Static Analysis of Mono Composite Leaf Spring for - Light Weight Vehicle

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ABSTRACT: Now a day to reducing weight of the vehicle is the challenging task for design engineers,while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. In this project reducing weight of vehicles and increasing or maintaining the strength of their spare parts is considered. The main function of leaf spring is not only to support vertical load but also to isolate road induced vibrations. Finite element analysis (FEA) has been carried out to determine the safe stresses and pay loads. The aim of this project is to reduce the weight of the component without any reduction on load carrying capacity and stiffness. A single leaf with variable thickness and width for constant cross sectional area of unidirectional glass fiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf spring, was designed, fabricated and tested. It can be seen that as compared to the steel spring, the composite spring has stresses that are much lower and the spring weight is nearly 80 % lower.
Keywords- FEA,Glass Fibre Reinforced Plastic, Composite Leaf Spring.

I.INTRODUCTION

The automobile industry has shown increased interest in the replacement of steel spring with fiberglass composite leaf spring due to high strength to weight ratio. The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the unsprung weight. Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced material products. The suspension leaf spring is one of most important part in automobile which reduce jerk, vibration and absorb shocks during riding. A suspension system of vehicle is also an area where these innovations are carried out regularly. As we review suspension system components and how they work together, remember that a vehicle in motion is more than wheels turning. As the tire revolves, the suspension system is in a dynamic state of balance, continuously compensating and adjusting for changing driving conditions. Today's suspension system is automotive engineering at its best. The automobile industry has shown increased interest in the replacement of steel spring with fiberglass composite leaf spring due to high strength to weight ratio. The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the unsprung weight. Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced material products. The suspension leaf spring is one of most important part in automobile which reduce jerk, vibration and absorb shocks during riding. A suspension system of vehicle is also an area where these innovations are carried out regularly. As we review suspension system components and how they work together, remember that a vehicle in motion is more than wheels turning. As the tire revolves, the suspension system is in a dynamic state of balance, continuously compensating and adjusting for changing driving conditions. Today's suspension system is automotive engineering at its best.

II. What is leaf spring?

Leaf springs also known as flat spring are made out of flat plates. Leaf springs are designed two ways: multi-leaf and mono-leaf. The leaf springs may carry loads, brake torque, driving torque, etc... In addition to shocks. The multi-leaf spring is generally made of several steel plates of different lengths stacked together. During normal operation, the spring compresses to absorb road shock. The leaf springs bend and slide on each other allowing suspension movement. In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing process and in order to achieve this introduction of composite materials is done to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness.

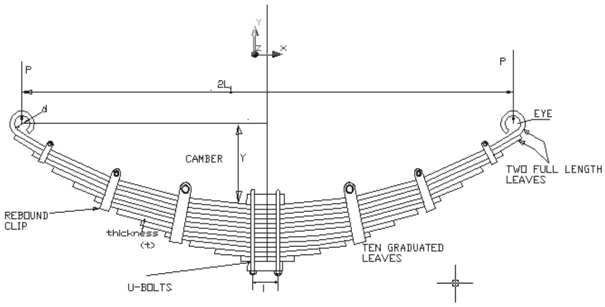


Fig No.1: General Leaf Spring

III.OBJECTIVE

This project is aimed at manufacturing of mono-composite leaf spring for light weight vehicle for the following basic objectives-

1. To reduce the overall weight of a component body without any reduction on load carrying capacity and stiffness
2. Maintain the high strength to low weight ratio.

IV.MATERIAL USED

Generally we are considering leaf spring made up of composite material. Materials of the leaf spring should be consist of nearly 60%-70% of the vehicle cost and contribute to the quality and the performance of the vehicle. Even a small amount in weight reduction of the vehicle, may have a wider economic impact. Composite materials are proved as suitable substitutes for steel in connection with weight reduction of the vehicle. Hence, the composite materials have been selected for leaf spring design. A combination of two or more materials (reinforcing elements, fillers, and composite matrix binder), differing in form or composition on a macroscale. The constituents retain their identities, that is, they do not dissolve or merge completely into one another although they act in concert. Normally, the components can be physically identified and exhibit an interface between one another. Examples are cermets and metal-matrix composites.

