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STUDY OF AUTOMOBILE LEAF SPRING FROM COMPOSITE MATERIALS: A REVIEW

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ABSTRACT:

This survey is intended to be a far reaching source for design a leaf spring involving different composites as the Automobile ventures are showing strong fascination for supplanting steel leaf spring with that of a composite leaf spring to get decrease in weight, which is a compelling measure for energy preservation as it decreases generally fuel utilization of the vehicle. Some authors are used CAITA, Creo etc. software for designing a leaf spring and ANSYS software is also used for the Analysis of the leaf spring. From different examination papers, it is presumed that contrasted with regular mono and multi steel leaf spring, composite leaf spring have less weight, stresses, vibration and expanding strength, exhaustion life and ride comfort.

Introduction to spring

A spring is an elastic body, which is used to soak up and launch energy when the load is applied or acted upon it. The Load-carrying capability and performance of suspension machine depend on the kind of material, geometry and mechanical properties of leaf spring. Leaf spring is used in heavy automobile vehicles like trucks. Buses etc. while helical springs are used in light automotive motors like small cars, motorcycles. Bicycles and railway suspension systems etc.

Leaf spring

A leaf spring is a simple structure of spring which is in Semielliptical shape. Leaf springs are considered as the oldest automobile suspension elements which will be used in heavy car motors like Trucks, Jeeps, Buses and light car passenger vehicles. Composite substances consist of two materials. They are called matrix and reinforcement.

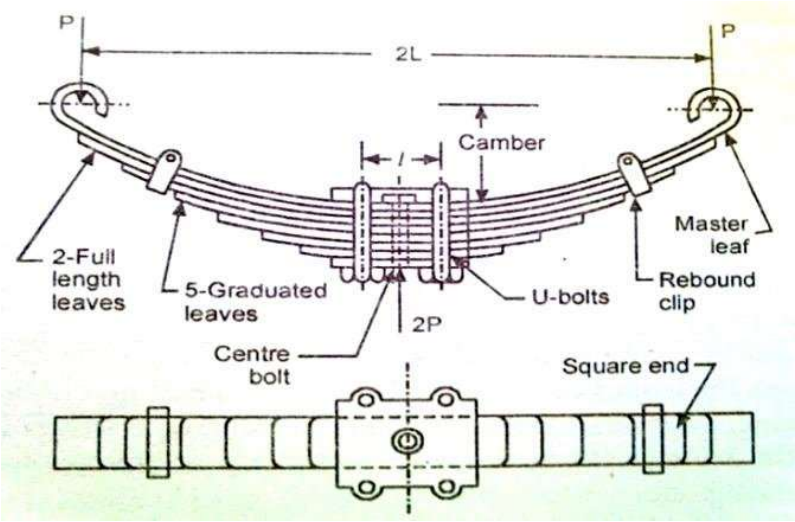

Figure 1. leaf spring [21]

Different shapes of leaf spring

- Elliptical
- Semi Elliptical
- Quarter Elliptical
- Three-Quarter Elliptic
- Transverse

