International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

A Review on Finite Element Analysis of Composite Leaf Spring for Automotive

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Abstract - *This paper reviews some of the general studies on the design, analysis, and fabrication of composite leaf springs. A lot of research has been done to improve the performance of leaf springs. This paper reviews few documents on the use of alternate materials and analysis the effect on leaf spring performance.*

Keywords: **Glass fibre, epoxy, natural fibre, FEA, leaf spring**

1. INTRODUCTION

Springs are machine elements that deform significantly under loading. A leaf spring is an example of large elastic deformations in machine elements. The leaf spring stress is constant throughout its length due to the equal increase in bending moment and cross-sectional area of the spring from the ends to the centre. The cantilever beam is one of the most superficial springs used in machine elements.

Leaf Spring is the oldest component widely used in commercial vehicles because of easy manufacturing cost and better load carrying capacity. Usage of Composite Materials is gradually increased in the Automobile Industry. Steel's Leaf Spring is still preferred due to its high strength and Energy Absorption Ratio.

Leaf springs are designed in two ways:

• Multi leaf springs

• Mono leaf springs.

An elastic suspension member was consisting of assembled steel sheets having the same width and different lengths. The multi-leaf spring suspension is a component that receives a dynamic load while the vehicle is running. Sliding friction between each leaf spring is a vital damping mechanism for the vehicle.

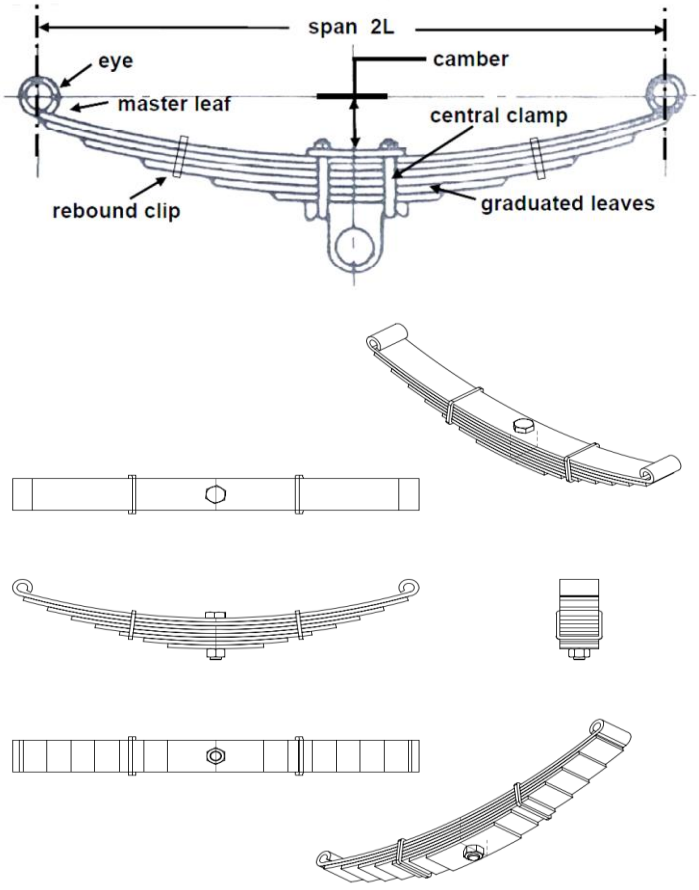

Figure-1.1 Multi-leaf spring

For cars also, these are widely used for the rear suspension. Semi elliptical leaf springs consist of several leaves called blades. These blades vary in length. The composite spring is based on the theory of a beam of uniform strength.

2. LITERATURE REVIEW

Pankaj Saini, Ashish Goel, Dushyant Kumar [1] –

In this paper, the author describes and explains how to reduce the leaf spring weight while maintaining strength. It is a significant research issue in the modern world. Therefore, when researchers compare composite material with steel, it is a solution to such an issue. In this paper author, describe the design and analysis of composite leaf spring. This research aims to compare the stresses and

weight saving of composite leaf spring with that of steel leaf spring.

The author uses glass fibre reinforced polymer (E-glass/epoxy), carbon epoxy, and graphite-epoxy material against conventional steel. The design parameters were selected and analysed to minimise the composite leaf spring weight compared to the steel leaf spring. The leaf spring was modelled in Auto-CAD 2012, and the analysis was done using ANSYS 9.0 software. They thought about for stresses and weight sparing of a composite leaf to that of the customary plate with plan imperative as firmness. A relative report demonstrates that E-glass/epoxy composite leaf spring can replace the steel leaf spring from the anxiety and firmness perspective.

