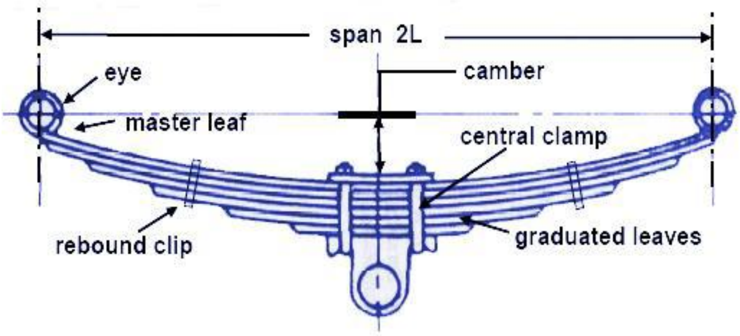
Abstract— A leaf spring is simple form of spring commonly used in interest for replacement of steel leaf spring with that of glass fiber composite leaf spring, since the composite material has high strength to weight ratio, good corrosion resistance properties. Traditional steel leaf spring was bulky hence in recent scenario conventional leaf spring is replaced with composite leaf spring. In this work steel leaf spring replaced by composite material which is E-Glass/Epoxy The modeling of the leaf spring has been done in PRO-E Wildfire5. Finite analysis of the leaf spring is carried out in Ansys 14.5 work bench. In the present work deflection and bending stresses induced in the two leaf springs are compared.

Keywords— **Leaf spring, Composite leaf spring, static analysis, Ansys**

INTRODUCTION

A leaf spring is define as the elastic body, those function are regain is original position when load is removed. The vehicles must have a good suspension system that can deliver a good ride and good human comfort. It is observed that the failure of steel leaf springs is usually catastrophic. According to studies made for leaf spring the material with maximum strength and minimum Modulus of elasticity in the longitudinal direction is the most suitable material. In order to reduce the accidents, arising out of such failures conventional steel leaf spring can be replaced with gradually failing composite leaf springs. The stresses in the composite leaf spring are much lower than that of the steel spring. The leaf spring model is created by modeling software like pro-E , Catia and it is imported in to the analysis software and the loading, boundary conditions are given to the imported model and result are evaluated by post processor.



The introduction of composites helps in designing a better suspension system with better ride quality if it can be achieved without much increase in cost and decrease in quality and reliability. In the design of springs, strain energy becomes the major factor.

LITERATURE REVIEW

Materials used for comparison are conventional, composite E-Glass/Epoxy, and E-glass fiber. In the present work deflection and bending stresses induced in the two leaf springs are compared. From the static analysis results, it is found that there is a maximum displacement of 15.12 mm in the steel leaf spring. For E-glass/ epoxy and Graphite epoxy maximum displacement was 267.67 mm and 5.12 mm respectively. From the static analysis results, it also seen that the von-mises stress in the steel leaf spring is 1047.01 MPa and in Eglass/ epoxy, and Graphite epoxy are 7927 MPa, and 434.43 MPa respectively.[1] The finite element results showing stresses and deflections verified the existing analytical and experimental solutions. Using the results of the steel leaf spring, a composite one made from fiberglass with epoxy resin is designed. The design constraints were stresses (Tsai–Wu failure criterion) and displacements. The results showed that an optimum spring width decreases hyperbolically and the thickness increases linearly from the spring eyes towards the axle seat. Compared to the steel leaf spring (9.2 kg) the optimized composite leaf spring without eye units weights nearly 80% less than the steel spring. The natural frequency of composite leaf spring is higher than that of the steel leaf spring and is far enough from the road frequency to avoid the resonance.[2] In present study the material selected was glass fiber reinforced plastic (GFRP) and the polyester resin (NETPOL 1011). It is observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications. It is observed that the weight reduction of mono leaf spring is achieved up 84.94% in case of composite than steel.[3] In this paper, Experimental reading has been taken in LABVIEW Hardware and software in the form of strain gauge measurement method. Eglass/Epoxy composite leaf spring was tested and it is found that the stresses at two different location is maximum as compare to stresses.[5] To design a new class leaf spring by using functionally graded material and functionally graded structural concept. Analysis is done on leaf spring of different materials having high structural strength and damping capacity.[9] The presented Fatigue Life Prediction of Multi Leaf Spring used in the Suspension System of Light Commercial Vehicle This work describes static and fatigue analysis of a steel leaf spring of a light commercial vehicle (LCV). The dimensions of the leaf spring of a LCV are taken and are verified by design calculations.[10] FEA are used for prediction about the total life cycle and fatigue life of composite and steel leaf spring. Results show that the composite leaf spring is 80% lighter than conventional steel leaf spring with similar design parameters. The natural frequency of composite leaf spring is higher than that of the conventional steel leaf spring and is far from the road frequency to avoid the resonance.

