

Comparative Analysis of Composite Leaf Spring for Light Commercial Vehicle

Rahul Khalate, PG student, Department of Mechanical Engineering, VPCOE, SPPU, PUNE
P.D.Kale, Assistant Professor, Department of Mechanical Engineering, VPCOE, SPPU, PUNE

Abstract—The automobile domain always been recognized from its superior quality of suspension. The automobile industry has shown increased interest in the replacement of steel spring with E-glass/epoxy composite leaf spring due to its high strength to weight ratio. The objective of current work is to compare the parameters like deflections and stiffness of composite leaf spring with that of steel leaf spring. Comparison made between leaf spring of light commercial vehicle and Fabricated composite spring. It is found by experimentation that composite leaf spring can be effectively take place of steel leaf spring of light commercial vehicle. Another aspect of this work is weight reduction by using composite leaf spring for same load carrying capacity. Experimental static analysis has been accomplished upon conventional steel leaf spring and composite steel leaf spring, reveals sound results between load and deflections.

Index Terms—:E-glass fiber, conventional leaf spring, composite leaf spring.

I. INTRODUCTION

The automobile domain always been recognized from its outstanding suspension system. Since occupant looking for the best comfort, it is necessary to have superior quality of cushioning. Such Criterion accomplished only by attempt has to made towards the best quality of material especially composite. Composite materials are now used extensively in the automobile industry to take the place of metal. In current work comparison made between composite leaf spring and conventional steel leaf spring. Objective of this work is to replace the conventional steel spring by composite one. suspension isolates the body of the vehicle from road irregularities. Shocks due to such irregularities from road surface results into repeated stress on vehicle parts. These parts later more sensitive's to reduce their operating life. All elements of the automobile support to the occupant from undesired things such parts collectively called as suspension system.[1, 2]

Springs are crucial suspension that works effectively to minimize the lateral vibrations, impact and bumps due to road irregularities. persistent and reliable element is of longitudinal type usually formed by stacking leafs of steel. Vibrations are always pointed from road surface towards occupant that has to be quickly absorbed by leaf spring and

stored in the form of strain energy. Apart from shock absorbing leaf spring perform the functions like carrying lateral load , Brake load, brake torque. The suspension leaf spring is the one of the potential elements that need for reduction in weight and it accounts for 10% to 20% of the unsprung weight. The elements whose weight is not transmitted to the suspension spring are called as unsprung weight. As per the formula of the strain energy, it is observed that modulus of elasticity and density are inversely proportional to the strain energy. It means that lighter the material more the strain energy carrying capacity as well as weight reduction upto greater extent. this is what the major cause to utilize the composite. In short we can say that material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring.[3, 4]

II. LITERATURE REVIEW

Several literature has been focus on stresses and deflections are lower in case of composite material as compare to existing material. It is found by results obtained from several analysis that the load carrying capacity of the composite material is always higher than conventional steel. There are plenty of parameters which support to the composite apart from stresses and deflections. Though stresses and deflections are prominent parameters, stiffness and weight reduction also contribute really well. Many automobile manufacturer seeking their attention for the weight reduction, this can be achieved by introduction of composite material such as glass fiber reinforced polymer(GFRP). The Composite refers to the“matrix”, material that is reinforced with the fibers. That is why fiber reinforced polymer indicating a thermosetting polyester matrix containing glass fibers. Leaf spring is attributed to carry, lateral load , Brake load, brake torque in addition to shock absorbing.[11, 4] Compared to steel spring, the composite leaf spring shows 67.35 % lesser stress, 64.95 % higher stiffness. [11]

Highly adverse atmospheric conditions have a significant influence on the durability and structural integrity of steel. Steel is subjected to corrosion is a potential cause for the structural damage of the leaf springs. In a new approach