Parkhe Ravindra, Mhaske Raman, Belkar Sanjay [2] - In this research paper, the author describes the design and analysis of composite mono leaf spring. They use an existing mono steel leaf spring for modelling and analysis of a light vehicle. A composite mono leaf spring with Carbon/Epoxy composite materials is modelled and subjected to the same load as a steel spring. The design constraints were stresses and deflections. The composite mono leaf springs have been modelled by considering a Varying cross-section, with a unidirectional fibre orientation angle for each lamina of a laminate. Static analysis of a 3-D model has been performed using ANSYS 12.0. Compared to mono steel leaf spring, the laminated composite mono leaf spring is found lesser stresses. Experimentally investigated composite mono leaf spring for static loading. The result shows that the stresses induced in Carbon/Epoxy composite leaf spring were nearly 42% less than that of steel leaf spring. Hence, they finally concluded that composite material could be used efficiently for lightweight vehicles to meet the requirements, along with considerable weight reduction.

P Sai Krishna, S Vigneshwaran, Rama Raju Srinivasa Rao [3] –

In this research paper, the author analyses the design of the leaf spring. The 3-D model was created using design software solid works 2017. The First 4mm thickness leaf spring then 5 and 6mm are modelled. Structural analysis is carried out in Ansys by applying three different materials such as carbon epoxy carbon steel and e glass epoxy at 6685N force is applied on leaf spring for three separate thickness leaf spring. The material properties of the above materials are studied. It is concluded that already 6mm thickness exists by reducing it to 5mm and 4mm by varying the thickness reduction in weight. The carbon steel material analysis for 5mm thickness shows less stress than 4mm thickness leaf spring. Leaf spring containing 4mm thickness undergone maximum stress though the weight reduction is maximum but stability to oppose the load is low, but 5mm thickness leaf spring got the values nearer to 6mm, and it has a low weight compared to 6mm leaf spring. The author concluded that the leaf spring containing 5mm thickness applied with carbon steel material shows the best results.

Dev Dutt Dwivedi, V. K. Jain [4] –

This research paper describes the design and analysis of composite leaf spring deflection and compares Conventional steel leaf spring results with the present results obtained for composite leaf spring.

For analysis of the result, they used the finite element analysis method. A three-layer E-Glass/epoxy composite leaf spring has used in this research. In this paper, they investigate the design and analysis of leaf spring and leaf spring fatigue life. It is clear that the E-Glass/Epoxy material is less deformation compared to conventional steel. In the composite leaf spring, the Equivalent stress generated is less as compared to steel leaf spring. Maximum shear stress and maximum principal stress are also less found in E-Glass/Epoxy material than conventional steel leaf spring.

Results demonstrate that composite leaf spring deflection for a particular load is less compared to conventional leaf spring. Stress generated in the E-Glass/Epoxy leaf spring is lower than steel leaf spring. Its directional deformation is low compared to steel leaf spring, and it is lighter in weight compared to conventional steel leaf spring. Steel spring results are compared with the results obtained for composite leaf spring; E-glass/epoxy material is good in strength and lighter in weight than conventional steel spring. A good amount of study has been conducted during this paper to investigate the style and analysis of spring and spring fatigue life.

Mr. Tharigonda niranjan babu, mr p. Bhaskar and mr. S. Moulali [5] –

The present work aims to design the E-Glass/ Epoxy and Jute E-Glass/ Epoxy composite leaf spring without change in stiffness for the automobile Suspension system and analyse it. In automobile sector tends to increase competition and innovation in design and tends to modify the existing products with new and advanced materials. Leaf springs are a special kind of springs used in automobile suspension systems. one of the functions of leaf spring isolate road induced vibrations. The primary function of leaf spring is to support a vertical load. Thus the leaf spring constantly subjected to millions of load cycles which leading to fatigue failure.

In this research paper, the author analysis leaf spring as made of composite materials, which is possible to reduce the leaf spring weight without reducing load carrying capacity and stiffness. Therefore, this paper aims to present a general study on the performance comparison of composite (E-Glass/Epoxy and Jute E-Glass) leaf spring and conventional leaf spring. In this paper, the author uses a 3-D modelling software CATIA V5R20 where Leaf spring is modelled and

imported in ANSYS 12.0. The conventional composite leaf springs were analysed under similar conditions using ANSYS software.

The stresses and deflection developed in steel leaf spring and composite leaf spring are found with a significant difference. When they compare both leaf springs with the same parameter, they found the deflection is less in composite leaf spring with the same loading condition. Conventional steel leaf spring is also 5.5 times heavier than Jute E-Glass/Epoxy leaf spring. Material saving of 71.4 % is achieved by replacing Jute E-Glass/epoxy in steel for fabricating the leaf spring.

