

Finite Element Analysis of Conventional Leaf Spring for Automobile Suspension System- A Review

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ABSTRACT: Using of composite materials attracting the researchers and providing solutions for reduction of weight. Weight reduction can be accomplished primarily for manufacturing processes. The aim of this paper is to reviews on reducing the weight of leaf spring. Leaf springs are one of the ancient suspension technique which commonly used, especially in commercial vehicles. Weight reduction can be achieved by using composite material having suitable properties and capable of carrying such heavy load of the vehicle are suggested in many article. Generally the material are used for leaf spring are Steel EN 45, EN 47 etc. Composite material like CARBON FIBRE, E- glass, Graphite epoxy are review in this paper to replace the steel for leaf spring. In this paper we reviewed many papers on use of alternate materials and effect of material on leaf spring performance. A wide amount of study has been conducted in this paper to investigate the design and analysis of leaf spring and also review designed in ANSYS.

KEYWORDS- FEA, Leaf spring, composite material, SOLIDWORKS, ANSYS.

I. INTRODUCTION

Leaf spring is a simple form of spring, purposed for the suspension in wheeled vehicles. It was originally called as laminated or carriage spring. It is also one of the oldest forms of springing, dating back to medieval times. Leaf springs serves locating, damping as well as springing function. Sometimes referred to as a semi-elliptical spring or cart spring, it takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The centre of the arc delivers location for the axle, while tie holes called eyes are provided at either end for attaching to the vehicle body. For heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves.

A leaf spring mount directly at one end, either be attached directly to the frame at both ends, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness [1].

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Figure 1: Leaf spring assembled at rear axle of automotive[2]

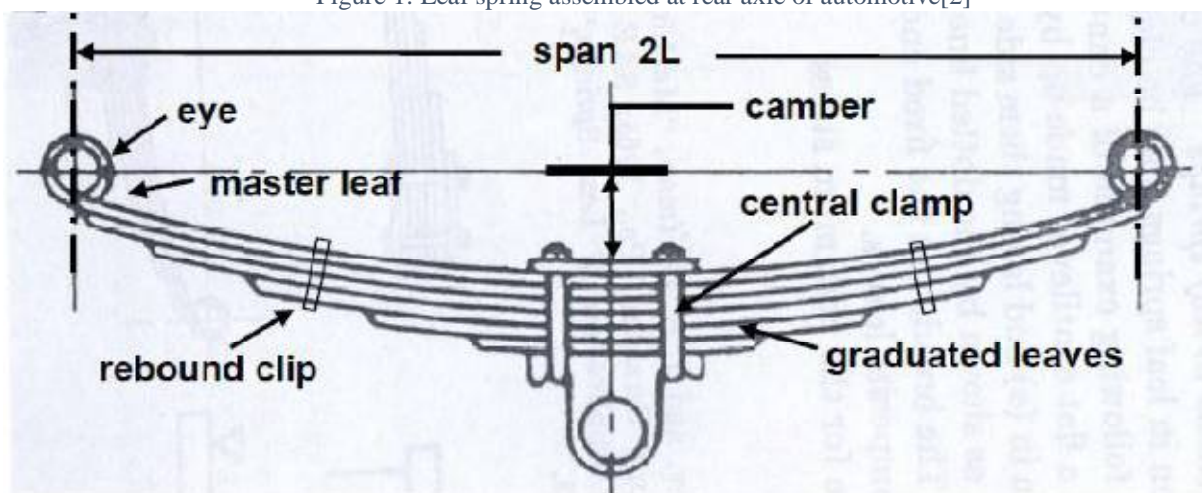


Figure 2: Multi-Leaf Spring [2]

II. PRINCIPLE OF LEAF SPRING

The weight reduction in automobile by suspension leaf spring is one of the impending items, as it accounts for ten to twenty percent of the unsprung weight. Without much increase in cost and decrease in quality and reliability, a better suspension system with better ride quality can be achieved with the introduction of composites. In designing of springs, strain energy becomes the major factor. The relationship of the specific strain energy can be expressed as;

$$U = \sigma^2 / \rho E$$

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 greater specific strain energy capacity can be achieved when material having lower modulus and density. To reduce the weight of the leaf spring without reduction of load carrying capacity and stiffness composites are introduced and due to the following factors composite materials are compared to steel.