fiber reinforced polymer are now being used as alternative for steel. Along with static analysis, fatigue characteristic of the composite shows considerable results which favour it completely. Fatigue strength of the composite is outstanding than steel. So the application of composite found in various sectors where parts failure takes place by fatigue. Many composites used today are at the leading edge of materials technology, with performance and costs appropriate to ultra-demanding applications such as spacecraft. But heterogeneous materials combining the best aspects of dissimilar constituents have been used by nature for millions of years. Various contents in the material provide adequate strength to it. Steel leaf spring used in the rear suspension of light passenger cars analysed by analytical and finite element solutions, It is observed that steel spring replaced with an optimized composite one. It is also found that the optimum spring width decreases hyperbolically and thickness increases linearly from eye towards the axle seat. stresses obtained in composites are much lower than steel spring. Also weight saving obtained upto 80% in case of composite.[13] Application of composite in leaf spring for light trucks and meet the requirements, together with substantial weight saving. It also shows better fatigue behavior. The development of composite spring having constant width, where stress level at any station in the leaf spring is considered constant due to parabolic tape of the thickness of the spring, has proved to be effective. Such spring normally has lower flexure stress.[14] Compared to steel leaf spring composite leaf spring is found to have 67.35% lesser stresses and 64.95% higher stiffness.[9] In another literature of composite, it is found that value of von mises stresses are less in composite while in conventional material it is higher .weight reduction observed upto 81.22 %.[7] In the study of composite many literatures focus over the main constraints that is nothing but stresses and deflections. Its values by experimentation and finite element analysis found least, as well as weight reduction in case of composite obtained 67.88 %. Many literature shows the relationship between spring rate and ellipticity ratio. spring rate found higher for optimum ellipticity ratio. In the entire work stiffness of the composite higher than conventional material. A single leaf with variable thickness and width for constant cross sectional area of unidirectional glass fiber reinforced plastic with similar mechanical and geometrical properties to the multileaf spring designed and tested. Result shows that composite spring found less stresses and deflection.[12]

III. MATERIAL SELECTION AND TECHNICAL SPECIFICATION

In the entire work comparison has been made between light commercial vehicle and composite leaf spring.

The attempt has been made here to replace the steel leaf spring of light commercial vehicle by mono composite leaf spring is of material E-glass epoxy. Steel leaf spring having uniform width and uniform thickness. The technical specification of steel leaf spring is as follows.

TABLE I
DIMENSIONS OF STEEL LEAF SPRING OF LIGHT COMMERCIAL VEHICLE.

Sr No	Parameter's	Values
1	Eye to Eye length	990 mm
2	Camber height	112 mm
3	No. of full length leave	02
4	Graduated leaves	03
5	Thickness of leaf	63 mm
6	Width of leaf	6 mm

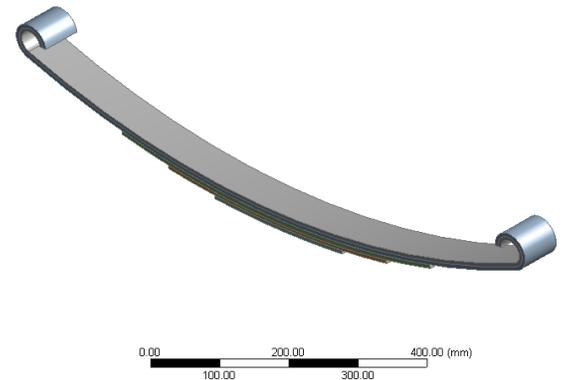


Fig. 1: Model of steel leaf spring

Fabricated composite leaf spring is of material E-glass epoxy which is having varying width and varying thickness throughout the leaf spring. This cross section reveals the superior strength of the material. It is well known fact that, the specific strain energy of the composite material almost higher than steel. Apart from this glass fiber having better corrosion resistance, higher impact strength and lower cost as compare to carbon fiber. A good combination between the material properties and cost is obtained with glass fiber. glass fiber consist of two major types E and S_2 . although S_2 fibers having better mechanical properties than E-fibers, the cost of E- fibers is much lower than S_2 fibers. Therefore E-glass epoxy material is selected for the entire work. This material is assumed to be linearly elastic and orthotropic.

TABLE II
DIMENSIONS OF MONO COMPOSITE LEAF SPRING .

Parameters	At center	At end
Width (mm)	54	95

Thickness (mm)	23	13
----------------	----	----

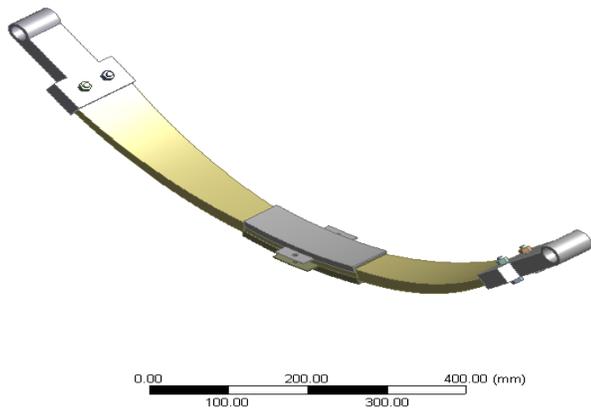


Fig. 2: Model of composite leaf spring.

IV. EXPERIMENTATION

Experimentation has been performed over the composite and conventional steel material. Load is applied over the spring till it becomes flat. This test is experimentally accomplished by universal testing machine which gives the sound results between load and deflections. Obtained results are used to express them in graph format. It reveals that composite leaf spring having higher stiffness value as well as stresses are reduced in greater extent. Theoretical load calculated is approximately 6000 N.



