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RESEARCH ARTICLE

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COMPOSITE LEAF SPRING ANALYSIS FOR LIGHT WEIGHT VEHICLE

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ABSTRACT

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. Therefore; the aim of this paper is to present a low cost fabrication of complete mono composite leaf spring and mono composite leaf spring with bonded end joints. Also, general study on the analysis and design. 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. Reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue. In this paper we describe design and analysis of composite leaf spring. The objective is to compare the stresses and weight saving of composite leaf spring with that of steel leaf spring.

Keywords: Composite material, leaf spring, ANSYS 14, Leaf Spring Glass Fiber Reinforced Material,

1 INTRODUCTION

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very good replacement material for conventional steel. Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing . The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device . According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring . To meet the need of natural resources conservation, automobile manufacturers are attempting to reduce the weight of vehicles in recent years . Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The suspension leaf spring is one of the potential items for weight reduction in automobiles unsprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of composite materials was made it possible to reduce the weight

of leaf spring without any reduction on load carrying capacity and stiffness . For weight reduction in automobiles as it leads to the reduction of un-sprung weight of automobile. The elements whose weight is not transmitted to the suspension spring are called the un-sprung elements of the automobile. This includes wheel assembly, axles, and part of the weight of suspension spring and shock absorbers.

2 LEAF SPRING

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 made of several steel plates of different lengths stacked together. All these will result in fuel saving which will make countries energy independent because fuel saved is fuel produced. A composite material is the combination of two or more materials that produce a synergistic effect so that the combination produces aggregate properties that are different from any of those of its constituents attain independently.

The composite materials made it possible to reduce the weight of machine element without any reduction of the load carrying capacity. Because of composite material's high elastic strain energy storage capacity and high strength-to-weight ratio compared with those of steel . FRP springs also have excellent fatigue resistance and durability. But the weight reduction of the leaf spring is achieved not only by material replacement but also by design optimization. Weight reduction has been the main focus of automobile manufacturers in the present scenario.

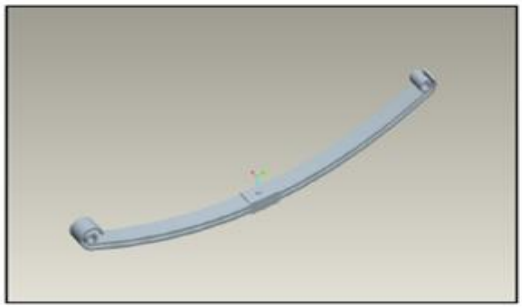

Fig. 1 : Leaf Spring

The replacement of steel with optimally designed composite leaf spring can provide 92% weight reduction. Moreover the composite leaf spring has lower stresses compared to steel spring. Leaf springs also known as flat spring are made out of flat plates. This is intentionally being done today to get different design, manufacturing as well as service advantages of products. Up on those products leaf spring is the focus of this project for which researches. are running to get the best composite material, which meets the current requirement of strength and weight reduction in one, to replace the existing steel leaf spring (Robert, 1999). Leaf spring should absorb vertical vibrations due to road irregularities by means of variations in the spring deflection so that potential energy is stored in the spring as strain energy and then released slowly. So, increasing energy storage capability of a leaf spring ensures a more compliant suspension system.

3 DESCRIPTION OF THE PROBLEM

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 un-sprung weight [9]. 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 [7]. The relationship of the specific strain energy can be expressed as it is well known that springs, are designed to absorb and store energy and then release it slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension system. Hence, thestrain energy of the material becomes a major factor in designing the springs. The relationship of the specific strain energy can be expressed as

$$U=\sigma 2/2Pe$$

Where σ is the strength, ρ is the density and E is the Young's Modulus of the spring material.It can be easily observed that material having lower modulus and density will have a greater specific strain energy capacity. The introduction of composite materials made it possible to reduce the weight of the leaf spring without

reduction of load carrying capacity and stiffness due to more elastic strain energy storage capacity and High strength to weight ratio.

