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Design, Analysis and Weight Optimization of Monoleaf Spring by using Composite Material

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***Abstract*— The leaf spring is widely used in automobiles as major component of suspension system. This spring is intended to bare jerks and vibrations during traveling on uneven surfaces. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for ten to twenty percent of the unsparing weight. The reduction in weight will achieve fuel efficiency and improve riding quality. The objective of the project is to apply FEA concept to compare two materials for leaf spring and proposed the one who is having best strength to weight ratio. In this paper I used composite Carbon Fiber Epoxy material to replace Omni leaf spring with steel material.**

Keywords*— Leaf spring, Composite material, E Glass Fiber, Static analysis, Weight optimization Introduction

INTRODUCTION

A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. Leaf springs absorb the vehicle vibrations, shocks and bump loads (induced due to road irregularities) by means of spring deflections, so that the potential energy is stored in the leaf spring and then relieved slowly. The spring consists of a number of leaves called blades. The blades are varying in length but in this case, blades are same length. The blades are us usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaf spring is based upon the theory of a beam of uniform strength. The lengthiest blade has eyes on its ends. This blade is called main or master leaf, the remaining blades are called graduated leaves. All the blades are bound together by means of steel straps.[1]

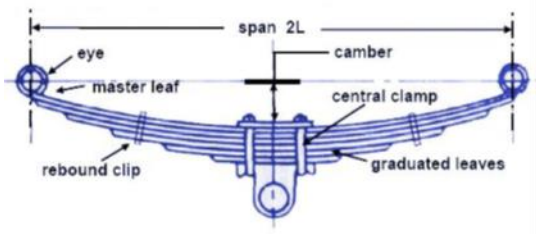

Fig.1 Geometry of Leaf Spring [1]

As shown in figure the leaves are held together with the help of two U-bolts and also Centre clip. Also, in that Rebound clips are provided to keep the leaves in alignment and save from lateral shifting of the plates during the working condition.[2]

The spring is mounted on the axle of the vehicle. The entire vehicle load rests on the leaf spring. The front end of the spring is connected to the frame with a simple pin joint, while the rear end of the spring is connected with a shackle. Shackle is the flexible link which connects between leaf spring rear eye and frame. When the vehicle comes across a projection on the road surface, the wheel moves up, leading to deflection of the spring. This changes the length between the spring eyes. If both the ends are fixed, the spring will not be able to accommodate this change of length. So, to accommodate this change in length shackle is provided at one end, which gives a flexible connection. The front eye of the leaf spring is constrained in all the directions, whereas rear eye is not constrained in X-direction. This rare eye is connected to the shackle. During loading the spring deflects and moves in the direction perpendicular to the load applied.[4]

Composite Material

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Typical composite materials are composed of inclusions suspended in a matrix. The constituents retain their identities in the composite. Normally the components can be physically identified and there is an interface between them. Many composite materials offer a combination of strength and modulus that are either comparable to or better than any traditional metallic materials. Because of their low specific gravities, the strength weight-ratio and modulus weight-ratios of these composite materials are markedly superior to those of metallic materials. The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates excellent. For these reasons, fiber composite have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries.

Objective

To reduce the weight of the mono leaf spring in vehicle to increase the fuel efficiency. Static analysis of standard Steel leaf spring, E-glass epoxy spring, & Carbon fiber spring using FEA. Determining effects of deflection and bending stress. Comparison results of ANSYS and concluded result for best material for leaf spring.

FINITE ELEMENT ANALYSIS

We have applied gradual increasing load on all material leaf spring, it's from 1000N to 6000N. In this paper we shows a results for maximum load applied condition.

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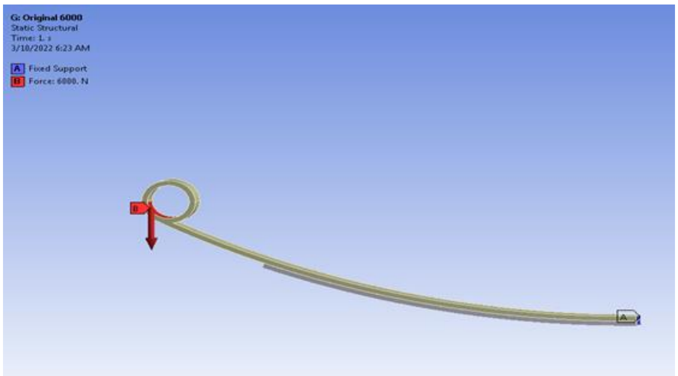