Fig. 3: Experimental Testing on Composite Leaf Spring.



Fig. 4: Experimental Testing on steel Leaf Spring.

V. RESULT AND ANALYSIS

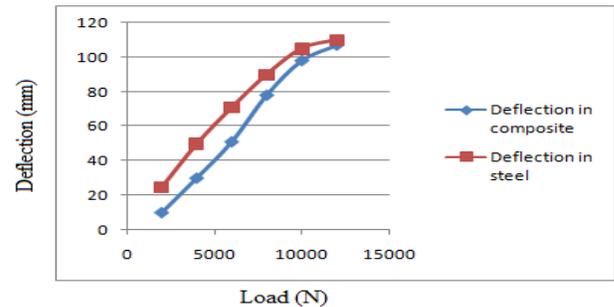


Fig. 5: Load Vs Deflection

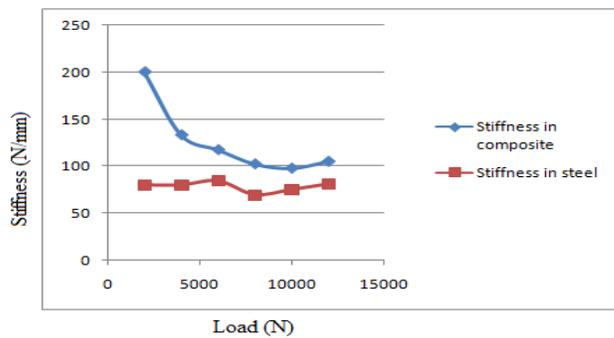


Fig. 6: Load Vs Stiffness.

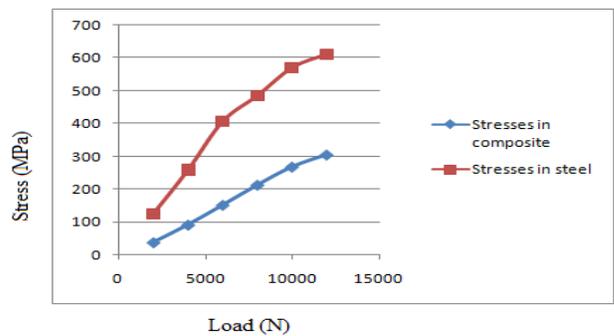


Fig. 7: Load Vs Stress

Composite and conventional spring mounted over the fixture. Here in this work fixture is used as a channel. It ensures perfect mounting for springs to carry gradual load.

VI. FEA ANALYSIS

Finite element analysis has been performed over the composite leaf spring. The results obtained in the analysis as prescribed below,

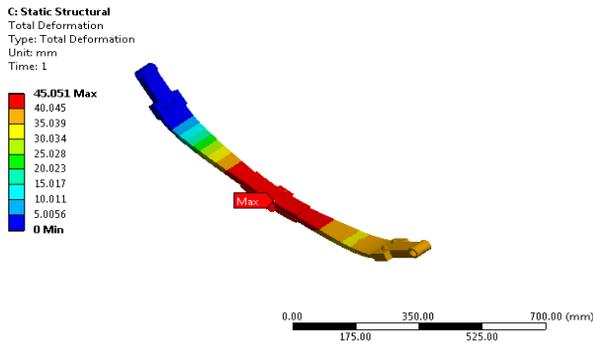


Fig. 8: Deformation plot for composite spring.

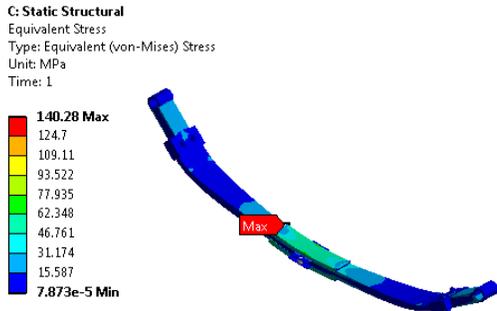


Fig. 9: Stress plot for composite spring.

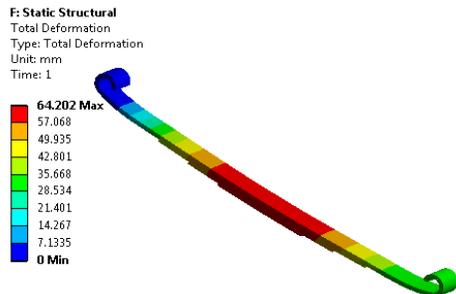


Fig. 10: Deformation Plot for steel spring.