DEMERITS OF CONVENTIONAL LEAF SPRING

- They have less specific modulus and strength.
- Increased weight.
- Conventional leaf springs are usually manufactured and assembled by using number of leafs made of steel and hence the weight is more.
- Its corrosion resistance is less compared to composite materials.
- Steel leaf springs have less damping capacity.

MERITS OF COMPOSITE LEAF SPRING

- Reduced weight.
- Due to laminate structure and reduced thickness of the mono composite leaf spring, the overall weight would be less.
- Due to weight reduction, fuel consumption would be reduced.
- They have high damping capacity; hence produce less vibration and noise.
- They have good corrosion resistance

4 DESIGN OF LEAF SPRING

Considering several types of vehicles that have leaf springs and different loads on them, various kinds of composite leaf spring have been developed. In the case of multi- leaf composite leaf spring, the interleaf spring friction plays a spoil spot in damage tolerance. It has to be studied carefully. In the present work, only a leaf spring with constant thickness, constant width design is analyzed.

The following cross-sections of leaf spring for manufacturing easiness are considered.

1. Constant thickness, constant width design
2. Constant thickness, varying width design
3. Varying width, varying width design. Considering several types of vehicles that have leafsprings and different loading on them, various kinds of composite leaf spring have been developed. In multi-leaf composite leaf spring, the interleaf spring friction plays a spoil spot in damage tolerance.

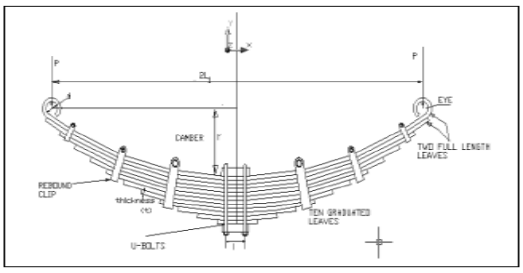

Fig.2 : Main Parts of Leaf Spring

Based on the specific strain energy of steel spring and some composite materials, the E-glass/epoxy is selected as the spring material.

Properties	Values
Tensile Strength	900 N/mm^2
Compressive strength	450 N/mm^2
Poisson ratio (T)	0.217
Mass density (ρ)	2.6e-10 kg/mm^3
Flexural strength(σ)	1200 N/mm^2
Flexural modulus(E)	40000 N/mm^2

Table 1:Parameters of Composite Leaf spring

5 RESULTS AND DISCUSSIONS

Analysis of Leaf Springs using ANSYS

All the analysis for the springs is done by using ANSYS 14.0. For composite leaf spring the same parameters are used as that of conventional leaf spring. For designing of leaf spring the camber is taken as 200 mm. Leaf spring is modelled in Catia software and it is imported in ANSYS 14.0 The stress and deflection analysis is done for conventional and composite leaf spring using ANSYS software.

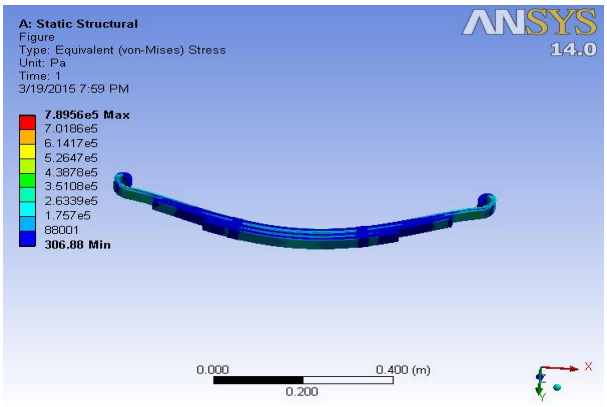

Fig. 3:Equivalent (non-misses) Stress

.Fig.3 shows the equivalent von-Mises stress induced in steel leaf spring The maximum stress is induced near the fixed eye end of the leaf spring its maximum value is 7.8956e5.Thisshows stress acted on model under safe zone, gives FOS= 4.5. Red zone indicates the area of maximum stress and blue zone indicates the area of minimum stress.