OVERVIEW OF LEAF SPRING:

To design Semi-elliptic Leaf Springs are almost universally used for suspension in light and heavy commercial vehicles. The spring consists of a number of leaves called blades. The blades are varying in length, thickness, width. The blades are us usually given an initial curvature or cambered so that they will tend to straighten under the various load. The spring is mounted on the axle of the vehicle. The entire vehicle load is rests on the leaf spring.

A. SUSPENSION SYSTEM:-

The automobile chassis is mounted on the axles, not direct but some form of springs. Broadly speaking, suspension system consists of a spring and a damper. The energy of road shock causes the spring to oscillate. These oscillations are restricted to a reasonable level by the damper which is more commonly called a shock absorber.

B. OBJECTIVE OF SUSPENSION:-

1. To prevent the road shocks from being transmitted to the vehicle components.
2. To safeguard the occupants from road shocks
3. To preserve the stability of the vehicle in pitting or rolling, while in motion

C. BASIC CONSIDERATIONS FOR VERTICAL LOADING:-

When the rear wheel comes across a bump or irregular road, it is subjected to vertical forces, tensile or compressive depending upon the nature of the road irregularity. The mode of spring resistance depends upon the type and material of the spring used. These vibrations die down exponentially due to damping present in the system. The rear wheel however, reaches the same bump after certain time depending on the wheel base and the speed of the vehicle. Of course, when the tear wheel reaches the bump, it experiences similar vibrations as experienced by the front wheel some time ago. It is seen that to reduce pitching tendency of the vehicle, the frequency of the front springing system be less than that of the rear springing system.

1. **Rolling: -**The centre of gravity of the vehicle is considerably above the ground. Due to this reason, while taking a turn, the centrifugal force acts outwards on the C.G of the vehicle, while the road resistance acts inward at the wheels. This gives rise to a couple turning the vehicle about a longitudinal axis. This is called rolling.
2. **Brake-dip: -** On braking, the noise of the vehicle has a tendency to be lowered or to dip. This depends upon the position of centre of gravity relative to the ground, the wheelbase, and other suspension.
3. **Side Thrust:-** Centrifugal force during cornering, cross-winds, cambering of the road etc, cause a side-thrust to be applied to the vehicle, such forces are usually absorbed by the rigidity of the leaf springs or by fitting pan hard rods.
4. **Unsprung Weight: -** Un-sprung weight is the weight of vehicle components between the suspension and then road surface. When the wheels strike against a bump, they

vibrate along with other unsprung parts which store the energy of the vibrations and then further transmit it to the sprung parts via the springs. Thus it is seen that greater the weight of the unsprung parts, greater will be the energy stored due to vibrations and consequently greater shocks.

MATERIALS FOR LEAF SPRING:-

The selection criteria of material are so much important in design and manufacturing of leaf spring. It is depends on the parameters such as High strength, Economy, Versatility & flexibility, Corrosion resistance, Weight advantages of material. The material used for leaf springs is usually a plain carbon steel having 0.90 to 1.0% carbon. The leaves are manufacturing by the heat treated after the forming process. The heat treatment of spring steel products has greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties. The conventional material is (50cr1v23) is replaced by E glass epoxy material.

Based on the specific strain energy of steel spring and some composite materials, the E-glass/epoxy is selected as the spring material. A combination of two or more materials are composite often ones that have very different properties.

Conventional Steel material for leaf spring:

(50cr1v23)

Sr. no	Properties		Steel
1	YOUNG MODULUS (E)	E_X(MPa)	200000 MPa
2	POISSONS RATIO	PR_{XY}	0.3
3	SHEAR MODULUS (G)	G_X (MPa)	76923 MPa
4	DENSITY	ρ (kg/m³)	0.000007850

Composite Material for leaf spring:

(E-glass/epoxy)

Sr. no	Properties		E-glass/epoxy
1	YOUNG MODULUS(E)	E_X(MPa)	34000
		E_Y(MPa)	6530
		E_Z(MPa)	6530
2	POISSONS RATIO	PR_{XY}	0.217
		PR_{YZ}	0.06
		PR_{ZX}	0.217
3	SHEAR MODULUS (G)	G_X(MPa)	4500
		G_Y(MPa)	2500
		G_Z(MPa)	2500
4	DENSITY	ρ (kg/mm³)	0.000002