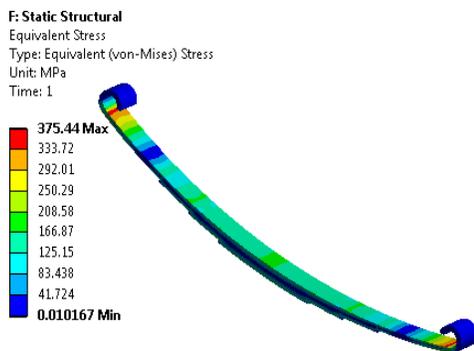


Fig. 11: Stress Plot for steel spring.

The parameters which has been tested for the theoretical load as tabulated below.

TABLE III
COMPARATIVE ANALYSIS BETWEEN STEEL AND COMPOSITE LEAF SPRING.

Sr No	Parameter's	Composite		Steel	
		(Exp)	(FEA)	(Exp)	(FEA)
1	Weight (Kg)	6	--	12.2	--
2	Displacement (mm)	51	45.05	71	64.20
3	Stress (MPa)	152.15	140.28	405.93	375.44
4	Stiffness (N/mm)	117.64	133.18	84.5	93.45

VII. CONCLUSION

The results obtained in above table by comparative study indicates that, in case of composite leaf spring, for the same load carrying capacity, there is reduction in weight by 51.86 %. Similarly composite spring shows less displacement which in turns its stiffness is 28.17% higher than steel leaf spring. Finally, stress value in composite is lower than steel.

REFERENCES

- [1] Amol Bhanage , K. Padmanabhan, “Design For Fatigue And Simulation Of Glass Fiber Epoxy Composite Automobile Leaf Spring”, ARPN Journal Of Engineering And Applied Science, 2014,9, pp 196-203.
- [2] S. Rajesh S. Nakkeran and G. B. Bhaskar, “A Survey of GFRP Composite Leaf Spring”, International Journal of Engineering & Technology, 2014, 3, pp 185-193.
- [3] Ahmed Naif Al-Khazraji, Ali Yasser Hassan, and Emad Abdul Hussein Abdul Sahib, “Mechanical Behavior of Polyester and Fiber Glass as a Composite Material Used in a Vehicle Under Dynamic Loading”, Tikrit Journal of Engineering Sciences, 2014, 21(1), pp 19-28.
- [4] Rupesh N. Kalwaghe and Prof. K. R. Sontakke, “Design and Analysis of Composite Leaf Spring by Using FEA and ANSYS”, International Journal of Scientific Engineering and Research, 2014, pp74-77.
- [5] Ravi Kumar V, R. Lalitha Narayana and Ch. Srinivas, “Analysis of Natural Fiber Composite Leaf Spring”, Journal of Latest Trends in Engineering and Technology, 2013, 3, pp 182-191.
- [6] Ashish V. Amrute, Edward Nikhil Karlus and R.K.Rathore, “Design and Assessment of Multi Leaf Spring, International Journal of Research in Aeronautical and Mechanical Engineering, 2013, 1, pp115-124.
- [7] Pankaj Saini, Ashish Goel and Dushyant Kumar, “Design and Analysis of Composite Leaf Spring for Light Vehicles”, International Journal of Innovative Research in Science, Engineering and Technology”, 2013, 2 ,pp 1-9.
- [8] S. S. Chavan, R. Anandkumar A. Satpute, “Mono Composite Leaf Spring Design and Testing”, Indian Journal Of Applied Research, 2013, 3, pp 282-284.
- [9] M. Raghavedra, et al, “Modeling and Analysis of Laminated Composite Leaf Spring Under The Static Load Condition By Using FEA”, International Journal of Modern Engineering Research, 2012, 4, pp 1875-1879.
- [10] M. Venkatesan, Dhelmendevaraj, ”Design and Analysis of Composite

- Leaf Spring in Light Vehicle”, International Journal of Modern Engineering Research, 2012, 2, pp 213-218.
- [11] Mouleeswaran. S. Kumar, et al, “Analytical and Experimental Studies on Fatigue Life Prediction of Steel and Composite Multi Leaf Spring for Light Passenger Vehicles Using Life Data Analysis”, Material Science, 2007,13, pp 141-146.
- [12] Gulur Siddaramanna, Shiva Shankar and Sambagam Vijayarangan, “Mono Composite Leaf Spring for Light Weight Vehicle-Design, End Joint Analysis and Testing, Material Science,2006,12,pp220-224.
- [13] Mahmood M, shokrieh and Davood Rezaei, “ Analysis and Optimization of a Composite Leaf Spring”,Composite Structures,2003,60,pp 317-325.
- [14] H.A. Al Qureshi, “Automobile Leaf Springs from Composite Materials”, Journal of Material Processing Technology”,2001,118,pp58-61.