Upturned spring eye is taken to attach the front end of semi-elliptic leaf spring to the chassis frame, and a free end with a bracket constraining vertical motion to attach the back end of semi-elliptic leaf spring to the chassis frame.

Engineering Composite materials that had physically assembled to form one single bulk without somatic blending to form a homogeneous material. The resulting material had components which are identifiable as the constituent of the

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different materials. One of the advantages of composite is that more than one materials can be mixed with each other, in order to take advantage of the good characteristics of each[1].

III. COMPOSITE MATERIALS

A combination of two or more materials that results in better properties than those of the individual components used alone can be defined as Composite material. As compared to metallic alloys, every material retains its separate chemical, physical, and mechanical properties. The two constituents are a reinforcement and a matrix. Advantages of Composite materials such as high strength and stiffness, combined with low density, when compared with bulk materials, which allows for weight reduction for the finished part[3].

IV. CHARACTERISTICS

A composite material is defined as a material when two or more constituents are combined mechanical and chemical bonds on a macroscopic scale.

Composite materials of typical type 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 either comparable or better than any traditional metallic materials in which there is high combination of strength and modulus. The strength weight-ratio and modulus weight-ratios of these composite materials are much better than metallic materials, because of their low specific gravities.

They also have excellent fatigue strength weight ratios as well as fatigue damage tolerances. For these reasons, fibre composite are considered as substitutions for metal in many weightcritical components in aerospace, automotive and other industries. Fibre reinforced composites have high internal damping, leads to better vibration energy absorption within the material, reduced transmission of noise and vibration to neighbouring structures.

Among the other environmental factors which causes degradation in the mechanical properties of some polymeric matrix composites are elevated temperatures, corrosive fluids, and ultraviolet ray.

V. APPLICATIONS

Composites material have their commercial and industrial applications of on major structural application areas, includes aircraft, space, automotive, sporting goods, and marine engineering. The corvette rear leaf spring in 1981, was the first major structural application of composite. Replacement a ten-leaf steel spring by Uni-leaf E-glass – reinforced epoxy had been used to reduce weight nearly an 80 %.

Other structural chassis components, such as drive shafts and road wheels, have been successfully tested in the laboratories and are currently being developed for future cars and vans.

BENEFITS:

1. Weight reduction: Composites are light in weight, compared to most woods and metals.
2. High strength: Composites can be designed to be far stronger than aluminium or steel.
3. Corrosiveness: Composites resist damage from the weather and from harsh chemicals that can eat away at other materials.
4. Design Flexibility: As compare to other materials composites can be moulded into complicated shapes more easily.
5. Part Consolidation: A single piece made of composite materials can replace an entire assembly of metal parts
6. Nonconductive: Composites are nonconductive, meaning they do not conduct electricity
7. Low Thermal Conductivity: Composites have low conductor of heat and cold and are good insulator
8. Durable: Structures made of composites have a long life and need little maintenance [4].

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TOOL:

Ansys is engineering simulation software used for general purpose finite element analysis and for numerically solving mechanical problems. Here Ansys 14.0 is used for analyzing the performance of conventional and composite leaf spring. Leaf spring is modelled in Solidworks software and it is imported in Ansys 14.0[5].

VI. LITERATURE REVIEW

Ranjit et al. [1] they compared load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. They opted stresses and deflections as design constraints. They took dimensions of an existing conventional steel leaf spring of a heavy commercial vehicle. and with same dimensions they fabricated composite multi plate leaf spring using these composite materials E-GLASS/EPOXY, C- GLASS/EPOXY, S- GLASS/EPOXY unidirectional laminates. They used CATIA V5R20 software for modelling and ANSYS for Static & Dynamic analysis of Leaf spring.

Pakale and Patil [2] They studied various properties such as material behaviour, fatigue life, weight, stresses by designing, modelling and experimental investigation of composite leaf spring. They aimed on safety, comfort and durability about leaf spring.

Wagh et al. [3] had tried to reduce the vehicle weight and cost. It gives high level of comfort. They studied the behaviour of Composite Leaf Spring by analysis on composite material. They aimed to review the paper about fabrication and analysis of composite leaf spring.