Fibers selection: The commonly used fibers are carbon, glass, keviar, etc. Among these, the glass fiber has been selected based on the cost factor and strength. The types of glass fibers are C-glass, S-glass and E-glass. The C-glass fiber is designed to give improved surface finish. S-glass fiber is design to give very high modular, which is used particularly in aeronautic industries. The E-glass fiber is a high quality glass, which is used as standard reinforcement fiber for all the present systems well complying with mechanical property requirements. Thus, E-glass fiber was found appropriate for this application.

Resins selection: The material used for leaf springs is usually a plain carbon steel having 0.90 to 1.0% carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel products greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties. The material for leaf spring generally used is: 1) Glass/Epoxy 2) Carbon/Epoxy 3) Graphite/Epoxy.

What is an Epoxy? Epoxies are polymer materials that begin as liquids and are chemically changed into a solid. An epoxy based polymer is mechanically strong, chemically resistant to degradation of the chemical elements in the solid form and highly adhesive during conversion from liquid to solid. There are a wide range of basic epoxy chemicals from which an epoxy system can be formulated.

V. METHODOLOGY

In this experimentation initially select an optimized raw material then create model by using modeling software and then create FEA model for (static) analysis that is testing the leaf springs under static loading condition to get optimized value of stresses and deflection. Then glass fibers were cut to desired length, so that they can be deposited on mold layer- by layer during fabrication of composite leaf spring.

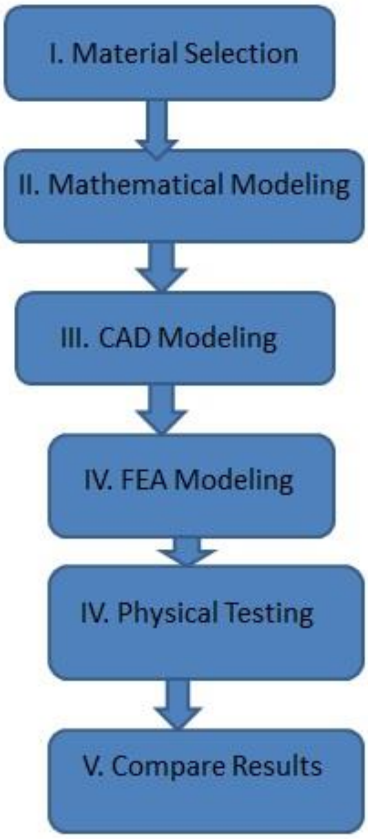


Fig No.2: Basic model of master leaf

VI. DESIGN FORMULAE FOR CALCULATING DIMENSIONS OF LEAF SPRING

- Moment of inertia $I = 1/12 \times bh^3$
- Maximum deflection $\delta_{max} = FL^3/3EI$
- Maximum stress $\sigma_{max} = 6FL/bh^2$

Where;

L=Length of master leaf
b=Width of master leaf
h=Thickness of master leaf
E=Young's modulus of elasticity
F=Force applied in Newton