Literature Review

2.1 The Noteworthy Contribution from the past work

1. This paper describes the design and analysis of Composite leaf spring used for the automobile industries. For this, various composite materials were used. Static, Fatigue and Modal analysis were performed using experimental and analytical methods. From various research papers, it is concluded that compared to conventional mono and multi steel leaf spring, composite leaf spring have less weight, stresses, vibration and increasing strength, fatigue life and ride comfort. As a result, composites provide a promising future and are an effective replacement for the existing steel leaf spring in automobiles.
2. In this paper, only a mono-leaf composite leaf spring with varying width and varying thickness is designed and manufactured. Computer algorithm using C-language has been used for the design of constant cross-section leaf spring. The results showed that a spring width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat. Many techniques can be suggested for the fabrication of composite leaf spring from unidirectional GERP. To design composite leaf spring, a stress analysis was performed using the finite element method done using ANSYS software. Testing has been done for unidirectional E-Glass/Epoxy mono composite leaf spring only. The weight of the leaf spring is reduced considerably about 85 % by replacing steel leaf spring with composite leaf spring.
3. A leaf spring is a simple structure of spring which is in Semielliptical shape. Strength, lifetime and better mechanical properties [9]. Composite substances consist of two materials. They are called matrix and reinforcement. Carbon fiber fabric, Glass fiber fabric and Random glass fiber fabric are taken in this investigation.
4. The main focus of this paper is to review all the work having aim to reduce overall weight of the vehicle. The introduction of composite materials has made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffnes. Therefore there is an immense scope for the future work regarding use of composite materials in leaf springs to reduce the overall weight of the vehicle as well as the cost of the vehicle.
5. Leaf spring is an essential part of automotive sector. In this paper we present our work on two types of leaf springs (i.e. Semielliptical and parabolic). The main intention of introducing this paper is to achieve modification in the design. Maximum stress introduce in semi elliptical leaf spring 23.60Mpa and in parabolic leaf spring maximum stress value observed 21.90Mpa and minimum stress observed in semi elliptical and parabolic leaf spring 19.402Mpa and 17.424 Mpa respectively.
6. The paper proposes a semi-analytical model to analyze large deformation elastic behaviour of leaf spring under static load. After validation of the proposed leaf spring model with finite element results, effects of various system parameters on system stiffness's are observed. Among the considered three types of curved leaf shapes, semi-elliptic shaped system shows lowest system stiffness, Witch of Agnesi shaped system shows highest, and master leaf shaped system lies in between them.
7. In the present work, a composite material is considered for the application of suspension system leaf spring. In this paper composite-material leaf spring (CMLS) has been studied for its characterization and mechanical properties. In this work, a rear leaf spring of Mahindra pickup made of conventional steel leaf spring (CSLS) has been used. A hand lay-up fabrication technique was used to make the CMLS. E-Glass/composite matrix (epoxy resin and hardener) CMLS has less weight of around 75% as compared to CSLS. The performance and efficiency of the vehicle are better if CMLS is used in the suspension system instead of CSLS.
8. A single leaf, variable thickness spring of glass fiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf steel spring was designed fabricated and tested. Others work has shown that composite leaf spring have better fatigue behaviour than steel spring.

9. In this paper, the influence of ellipticity ratio on performance of woven roving wrapped composite elliptical springs has been investigated both experimentally and numerically. Typical failure histories of their failure mechanism are presented and discussed. In general, this study demonstrated that composites elliptical spring can be used for light and heavy trucks and meet the requirements, together with substantial weight saving. The results showed that the ellipticity ratio significantly influenced the spring rate and failure loads. Composite elliptic spring with ellipticity ratios of a/b 2.0 displayed the highest spring rate.

10. Fiber reinforced plastics are undergoing extensive studies as potential structural materials for automotive applications. This paper describes the design, fabrication, weight analysis and testing of a composite integrated rear suspension in a Ford Escort vehicle. Ride and handling issues were determined. A system weight saving of 7 lb. was demonstrated. Component integration was demonstrated. A concept demonstration vehicle was built. Concept durability was demonstrated.

11. The addition of carbon nanoparticles in the composites improves their mechanical properties, including wear enhancement, which leads to the utilization of these composites in different fields. The present work investigates the wear performance of glass fiber and carbon nanotube (CNT) reinforced hybrid polymer composites. The AFM utilizes a sharp pointed tip to scan across the sample. Figures 23, 24 and 25 show the AFM images of the GFRP composites with 1%, 3% and 5% CNTs after the wear test. The result shows that the increment in applied load leads to an increase in the rate of wear, which is based on the time span of scrubbing. The increment in the volume percentage of CNTs in GFRP composites decreases the wear rate.

12. Fiber-reinforced composites are the materials of choice in numerous advanced applications in the fields such as automotive, aerospace, and marine as compared to conventional engineering materials. Tensile strength was found in the order of UD>2D>3D>CHOPPED. This was due to the fact that in UD all the fibers were in one direction, whereas in 2D and 3D fibers, they were distributed in three directions, respectively. Flexural stiffness was found in inverse trend with the energy absorption due to the fact that stiffer the material lower will be the energy absorption.

13. The paper describes static analysis of steel leaf spring and laminated composite Multi leaf spring. The objective is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. From that 79.617 % weight reduction in composite material has been achieved for same number of leaves. If we consider mono composite leaf spring then weight reduction achieved up to 90.09%.