Nutalapati [4]. had done comparison between the stresses, deformations and weight saving between an existing dimension of Mahindra "Model-Commander 650 Di" steel leaf spring and composite leaf spring. Stiffness was their designing constraint. They selected glass fibre reinforced polymer (E-Glass/Epoxy) as their composite. Their Result showed that up to 85% of weight of composite leaf spring was reduced as compared to steel leaf spring. They modelled leaf spring in Pro/ENGINEER and they did analysis by ANSYS 12.0 software.

Burande et al. [5] they mainly focussed on static and dynamic characteristics between steel and composite multi-leaf spring. They took existing dimensions of Steel SUP9(AISI) leaf spring of Tata Sumo vehicle and then same dimensions were used to design composite multi-leaf spring form the. They carried out analysis by ANSYS V12 of conventional leaf spring and the results were validated by experimental method. Bending stresses and deflection were their design constraints. Lower bending stresses and deflections were observed on composite multi-leaf spring than that of steel.

Sharma et al. [6] In this paper main focus is to review all such work in which the weight reduction of the vehicle was achieved by considering leaf spring. Many of authors suggested that weight reduction can be achieved by using composite material having suitable properties and capable of carrying such heavy load of the vehicle. Different methods for analysing and manufacturing for composite leaf spring are also discussed. It was shown that the weight reduction can be easily achieved but there are more aspects which should also be consider i.e. cost, new composite materials.

Wahane et al. [7] They did comparison between composite leaf spring and of EN45 steel leaf spring. The parameters of comparison was load carrying capacity, strength and weight saving of with. Stress, deflection and weight saving were the design constraints. Dimensions opted are of existing EN45 steel leaf spring and same with that of composite material of TATA SUMO GOLD for rear suspension. Composite material opted was Thermoplastic polyimide with 30% carbon fibre. ANSYS R15 was used for analysis and modelling from CATIA V5R20.

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Tharigonda et al. [8] they performed comparison of composite (E-Glass/Epoxy and Jute E-Glass) leaf spring and conventional leaf spring. Modelling was done in CATIA V5R20 software and analysed in ANSYS 12.0. Both composite and conventional leaf spring were analysed in ANSYS12 with same dimension.

Shamim and Anwer [9] They performed Comparison between AISI 6150 Steel (Oil Quenched 845 °C and 650 °C tempered), Ti-6Al-4V alloy (Annealed) and S-Glass Fibre Composite Multi-Leaf spring in terms of static analysis and harmonic analysis. Static analysis were deformation, von-Mises stress and harmonic analysis were Amplitude (mm) versus frequency curves. Finite Element Analysis had been carried out in ANSYS 14.

Ajay et al. [10] They selected and performed analysis on existing commercial vehicle carrying leaf spring with 8 leaves. They performed replacement of conventional steel material leaf spring and composite leaf spring. Composite material selected was glass fibre reinforced plastic. They considered 2.5 as factor of safety. Their results show that stresses were lower on composite than steel leaf spring. Static analysis was performed on ANSYS software. Deflection and Stresses result parameters.

PATEL [11] They performed study on comparison made between steel and composite leaf spring. Strength and weight were parameter. They opted an existing dimension steel leaf spring of Force Motors- TRAX, and same dimension was used in fabrication of composite materials. Composite material selected was E-glass/epoxy, Carbon epoxy, and Graphite epoxy. Weight reduction in composite materials observed was 74.54% for E-glass/epoxy, 79.66% for Carbon epoxy and 79.77% for Graphite epoxy over steel leaf spring.

Chandrabose et al. [12] the aim of this research work is to present a general study on the analysis, design and fabrication of parabolic leaf springs. This research work is based on a complete study and design of leaf spring. Here Finite element models been deployed to optimize and improve the material with complete geometry of the parabolic spring based on the spring rate, long life and shear stress. The influence of elasticity ratio on performance of parabolic springs was investigated computationally.

Jadhao and Dalu [13] Showed various reviews on many things in table form. 1st review table was of Composite Materials Proposed for Leaf Spring, 2nd review table was on Performance Parameters of Composite Leaf Spring (1986-2014), 3rd review table made was on objectives and analysis of leaf springs.