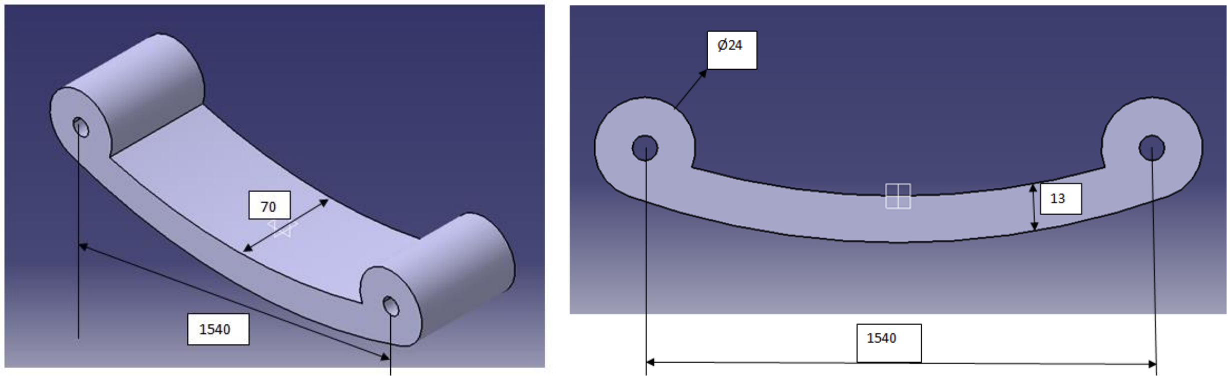
Taking width 70mm & height 13mm

- $I = 1/12 \times bh^3$ I= Moment of inertia
  $= 1/12 \times 70 \times 13^3$
  $= 12815.83$mm

- $\delta_{max} = FL^3/3EI$ $\delta_{max} =$ Maximum deflection
  $= 245.25 \times 1540^3/3 \times 2.1 \times 10^5 \times 12815.83$
  $=166.40$mm

- $\sigma_{max} = 6FL/bh^2$ $\sigma_{max} =$ Maximum stress
  $= 6 \times 245.25 \times 1540/70 \times 13^2$
  $= 191.556$mm

VII. CAD MODELING



(a) (b)

Fig No.3: Basic model of master leaf

VIII. FINITE ELEMENT ANALYSIS (FEA)

All the analysis for the composite leaf spring is done by using Hypermesh.For composite leaf spring the same parameters are used that of conventional leaf spring. For designing of composite leaf spring also the camber is taken 136 mm. The constraint is given at the two eye rolled ends. One of the end is provided with translational movement so as to adjust with the deflection. This eye end is free to travel in longitudinal direction. This particular motion will help leaf spring to get flattened when the load is applied. Modeling is done without Roll Eye End because their DOF are constrained in specific directions. Produced results are very well compared with the realistic leaf spring and it's Experimental Procedure. The range of loads is applied and results are analyzed. The maximum principle stress is evaluated by software i.e. Von Mises Stress and Maximum Deflection is also observed. It is very much clear from the results produced by the Hypermesh for Conventional Steel Leaf Spring, that red colored area indicated that eye end is the possible failure area for leaf spring. This failure at eye end is occurred when the load of 3850N is applied (Hypermesh Result 1). It is also interesting to see the results for Composite Leaf Spring when same load is applied i.e. 3850N (Hypermesh Result 3). Observation shows the absence of red colored area on Composite Leaf spring. Element Solid 46 is used for Composite Leaf Spring. Material is specified with 39 layers of fibers with the orientation (-45, 90, +45). Entire volume is mapped meshed with hexahedral shape. Hypermesh Result 1 and 2 represent the Stress and Deflection analysis of Conventional Steel Leaf Spring. Hypermesh Result 3 and 4 represents the Stress and Deflection of E-Glass/Epoxy material respectively.

