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Comparative Analysis of Composite Leaf Spring for Light Commercial Vehicle

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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.

Keywords: E-glass fiber, conventional leaf spring, composite leaf spring, FEA Analysis, experimental analysis, stress strain parameters.

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 make 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

II. LITERATURE REVIEW

Several literatures have 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 fibre reinforced polymer (GFRP). The Composite refers to the "matrix", material that is reinforced with the fibres. That is why fibre reinforced polymer indicating a thermosetting polyester matrix containing glass fibres. 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 fibre reinforced polymer are now being used as alternative for steel. Along with static analysis, fatigue characteristic of the composite shows considerable results which Favor 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 up to 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 behaviour. 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 up to 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 literatures show the relationship between spring rate and elasticity ratio. Spring rate found higher for optimum elasticity ratio. In the entire work, stiffness of the composite material is higher than conventional material. A single leaf with variable thickness and width for constant cross sectional area of unidirectional glass fibre reinforced plastic with similar mechanical and geometrical properties to the multi leaf spring designed and tested. Result shows that composite spring found less stresses and deflection.[12]

III.MATERIAL SELECTIONAND 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

TABLE I DIMENSIONS OF STEEL LEAF SPRING OF LIGHTCOMMERCIAL VEHICLE.

SrNo	Parameter's	Values
1	EyetoEyelength	990mm
2	Camberheight	112mm
3	No.offulllength leave	02
4	Graduatedleaves	03
5	Thicknessofleaf	63mm
6	Widthofleaf	6mm

Leaf spring of light commercial vehicle by mono composite leaf spring is of material E-glass epoxy. Steel leaf spring is having uniform width and uniform thickness. The technical specification of steel leaf spring is as follows.

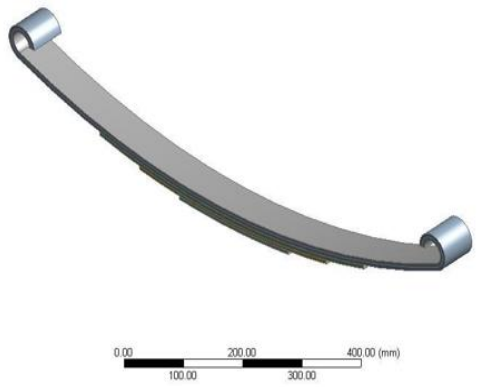

Figure1:Model of steel leaf spring

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 fibre having better corrosion resistance, higher impact strength and lower cost as compare to carbon fibre. A good combination between the material properties and cost is obtained with glass fibre. glass fibreconsists of two major types E and S2. Although S2 fibres having better mechanical properties than E-fibres, the cost of E-fibres is much lower than S2 fibres. Therefore E-glass epoxy material is selected for the entire work. This material is assumed to be linearly elastic and orthotropic

TABLE III DIMENSIONS OF MONO COMPOSITE LEAF SPRING

Parameters	Atcentre	Atend
Width(mm)	54	95
Thickness(mm)	23	13

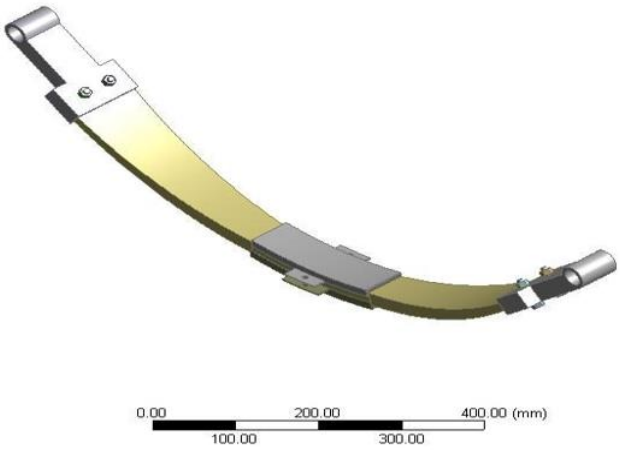

Figure2:Model of composite leaf spring

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 values as well as stresses are reduced in greater extent. Theoretical load calculated is approximately 6000 N.

Figure3:Experimental Testing on Composite Leaf Spring.

Figure4:ExperimentalTesting on steel Leaf Spring.

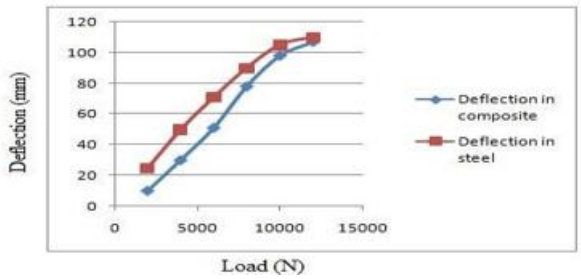

Figure5:Load Vs Deflection

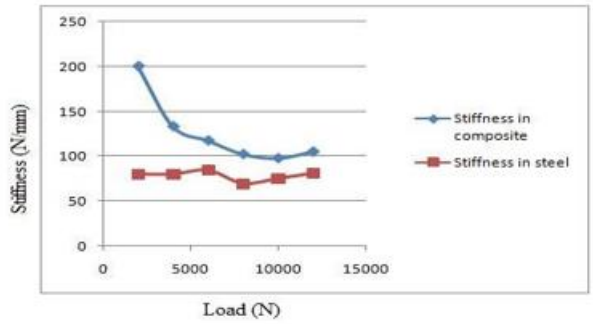

Figure6:Load Vs Stiffness.