DESIGN CALCULATION:-

i. Load acting on the eye are as under: $W = d * l_l * p_b$

ii. Maximum bending moment acting on the pin is as under: $M = \frac{W * lp}{4}$

iii. shear stress: $\tau = \frac{W*4}{2*\pi*d^2}$

iv. Bending Stress in spring: $\sigma_b = \frac{6*W*L}{b*t^2}$

v. Deflection of spring: $y = \frac{12*W*L^3}{E*b*t^3(2n_g+3n_f)}$

SOFTWARE USED:-

i. **Modeling software:-** PRO-E Wildfire-5, CATIA V-5, Solid Work

ii. **Analysis Software:-** Ansys 14.5, Hypermesh etc.

CONCLUSION

From the literature review it is observed that the objective was to obtain a spring with minimum weight that is capable of carrying given static external loads by constraints limiting Stresses and displacements. For that the steel leaf spring is replaced by composite leaf spring. Composite leaf spring is better than using steel leaf spring. Results show that the composite leaf spring is lighter than conventional steel leaf spring with similar design specifications but not always is cost effective over their steel counter parts. The natural frequency of composite leaf spring is higher than that of the steel leaf spring and is far enough from the road frequency to avoid the resonance. Conventional steel leaf spring is also found to be 3.5 times heavier then E-Glass/Epoxy leaf spring. Material saving of 64.12 % is achieved by replacing E-Glass/epoxy in place of steel for fabricating the leaf spring.

REFERENCES

[1]Darshan Kapadia, Palak H. Desai, 'DESIGN AND ANALYSIS OF COMPOSITE LEAF SPRING FOR LIGHT WEIGHT VEHICLE', *International Journal of Engineering Sciences & Research Technology,* 5(6): June, 2016

[2]Mahmood M. Shokrieh, Davood Rezaei, 'Analysis and optimization of a composite leaf spring', doi:10.1016/S0263-8223(02)00349-5

[3]Ghodake A. P., Patil K.N, 'Analysis of Steel and Composite Leaf Spring for Vehicle', *Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684 Volume 5, Issue 4 (Jan. - Feb. 2013), PP 68-76*

[4]Mr. S. S. Kale, Prof. A.V. Gaur, 'Stress Analysis of Multi Leaf Spring by using FEM and Experimental Method -A Review' *IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 07, 2015 | ISSN (online): 2321-0613*

[5] P. D. Wadile, K. A. Mahajan, 'Experimental Investigations of Composite Leaf Spring', *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X PP. 18-23*

[6]Bhaumik A. Bhandari, Bhavesh C. Patel, 'Parametric Analysis Of Composite Leaf Spring', *IJSTE–International Journal of Science Technology & Engineering| Vol. 1, Issue 1, July 2014| ISSN(online): 2349-784X*

[7]A.Sivasankar, 'Design and Numerical Investigation of Static and Dynamic Loading Characters of Heterogeneous Model Leaf Spring', International Journal of Mechanical Engineering and Research, ISSN 0973-4562 Vol. 5 No.1 (2015)

[8]Mahendra Sharma, Pawan Sharma 'Analysis of Steel Made Leaf Spring using FEA Tool ANSYS', International Journal of New Technology and Research (IJNTR) ISSN: 2454-4116, Volume-1, Issue-2, June 2015 Pages 05-08

[9] Madhava M C, Deepak G, 'Design and analysis of functionally graded leaf spring structure', International Journal of Engineering Research ISSN: 2319-6890)(online),2347-5013(print) Volume No.5 Issue: Special 6, pp: 1129 - 1254 20 May 2016

[10] Pulkit Solanki, Dr. Ajay Kumar Kaviti, 'Study and Review on the Analyses of Leaf Spring', *IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 09, 2015 | ISSN (online): 2321-0613*

[11] Yogesh Nikam, Dr.Avinash Badadhe, 'DESIGN ANALYSIS AND FAILURE MODES OF LEAF SPRING IN SUSPENSION SYSTEM', International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 10 | Oct-2016

[12] Mr.Kautuk J. Awati, Mr. V. J. Khot, ' An Overview of Disarray in Finite Element Analysis and Experimentation with Fatigue Characteristics of Composite Multi-Leaf Spring' , *IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 01, 2015 | ISSN (online): 2321-0613*

[13] N.Lenin Rakesh , G R Kaushik, 'Finite Element Analysis of Composite Leaf Spring for Automotive Vehicle', International Journal of Innovative Research in Science, Engineering and Technology,Vol. 4, Issue 8, August 2015