Pozhilarasu and Pillai [14] They performed a general study on comparison between composite (Glass Fibre Reinforced plastic - GFRP) leaf spring and conventional leaf spring. They opted Unigraphics NX4 software for modelling of leaf spring and then they imported it in ANSYS 11.0. They did analysis between composite and steel leaf spring with same dimension under similar conditions by ANSYS. For experimental set-up, they fabricated E-glass/Epoxy composite leaf spring fabricated using hand layup method. They performed testing on Universal Testing Machine and they compared the results.

Dubey and Mahakalkar [15] They selected mono parabolic leaf spring of a Maruti Omni Car. They performed design and experimental analysis on mono-parabolic leaf spring with that of composite leaf spring. Composite material opted was HM and HS carbon polymers. They did Modelling in Pro-E V5.0. They carried out analysis on ANSYS 10.0. They opted stresses and deflections as their design constraints.

Saini et al. [16] They performed study on comparison between the stresses and weight saving of composite leaf spring with that of steel leaf spring with existing same dimensions. Stiffness was their design constraint. They selected glass fibre reinforced polymer (E-glass/epoxy), carbon epoxy and graphite epoxy as their composite material which they used against conventional steel. They modelled leaf spring in Auto-CAD 2012 and they performed analysis by done using ANSYS 9.0 software. Their results showed that weight got reduced up to 81.72% on E-glass/Epoxy, 90.51% on carbon epoxy, 91.91 on graphite epoxy as compared steel leaf spring.

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Amrute et al. [17] They focused to implement composite materials by replacing steel in conventional leaf springs of a suspension system to reduce product weight, improve the safety with comfort and durability. They compared the stresses, deflection and weight savings of composite leaf spring with that of steel leaf spring. They selected 65Si7 as their steel material. They first calculated stress and deflection analytically. They selected E-Glass/Epoxy as their composite material. Then they performed analysis through ANSYS V12. Load given on both springs was 4169N. Weight of composite leaf spring was reduced to 67.88%.

Rai and Saxena [18] they performed study on comparison by replacing steel multi-plate leaf spring by mono composite leaf spring. They considered same load carrying capacity and stiffness. They selected E-Glass fibre for their composite material and EN47 as their steel material. They selected limiting stresses and displacement as their design constraints. They performed modelling in Pro-E 4.0 and analysis by ANSYS V12.1. They gave 2446N load on both leaf spring.

Kumar & Teja [19] They performed general study by comparison between composite leaf spring and steel leaf spring. They did replacement of steel leaf spring with a Mono objective of minimizing Composite leaf spring. They used E-Glass/Epoxy as their composite material. The modelled leaf spring in Pro/E and they performed analysis by using ANSYS Metaphysics software. Then they compared their results from parameters such as stress and deflection.

Devaraj and Venkatesan [20] They performed their study on comparison between existing dimensions conventional steel leaf spring and fabricated same dimension composite leaf spring of light commercial vehicle. They opted E-Glass/Epoxy as their Composite material. They selected stresses and deflections as their design constraints. They did finite element analysis on ANSYS V12 3-D model. On their result, they obtained 76.4% of reduction in weight, 67.35% lesser stress, 64.95% higher stiffness and 126.98% higher natural frequency of composite leaf spring than steel leaf spring.

Lakshmi and Satyanarayana [21] They performed their study on comparison between existing dimensions conventional steel multi leaf spring and fabricated same dimension composite multi leaf spring of heavy commercial vehicle. They selected mild steel for conventional steel leaf spring. They opted E-Glass/Epoxy, C- Glass/Epoxy, S- Glass/Epoxy as their Composite material. They did modelling on Pro/Engineer and analysis on COSMOS. They selected stresses and deflections as their design constraints. They compared their results on parameters such as static analysis - stress, strain, displacement and on harmonic analysis.

VII. CONCLUSION

This paper initiated a review based research into analysis of conventional leaf spring for automobile suspension system. This work offers tremendous significant for developing new technologies pertains to weight reduction from a conventional steel leaf spring, in order to achieve high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished. So, more attention is needed in this area and lots of work has to be done based in terms of its background, originality, current status, and researches.

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