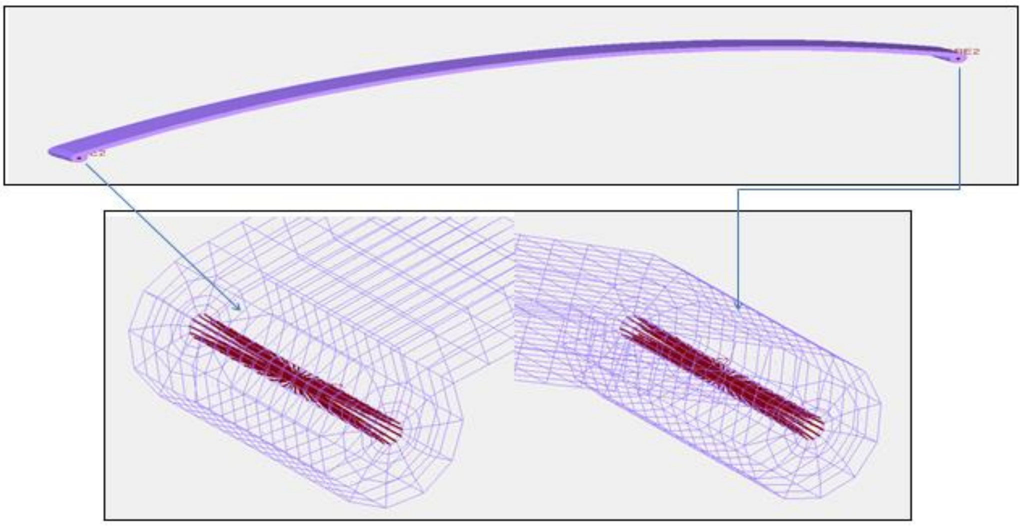


Fig No.4: FEA model with rigid element

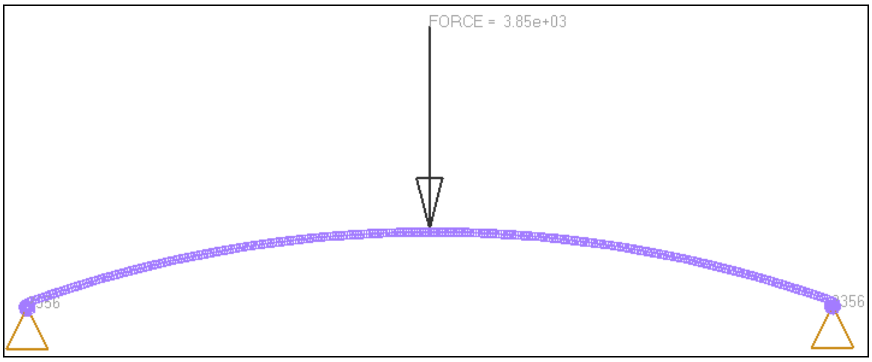


Fig No.5: FEA model with boundary condition

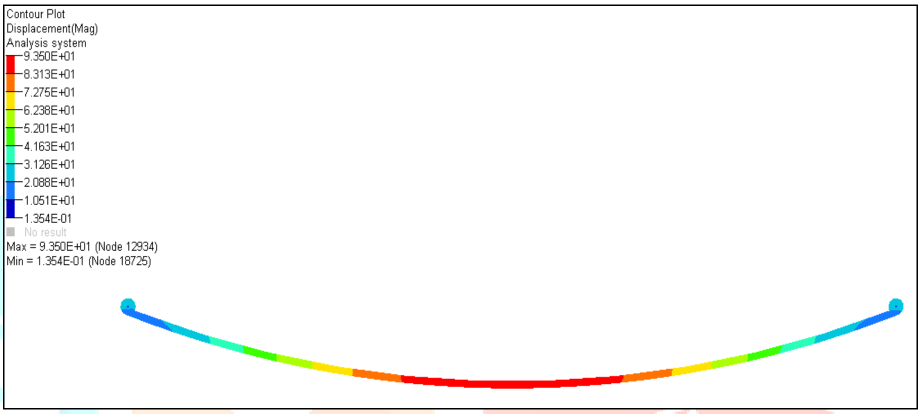


Fig No.6: Displacement of steel material

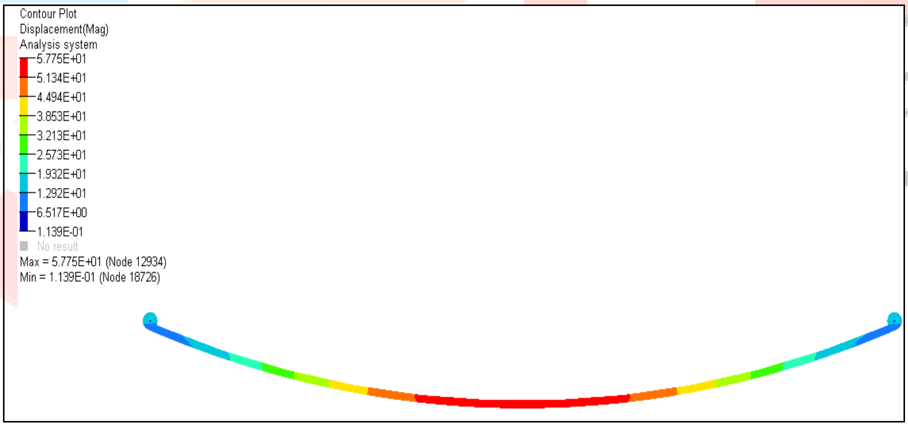


Fig No.7: Displacement of composite material

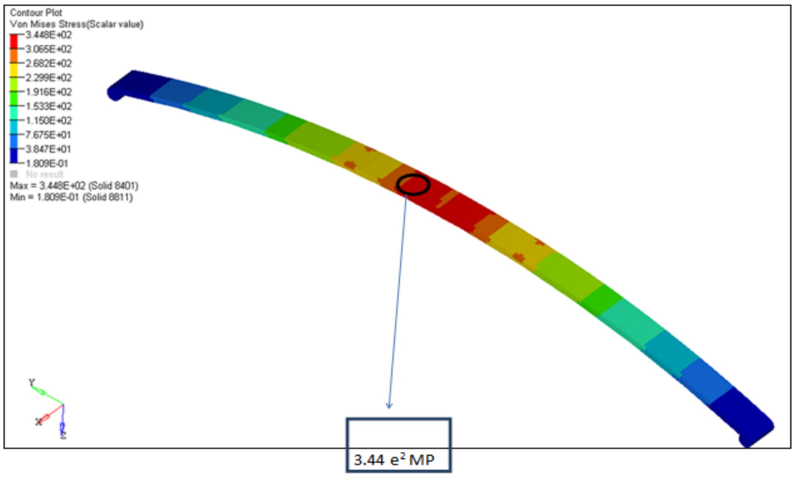


Fig No.8:Max.stress for steel material

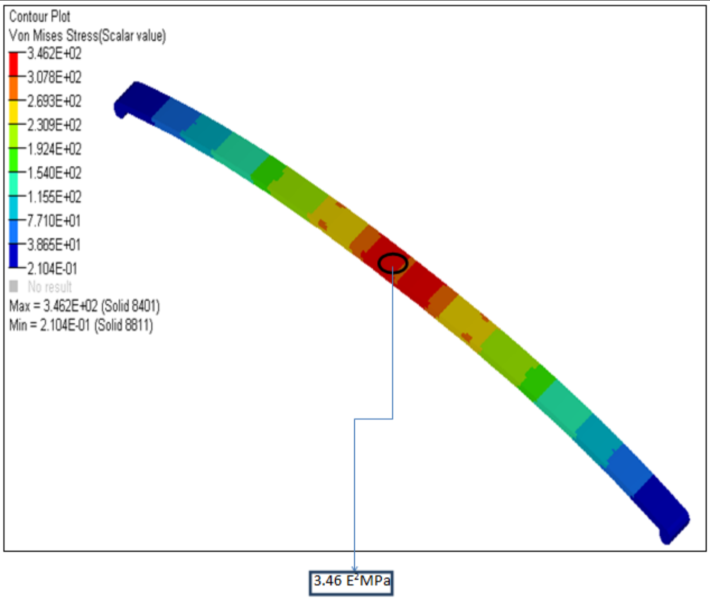


Fig No.9: Maximum stress induced for composite material

IX. RESULT

		Maximum deflection (mm)		Maximum stress (MPa)		
	Static Load (N)	**FEA**	**Mathematical**	**FEA**	**Mathematical**	**Weight (kg)**
Steel	**3850**	**93.5**	**166.40**	**346.2**	**191.55**	**21**
E-Glass/Epoxy	**3850**	**57.75**	**105.5**	**344.8**	**473.0**	**4.0**

X. CONCLUSION

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 and is satisfactorily achieved as per the analysis we have done. As leaf spring contributes considerable amount of weight to the vehicle and needs to be strong enough, a single E-glass/Epoxy leaf spring is designed and simulated following the design rules of the composite materials. And as per the results it is shown that the resulting design and simulation stresses are much below the strength properties of the material satisfying the maximum stress failure criterion. Researches are going on to reduce cost of fabrication also so as to make composite made leaf springs more economical.

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