Manjunath H N, Manjunath K, T. Rangaswamy [6] –

Dynamic analysis of a composite leaf spring was carried out and considered five different composite materials (E-glass/epoxy, Graphite/epoxy, Boron/ Aluminum, Carbon/epoxy, and Kevlar/ epoxy) respectively. In this research work, the author analysis a mono composite leaf spring of TATA ACE with constant width and constant thickness with uniform cross-section. The design parameters such as spring length, spring thickness, spring width, and camber remain the same in both steel and composite leaf springs. Modal analysis is a technique used to obtain Eigenvalue and Eigenvectors under forced free vibration. The first two bending frequency modes of Steel, E-Glass/Epoxy, Graphite/Epoxy, Boron /Aluminum, Carbon/ Epoxy and Kevlar/Epoxy of leaf springs.

The objective for the optimum design of the composite leaf spring is the minimisation of weight, and this objective function by considering the functional requirements of the leaf spring, which is, Fundamental natural frequency in bending. Thus, together with constraints from the applicable requirements, the objective function is optimised by varying the design variables so that functionally sound, minimum weight leaf spring is realised. Material properties of different composite harmonic response analysis are used to determine the steady-state response of a linear structure to loads that vary harmonically with time. The harmonic response of Steel, E-Glass/Epoxy, Graphite/Epoxy, Boron/Aluminum, Carbon/Epoxy and Kevlar/Epoxy leaf Springs results obtained from analysis for steel and various composite leaf springs observed that Boron/Aluminum possess a high natural frequency compared to other materials. The response for steel and composite leaf springs at their corresponding resonance frequencies observed that E-glass/Epoxy and Kevlar/Epoxy have more amplitude of response when compared to all other materials. The Steel and Boron/Aluminum are having less amplitude of response compared to other materials.

FEA solver results show that the deflection and von mises stress for Boron/Aluminum leaf spring is comparatively less than other leaf springs. Hence vibration capacity is more in composite leaf spring than in conventional steel leaf spring.

In this research work, eigenvalue, harmonic and random vibration analysis for steel and various composite leaf springs is carried out using ANSYS.

Results showed that Boron/Aluminum had the highest natural frequency compared to other composite materials.

Sagar B Mahajan, Prof.M.C.Swami, Permeshwar Patil [7] - This paper aims to present a general study on the Design and Analysis of composite (Glass Fibre Reinforced Composite-GFRC) leaf spring. The objective is to design the E-glass/epoxy composite leaf spring for the automobile suspension system and analyse it. By varying thickness, stress, and deflection of glass fibre reinforced composite (GFRC) was different from conventional leaf spring. They compared analytical results with FEA for composite design with varying thickness and found that FEA results show good agreement with stress and deflection. Their study demonstrated that composites could be used for leaf springs to meet the requirements. To achieve weight reduction in the suspension by replacing steel leaf spring with composite leaf spring. Static analysis is performed out in FEA based software Ansys14.5 with design constrain as Stress, Deflection with varying thickness.

In this research work, the authors have selected materials for leaf spring that should be consist of nearly 60%-70% of the vehicle cost and contribute to the quality and the performance of the vehicle. Even a tiny amount in a weight reduction of the vehicle may have a broader economic impact. Composite materials are proved as suitable substitutes for steel in connection with the weight reduction of the vehicle. Composite material with less weight due to this fuel consumption would be reduced, high damping capacity due to less vibration and noise, good corrosion resistance, high specific modulus and strength, and longer fatigue life. Hence, the composite materials have been selected for leaf spring design. The commonly used fibres are carbon, glass, keviar, etc. Among these, the glass fibre has been determined based on the cost factor and strength. A virtual model of steel and mono composite leaf has created in DM-design modular in Ansys14.5. for analysis. After analysis, a comparison is made between the existing conventional steel leaf spring and mono composite leaf spring in deflection and stress.

The analytical result was compared with FEA of varying thickness shows good agreement with stress and deflection. The study demonstrated that composite could be used for leaf spring to meet the requirements.

3. CONCLUSION

From the literature review, it is seen that the objective was to obtain a spring with a minimum weight that is capable of carrying given static external forces by constraints limiting stresses and displacements. For that, the steel leaf spring is replaced by a composite leaf spring. The steel leaf spring

performance was compared with the composite leaf spring using analytical and experimental results. FEA is used to predict the total life cycle and fatigue life of composite and steel leaf spring. Results show that the composite spring is lighter than conventional steel spring with similar design specifications but not always is cost-effective over their steel counterparts. The natural frequency of composite leaf spring is higher than that of steel leaf spring and is far enough from the road frequency to avoid the resonance. The stresses generated in the composite leaf spring are lower than that of the steel spring. Composite materials have more elastic strain energy storage capacity and high strength to weight ratio than steel; therefore, it is concluded that composite leaf spring is an adequate replacement for the existing steel leaf spring in an automobile.

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