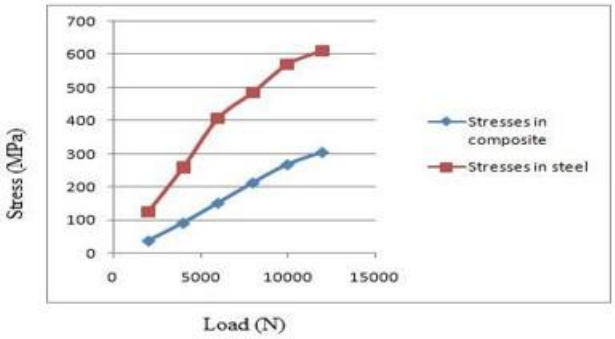

Figure7:Load Vs Stress

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. Static vertical force is applied to determine the load deflection curve as well as load stress curve. [Fig 5, 6, 7]

V. FEA ANALYSIS

Finite element analysis has been performed over the composite leaf spring. The results shows here,

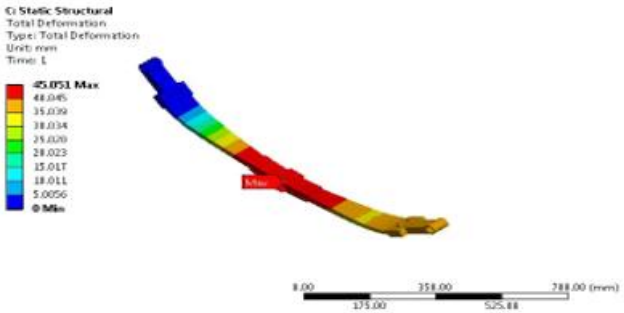

Figure8:Deformation plot for composite spring.

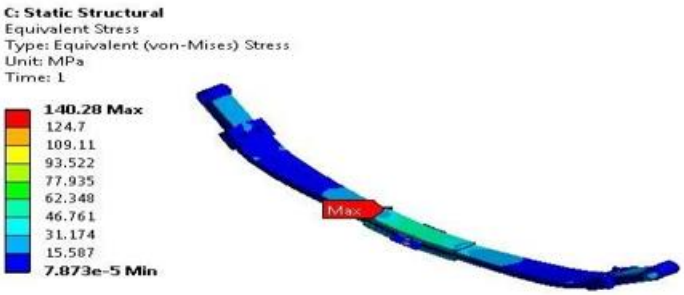

Figure9:Stress plot for composite spring

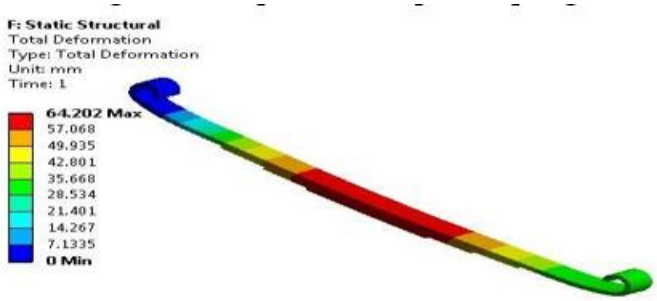

Figure10:Deformation Plot for steel spring

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

TABLE IIIII COMPARATIVE ANALYSIS BETWEEN STEEL AND COMPOSITE MATERIAL

SrNo	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

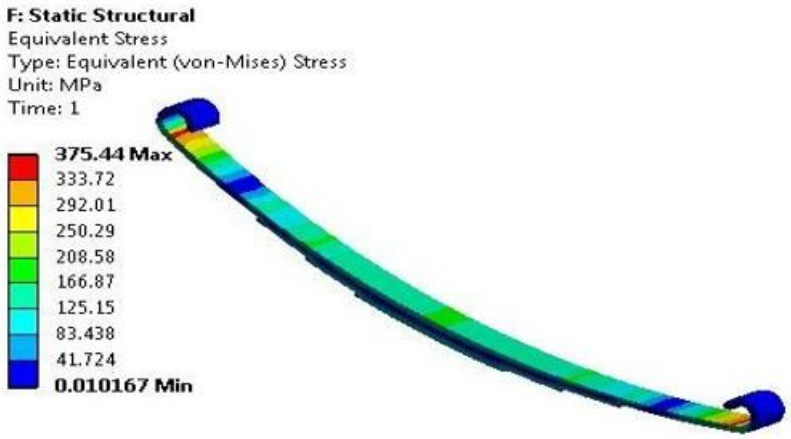

Figure11:Stress Plot for steel spring

VI. EXPERIMENTAL PROCEDURE

- Check for ON and OFF mode of machine.
- Observe the universal testing machine carefully. Make a quick check on circular dial or display. Note down the least count of circular dial.
- Universal testing machine contain two circular knobs, one for application of load and another for hydraulic fluid inlet and outlet supply.
- Put the fixture over the base of machine.
- Arrange leaf spring with the help of fixture on the base of machine.
- Adjust the actuator on the center of spring.
- Start the machine & apply the load gradually from 2000 N – 12000 N on center of leaf spring.
- Record the reading of load, deflection & stress.
- Store the data in laptop so that we will get the graph of load Vs deflection & stress.
- Release the load, so that actuator moves in original position.
- Collect the reading from display.

VII. CONCLUSION

The results obtained in above table by comparative study indicate 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. In entire work there is such a good agreement between finite element analysis results and experimental results. It is quite difficult to deal with analytical solution as mathematical formulation in case of composite always been a tough task. So experiment and finite element oriented task fulfil the desired values.

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