14. This work dealt with the textile structural reinforced composites (TSRC) prepared by different textile structures as reinforcement in epoxy by employing vacuum assisted resin infusion molding (VARIM) process. The composite reinforced with 3D woven structure depicted high energy absorption capability and storage modulus. However damping properties of 3D was not found to be better, due to the presence of through thickness yarn.

15. This paper investigated the static and fatigue behaviors of steel and composite multi-leaf spring using the ANSYS V12 software. The dimensions of an existing conventional leaf spring of a light commercial vehicle were used. The same dimensions were used to design composite multi-leaf spring for the two materials, E-glass fiber/epoxy and E-glass fiber/vinyl ester, which are of great interest to the transportation industry. Main consideration was given to the effects of material composition and its fiber orientation on the static and fatigue behaviors of leaf spring. The design constraints were bending stresses, deflection and fatigue life. Compared to the steel leaf spring, the designed composite spring has much lower bending stresses and deflections and higher fatigue life cycles.

16. Due to heavy competitive market and strict rules from governments, automakers want to reduce pollution, fuel consumption etc. Further weight reduction is the most effective way of improving fuel economy without losing the performance of the vehicle. The main objective of this paper is weight reduction of Leaf Spring and thereby improving performance of the vehicle. Weight of both Steel and Carbon/Glass Epoxy Leaf Springs obtained using ANSYS. Approximately 79% weight reduction is achieved. Improved Vehicle performance and Efficiency. Corrosion problem is eliminated.

17. The objective of the present work is design, analysis and fabrication of mono composite leaf spring. The design constraints are stress and deflections. The material selected is glass fibre reinforced plastic (GFRP) and the epoxy resin can be used which is more economical to reduce total cost of composite leaf spring with similar mechanical and geometrical properties to the multileaf spring. The weight of the leaf spring is reduced considerably about 74 % by replacing steel leaf spring with FRP leaf spring.

18. . Weight reduction is the major problem faced by many automobile industries. Weight reduction can be achieved by designing new materials and sophisticated manufacturing processes. Stresses produced in composite leaf springs are also 20–30% less than conventional steel leaf spring which also depends on type of constituents used. This paper may also provide an intension on natural fiber-based hybrid composite over synthetic fiber-based mono composites due to their cost, recyclable, availability, and also considerable weight reduction.

19. This paper taken the composite materials like carbon fiber and tested the mechanical properties of the materials. The specific pattern used like Triangular and Tri-Hexagon in the gauge length to show the how much deformation is being measured. Different types of infill also used in the gauge length. Here we have seen that the 100% infill gives the highest mechanical properties.

20. In this study, experimentally obtained mechanical properties of different fiber-reinforced polymer materials are presented first, followed by the description of the finite element analytical model created in Abaqus 6.12-1 (Dassault Systemes Simulia Corp., RI, US) using the obtained properties. The results from the finite element analysis are presented next and compared with actual size experimental tests conducted on manufactured prototypes. The prototypes showed significant weight reduction of about 80% with improved mechanical properties.

21. This study presents the investigation of mechanical properties of composite materials. The aim of this thesis is static investigation consequences of existing leaf spring made of EN 45 steel material with three different sort of composite material leaf spring. Comparing with steel spring result with composite spring result we have seen that the wt. of the composite material leaf spring made of Kevlar/epoxy fiber, is diminished by 6.01%, by utilizing material E-glass/epoxy Fiber it is diminished by 59.1% and by utilizing material carbon/epoxy fiber it is diminished by 63.7%.

In above paper most of the authors presented the weight reduction of leaf spring. The several types of materials used for fabrication of leaf spring some of them are Kevlar, carbon fiber, E-Glass, Graphite reinforced with the epoxy materials to increase the strength of spring. This review describe the all authors taken the materials and studied the mechanical properties.

Conclusion

This paper provides a brief review over the recent researches carried out on leaf spring in the view of weight reduction in which each paper consists of material selection, processing techniques, modelling, Numerical analysis, FEA analysis and experimental investigation also. The authors worked in the past are briefly presented here which types of materials are taken and what the final output of the process. This investigation is very helpful for the researcher that they can see what types of worked has done before and what next we do in the leaf spring topic. The future scope of the present study is that authors also find out the different types of properties including static and dynamic and also take the different types of materials with reinforcement or without reinforcement.

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