Fig. 2 Boundary condition of 6000N force applied on original leaf spring

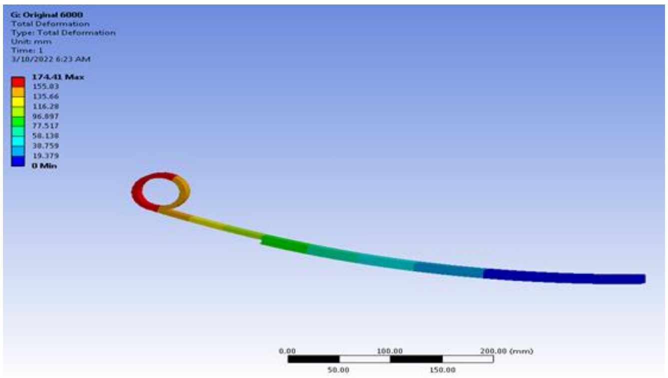

Fig. 3 Total deformation of Original leaf spring due to applied load of 6000N

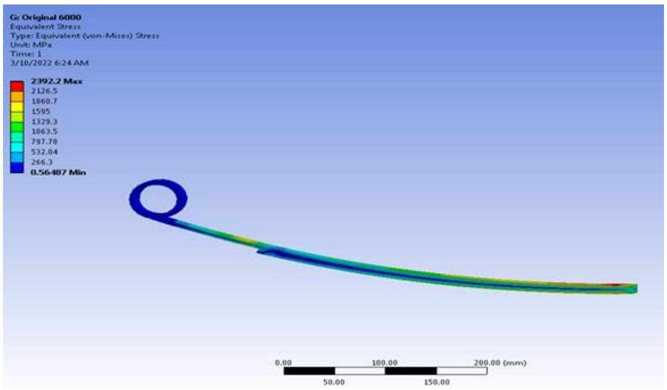

Fig. 4 Stress generated due to applied boundary condition in original leaf spring

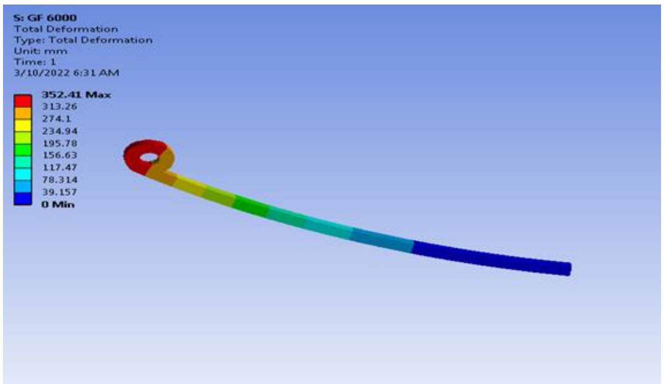

Fig. 5 Total deformation of Glass fiber leaf spring due to applied load of 6000N

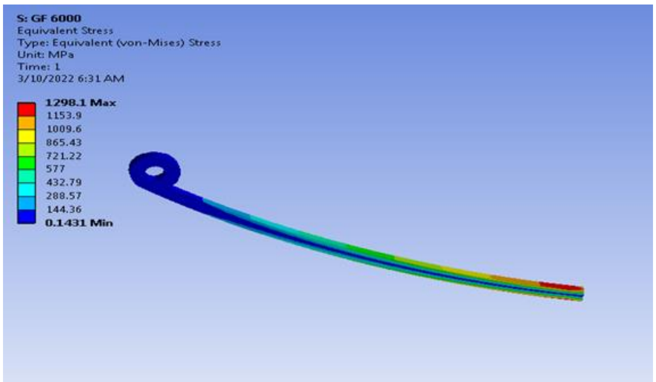

Fig. 6 Stress generated due to applied load of 6000N in Glass fiber leaf spring

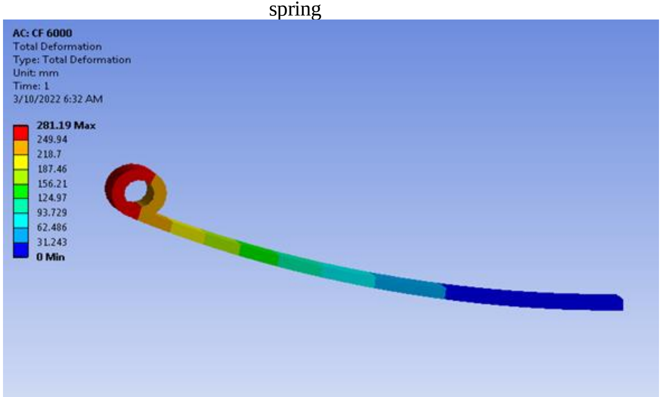

Fig. 7 Total deformation of Carbon Fiber leaf spring due to applied load of 6000N

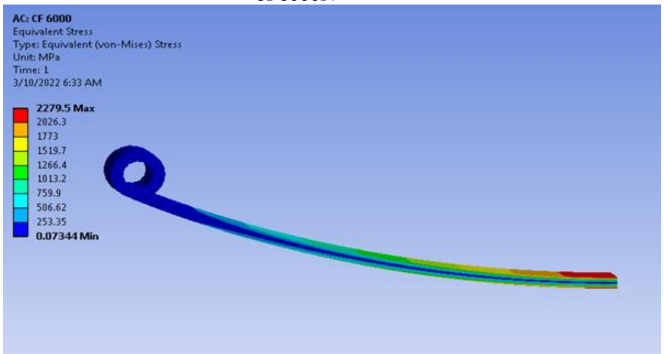

Fig. 8 Stress generated due to applied load of 6000N in Carbon fiber leaf spring

RESULT TABLE

Sr. No.	Material	Stress (MPa)	Deformation(mm)	Weight(gm)
1	Steel	2392.3	174.41	2366
2	Glass Fiber	1298.1	352.41	942
3	Carbon Fiber	2279.5	281.19	580

Table1. Results of leaf spring with different loading condition due to applied load of 6000N

CONCLUSION

1. Bending stress and deflection occurred in the composite leaf spring is less as compared to conventional steel spring.
2. Results obtained through ANSYS are got validation from Theoretical calculations and Testing.

3. Composite E-glass epoxy spring has 30 %and carbon fiber has 55 % less weight than conventional steel spring. So composites can be suggested for mono leaf spring.

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