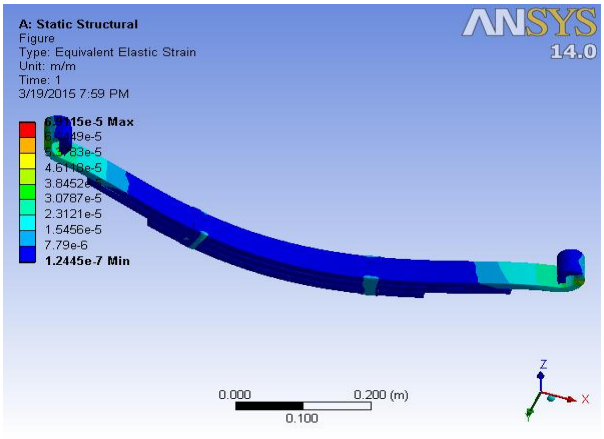

Fig. 4:Equivalent Elastic Stress

The constraint is given at the two eye of the ends 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.

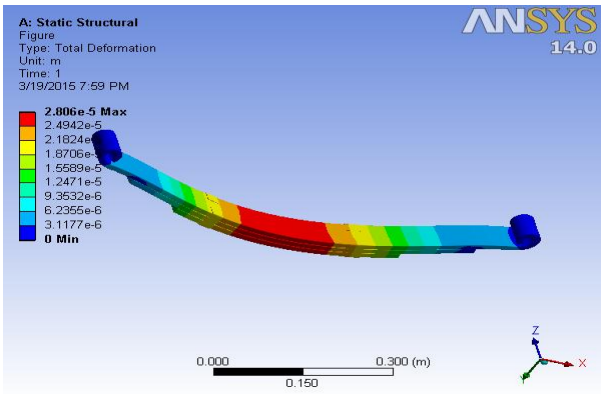

Fig. 5:TotalDeformation

The maximum deflection is at the centre of the leaf spring its maximum value is 2.806e-5.

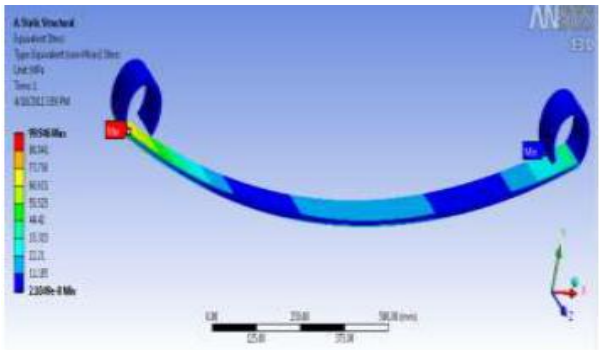

Fig.6:Stress of Steel leaf Spring

Fig 6 shows the equivalent von-Mises stress induced in steel leaf spring under the action of 2500N load. The maximum stress is induced at the fixed eye end of the leaf spring its maximum value is 99.95 N/mm2.Red zone indicates the area of maximum stress and blue zone indicates the area of minimum stress.

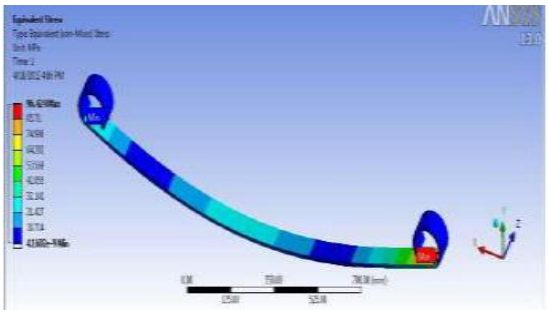

Fig.7:Stress of Composite leaf Spring

Fig 7 shows the equivalent von-Mises stress induced in composite leaf spring under the application of 2500N load. The maximum stress is induced at the fixed eye end of the leaf spring its maximum value is 96.424N/mm2.

6 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. The 3-D modeling of both steel and composite leaf spring is done and analyzed. From the results, It is observed that the composite leaf spring is lighter and more economical than the conventional steel spring.

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